ENTREPRENEURIAL RISK LINKED TO WATER QUALITY, WATER SECURITY FOR URBAN-BASED FARMING AND AGRO-PROCESSING

Report to the
WATER RESEARCH COMMISSION

by

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EXECUTIVE SUMMARY

Water serves several purposes. It sustains life and facilitates economic activity that manifests itself in homes, businesses, and industries, along diverse value chains. There is a need for increased agricultural production, safe food supply chains, improved agro-processing and improved water quality and safety. Water is also used for cleaning crops; thus water supply interruptions in storage facilities may result in crop losses, impacting on food distribution. Despite having entrepreneurial characteristics, intentions and spirit, many urban farmers do not have access to resources like land, microbiologically safe water, financial redit and markets, which renders them susceptible to health hazards and entrepreneurial risks.

A team of investigators from the African Centre for Food Security (ACFS) in the discipline of microbiology at the University of KwaZulu-Natal (UKZN), ably headed by the project leader Professot Joyce Chitja, in cooperation with the Obafemi-Awolowo University of Nigeria, implemented a research project commissioned and managed by the Water Research Commission (WRC), titled *Entrepreneurial Risk linked to Water Quality and Water Security for Urban-based Farming and Agro-processing* (WRC PROJECT NO: **WRC C2020/2021-00203)**.

In order to address food security at a household level, the research sought ways of linking water quality to urban farming and of evaluating the entrepreneurial risks related to urban-based farming in urban farms and home gardens. The study was undertaken using activities that are designed to enhance action-based learning. Firstly, a literature review and analysis were undertaken, where an assessment was made of the water quality, water access, urban farming practices, agro-processing, as well as the nature and role of the stakeholders and the entrepreneurial risks in urban farming.

Three research sites were selected, namely, Sobantu, Mpophomeni and Sweetwaters under uMngeni and uMsunduzi local municipality in the KwaZulu-Natal Province.

The overall research methodology adopted was a mixed-methods methodology encompassing qualitative and quantitative data collection and analysis tools. The sampling approach was multi-staged purposive sampling. Established microbiology water analysis methods were employed for water quality assessment.

The results show that natural, institutional, social and economic problems seem to be responsible for the lack of access to consistent safe water and the water shortages that are experienced by these farmers. The lack of water and other resources, including finance, weakens the ability of the farmers to access and supply their goods to the market throughout the year. The farmers need to be empowered in technologies for water harvesting and retention, where mulching and water safety improving practices are used to reduce the microbial load. These technologies and empowerment were being shared on an ongoing basis by means of field schools as a cultural practice in Sobantu. These findings demonstrate the need to enhance farmers' knowledge and behaviour regarding irrigation practices through human developmental training, which will enable them to produce on a larger scale and to gain access to markets. This will likely add to food security by improving access and availability. Given the limiting factors, including the constant water-cuts, high water tariffs, and climate change effects such as flooding, poor smallholder urban farmers require cost-effective, but reliable water sources.

The findings also revealed that the lack of access to water and water scarcity experienced by farmers affected entrepreneurial endeavours. Their capacity to investigate market access and supply throughout the year is weakened by a shortage of water and other resources including storage and packing facilities. For example, small agro-processors have a significant need for a physical facility and quality water for washing their fresh items. Furthermore, good agricultural practices and hygiene awareness are important because they are crucial for decreasing pre- and post-harvest microbial contamination and for market access.

The results further indicated that the low adoption of water quality management practices can be attributed to the fact that the majority of the farmers are dependent on tap water provided by the local municipality. However, there are local government limitations on tap water use for agricultural purposes, while the quality of alternative water sources is not actively monitored.

Due to their high need for water, leafy vegetables are predicted to experience the consequences of climate change and water scarcity more severely, which makes vegetable growers more susceptible to climate change effects. Because urban farmers are exposed to various risks, regardless of the type of enterprise, there is therefore a need to address the risk factors of urban agriculture holistically including appropriate production systems.

The study recommends a business-driven action learning (BDAL) process that conducts baseline assessments of the farmers, identifying the internal and external factors for the success of urban farming. The study further recommends that water security is ensured through improved access and smart use. Further, water safety improvement by both farmers and local government needs attention to ensure food safety. Recommendations regarding the strengthening of urban farming and agro-processing include entrepreneurial capacity-building of farmers and physical market entry to encourage produce aggregation for market access and to enable distribution.

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ABBREVIATIONS AND ACRONYMS

DoH	Department of Health
DUCT	Duzi-uMngeni Conservation Trust
DWAF	Department of Water Affairs and Forestry
FAO	Food and Agriculture Organisation
FCD	Foodstuffs Cosmetics and Disinfectants
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GMO	Genetically-Modified Organisms
HACCP	Hazard Analysis Critical Control Point
HDDS	Household Diet Diversity Score
HFIAS	Household Food Insecurity Access Scale
IPM	Integrated Pest Management
MDGs	Millennium Development Goals
NDP	National Development Plan
PESTEL	Power Environment Social Technical Economic and Legal
PHA	Philippi Horticultural Area
SA	South Africa
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Science
SSA	Sub-Saharan Africa
UA	Urban Agriculture
UFOTI	Umgibe Farming Organics and Training Institute
UKZN-ACFS	University of KwaZulu-Natal-African Centre for Food Security
UN	United Nations
UNDP	United Nations Development Programme
WHO	World Health Organisation
WRC	Water Research Commission
WUA	Water User Association

CHAPTER 1: INTRODUCTION

1.1 Background

Despite there being enough freshwater to support all life on the earth, the global water demand is expected to rise by 55% (OECD, 2012; Van Beek et al., 2011). In fact, agriculture is consuming about 70% of global freshwater (United Nations, 2022), and specifically Africa suffers from substantial water access and security challenges (United Nations, 2022). However, it has been established that water's distribution and spatial characteristics prevent it from being shared evenly, especially given the rising demand by all users (Cosgrove and Loucks, 2015). While agriculture, and particularly its value chains, offers possibilities for job development in the small- and medium-enterprise sector, South Africa's rapid urbanisation presents a dilemma for cities, where the employment hopes of the unemployed, particularly the youth, are limited.

Urban agriculture may boost the growth of agriculture if appropriate support is given to access the markets. It is significant to highlight the fact that there has recently been an increase in Black farmers in South Africa (Sihlobo, 2018), which demonstrates that young people can enter this industry if there is adequate access to the market, as well as other production and institutional assistance. Agro-processing also provides agricultural employment that is not exclusively 'farm-centred', as this may put off some young people who are dissatisfied with agriculture. Water is a scarce and non-replaceable resource, especially in South Africa, where there is a severe water shortage. According to the National Development Plan (NDP, 2030), one industry that can assist South Africa to grow is agriculture; however, water scarcity is a concern for both the present and new stakeholders in the industry (Cheteni and Umejesi, 2022). This project seeks to find ways of linking water quality to urban farming and to evaluate the entrepreneurial risks related to urban-based farms and home gardens to address food security at a household level.

Globally, the urban agriculture share of world food production is said to have increased from 15% to 33%; while the share of fresh vegetables, eggs, fish and meat consumed in cities has increased from 30% to 50% (Baumgartner and Belevi, 2001). Generally, agriculture can play a role in job creation, improving food security in rural and urban communities in a country while also contributing to the GDP (Pawlak and Kolodziejczak, 2020). South Africa is seen as a developing country because its agricultural contribution to its GDP, which fluctuates between 4.2% in 2023 and has been ashigh as 10% in 2023 (Stats SA 2023). On the other hand, South Africa experiences rapid rural to urban migration and thus a new food insecurity challenge is increased as few job opportunities meet the rural migrants. Therefore, urban agriculture may provide a means to address poverty at a household level, even though its contribution to the GDP is relatively unknown. Furthermore, urban agriculture can meet urban demands for certain food including fresh vegetables, poultry, potatoes, fish, and eggs (Danso et al., 2014). Additionally, urban agriculture is already producing about 15% to 20% of the world's food supply, and this plays a critical role in ameliorating food insecurity during the global crisis created by the COVID-19 virus (Lal, 2020).

Several years ago, it was not common for cities, particularly African cities, to have agricultural activities (Thomas, 2012). However, rapid migration from rural areas introduced new food security realities to the migrants because of a decline in jobs, as the mining and industrial hubs are the main job providers for migrants (Ratshitanga, 2017). Even though agricultural activities are increasing in urban areas, water supply to this sector falls short when compared to water supply for industrial activities.

The definition of urban agriculture is associated with the farming activities that take place in urban areas, as people see it as a source of livelihood (Cofie et al., 2003). The term is defined by Van Veenhuizen (2014) as "the growing of plants and the rearing of animals for food and for sales within and around cities and towns, and related activities such as the production and delivery of inputs and the processing and marketing of products". By contrast, in high-income (global north) households, urban agriculture is a tool for ensuring a more environmentally friendly way of food production and an investment (Lupia and Pulighe, 2015). The agricultural activity is done on very small plots of land mainly for food production (and to sell) for survival purposes (Prian and Zeeuw, 2007). Urban agriculture increases the use of vacant spaces to enforce food production in green spaces in the cities where farming was a distant concept (Lupia and Pulighe, 2015; Ghaleh, 2019). The farmers also introduce different social, physical, and economic functions on the land around the home to supplement the supply of fresh food at the household level (Lal, 2020). The food supplied is, however, often not sufficient due to water shortages in the cities. As a result, farmers opt for other sources of water, such as wastewater, rainwater harvesting, local rivers and greywater.

Wastewater reuse is an ancient practice, used to irrigate and fertilise agricultural fields with crops and orchards. Wastewater has not been properly managed or has not met quality standards (Jaramillo and Restrepo, 2017). The reduced water capacity globally, specifically in urban areas, has resulted in wastewater becoming the next best option for farmers (Elamin, 2019; Pulighe et al., 2020). This has been the case in countries such as China and Mexico, because of water scarcity in arid and semi-arid areas, some of which have urban farmers who are faced with production risks caused by factors such as climate change which led to droughts (Cirelli et al*.,* 2012; Pulighe et al*.,* 2020). In South Africa treated municipal wastewater (TMWW) is said to be a source of water that is almost always readily available for crop irrigation, however, the inefficient water distribution networks and water quality degradation has aggravated the water demand (Cirelli et al*.,* 2012). Moreover, some countries do not treat wastewater as it is costly and the water is therefore dumped, untreated, into water bodies or onto land (Buechler et al*.,* 2006), further exacerbating the issue of reduced water quality in areas where wastewater is left untreated and raising concerns about food hygiene if wastewater of poor microbiological quality is used for irrigation or processing in food production (Antwi-Agyei et al*.,* 2016; Alegbeleye and Sant'Ana, 2023).

Those producing in urban and rural areas face challenges related to access to and affordability of water due to the lack of governance mechanisms and investment in water technologies and infrastructure as well as the growing need for water causing shortages (Pulighe et al*.,* 2020). There is a need for all stakeholders to work together for better water governance. However, the plethora of stakeholders in urban agriculture from the political, environmental social, and technological fields is also daunting, such as in Johannesburg, where wastewater plays a key role for urban farmers as the area lacks freshwater facilities (Ratshitanga, 2017). The assessment of water quality is an important element in governance both in terms of food safety and clean water for drinking and requires good governance.

Urban farmers should also pay close attention to other risks relating to agriculture be it in a rural or urban setting, as the challenges are somewhat similar and can have a detrimental effect on the business if not accounted for accordingly. Such risk factors include financial risk, institutional risk, as well as market risk (Korir, 2011; Korir et al., 2014). All of these can be referred to as entrepreneurial risk factors which have been evaluated in agriculture and other industry sectors, however, there are limited studies on the nexus of entrepreneurial risk factors and urban agriculture.

The concept of entrepreneurial risk was first distinguished by Cantillon in 1755, who noted that both farmers and most urban entrepreneurs (that is, manufacturers, wholesalers and retailers, homeowners, and artisans) operate in conditions of uncertainty (Pinkovetskaia et al*.,* 2019). The concept was further explored by Knight (2012), who investigated the relationship between risk, uncertainty, and profit of an enterprise, and proposed that profit is viewed as the gain for the risky situation (Pinkovetskaia et al*.,* 2019). Urban agriculture is also found to have risk factors that affect profitability and production yield and quality. There are five currently known risk factors in agriculture that impact production yield and quality, namely production risk, price/market risk, financial risk, institutional risk and human or personal risk (ERS, 2020; Komarek et al., 2020). Urban farmers are faced with the above-mentioned risk factors, which can affect the farmer's profitability and food security status. Hence, the necessity for urban farmers to become risk managers, considering the vital role they play in urban societies in providing social, physical and economic functions (Lal, 2020; Komarek et al., 2020). The farmers' perception and attitude toward risk are also what make them good risk managers, that is implementing risk management strategies (Kahan, 2013). Risks in agriculture can discourage farmers from practising agriculture, making the assessment of risk factors an important endeavour.

Given the fast expansion of urbanisation in the world, including South Africa, the need for nutritious food will increase further, putting more strain on the urban food system. Urban agriculture has the potential to mitigate poverty and improve food and nutrition security. However, entrepreneurial endeavours in overpopulated areas may be impeded by poor water quality, and limited profitability, land, and access to markets. However, there are growing benefits of urban agriculture including social urban and environmental renewal (Yuan et al., 2022). The study had several objectives to fulfil namely:

Objective 1: A detailed literature review on the entrepreneurial risks that are associated with the quality and security of water supplied to urban-based farming and related agro-processing, as well as equity among the water users and water recycling.

Objective 2: The assessment of the nature and role of stakeholders, water quality, water access, urban farming, and agro-processing on the entrepreneurial risks in urban farming.

Objective 3: A stakeholder workshop to establish a Political, Environmental, Social, Technical, Economic and Legal (PESTEL) environment for urban farming and agro-processing.

Objective 4: An assessment of the microbial burden of irrigation water.

Objective 5: An assessment of water security, which is defined as availability, accessibility, utilisation, and stability of water supply.

The study fulfilled the objectives over four years and produced several graduates along with matching theses, conference presentations and journal papers that continue to be submitted for future publications.

1.2 Summary

Rapid migration from rural areas to urban areas has increased the demand on urban food systems and has introduced new realities for employment and food security due to limited job opportunities, as the mining and industrial sectors remain the main providers of employment in urban settings. Over recent years, urban agriculture has been recognised as having great potential in strengthening urban food systems, generating income, and improving food security for households in urban areas. However, urban farmers are faced with entrepreneurial risks that can affect their profitability and food security status. This project therefore aimed to find ways of linking water quality to urban farming and evaluating the entrepreneurial risks related to urban-based farming to address food security at a household level.

The following sections will address the Literature Review, which lays the theoretical foundation for the study, followed by the Methodology, outlining the research design and data collection methods. Subsequently, the research chapters, specifically tailored to address the objectives of this study, will be detailed. Following the presentation of the research findings, a comprehensive chapter of conclusions and recommendations will provide insights into the key takeaway points and practical suggestions. Lastly, the report is concluded with a guideline for entrepreneurial risk linked to water quality, water security for urban based farming and agro-processing as an addendum.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

It has been estimated that the global water demand will increase by 55% (Wu et al., 2022), even though there is enough fresh water to support all life on earth (Contador et al., 2023). However, it has been established that, while the demand for water by all its users is increasing, its spatial distribution makes it impossible to be shared equally (Cosgrove and Loucks, 2015; Ghosh et al., 2023). The rapid urbanisation in South Africa poses a challenge for its cities, where the hope of finding employment is scarce, particularly among the youth; however, agriculture, particularly its value chain, offers opportunities for job creation in the small- and medium-enterprise space. Provided that adequate support exists and that it is supported by access to the markets, urban agriculture may contribute to the growth of agriculture. It is important to note that there has recently been a rise of Black farmers in South Africa (Sihlobo, 2018), which indicates that with market access and other production and institutional support, the youth can enter this sector. Agro-processing also offers a role in farming that is not necessarily 'farm-based', as this could be a deterrent to some youth who lack any interest in agriculture. However, water is a scarce resource that cannot be substituted, even more so in a water-scarce country like South Africa. The NDP (2030) states that agriculture is one industry that can contribute to South Africa's growth, although water scarcity is a concern for new and current entrants in the sector. The water demands are increasing in all sectors, including agriculture. One of the predictions is that increases of up to 400% will come from the manufacturing sector (PWC, 2014). Agro-processing can be seen as part of manufacturing, albeit food manufacturing, while on the other hand, agricultural water use is also a significant driver of water consumption as it is consuming a large share of the fresh water. It is therefore prudent to investigate the demand for, and use of, water in urban agriculture, particularly in eThekwini, which is one of the largest and fastest-growing metro cities in South Africa.

Water distribution differs significantly from one region to another, depending on the geographic location of a particular region and its particular climate. The spatial and temporal distribution of water makes it impossible for it to be shared equally (Cosgrove and Loucks, 2015). Such an imbalance in its distribution, coupled with other challenges, including the quality of the fresh water, results in developmental- and entrepreneurial-related challenges and risks. Water shortages have a direct impact on domestic requirements, on food production and on other productive uses. This is one contributing reason why more than 800 million people, which is 15% of the world's population, get fewer than 2,000 calories a day to eat significantly due to lower yields (Cosgrove and Rijsberman, 2014.

Urban agriculture refers to the practice of planting crops and keeping livestock in urban and peri-urban areas. It is different from normal agricultural practices, as it is integrated into heavily-populated zones, it often competes for municipal water and there is a shortage of arable open spaces, which are already in high demand (Nolasco, 2011). While there is a growing challenge of water shortages and insecurity, ensuring water security for urban-based farming and agro-processing puts further pressure on the water supply in the mostly high-priced urban areas. The unaffordability of water for farming may be one of the main reasons why urban farmers retreat from practising farming, which may promote unsafe wastewater usage. However, if proper irrigation is implemented correctly, it may provide some solutions. Wastewater related to production and consumption activities contains pollutants that may be produced daily by households, factories and commercial sources (Hussain et al., 2002). The benefit of wastewater is that it is available all year round and it contains nutrients, which support plant growth (Roy et al., 2013; Dickin et al., 2016). With sufficient knowledge, farmers can possibly minimise their fertiliser expenses, as wastewater may contain nutrients that are required for plant growth. However, it is critical to have an astute knowledge of wastewater usage, in order to avoid a myriad of hazards that are caused by the concentration of waste (heavy metals) that is often found in wastewater, because up to 80% of water that is not treated contains unknown contaminants (Michetti et al., 2019). A study by Roy et al. (2013) found that the potential risks of wastewater usage are linked to insect attacks, diseases and excessive weed problems, as well as the spread of malaria and other water-borne diseases (Stewart and Korth, 2013). Excreta-related pathogens, skin irritants and the toxic effects caused by wastewater chemicals could result in health risks for the farmers and agricultural workers and their families, as well as for the communities who live in proximity to wastewater irrigation and the consumers of wastewater-irrigated crops (Dickin et al., 2016).

A review of the literature on the theory and the evidence relating to the assessment of entrepreneurial risk and water quality in urban agriculture are presented in this chapter. An overview is given of the contribution of entrepreneurship to the growing literature on urban agriculture, by examining the validity and applicability of the mainstream concept of water quality in the context of smallholder farming, with empirical evidence from South Africa. The chapter uses insights from the literature and empirical findings to validate the arguments that are presented. The concepts of urban agriculture, entrepreneurial risk and water quality in urban farming will also be addressed in this chapter. It includes literature on empirical works relating to the following: an assessment of relevant policies impacting the access to, and quality of, the water used for urban agriculture; the determinants of the entrepreneurial risks associated with engaging in urban agriculture, as well as water access and use and their effects; an investigation into the role played by urban farmers in urban markets for low- and high-income households; and the theoretical and empirical evidence on the assessment of entrepreneurial risk and water quality in urban agriculture.

Food insecurity remains a global challenge and despite the decrease in its prevalence, the ever-increasing population threatens the stability of food systems, as approximately 9 billion people will likely inhabit the earth by 2050, which will result in increased stress on the food supply (Brooks et al., 2013; Rutten, 2013). Climate change, water scarcity and socio-economic inequality will most likely also have dire implications, which will be further exacerbated by economic slowdown, (Wheeler and von Braun, 2013; Fraval et al., 2019). The FAO estimated that approximately 822 million people suffered from chronic hunger before the COVID-19 pandemic in 2019, and that this resulted in uncertainty about the extent of the adverse effects that would follow. Approximately 132 million people could suffer from chronic hunger as a result of COVID-19, with developing countries accounting for the majority of them, as Africa accounts for about 256 million people who suffer from hunger (FAO, 2020). Food security is a means of attempting to circumvent hunger and poverty and is defined as, "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2002).

Poverty and famine remain very serious issues, particularly in the developing regions of the world. Poverty refers to a state where people are met by a lack of basic services, a low-income, a low education and poor health (Gupta et al., 2007; Skoufias et al., 2011). According to the Millennium Development Goals (MDGs), the severity of poverty was intended to be halved by 2015, but this goal was not reached, as many people are still living below the poverty line of $1.90 per day, particularly within the Sub-Saharan Africa (SSA) region, where there was an increase of approximately 42.9 million people who experienced hunger between 2014 and 2018 (Roser and Ortiz-Ospina, 2013; Haileamlak, 2014; Lomazzi et al., 2014; Sulla and Zikhali, 2018). This could likely be attributed to the global food crisis that occurred around 2007-2008, which led to an increase in food and oil prices. There were also economic slowdowns between 2014 to 2018 and, coupled with climate change, this accounts for the increase in undernourished people. The Sustainable Development Goals (SDGs) were established, with SDG 2 aiming to eradicate hunger and to achieve food and nutrition security by 2030 (Liu et al., 2015; FAO, 2020). Despite there being a significant decrease in global poverty, the SSA regions suffer the most from food insecurity as over 230 million people are malnourished (Gassner et al., 2019). According to a report by the United States Department of Agriculture's International Food Security Assessment, it is projected that the number of food-insecure people is likely to fall from 728 million to around 399 million by 2029 (USDA, 2013).

Hunger and poverty will generally lead to food insecurity, as affordability becomes a major constraint for most people. The United Nations Development Programme Report (UNDP, 2006) highlighted that food insecurity is linked to unemployment, poverty and income. Poverty brings about additional constraints that contribute to chronic unemployment, which results in a reduced standard of living (du Toit, 2011). In Asia and the Middle East regions, approximately 40 million people are suffering from the food crisis. Africa is also experiencing a severe food crisis, affecting approximately 37 million people. COVID-19 also resulted in overburdened health facilities, which exacerbated food insecurity and poverty (Leddy et al., 2020). Although COVID-19 has affected many countries around the world, Africa was shown to be the most vulnerable continent, as it is likely to have a severe impact, given the pre-existing challenges, such as the economic crises (Lone and Ahmad, 2020; Zambrano-Monserrate et al., 2020). East African countries are faced with the threat of swarms of desert locusts that have already caused damage to thousands of acres of crops and that have put rural livelihoods at risk and allowed food insecurity to proliferate. Smallholder farmers in Botswana also lost their crops due to the African Migratory Locust outbreak (FAO, 2020). Adopting sustainable agriculture would play a large role in achieving SDG 6, which focuses on clean water and sanitation. Income growth is crucial for effectively reducing hunger and poverty, and agriculture could play a significant role in developing countries (Brooks et al., 2013; Brooks, 2016; Gassner et al., 2019).

Urban agriculture, which involves the cultivation of crops within cities, could potentially alleviate the need for food without needing more land. Urban agriculture has been shown to produce around 15% to 20% of the global food supply (Gosh, 2023). The role of urban agriculture may be more important for subsistence and income-generation, given the unfolding impact of COVID-19 on the incomes and access to food of the poor and those who have lost their jobs. Although the focus of urban agriculture focused more bridging the gap between the effects of urbanisation and the socio-economic factors, such as a low-income, it can potentially promote food security by addressing the social issues that are faced by many. It can help low income communities to contribute to household livelihood, due to the relative ease of keeping a home garden. There is also the possibility of recycling organic waste, wastewater or greywater (Hazell et al., 2015; Masuku et al., 2017; McDougall et al., 2019).

2.2 Smallholder Farming

Smallholder farmers generally use small plots (around 2 ha of land) relying on family members as a source of labour to cultivate food crops. In some cases, smallholder farmers will practise crop-livestock farming, with only a small number of livestock. Smallholder farmers in developing countries generally have low yields and poor profits, which contributes to their poverty (Herrero et al., 2014; Nyambo et al., 2019). Market access has been shown to allow smallholder farmers to overcome these barriers. There are, however, many definitions of smallholder farmers, as their conditions may differ, depending on the region (Meemken and Bellemare, 2020), and smallholder farming has been recognised as a means of contributing to food security.

2.2.1 Smallholder farming in South Africa

Agriculture in South Africa is comprised of subsistence farmers and large-scale commercial farmers. These are farmers who produce food products to feed their families and hope to sell their excess produce to generate an income, as well as those who produce food on a large-scale and contribute to the total agricultural output of the country (Baiphethi and Jacobs, 2009; Mdluli et al., 2014; Pienaar and Traub, 2015). Smallholder farming is seen as having the potential to greatly contribute to food security (von Loeper et al., 2016); however, smallholder farmers are generally unable to make effective use of the markets because they are hindered not only by the limited resources, such as land and water, but also by their lack of experience and the appropriate skills required. They are at a disadvantage when they have to compete in the markets, where they are rejected due to strict quality and hygiene standards that are required (Matshe, 2009; Mdluli et al., 2014). Factors that need to be taken into consideration are microbial contaminants and their potential sources. Furthermore, antibiotic resistance and the biofilm formation capacity of these microbial contaminants pose a serious problem regarding hygiene and quality standards (Beharielal et al., 2018). This raises the importance of the pre- and post-harvest practices of smallholder farmers with regards to gaining market access and the consumption of food products, especially considering that smallholder farmers are also known to produce organic food products. Furthermore, the implementation of policies requires revision, as it needs to work for smallholder farmers and support them in their endeavours to achieve market access (von Loeper et al., 2016; Myeni et al., 2019).

Livestock production has also been found to be a contributor to the household economy and food security. The ever-increasing population has resulted in an increase in the nutritional demand, particularly for animal protein, (Oduniyi et al., 2020; Visser et al., 2020). The demand for livestock products presents an opportunity for those living under poor conditions to improve their livelihoods, as they are also able to utilise their livestock as collateral in the event of dire need, which is particularly true in the deep rural areas of South Africa (Redding et al., 2012; Meissner et al., 2013). A dual system exists in the livestock farming sector where subsistence and commercialised farming exist. Stud and commercial farmers have access to the abattoirs while small herds are produced for the informal trade (Oduniyi et al., 2020). Compared to dairy cattle, beef cattle account for the majority of cattle production, where commercial farmers own about 60% of all cattle (DALRD 2021). Land issues are some of the key reasons why livestock farmers see it as a poor investment (FAO, 2018a). Poor access to extension services and poor management practices are limiting smallholder livestock farmers from progressing and becoming commercialised farmers (Macleod et al., 2008). The environmental implications are water pollution and depletion, land degradation, and biodiversity, in terms of maintaining the genetic resources (Meissner et al., 2013). Genetic resources are of particular interest; they offer a potential niche market for stud breeders, as it is a lucrative market. There are programmes such as the Independent Development Corporation Nguni and the Land Redistribution for Agricultural Development which are aimed at assisting smallholder farmers to transition towards becoming commercial farmers. Despite the growth in the developing sector, with an estimated 1.3 million farmers, most of them have small herds or flocks and these are marketed mostly for the informal trade, such as slaughtering (van Marle-Köster and Visser, 2018; Visser et al., 2020).

A limited number of people practise urban agriculture for various reasons including easy access to fresh food in urban supermarkets, limited space and inputs (FAO, 2020). In certain South African communities, whether rural or urban, there is a risk of developing dependency on external assistance for agricultural inputs. Ideally, agricultural programmes should be designed to act as a 'foot-in-the-door,' as suggested by Olivier (2018). This means that such programmes should serve as initial support to help communities become self-sustaining and gradually reduce their reliance on external aid, fostering long-term independence and self-sufficiency. Additionally, some initiatives that are aimed at encouraging smallholder farming have been established by the South African government and other stakeholders, and these have been run by universities, research institutes, as well as non-profit organisations (NGOs). Initiatives such as ‘One Home, One Garden’ is one such programme that aims to promote household self-sufficiency (Johnson, 2010). ‘Abalimi Bazekhaya’ promotes smallholder farming within an urban setting; it involves training individuals or groups and encourages the people to work together and to become self-sufficient. Although there has been some progress in implementing such programmes, there are still constraints that need to be addressed; for example, there is not enough media coverage or marketing of these programmes, and so many farmers do not know that they can be assisted. The other main challenge is that many smallholder farmers do not possess the adequate skills and knowledge and, as a result, very few smallholder farmers progress to becoming commercial farmers (Louw and Jordaan, 2016; Olivier, 2018).

2.2.2 Challenges faced by smallholder farmers

Smallholder farmers are faced with numerous challenges when it comes to accessing markets; for example, their vulnerability to natural disasters and price shocks, the lack of adequate capital, and the variability of the weather patterns (Thamaga-Chitja and Hendriks, 2008). Smallholder farmers generally lack awareness of the potential niche markets that could be advantageous to them. Furthermore, they often receive insufficient training regarding the strict hygiene standards of the markets. Consequently, they tend to engage in market competition where they may not have the requisite preparation or resources (Mdluli et al., 2014). Market access is affected by several factors that normally hinder smallholder farmers, such as the safety of their products and the demand for them, because they do not have the required skills and do not understand how these markets operate (Pienaar and Traub, 2015). This puts them at a disadvantage, compared to commercial farmers, who are more experienced (von Loeper et al., 2016). When they have adequate knowledge, smallholder farmers can perform organic farming in the proper manner (Mdluli et al., 2013). It is evident that smallholder farmers are faced with challenges, such as capacity-building, market access and resource access (Louw and Jordaan, 2016). Hygiene quality seems to be one of the major problems that they face, because they have little or no knowledge of microbial contamination; this is a concern that could be resolved by capacity-building and proper policy implementation.

2.3 Conventional Agriculture vs Agro-ecologically-based Agriculture in Urban Areas

Agriculture refers to the production of livestock and the cultivation of other products that can be used for, although they are not limited to, consumption. Many important agricultural products can be used for food products, pharmaceuticals, fuels and other exotic products. However, the main purpose of agriculture is to produce food to sustain human life (Piperno, 2011; Harris and Fuller, 2014). Seufert et al. (2012) argued that organic agriculture produces lower yields, as more land is required to produce the conventional equivalent; however, organic produce can match the yields of conventional produce, but this depends on the conditions of cultivation.

Conventional agriculture is the main method of food production; it entails the high-volume production capacity of crops, primarily through hybrid crop production techniques, and relies on the application of fertilisers and pesticides to enhance yield and productivity. In urban areas, less input-intensive types of agriculture, such as organic farming, may be suitable for supplying niche markets, provided that the appropriate soil nutrition is used. Crops are generally cultivated at a lower cost under conventional agriculture practices. However, this cost advantage comes at the expense of the environment due to the extensive water usage, particularly as the same crop is produced continuously over an extended duration (Seufert et al., 2012; van Beilen, 2016). Conventional agriculture emphasises the monoculture of crops that are produced on the same plots of land at a cost to the health of the soil, due to the depleted nutrients and leaching of pesticides and fertilisers; this affects the water quality, reduces the biodiversity and can affect human health (Gomiero et al., 2011; van Beilen, 2016). Although conventional agriculture is largely unsustainable, there has been some progress and improvements in the methodology, which ensures the protection of soil and water quality (Tal, 2018).

Organic agriculture is seen as a more environmentally-friendly alternative to conventional agriculture. It is an attractive option for smallholder farmers, as it is largely affordable and accessible (Uhunamure et al., 2021) and because it can be carried out without the use of pesticides, fertilisers, herbicides, Genetically-Modified Organisms (GMOs) or synthetic compounds, i.e. preservatives. Organic farming makes use of crop rotation and mechanical weeding to control the weeds. The use of biological control agents is a promising alternative to pesticides, reducing their use (Gomiero et al., 2008; Puech et al., 2014). Similarly, organic animal farming promotes natural inputs in terms of breeding, nutrition and health, where genetic engineering, drugs and additives are avoided, as good management is emphasised to prevent illness (Reganold and Wachter, 2016). Certified organic agriculture does not allow for the use of GMOs and irradiation (Kristiansen et al., 2006). The international standards for the production of organic food are as follows: the Codex Alimentarius Guidelines, which detail the appropriate means of production and processing of foods, and the International Federation of Organic Agriculture Movements (IFOAM) (Randell and Whitehead, 1997; Beharielal et al., 2018). There are also more traditional means of organic production that do not include chemicals, pesticides and fertilisers. Integrated Pest Management (IPM) emphasises the reduction of pesticide use to levels that are economically and ecologically justified. Although they are not as stringent as the international standards, they are referred to as organic, but are not certified organic practices. These practices refer to ecological practices that promote the production of crops, such as organic composting and the prevention of pests and diseases by using medicinal plants (Reganold and Wachter, 2016; Zhu and Habisch, 2019).

2.4 Urban Agriculture

Urban agriculture has attracted the global attention of urban planners and researchers because of its multi-functionality, which is expected to encourage development and generate employment (Marsden and Sonnino, 2008). Furthermore, Lovel (2010) and Surls et al. (2015) have claimed that the social and environmental impacts of urban agriculture make a significant contribution to urban sustainability. Its social impacts include human health benefits (physical and mental), community development and educational benefits. Urban agriculture is also credited with having a positive environmental impact, such as the greening of cities, boosting biodiversity and improving the efficiency of natural resources.

2.5 Entrepreneurial Risk

Water has multiple uses as it supports life and enables economic activities that are used in households, businesses and industries, along various value chains. It is coupled with the demand for the intensification of agricultural production and providing safe foods, particularly with regard to agro-processing, water quality and water safety. This ever-increasing demand for water, coupled with climate change, will affect current businesses and entrepreneurs. Therefore, both communities and businesses need to adapt to the changing environment by assessing the current demands and their future exposure to risks. From a business perspective, the demand for water, as well as its quantity and quality, pose serious production and economic challenges that may affect future agri-entrepreneurs as a result of water scarcity.

Any business is concerned about its reputation and longevity. In agriculture, water is used across the value chain, not only in production. While in agro-processing, it is used for cleaning, cooling, heating, storage and value addition thus affecting the microbiological environment and food safety. Markets are important for agri-preneurs and thus the growing demand for ‘minimally-processed’ fresh produce is an opportunity for small farmers to grow, particularly land-constrained farmers, such as urban farmers. However, the microbial quality of agricultural produce is important, therefore, water quality is critical for all the actors along the value chain. Beharielal et al. (2018) found that water contamination was evident among smallholder farmers. The quality and quantity of water, in the present and in the future, coupled with the increasing cost of water, must be considered when planning for farming activities. The disruption of the water supply in storage can cause losses and affect the distribution of food. For businesses to survive, new and responsive governance and the regulation of water use will need to be in place, together with an awareness of climate change and a disaster and risk management strategy.

Entrepreneurial risk is a complex issue that requires far more explanation than the economic risk (Allah and Nakhaie, 2011; Singh, 2017). Singh (2017) names the four likely basic risks that entrepreneurs could encounter, i.e. a financial risk, a career (job) risk, a family and social risk and a psychological risk. All of these can significantly make or break the entrepreneurial spirit if not understood before attempting to engage in entrepreneurship. Many urban farmers have an entrepreneurial spirit, but they lack access to resources, such as land, water, credit and the market, which then makes them vulnerable to entrepreneurial risks.

- According to the FAO (2007), there are four major urban agriculture criteria, i.e. Subsistence home intra-urban farmers
- Family-type (semi) commercial farmers (intra- and peri-urban)
- Intra- and peri-agricultural entrepreneurs (intra- and peri-urban); and
- Multi-cropping peri-urban farmers (mainly rural producers who are influenced by the city, who adapt their production systems to the demands of the nearby cities and diversify their livelihoods with other occupations).

The FAO (2007) illustrates the differences between the second and third groups, in terms of the size of the enterprise, the use of salaried labour and the investment of urban entrepreneurs in intensive, temperate vegetable production, poultry, fish farms and fruit-growing, to mention only a few.

2.6 Entrepreneurship in Urban Agriculture

This section looks at the potential entrepreneurship of urban farmers, where they engage in urban agriculture not merely as a subsistence farming activity for survival (Hovorka, 2004). This section assesses the importance of entrepreneurial efforts in an urban setting. Several studies have revealed that urban agriculture can be performed innovatively and dynamically, which includes the use of the facilities at their disposal, such as inside buildings, plastic bottles (packets) and hydroponic systems.

The rate at which urban growth is occurring has ultimately resulted in a rise in malnutrition and unemployment (Eisazadeh et al., 2015). As a means of survival, urban dwellers may use their agricultural background and knowledge to address their poverty and growing vulnerability, and this has caused the expansion of urban agriculture due to the scarce livelihood opportunities (Hovorka, 2004). In a time of urban growth with an increased unemployment rate, entrepreneurship in agriculture is another source of making a livelihood for urban dwellers. Eisazadeh et al. (2015), believe that entrepreneurship will be the factor for creating and developing occupation opportunities, while also reducing unemployment. Entrepreneurship plays a significant role in economic development and cultural improvement; however, it also entails a certain level of uncertainty that needs to be known and understood. Urban agriculture presents several opportunities for the unemployed and for those who want to invest in greener cities, especially if they want to accumulate another source of income by becoming entrepreneurs (Thomas, 2012). However, the concept of farmers becoming entrepreneurs needs to be thoroughly understood, as entrepreneurism is described as have two distinct components.

The first component requires managerial skills to run a profitable farm enterprise, while the second component is to have an 'entrepreneurial spirit’ (Kahan, 2013). While urban farmers may possess the skill to be successful farmers, if they lack the spirit of entrepreneurship, they are less likely to succeed in their endeavours; therefore, the two must be interrelated for a farmer to be successful. Urban agricultural entrepreneurs are relatively different from family commercial farmers, in the sense that they mainly depend on salaried labour, and they sometimes do not have an agricultural background (van Veenhuizen, 2014). According to Kaufmann and Bailkey (2000), entrepreneurial urban agriculture projects have different characteristics: some grow food in the soil, while others use hydroponic (non-soil) techniques; some are located in greenhouses and old warehouse facilities in industrial areas, as well as in residential areas. Urban land suitable for horticulture often competes with industries and infrastructure, often being repurposed for urban housing (Thomas, 2012). Evidence shows that large areas could be zoned for horticultural production; for example, in Kigali, Rwanda, where 15 000 ha of agricultural land and wetlands were reserved, and in Lagos, Nigeria, where 4 400 ha of land was suitable (Thomas, 2012); however, land availability remains an issue for urban farmers. In South Africa, land is available in the cities for urban agriculture; for example, 1 200 ha of the 3 000 ha of land in the Cape Town area is suitable for food production, yet there is still competition for land (Haysom et al., 2012).

2.7 Food Insecurity in South Africa and Urban Agriculture

Although South Africa is mostly food secure, it is faced with a high level of income inequality, where approximately 56% of the population lives in extreme poverty (Statistics SA, 2017a). Although the country is food secure on a national level, many households are faced with daily food insecurity (Chakona and Shackleton, 2019). The majority of people living in informal settlements were found to be moderately or severely food insecure, as they could not access food due to a lack of income. A report by Statistics SA (2017a) illustrated that approximately 25.2% of the population lived below the poverty line (R441 per person per month, according to 2015 prices). As household food insecurity is linked to the socio-economic situation of a household, it stands to reason that there is a high poverty level because many households have a low purchasing power, due to the rise in food prices (Hendriks, 2005; Kirkland et al., 2013). To make matters worse, the recent global economic crisis, coupled with the high unemployment rate, has placed serious pressure on many South Africans who are already struggling to make ends meet, which has resulted in even more people experiencing food insecurity.

Despite the seemingly bleak situation, the government has tried to promote food security by means of the NDP, which is aimed at addressing poverty, job creation and food security by carrying out the Food and Nutrition Security Policy (Statistics SA, 2019). The South African economy suffered severely due to the COVID-19 pandemic, resulting in a significant slowdown in the GDP. Ultimately, many people have had to reduce their spending to compensate for their loss of income, as indicated by 74.9% of respondents in a Statistics SA survey. Many industries, particularly the service sector, such as restaurants, suffered from severe a decline which affected their employment and the demand for their products (Labadarios et al., 2011; Arndt et al., 2020; Statistics SA, 2020). This highlights the fact that many people, particularly those working in the informal sector, find themselves in a deeper state of food insecurity, and although many rely on other livelihood strategies, such as social grants and remittances, this was not enough to obtain adequate food during the Covid lockdown, during which time the inequalities were deepened further (Carlitz and Makhura, 2020). Given the need to explore many ways of accessing food, the role of urban agriculture is important for current and future food availability in a fast-urbanising Southern Africa, for historical reasons. The section below discusses the relationship between urban agriculture and food security.

2.8 The Role of Urban Agriculture and Food Security

This section outlines the role of urban agriculture for ensuring food security at a local and household level. There is a demand for perishable products in cities, and urban farmers are better able to attain food security at a household level, where there is food and nutrition security. “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” World Food Summit 1996 cited by Shaw (2007). The FAO’s (1996) definition of ‘food security’ also highlights the key factors in food security, namely, the accessibility and availability of food at all times, to all the household members. Korir et al. (2015) illustrates how the urban poor respond to the inadequate access to food and the lack of purchasing power by engaging in urban agriculture as a strategy for increasing their access to, and the availability of, food at a household level, thus ensuring food security. Chaminuka and Dube (2017) noted how urban agriculture has created production processes and the marketing of produce, by providing employment and promoting savings for the urban population, all of which ensure their continued livelihoods and food and nutrition security.

According to Eisazadeh et al. (2015), urban agriculture is said to be an agent of reduction or elimination of poverty, as many vulnerable groups, such as the orphans, disabled persons, women and refugees are part of the government or non-governmental organisation of urban management systems. Urban agriculture provides for the mental and physical health of people. The participation of women in urban agriculture has also provided health and economic liberation for numerous households (Seed-Uno, 2014). Chaminuka and Dube (2017) also attest to the above statement as they note how women make up a larger proportion of urban farmers, and they state that juggling agricultural activities and household chores is easier for them. In a study conducted in the low-income section of Bogota, the capital of Columbia, the women who grew vegetables on their rooftops were found to earn three times more than their semi-skilled husbands (Eisazadeh et al., 2015). In the urban communities of developing countries, urban agriculture is driven by the unreliable transportation of food from the rural areas, which makes local food production an everyday activity (Kaufman and Bailkey, 2000). Therefore, urban agriculture can ensure continued food security and job creation with the support of governmental and non-governmental institutions (Chaminuka and Dube, 2017). In developed countries, for example in New York City (Cornell University), a project called 'New Farmers/New Markets' played a significant role in addressing the social aims of urban agriculture, namely, to serve as a vehicle for food security for the community, by producing for soup kitchens (Kaufmann and Bailkey, 2000). The community was organised around food production, youth employment, small business incubation and training in direct marketing, by private entities other than the government (Kaufmann and Bailkey, 2000).

In developing countries like South Africa, urban agriculture plays a significant role in social and individual benefits, which may, in turn, supersede the food security and economic benefits (Battersby et al., 2015). In developed countries like the United States (Detroit and New York City), thousands of hectares of land are dedicated for unemployed labourers to work on, while in countries like England, farming is done on 20 city farms that were previously abandoned (Eisazadeh et al., 2015). However, developing countries may see urban agriculture as a way of creating a sustainable economy and addressing food security. Conversely, in developed countries, urban agriculture primarily serves the purpose of creating green urban spaces, providing nourishment to underprivileged city residents, and adhering to health-conscious dietary practices, which include the consumption of free-range produce and GMO-free foods (Tujil et al., 2018). The advantages extend beyond the economic realm; they encompass community building, nurturing social capital, restoring a sense of belonging, improving psychological well-being, and fostering a heightened sense of purpose and self-worth (Battersby et al., 2015).

According to Tujil et al. (2018), urban agriculture has at least three benefits: firstly, it is to maintain food security, to fight chronic hunger and feed the citizens in developed countries. Secondly, it is to develop the community by increasing social cohesion between different groups in society, providing work and training for the unemployed and to be a tool for the prevention of crime; and thirdly it functions as an educational tool through workshops, short courses, and awareness campaigns, educating urban farmers about the origin and production of food products (Tujil et al., 2018). Projects like UFOTI, PHA and Abalimi Bezekhaya have played a crucial role in their societies, as many of the participants were females. Women engage in urban agriculture to ensure sustainable livelihoods in times of shortages and shocks to overcome long-term vulnerability (Jacobs and Xaba, 2008). According to Lynch (2001; cited by Jacobs and Xaba, 2008), urban farmers can access land and markets by 'trading on the social capital’. Projects like Abalimi Bezekhaya have proved to be beneficial in doing just that, which alleviates the production costs and institutional constraints that smallholder farmers face, while also addressing their food security and income mechanisms, and benefiting the Urban and Peri-urban Agriculture participants.

2.8.1 Examples of the positive role played by urban farms at a provincial level

There are several urban farms in cities like Durban, Pretoria and Cape Town that produce commodities which are sold at the local markets. In the eThekwini Municipality, UFOTI provides training to farmers and facilitates the sale of their produce, improving market access and increasing local income. This approach, supported by UNO Seed in 2014, plays a significant role in fostering innovation and entrepreneurship, especially among smallholder urban farmers, including youth and elderly women. Haysom et al. (2012) outline the role played by the Philippi Horticultural Area (PHA) in the livelihoods of commercial and smallholder farmers in the Western Cape Province. The farmers grow an important variety of vegetables, including cabbage, lettuce, cauliflower, broccoli, spinach, carrots, potatoes, as well as onions. These commodities play a role in the food systems in the Cape Flats and Durban communities, as they are the most affordable staples that are rich in nutrients and allow for diverse diets at a household level (Haysom, 2007; Sonday, 2014). Bettersby et al. (2015) also note the commodities sold at the Gauteng Provincial Food Gardening Programme, which include beetroot, spinach, tomatoes, beans, carrots, etc., which also provide diverse diets for residents, thus ensuring food security at a household level. Battersby et al. (2015) highlighted that most of the produce sold in the Gauteng Provincial Food Gardening Programme accrued a significant economic value from urban agriculture; however, there appears to be a relatively minor financial benefit.

2.9 The Role of Urban Agriculture in the Economic Growth of Cities

Urban agriculture is an important livelihood source for those who may not necessarily have the skills or education to compete in the formal sector (Nzimande, 2013). Kahan (2013) notes that urban dwellers are the most vulnerable, as they spend 60%-80% of their income on high food prices. Urban agriculture is one way in which urban farmers can provide food, while also generating savings on their household expenditure on consumables, thus increasing the amount that they can allocate for other uses (Nzimande, 2013). Kahan (2013) notes the growth of UPA (Urban and Peri-urban Agriculture) through the production, processing, packaging and marketing of consumables, thus increasing the entrepreneurial activity, while also creating job opportunities. UPA provides employment, an income and access to food for urban dwellers, thus alleviating chronic hunger and food insecurity (Kahan, 2013).

2.9.1 Empirical evidence of the economic growth of cities

According to Eisazadeh et al. (2015), urban agriculture plays an essential part in the local food systems of cities, while also reducing the food shortages among vulnerable groups. Localised food production systems in urban and peri-urban areas are major contributors to job creation and the production of valuable products (Nzimanade, 2013). Since most people in the towns of developing countries spend a significant amount of their incomes (50%-70%) on buying food, producing their food locally will reduce their costs (Eisazadeh et al., 2015). According to Ackerman et al. (2014), participation in urban agriculture fosters community development, food security and economic growth; it also strengthens social ties, provides sustenance for households where it is lacking, creates jobs and contributes towards the household income, while offsetting their expenditure on food. In a study conducted on buildings in Toronto, Ghaleh (2019) found that 6% of all agricultural activities indirectly and directly created 1 350 jobs, and the commercial value of urban products in urban agriculture was about 5.5 million US Dollars. Eisazadeh et al. (2015) illustrated the role played by community gardens in economic growth and agro-tourism, while they also motivated commercial development and even attracted micro- and macro-investments within the field, thereby making urban agriculture an essential part of the growing local economy, more so in socially-deprived areas where there is less investment by the governmental or private entities.

Ackerman et al. (2014) found that urban agriculture plays a significant role in households with children and adolescents that are vulnerable to chronic food insecurity, and families engaged in urban agriculture have benefited in terms of the quality and quantity of food that is available for their low incomes. Ghaleh (2019) outlined the role of urban agriculture by noting that urban gardens promote economic improvement and tourism. Studies indicated that urban gardens not only enhance the quality of life for residents but also elevate the value of commercial areas. Ackermann et al. (2014) also highlights the extent to which urban agriculture can complement a household's income; it can be diverse and is dependent on the crop type, as well as the scale of production. For instance, staples such as rice, provide income security for households, but vegetables fetch a higher price on the market (Ackermann et al., 2014). The authors also illustrated that animal husbandry is a source of higher profits, through the sale of dairy products, manure (which is used as fertiliser), as well as animal hides and skin. Battersby et al. (2015) noted that the contribution of urban agriculture in the South African economy is significantly small, but the social benefits outweigh the economic benefits. Seed-Uno (2014) noted the role of UFOTI in the Durban community: it provides 497 families with an income from its product sales, and it also creates a local market, while generating revenue and a stable market for Umgibe and the cooperatives, by means of the contracts with the hospitals. Despite the various obvious and positive contributions of urban agriculture, its water resource demands are a critical concern. In a water-scarce world, particularly in South Africa, it is necessary to explore the efficient use of water, water quality and water recycling, in order to meet the demands of urban agriculture.

2.10 Water Quality

The quality of water describes the physical, chemical, biological and aesthetic properties of water, which determine its fitness for use, for various reasons, and also for the protection of aquatic life (DWAF, 1993). The interaction of water quality and agriculture are many and complex. According to Mateo-Sagasta et al. (2018), agriculture is believed to be the source of much water pollution because of the following: the excessive accumulation of excess nutrients in the soil and coastal waters, which causes eutrophication, hypoxia and algal bloom; the accumulation of nitrates in the groundwater; and pesticide accumulation. In South Africa, the Department of Water Affairs & Environmental Affairs have policies that govern the use of water for irrigation, and these need to be implemented at all times, in order to reduce the health hazards caused by the presence of contaminants in irrigation water.

The contaminants can include aluminium, zinc, total and faecal coliforms, arsenic and sodium which, in abundance, could cause harm to the crop life and also to human health, if crops are eaten raw (DWAF, 1996). The use of unsafe and unclean water can render a person to be food insecure, as cases of foodborne diseases due to microbial contamination have been reported where the vegetables were consumed raw, thus making the quality of water essential (IFSAC 2022)
Further, the recent outbreak in SA highlights the importance of water safety.

The use of unsafe and unclean water can render a person to be food insecure, as cases of cholera have been reported where the vegetables were consumed raw, thus making the quality of water essential. According to DWAF (1993), several irrigation water users may experience a range of impacts due to changes in the water quality; these include a reduced crop yield, impaired crop quality, the impairment of soil suitability and damage to irrigation equipment. The use of wastewater for crop irrigation has increased significantly over the years, for various reasons, including the absence of alternative water sources for irrigation, the acknowledgement of water resource management bodies regarding the potential use and relevance of water re-use, the growing social-cultural acceptance of water re-use in agriculture and the mounting confidence in the re-use of water for public health and the environment, provided that the necessary precautions are taken (Bizari and Cardoso, 2016).

2.11 The Role of Water in Urban Agriculture Livelihoods and Water Policies, Governance, Use, Access and Quality

The following section will assess the role of water in urban agriculture, and it will also assess the relevant water policies that are in place in South Africa that govern the use, access and the quality of the water used by urban farmers. The section will explore the use of wastewater as an alternative source of irrigation. For example, Smit et al. (2001) illustrated that the use of wastewater is a long-standing tradition that has now been formalised by the local government in countries like Tunisia. They also stated that, prior to 2001, the area used wastewater for the irrigation of 1 750 ha of land, and they expected this number to rise to 6 700 ha by using 95% treated wastewater in the Tunis region.

2.11.1 Water use in agriculture

Water plays an essential role in our daily lives, and it is useful for cleaning, cooking and drinking. Water balances the human body, which is made up of about 75% water (Roland, 2019), and it also plays a vital role in the agriculture sector, which uses about 50%-63% of the available water (Bonthuys, 2018). The quality of the water used is crucial, as it can significantly impact the health and the food and nutrition status of the consumer. According to DWAF (1996), the quality of drinking water and that which is used in agriculture must have a limited number of constituents, i.e. its temperature (20°C), the colour of the water (green), the concentration of calcium (60 mg Ca/L). Kgari et al. (2016) also shows that there are water standards to control the quality of water used for consumption, aiming to prevent potential adverse health effects on consumers. Water is therefore sampled, tested and treated before being distributed to households for drinking and sanitation (Kgari et al., 2016). South Africa is a water-scarce country; the drought of 2015-2016 showed the severity of this scarcity, as Cape Town was ready to implement Day Zero due to the severe drop in the dam levels (20%) (Millington and Scheba, 2020). Furthermore, the situation was exacerbated by its geography, by climate change and by the impending climate crisis.

2.11.2 Water use and access in the agricultural sector

The agricultural sector is believed to be a major user of the country's water resources, and its contribution to the economy and food security remains undisputed (Bonthuys, 2018). Bonthuys (2018) also illustrates the importance of irrigation to the economy, despite its relatively small but direct contribution (between 4% and 5.3%) to the GDP. The urban agriculture sector is also a major user of water; however, it has a significant disadvantage, because water allocation in cities is more directed toward the industrial sector (Haysom et al., 2015). According to du Plessis (2006), South Africa is one of the most water-scarce countries in the region, it is ranked the second-most endangered country in the world and it faces a water scarcity calamity. This results in uncertainty among the farming communities as to whether they will be able to produce enough food to meet the growing demand for the ever-rising population (du Plessis, 2006).

Water is a scarce resource in cities; as a result, urban farmers have opted to use alternative water sources to ensure their continued livelihoods, namely, untreated and treated wastewater, as well as dams; however, this presents many challenges that can be detrimental to human health. In countries where wastewater is used, there is social-cultural bias; for example, the Muslim community view it as taboo to use 'soiled water' for irrigation, and they also deem it to be unsafe. Dippenaar (2016) cited the presence of treatment plants in Cape Town where there are 16 larger and six smaller plants that ensure their compliance with the State's water quality requirements. The Philippi area is one of the areas with wastewater treatment plants; however, according to Malan (2014), the presence of pollutants in the Philippi groundwater has brought about concerns by the stakeholders and the municipality, as the groundwater is shallow and the contaminants may seep into it, thus compromising the quality of the water used in irrigation.

The Cape Flats Aquifer has been used by farmers in the Philippi Horticultural Area for more than a century, but competition for land and urbanisation have put a strain on it (Malan, 2014; Haysom et al., 2012). The area provides about 70% of the vegetables in Cape Town; however, the demand for vegetables has increased, which has resulted in added pressure on the aquifer as it is the primary source of irrigation water (Malan, 2014). Thomas (2012) notes the importance of quality water for urban dwellers, as they are without proper hygienic sanitation, this has resulted in a large number of cholera and diarrhoea incidents in sub-Saharan regions. However, this has changed, as the number of urban residents with access to proper sanitation facilities has increased from 82 million to 180 million. Thomas (2012) noted that the primary source of water for about 24% of urban residents in the sub-Saharan region is groundwater, which comes from boreholes and wells, and a growing proportion of households have turned to surface water for their drinking water.

2.11.3 Water scarcity and how it affects agriculture

Water is essential; it supports life on earth and is the key for achieving SDG 6, which aims to attain clean water and sanitation for all (Vilakazi et al., 2019). Water of high quality and quantity is essential for food security and agricultural production. Furthermore, water is also crucial for industrial use and for use in other economic sectors. With the ever-growing population and increasing urbanisation, there is a greater need to look at better water management that is aimed at achieving food and nutrition security (Kirby et al., 2003; Pereira, 2005). Approximately four billion people are living with water shortages, at least once per annum, and with the ever-looming issue of climate change, this number is likely to increase. As more areas are faced with water scarcities, more water stress will result and the populations already living with water stress will soon reach a point where they are unable to sustain themselves (Mekonnen and Hoekstra, 2016). Furthermore, the unsustainable use of water threatens those whose livelihoods revolve around agriculture and water.

Agriculture has the greatest global water footprint, as it is used for more than just fishery, livestock and crop production, but also for the processing of raw materials into foods and products, which is one of the causes of the water scarcity. Furthermore, the agricultural use of water threatens the availability of water, due to water pollution from the excessive use of fertilisers and pesticides (Fereres et al., 2011; Misra, 2014; Sundström et al., 2014). Climate change also threatens agriculture, as reduced crop yields are likely to result from the changing seasonal patterns (Allan et al., 2013). Livestock also requires a large amount of water for producing beef or milk, although it is not as much as for crops (Scholtz et al., 2013). A lack of water is also related to poverty, as it affects the health, energy and food supply of people and therefore hinders the socio-economic development of areas affected by poor water availability (Mancosu et al., 2015).

Droughts are a recurring problem in South Africa and have a significant effect on agricultural production as well as on the functioning of the nation (Baudoin and Ziervogel, 2017). A drought occurs when a region receives less than the normal amount of precipitation and this can have an impact on consumption, on food production, as well as on the environment (Schreiner et al., 2018). Areas that are water-scarce generally have a high population density and low water availability, and this is most likely attributed to the high rate of urbanisation and immigration (Calow et al., 1997; Mekonnen and Hoekstra, 2016). It was estimated that the average South African consumes roughly 237 litres of water per day, compared to the world average of 173 litres per day. Furthermore, the water infrastructure in South Africa is poor, which makes it harder to achieve water security (Department of Water and Sanitation, 2019). Water scarcity is not only linked to the amount of water available for use, but it is also governed by how much of that water is readily-available for use. Water pollution, which is caused mostly by industrial water use, agriculture, mining and mostly by domestic sewage, which can also seep into the groundwater sources, effectively reduces the amount of available water (Taing et al., 2019). The over-use of fertilisers and pesticides threatens both the land and water, as they pollute the water system, which can affect the soil composition and soil microbiota, which ultimately decreases the soil fertility (Zhang et al., 2018; Lin et al., 2019). The implication of this is that major changes are required in how South Africa regulates its water use and that it needs to adopt a more sustainable way, in order to prevent a significant water disaster from occurring.

In most developing countries that are faced with water scarcity, wastewater is generally regarded as an alternative to freshwater and is it mainly used in agriculture. The utilisation of wastewater for agricultural purposes has a history, but it has not consistently conformed to the requisite quality standards. It has therefore become a global health concern prompting the World Health Organisation's (WHO) provision of guidelines, although the microbiological quality of water was only considered at a much later point in time (Jaramillo and Restrepo, 2017; Miller-Robbie et al., 2017). Wastewater is also being used in Europe, where they try to limit the use of groundwater sources and freshwater in favour of wastewater, in an attempt to reduce the adverse effects of treated wastewater being discharged into the water systems. Developing countries, such as South Africa, have also considered the use of wastewater in their policy framework, although there could be differences in the implementation of the respective policies (Saldías et al., 2016). Although wastewater can be useful for overcoming drought and water scarcity, the issue of water quality and safety arises. Wastewater re-use could potentially contribute to nutrient recovery and, therefore, no additional nutrients would need to be added to the soil. Part of the policy implementation that governs wastewater usage should be to prioritise proper training on the way that wastewater is used. Existing guidelines, namely (ISO 16075, 2015) could be incorporated into projects that are aimed at assisting smallholder farmers (Alcalde-Sanz and Gawlik, 2017; Hettiarachchi and Ardakanian, 2017; Jaramillo and Restrepo, 2017).

2.12 Health Implications

The health concerns relating to the use of wastewater for irrigation are brought about by the fact that the water used for agricultural production is untreated (Antwi-agyei et al., 2016). Wastewater treatment is costly, and even when there is a source of funding in the cities, they rarely treat all the water sources (van Veenhuizen, 2014). A large volume of the wastewater remains untreated and is left to flow into the natural water bodies. According to Hallett et al. (2016), the suitability of the land, soil and water used in farming can significantly affect food production, as well as the safety of workers and consumers, which sometimes makes urban environments unsuitable for agricultural production. Amoah (2008) highlights the fact that these concerns relating to water scarcity and wastewater use stem from the evidence of disease outbreaks (i.e. cholera, typhoid and shigellosis) due to the use of untreated wastewater irrigation on vegetables. This results in the disruption of one of the four food security pillars, namely, utilisation, which advocates for food that is safe, nutritious and is prepared in a healthy and sanitised manner. Furthermore, the enhanced vulnerability of urban agriculture to financial risk in the case of an outbreak of disease, could result in the confiscation or discarding of contaminated products, as well as a quarantine period, which means that farmers would be unable to produce and sell their products.

Table 2.1 depicts how exposure to disease, whether external or internal, could lead to physical health hazards that could be unfavourable to businesses in the area, as it could result in the authorities and local municipalities calling for their shutdown, which would bring about financial ruin. Table 2.1 also shows how the effects can be psychological, as the internal and external exposure could be draining; the constant fear and uncertainty of the urban farmer could lead to adverse business performance. A biological hazard could make urban agriculture highly risky, and it is therefore not recognised or recommended by city authorities and policymakers, regardless of the economic and social role that urban agriculture plays in urban communities.

Table 2.1 Potential health hazards linked with urban and peri-urban agriculture

Type of hazard	Related exposure Groupings	UA examples
Physical	Internal External	• Repeated bending forward to weed plots • Noise from small millets grinding mill
Chemical	Internal External	• Upstream waste discharges into irrigation water • Lead and Polyaromatic Hydrocarbons (PHA's) from the vehicular exhaust in roadside vegetables
Biological	Internal External	• Swine fever from pigs • Salmonellosis from *Salmonella* species multiplying in eggs • Malaria breeding in pools of water
Psychological	Internal External	• Long hours of work with multiple demands • Unclear land tenure, fear of theft or assault

Source: Boischio et al. (2006)

The use of wastewater has several implications for those who reside in neighbouring towns adjacent to irrigated fields, as well as for the families of those who have direct contact with crops, including crop handlers and consumers of the products (van Veenhuizen, 2014). According to Dreschel et al. (2008), the concerns over the use of wastewater for irrigation stem from the fact that leafy vegetables may be eaten raw, and that some people may not necessarily wash their fruit and vegetables thoroughly before consumption. Hence, the recommendations of the World Health Organisation (WHO) on wastewater use for irrigation purposes state that there should be water treatments, crop restrictions and waste application techniques that minimise contamination, for example, drip irrigation, as well as withholding periods, to allow for the pathogens to die-off after the last application of wastewater, and hygienic practices in the markets and during food preparation (WHO, 2006). If the WHO guidelines are used, there should be better care when using wastewater. However, a study by Antwi-agyei et al. (2016) in Accra, Ghana, showed that this is not the case. The authors found that the farmers were aware of the water source they were using for irrigation and the market vendors were mindful of the origin of the irrigation water used on the produce that they are selling. The consumers stated that "we are aware of the source of water that farmers used to irrigate vegetables in Accra – you can even smell it when you buy the produce" (Antwi-agyei et al., 2016).

2.12.1 Relevant water policies governing water access, use and quality

According to Folifac (2007), South Africa has been recognised for significant progress in water supply development. Even though it has been labelled as a champion in this regard, nevertheless it faces substantial challenges within the water supply sector. This can be traced back to a historical period when the responsibility for water supply was divided, with no centralised government department to oversee it. As a consequence, this fragmentation led to disparities in the level and quality of services provided, particularly between White and Black communities (Folifac, 2007). As posited by William (2018), the water allocation reform strategy is one of the pillars of water allocation; the targets have been set and are expected to be fulfilled by the year 2024. The Department of Water and Forestry (2008; cited by William, 2018), states that 60% of the allocated water should be directed to Black people, with half of it being allocated to Black women. The DWAF policy and functions were historically mainly concerned with irrigation and forestry, while leaving millions of individuals without access to water and basic sanitation. After 1994, the new non-racial reforms on water allocation were implemented to address the social ills of the past.

These policies include:

a) **The Water Service Policy (White Paper, 1994):** this addresses the country's backlogs in water service and institutions and the mechanisms needed to remedy the backlogs.

b) **The Republic of South Africa Constitution (Act 108 of 1996):** this establishes the human right of access to adequate and sustainable water supply and service, which is enshrined in the Bill of Rights.

c) **The Water Service Act (WSA) of 1997 (Act 108 of 1997):** this ensures the right to, and access to, essential water supply and sanitation, and it also provides a regulatory framework and the establishment of water service institutions, such as water boards and water services.

d) **The National Water Policy of 1997 (DWAF 1997):** this redefined the ownership and allocation of water, by declaring that all water, irrespective of where it occurs in the hydrological cycle, is public water and that the national government will act as a trustee.

e) **The National Water Act of 1998 (Act 36 of 1998):** this is founded on two pillars, i.e. sustainability and equity, which, amongst other resources, required the establishment of a national water resource strategy for setting out a national framework for managing the water resources.

f) **The National Water Resource Strategy (DWAF, 2004):** this provides the national implementation framework for water use and divides the country into 19 Water Management Areas (WMAs).

g) **The National Water and Sanitation Programme**: this is an international partnership aimed at enhancing an accessible, safe and affordable water supply and sanitation for the poor.

These policies address water access and allocation for all households in South Africa, where Black communities were previously disadvantaged, due to the social ills of apartheid. The key objectives of the water resources management regulations were to ensure social development, economic growth, ecological integrity and water access equality (Perret, 2002). According to Perret (2002), at a rural community and smallholding farming level, individuals are authorised to take water for "reasonable domestic use, gardens and stock watering" (not for commercial purposes) without registration, licensing or payment, as stipulated in Schedule 1 of the Act. The Act states further that for irrigation schemes, farmers and rural communities should form Water User Associations (WUAs), which requires licensed registration, which determines the collective rights to water resources and the associated obligations (Perret, 2002). The water rights of smallholder irrigation farms remain uncategorised let alone those in urban areas who wish to expand and use more water. The application for, and the right to, a license is dependent on conditions, where failure to comply with the requirements limits the individual's right to use water for purposes other than for the Schedule 1 water licence. There is an argument that rural communities and smallholder farmers should form WUAs, which can be licensed, registered and charged water fees accordingly. However, Chitja et al. (2016) have noted poor organisational capacity and capability to form and participate in Water Use Associations.

Farming in the cities could help to reduce the risk of contamination by using eco-friendly cultivation techniques (i.e. drip irrigation), which could grow more fruit and vegetables, while cutting the cost of production and promoting a greener economy (Thomas, 2012). Wastewater in cities can be safe when it is pre-treated for irrigation purposes and it can supply some of the nutrients required for horticultural production (Thomas, 2012). In the Cape aquifers, where there is a direct relationship between the PHA (Phillipi Horticultural Area) and Cape Flats Aquifers, which are the primary sources of water for irrigation all year round (Haysom et al., 2012), wastewater is already being used in a safe way. According to van Veenhuizen (2014), there are numerous wastewater sources in urban areas, and they are continuously rising, due to the increasing population. The sources include sewage drains, shallow wells, house drainage, channels and wastewater treatment plants. Factors such as urbanisation, the effects of climate change, as well as the expected water deficit, will increase to 27.6% by the year 2050. Drip irrigation and rainwater harvesting are some of the techniques that urban farmers could adopt to reduce the demand on the urban supply of water, thus contributing to climate change mitigation techniques (Colvin et al., 2016). Stevens and van Koppen (2015) noted the difficulties and costly effects of meeting the water demands, and hence the following range of measures was initiated:

- A greater focus on water conservation and demand management.
- The increased utilisation of groundwater.
- The re-use of water at the coast, as well as in inland systems.
- The use of the most cost-effective and suitable sites for dams and transfer schemes.
- The desalination of seawater and the de-acidification of mine water; and
- Catchment rehabilitation, the clearing of invasive alien plants and rainwater harvesting.

The institutions that are there to provide water services are the water boards, which play a crucial role in the water sector, as they operate the dams, the bulk water supply infrastructure, some of the rail infrastructure, as well as some wastewater plants (Stevens and von Koppen, 2015). However, the policies that are in place do not account for urban farmers, as farmers in rural areas and smallholder farmers are expected to form part of the WUAs, in order to be registered and obtain a license. Urban farmers are therefore excluded from the policies that address water use, access and quality. There are three water boards in South Africa: Rand Water in Gauteng Province, Umgeni Water in KwaZulu-Natal and Overberg Water in the Western Cape. They are supposed to extend services, such as wastewater treatment and water resource management, which is the water that is most used by urban farmers. Irrigation is one method that is used in farming to ensure an increased yield and cropping frequency on farms, thereby ensuring their continued productivity. Irrigation compensates for its prominent use of water (62%) by re-using wastewater (Molle and Berkoff, 2009). Irrigation is used to deal with food insecurity, poverty, unemployment and regional development (Molle, 2008).

2.13 Climatic and Environmental Implications

Climate change-related occurrences such as intense rainfall, floods, hailstorms, and high temperatures in the KwaZulu-Natal province have had detrimental impacts on crop production and urban farmers. These events not only jeopardise the socioeconomic progress of communities but also pose a threat to the sustainability of urban food systems. Furthermore, there has been a noticeable increase in recurring droughts and localised flooding, especially during the middle of the growing season, affecting various regions in Southern Africa. It is anticipated that these challenges will persist, accompanied by other catastrophic climatic events, with floods being a notable concern. According to Dubbeling et al. (2019), cities are gradually being affected by both acute shock and chronic stress, which are intensified by climate change and exacerbated by the uncontrollable urban growth. The vulnerable cities are those in arid areas and water-stressed countries, island states and less-developed countries, as well as coastal and low-lying areas. According to Ghaleh (2019), urban agriculture plays a significant role in environmental restoration; it also benefits the environment as different products are produced, and there is the interaction between unique products, i.e. between bees, bats and birds, which act as the pollinators of the crops and wildflowers (Steel, 2017). The different products play a role in ensuring the continued protection of endangered or scarce species, fruit, vegetables, flowers and shrubs. Therefore, proper planning and suitable integration with urban design can provide pleasant spaces for citizens (Ghaleh, 2019).

Agriculture plays a dual role in contributing to greenhouse gas (GHG) emissions, which have a negative impact on the climate, while also positively affecting the ecosystems. For example, the forestry industry ensures a reduced amount of GHG emissions, due to the respiration cycle of forests (FAO, 2007). An example of a negative impact is in the Cape Flats Aquifers, where human activities contaminate the water resources through a combination of pesticides, fertilisers from the agriculture sector, waste-treatment plants, waste disposal sites and informal settlements that lack adequate sanitation (Haysom et al., 2012). However, recent developments, especially in the city of Cape Town, aim to ameliorate the stress on urban water by artificially replenishing aquifers and by managing the urban stormwater better (Kgari et al., 2016). Steele (2017) illustrates the role of urban agriculture in supporting biodiversity, reducing stormwater run-off, improving air quality and mitigating an urban heat-island effect; in the case of organic farming, it eliminates the use of herbicides, pesticides and synthetic fertilisers. These are valuable lessons for everyone to learn, as urban water management affects all the downstream users and ecosystems (Kgari et al., 2016).

Another example is the Umgibe Farming Organics and Training Institute (UFOTI), which uses as little water as possible and no chemical fertilisers, while it also diverts more than 10 000 plastics from landfills and uses them for cultivation purposes. They also avoid CO_2 emissions by reducing the transport activities in the local food production area. Hallett et al. (2016) also illustrated the role played by urban agriculture as an alleviator of the effects of climate change, by noting that growing beans resulted in the reduction of GHG emissions, while the opposite occurred with strawberry production. Khalil and Najar (2012) highlighted that strawberries grown in greenhouses contribute more to GHG emission, and their water consumption is 1500 m^3/dunam/yr. Therefore, crop selection and the techniques that are used for growth are vital aspects of decision-making, in terms of improving the sustainability and profitability of urban farmers, while also reducing the uncertainties.

2.14 Financial Implications

Urban farmers tend not to have access to financial facilities, due to the high level of risk associated with their agricultural activities. They are less likely to have any assets that they could pledge as collateral, for example, land, machinery and retained earnings, which smallholder and commercial farmers are likely to have (Kerr and Nanda, 2009; Kahan, 2013). Urban farmers are thus vulnerable to financial risk, which occurs when money is taken to finance the business at high interest rates and, with the lender's willingness, the ability to continue to provide funds when needed. The farmer's ability to generate an income in order to make the loan repayments is uncertain and is generally referred to as a ‘risk’ (Kahan, 2013). For financial institutions to take on the risk, there is a need for reinsurance companies and banks to effectively estimate the amount of risk involved in an investment, based on the calculations of the estimated impact of the loss; this implies that the risk profile for insurance contracts and financial instruments must first be assessed (Gerasymenko and Zhemoyda, 2009). Commercial and smallholder farmers have a greater chance of accessing financial services from institutions such as banks, farmers’ associations and micro-finance institutions (FAO, 2007; Kahan, 2013; Eisazadeh et al., 2015). However, urban farmers rarely have access to credit services. Women tend to be more involved in urban agriculture, and some institutions are only willing to lend money to males; as a result, they must go to the informal sector, who are eager to assist (FAO, 2007).

According to Kerr and Nanda (2009), emerging entrepreneurs face a disadvantage due to their limited assets available for use as collateral when seeking loans. Additionally, their lack of financial history and retained earnings for partial funding further compounds this challenge. Eisazadeh et al. (2015) note that urban agriculture does not require much financing, as it is done on a small scale and has no need for advanced or modern equipment. Eisazadeh et al. (2015) highlight that the essential needs and initial equipment for producers are commonly addressed through financial assistance provided by agricultural organisations within the banking sector. The willingness, or the lack thereof, to fund urban farmers stems from gender bias, as well as the type of business that they are in; as a result, they turn to informal lenders (loan sharks) who are willing to lend, but at a higher interest rate (FAO, 2007). Battersby et al. (2015) also attest to the fact that urban residents often resort to informal lenders to secure credit at elevated interested rates, which may lead to the continued borrowing of funds for household expenses.

2.15 Market Price Implications

The fluctuation of market prices can significantly affect the consumer as well as the producer. Gerasymenko and Zhemoyda (2009) define price (market) risk as a contract between independent producers and other businesses, and such agreements reduce the risk for producers. According to Kahan (2013), the price of a product is affected by the supply of, and demand for, a product and the cost of its production. The demand for the product is affected by the consumers' preferences, their level of income and the strength of the general economy, as well as the supply and price of the competing products (Kahan, 2013). The supply of the product is said to be affected by several factors, including the production decisions made by farmers as a group and by the weather patterns, and the cost of production depends on the input cost and yield (Kahan, 2013). According to the FAO (2007), the cost of the supply and distribution of food from rural to urban areas, or to import food to the cities, is rising continuously and its distribution within cities is uneven.

Urban farmers form an essential part of society, as they provide these services at a reduced cost because of the low transaction costs involved. The produce is sold at the farm-gate, by cart in the same or different neighbourhood, in local shops, in local farmers' markets, or to intermediaries and supermarkets (FAO, 2007). For example, the farmers in Cape Town who are involved with the Philippi Horticultural Area can sell their produce to the Cape Town Fresh Produce Market, to major retailers, wholesalers, informal traders and other interested buyers, such as restaurants and selected stores, which allows for their market participation and for job creation in the community (Haysom et al., 2012; Sonday, 2019).

However, gaining access to markets comes with inherent risks, encompassing aspects such as price volatility and uncertainty, challenges related to contract enforcement, an insufficient number of middle-men, the cost of putting quantities of produce together, and the potential difficulty in meeting stringent hygiene standards (Ngqangweni et al., 2016). These authors also explained how those that farm to supply their households and who only sell the surplus (with varying production quantities) face problems in accessing the markets, because their surplus production may not meet the standards and requirements of the market. The market standards for the formal markets include food safety, consistency in the food supply and environmental post-production management, in which smallholder farmers in South Africa need to be trained (Ngqangweni et al., 2018). The UFOTI project is an example of how urban farmers can create their markets, while also addressing food security at a household level, as the production quantities may not always be adequate for formal market sales. Furthermore, despite being small, it is prudent for small businesses such as urban farms to be afforded business development interventions including Mackinsey 7s; PESTEL and SWOT analysis in order to establish a strategic direction that will improve market access.

According to the FAO (2007), one of the major advantages of practising urban agriculture is the farmers' proximity to the market, in order to sell their produce directly to the retailers, increasing the number and the type of consumers, and the ability to achieve a higher degree of local processing (including street-food). However, farmers in rural areas fail to access the market easily because of the distances they need to travel, and therefore, they rely heavily on marketing by means of a chain, in which little to no processing is done (FAO, 2007). Haysom et al. (2012) outlines the role played by the Philippi Horticultural Area (as urban agriculture) in the livelihoods of commercial and smallholder farmers in the Western Cape Province. It is a peri-urban area of about 3 000 ha, of which 1 200 ha are suitable for food production, and farmers can produce about 50 horticultural crops within the PHA. A variety of essential vegetables are grown, including cabbage, lettuces, cauliflower, broccoli, spinach, carrots, potatoes and onions. These play a role in the Cape Town community's food system, as they are the most affordable staples, they are rich in nutrients and they allow for a diverse diet at a household level (Haysom, 2012).

2.16 Institutional Implications

According to Kahan (2013), the institutional risk is the unpredictability of how the farming services from institutions are offered. These institutions can be both formal and informal, and they include banks, cooperatives, marketing organisations, input dealers and government extension services. According to Smit et al. (2001), in less-developed countries several constraints hinder the progress of urban agriculture, and the planning, cultural attitudes and colonial heritage have conspired to produce policy, administrative and legal hurdles. Urban agriculture is therefore not included in the planning process, and in some countries, it is often less supported, policies deter it, and laws and regulations limit or prohibit it (Smit et al., 2001). According to Nugent (2002), the idea of UPA could be a potent and essential part of economic activity under certain conditions, which is why policymakers should take it seriously; however, this is not the case in some countries. For instance, Kekana (2007) noted that new policies were initiated in South Africa in 1994, which were offered and promoted as a strengthening tool for creating an asset base for the poor. However, Smit et al.

(2001) noted there were few policies in place that actively promoted the growth of urban agriculture and the realisation of its associated advantages, even in regions where it was permitted. In addition to suitable policies, institutional arrangements for enterprise development, organised for market access through secondary co-operation, networks and farmer organisations is important.

Kahan (2013) additionally demonstrated that institutional risk arises from the uncertainty related to government policies, which directly influence farming support, including factors such as prices and subsidies. This is further illustrated by the response of farmers in a study by Antwi-agyei et al. (2016) in Accra, Ghana, where the respondents in a focus group discussion voiced their pleas to the government, saying that: "the government should take charge and subsidise the cost of fertilisers and vegetable seeds, since these are sold at a far higher price on the private market. It even becomes difficult to get a supply at certain times". This makes the farmers susceptible to institutional risk, due to the price-fixing on the market, which inadvertently affects the consumers. Urban agriculture has introduced the use of vacant spaces to produce food in green spaces in cities (Lupia and Pulighe, 2015). According to the FAO (2007), urban agriculture enhances the development of micro-enterprises in the production of the necessary agricultural inputs, the processing, packaging, and marketing of products, as well as the rendering of services, such as animal health services and transportation, thereby contributing to the local economic development. Since the government does not support this type of farming, the farmers involved in this type of food production lack the resources, such as the capital to purchase or lease land, and so they practise farming on vacant land, which makes them vulnerable to evacuation and also to the destruction of their produce, because they do not have permits to cultivate the land (Orton, 2010; Haysom et al., 2012). Therefore, these risks result in farmers' being reluctant to participate in urban agriculture, as there are no institutions that govern its existence, and they are unable to minimise or manage the risk of eviction from municipal land.

2.17 The Benefits and Challenges of Urban Agriculture in the Cities' Food Production Systems

This section will evaluate the food systems in urban areas, which tend to be faced with numerous challenges, such as the products' failing to reach the retail markets on time. Some of the factors affecting the food systems could be a result of natural (outbreaks/disasters), economic and political shocks. The proximity of urban farmers to the market offers them an advantageous position to ensure continued food production; however, some drawbacks tend to affect the flow of commodities from their farms to the market. An evaluation of the research on the benefits and challenges that have an impact on the cities' food production systems, can be found below:

2.17.1 Benefits of urban agriculture in the food production systems of cities

Due to climate change, rising temperatures are anticipated in the Western Cape, making the Philippi Horticultural Area (PHA) increasingly vital as a food source for Cape Town and the Cape Province, as noted by Haysom et al. (2012). This will ensure that consumers are less vulnerable to the market risks associated with extreme events that result in commodity price changes. This will lead to food and nutrition security, and since the products are affordable, compared to those in the formal markets, the poor households in the cities will be better accommodated (Haysom et al., 2012). The role of peri-urban agriculture in the cities' food systems has been identified, as the previous studies that have focused on the larger parts of Cape Town are evidence of the ability of its resilient local food system to respond to the changing circumstances of various households and communities (Haysom, 2012). South Africa has 19 fresh produce markets, some of which are said to be the largest in the southern hemisphere; these markets distribute large volumes of tomatoes, potatoes and onions to several buyers, i.e. informal traders, retail chain stores and restaurants (Battersby et al., 2015). Fresh produce markets are the primary markets for urban farmers; however, the decline in the proportion of fruit and vegetables at these markets, due to the increase in direct sales to the supermarkets and the export market, means that urban farmers might not have adequate access to the markets. The fresh produce markets in South Africa still account for 40% of the vegetable production, which makes them an essential component of the community, and more so for the urban farmers (Battersby et al., 2015).

2.17.2 Challenges of urban agriculture in the food production systems of cities

Urban farmers face several challenges, including access to agricultural land, due to the marginalisation of poor communities to areas with poor soils, competition for land use with housing development, poor access to markets due to the quantities and inconsistent quality that are produced, poor extension services, the lack of access to agricultural inputs, such as seeds, fertilisers, compost, mulch and water, as well as restrictive by-laws and the attitude of municipal managers, thus limiting the uptake of urban agriculture (Battersby et al., 2015). Chaminuka and Dube (2017) also noted that the lack of support from both the local and central governments is another challenge faced by urban farmers. They also noted that there is a lack of funding for urban agriculture projects, with some local authorities regarding the practice as illegal; this has affected the local food systems, because of the reluctance of urban farmers to produce more food (Chaminuka and Dube, 2017). Kennard and Bamford (2020) highlighted the difficulties faced by urban agriculture operations for improving healthy food and for accessing the cities as commercial entities, as there is a struggle to balance the "unattainable trifecta of urban agriculture". Urban agriculture faces multiple goals, including to provide quality food to people at affordable prices and to provide jobs and work experience to those who are typically excluded from employment while simultaneously also remaining profitable and sustainable in the long-term (Kennard and Bamford, 2020).

2.18 Fresh Produce, Animal Products and the Associated Microbial Contamination

Fresh produce and animal products are susceptible to microbial contamination. This can occur at various stages, from production to processing and distribution. Bacteria such as Salmonella and Escherichia coli, as well as viruses like norovirus, are common culprits.

2.18.1 Fresh produce

As more consumers adopt a healthier lifestyle, the consumption of raw produce that is minimally-processed is an increasing trend and promoted by various governments and international institutions (Augustin et al., 2016). The global production of fruit and vegetables has seen an increase due to the high demand for fresh produce, and this has resulted in the increased export and import of fruit and vegetables (Pezzuto et al., 2016; Balali et al., 2020). However, it has also resulted in an increase in food-borne disease outbreaks over the past two decades (Bartz et al., 2017). Fresh produce is an essential component of a balanced diet and is linked to a reduction in chronic diseases (Gustat et al., 2015). In developing countries, vegetables are generally produced locally and make up the bulk of the diet for the majority of households. It has also been shown that as socio-economic status improves, so the consumption of a greater diversity of fresh produces occurs, and that the emphasis is on organic produce and other exotic produce, which is imported (Pollack, 2001; Mason-D'croz et al., 2019). However, fresh produce that is consumed raw is increasingly being recognised as a means of transmitting human pathogens, which is frequently due to microbial contamination via the usage of poor-quality irrigation water (IFSAC, 2022, and similar).

Most smallholder farmers in South Africa cultivate fresh produce, as it is easy to produce, nutritionally valuable and inexpensive, while requiring only a little land. This makes fresh produce attractive, as most smallholder farmers look to improve their food security status and its stability; and with the increasing urbanisation and the growing population, there is likely to be an increase in the number of smallholder farmers, who can cultivate food products with a quick turnover and affordability, which means there are some potential market opportunities for them (Mdluli et al., 2013; Louw and Jordaan, 2016).

2.18.2 Microbial contamination of fresh produce

Disease transmission via fresh produce is well-documented and fresh produce has been identified as being the source of many outbreaks. It has been reported by the European Centre for Disease Prevention and Control (ECDC) and the European Food Safety Authority (EFSA) that fresh produce consumption has increased food-borne outbreaks in Europe (Machado-Moreira et al., 2019). Contamination can be introduced at any point along the fresh produce value chain, and it has even been shown that post-harvest washing has its limitations, in terms of decontamination, in that it can allow cross-contamination to occur (Murray et al., 2017). Furthermore, contamination can also be linked to the environmental stressors under which the fresh produce is cultivated; for example, it has been shown that susceptibility to contamination can be increased by bruising, which leads to the rapid spoilage of fresh produce (Beharielal et al., 2018). The survival of microbial pathogens depends on several factors, including pre- and post-harvest practices, environmental conditions, ripeness, microbial features and resistance to stress. Current industrial treatment and sanitising does not always ensure the complete removal of pathogens (Luna-Guevara et al., 2019). In fact, pathogens such as *Salmonella* spp. can actively enter plants such as lettuce via stomata, thus escaping post-harvest sanitation (Kroupitski et al., 2009).

Livestock manure is known to harbour a wide range of microbial pathogens, including bacteria, protozoa and parasitic pathogens, which are generally transferred from manure into the surface water and, in some cases, these can leach into the groundwater sources and onto the crops via irrigation (McAllister and Topp, 2012). Livestock-related pathogens can transfer between hosts, which may result in a wider distribution of the pathogens. The type of manure (wet or solid), active microbial counts, manure treatment and handling, as well as environmental conditions, such as the soil pH and water content, can influence the survival and subsequent proliferation of microorganisms. This highlights the importance of the proper management and treatment of manure as a means of preventing contamination (Manyi-Loh et al., 2016). Many manure-based microbial pathogens, such as *Salmonella* spp, *Listeria monocytogenes* and pathogenic strains of *Escherichia coli* exist in livestock manure. The dispersal of pathogens occurs through the over-use of manure, uncontrolled run-off and via the infiltration of soils into the groundwater source. This elevated risk is exacerbated by the excessive application of antimicrobials on livestock, potentially promoting the emergence of drug-resistant pathogens. In the event of an infection, the potential consequences are substantial, as indicated by Bicudo and Goyal (2003) and Ebner (2017).

Fresh produce, or minimally-processed vegetables (MPVs), show a high-water activity (> 0.99) and typically maintain a pH range of between 4.9 and 6.5, which allows for microbial growth; all that is required is physical damage by external stressors, such as insects, weather, storage conditions and processing. Biosurfactants are also produced by microorganisms, which allows them to alter the physico-chemical characteristics of the fresh produce surfaces. For an environment to be considered favourable, nutrients are also required by the microorganisms (Ragaert et al., 2007). Under normal conditions, epiphytic bacteria, such as *Pseudomonas fluorescence,* are generally found to colonise fresh produce. However, pathogens that cause food-borne diseases are also able to colonise fresh produce. Microbial counts generally range between 3.0 and 6.0 log CFU/g on fresh produce (Lund, 1992; Beharielal et al., 2018). Leafy fresh produce, such as lettuce, might stand out as one of the main means of microbial contamination, due to its leaf structure, which provides conditions that support microbial growth. In a recent outbreak, where romaine lettuce had been contaminated by an *E. coli* O157:H7 strain, 167 people from 27 states were infected in the United States (CDC, 2020).

2.18.3 The composting and decontamination of manure

Composting consists of three phases, namely, the mesophilic, thermophilic and maturation and stabilisation phases. Bacteria and fungi are generally most active during the mesophilic phase, where they break down complex polymer substances, such as carbohydrates, starch and fats. The initial microorganisms are inhibited due to the high temperatures, which results in the stimulation of the thermophiles, such as *Aspergillus fumigatus* (Partanen et al., 2010). These microorganisms simply continue to increase with the degradation process, although it is at a faster rate. Any mesophilic pathogens that may have been present are normally killed off, as temperatures will generally be more than 55°C during the thermophilic phase. Once the organic matter is decomposed, there is a reduction in the temperature and at this stage, the heap will generally become much smaller and more compact (Partanen et al., 2010; Mdluli et al., 2013). A secondary mesophilic phase is reached until the nutrients become depleted, which results in the microorganisms being killed off. Maturation results in the formation of lignin-humus complexes; thereafter, no further degradation occurs, and the composting is completed (Mdluli et al., 2013; Sarkar et al., 2016).

2.19 Food-borne Diseases, Food Safety and the Hygiene Quality of Fresh Produce

2.19.1 Food-borne diseases

According to the World Health Organization's efforts to assess the worldwide impact of food-related diseases, it was reported that in 2010, a total of 600 million cases of food-borne illnesses and 420,000 associated deaths were attributed to 31 different global hazards (Kirk et al., 2015). However, the actual statistics are lacking, as most cases are unreported (Uçar et al., 2016; WHO, 2020). The interconnection of food safety, nutrition, and food security is clear. Contaminated food triggers a detrimental cycle of illness and malnutrition, with a significant effect on infants, young children, the elderly, and those with health vulnerabilities (WHO, 2019). Food-borne diseases are classified as either a food-borne infection or a food-borne intoxication, both of which involve the production of a toxin, with food-borne infections normally involving a longer incubation period. Food-borne diseases are a result of the consumption of food products that are contaminated by microbial pathogens, and fresh produce remains the leading cause, compared to animal-related products (Bintsis, 2017; Centre of Disease Control, 2017). These diseases range from mild to potentially lethal illness and are caused by biotoxins that are released by bacterial pathogens (Scott, 2003; Bold and Rostami, 2011). They are generally associated with raw fruit and vegetables and other food items that do not require cooking before consumption. In a report by the Food-borne Disease Active Surveillance Network (Tack et al., 2019), *Salmonella* was identified as having caused 8556 infections, 2430 hospitalisations and 46 deaths between 10 sites, from 2016 and 2019. According to the United States Food and Drug Administration, there were three outbreaks of *E. coli* O157:H7 food-borne diseases due to the consumption of lettuce, and in one of the outbreaks, the source was traced back to the faecal matter of cattle (USFDA, 2019). Microbial pathogens can occur at any time during the production stage. Numerous incidents of food-borne disease outbreaks have been reported to date and are a matter of global concern, given the severity of the problem (Beharielal et al., 2018; Lytton, 2019).

Escherichia coli is a commensal gut bacterium that is found in both the human and animal gastrointestinal tracts and it is generally used as a hygiene indicator organism. Therefore, its presence is generally linked to faecal contamination (Bélanger et al., 2011). Although *E. coli* is generally harmless, certain pathogenic strains, including the Shiga toxin-producing *E. coli* (STEC) and enterohemorrhagic *E. coli* (EHEC), have been found in several food-borne outbreaks (Eppinger et al., 2011; Luna-Guevara et al., 2019; CDC, 2020). *Salmonella* spp. is a common food-borne disease-causing bacterial pathogen that has been reported in recent cases in the European Union and the United States, and it is one of four key global causes of diarrhoea (WHO, 2018; EFSA et al., 2019). *Salmonella* spp. (non-typhoid) has been frequently associated with foodborne disease outbreaks due to contaminated fresh produce. The presence of such bacterial pathogens is therefore unacceptable as it might put consumers – particularly those that are most susceptible to infections such as the YOPI group – at risk (Aljoudi et al., 2010; Weam et al., 2016; Pijnacker et al., 2019).

2.19.2 The role of food handlers in food-borne diseases

Food represents an important vector for the transfer of pathogens, and there are many reasons why food-borne diseases remain a serious issue in society today. Although they tend to occur frequently in developing countries, particularly in Africa, a higher susceptibility to food-borne diseases is experienced by people belonging to the YOPI group, namely, the Young, Old, Pregnant and Immuno-compromised group, as they commonly have weaker immune systems. Despite this, food-borne diseases are not only limited to these regions or populations (WHO, 2008; Beharielal et al., 2018; IFSAC, 2022) and EFSA). Between 2010 and 2017, there were 1 797 food-borne outbreaks, of which 228 were associated with fresh produce in the US (Carstens et al., 2019). Approximately 63 153 cases of the Shiga toxin-producing *E. coli* O157:H7 occur every year in the United States (Carstens et al., 2019). According to a report by the Public Health Agency of Canada, a recent outbreak confirmed that there were 506 cases of *Salmonella* caused by onions (Carstens et al., 2019; CCME, 2020).

Travel history is also crucial in the event of outbreaks; Watkins et al. (2020) illustrated that among 96 *Salmonella* serotype Typhi infections, 30 were identified as being caused by extremely drug-resistant strains (XDR). Globalisation has allowed for the distribution of foods across the globe, which also means that an infection can carry over into another country, should it not be detected. This probably accounts for the high number of outbreaks that occur every year. Food safety not only affects developing countries, but it also has an impact on food markets and employment within the food processing and distribution sectors. Therefore, food safety issues can result in the loss of livelihoods, which can lead people into poverty and result in changes in the purchasing patterns of consumers (Jaffee et al., 2018).

Food handlers are people who work in places that serve cooked food and who are likely to be in contact with crockery (plates, bowls and cups) and cutlery. This can include street vendors who work under more informal conditions, such as open kitchens (FAO, 2017). Food handlers can serve as a potential source of contamination, as they can passively allow the transmission of food-borne pathogens when they come into contact with a contaminated source when preparing salads or cold meats, e.g. raw vegetables that are generally ready to eat (Angelillo et al., 2000; Scott, 2003). However, more often than not, food handlers may have contracted some gastrointestinal tract disease, such as a mild form of diarrhoea, and they may come to work, even though they no longer show any symptoms; this may result in them spreading the disease when they are preparing food (Sousa, 2008; Hofmeister, 2020). There are also food handlers who present no symptoms, but who can still transmit the disease through their bodily fluids.

In essence, adhering to good hygiene practices is generally effective in preventing the transmission of food-borne diseases among food handlers and between handlers and customers. Neglecting these practices can lead even minimal microbial counts to multiply into infective doses, posing a serious and potentially fatal risk, as highlighted by Camino Feltes et al. (2017) and FAO (2017). A lack of preparation within the kitchen environment, long working hours, inadequate food preparation and poor supervision are just a few reasons why the issue of improper food-handling may result in food-borne diseases. This also illustrates that there is a gap between knowledge and the actual implementation of the necessary knowledge to prevent food-borne diseases (Hofmeister, 2020).

2.20 The Sources of Contamination

The contamination of fresh produce by bacteria occurs at any given point during the various stages of farming and, as a result, the hygienic quality of the fresh produce can be affected. Contamination results in reduced production, due to spoilage and concerns relating to market access and health implications, and therefore, controlling and preventing microbial contamination is of utmost significance (Mdluli et al., 2013; Beharielal et al., 2018).

2.20.1. Soil

Soil is perhaps one of the most important potential sources of microbial contamination and this is mainly dependent on the pre-harvest practices. When there is direct contact between the soil and the produce, it can be contaminated by bacteria, as there is already a pre-existing microbiome present in soil (Machado-Moreira et al., 2019). The use of untreated animal manure (wildlife and livestock) as an alternative to fertiliser is likely to introduce enteric pathogens into the soil. *E. coli* O157:H7 has been found to survive up to 25 weeks, depending on the soil conditions (Chauret, 2011). Soil that has not been treated properly and/or is in close proximity to grazing livestock can also increase the chances of contamination by pathogens (Rajwar et al., 2016). These pathogens are then able to attach to the surfaces of the fresh produce or enter via the roots and/or stomata, and they subsequently remain viable, unless the proper processing and storage regimes for fresh produce are followed (Murray et al., 2017).

2.20.2 Water

Water sources are crucial as they can introduce microbial contamination at any point in fresh produce processing, and they are not limited to pre-harvest practices (Alegbeleye and Sant'Ana, 2023). During the pre-harvest period, water is mainly utilised for irrigation and then it is used for washing during post-harvest practices (Murray et al., 2017). The contamination of fresh produce can occur via the water-to-soil contact, as well as via the produce-to-water contact (Machado-Moreira et al., 2019). Recent outbreaks have been linked to the use of contaminated water during post-harvest processes. Run-off from animal pastures is generally considered to be a primary source, as irrigation with contaminated water allows for enteric pathogens to easily enter via the roots and damaged skin of fresh produce. This is common during the heavy-rain seasons. The use of drip irrigation was found to have less chance of introducing pathogens onto fresh produce, compared to overhead irrigation (Delaquis et al., 2007; Luna-Guevara et al., 2019). Delaquis et al. (2007) reported that *E. coli* O157:H7 can enter leafy vegetables and can even survive storage at 1°C, with only some decline in microbial counts. It is often difficult to control the water quality, as there may be multiple water sources and so pollutants can be easily introduced. It has become widely accepted that pathogens are likely to be detected in river water or similar water sources; therefore, acceptable limits for hygiene indicator bacterial species have been devised (Murray et al., 2017). The use of hygiene indicator organisms, as well as using the international recommendations and guidelines, is the most effective way of ensuring water quality (see Table 2.2 below).

2.20.3 Manure and faecal matter

The application of manure, as an alternative to fertiliser, should normally be carried out via composting, which lowers the risk of pathogenic contamination, if it is done correctly. Furthermore, the use of untreated manure increases the chances of the contamination of fresh produce (Delaquis et al., 2007; Luna-Guevara et al., 2019). It is well-known that faecal matter hosts numerous microorganisms, including enteric bacteria, which have been reported to survive long periods in manure. A count of 2.6×10^8 CFU/g of *E. coli* O157:H7 has been detected in cattle manure. Even with composting, unless the process reaches maturity, there is a high chance that microbial contamination may occur (Alegbeleye et al., 2018). Insects found in manure piles, such as houseflies, are carriers of *E. coli* O157:H7, which suggests that they may allow for the transmission and persistence of food-borne pathogens (Martínez-Vaz et al., 2014).

2.20.4 Contact surfaces

Post-harvest practices are just as important when it comes to preventing microbial contamination, as there is a lot that can happen during harvest, processing, storage and transportation (Machado-Moreira et al., 2019). The microbial counts in fresh produce are known to increase significantly towards the final stages of the post-harvest processes because the sources of direct contamination, or pathogens, will have generally multiplied within the fresh produce (Luna-Guevara et al., 2019). Collection containers, when placed onto contaminated soil, can allow for the transferral of microorganisms. The equipment that is used during harvesting may not be washed and may carry residual contaminants, which also allows for the transfer of microorganisms (Alegbeleye et al., 2018). Several studies have shown that shredding, fuming, dewatering and transporting serve as sources of contamination, as the fresh produce can become injured, which allows for the subsequent colonisation and dispersal of enteric pathogens (Delaquis et al., 2007; Bartz et al., 2017; Beharielal et al., 2018). Contact among individual units of fresh produce can also result in the cross-contamination of pathogens, while the hands of labourers can also allow for the transfer of microbial contamination to another person, or directly to the fresh produce or the storage containers. It is therefore crucial to ensure that proper procedures are in place to prevent contamination via this route, as it would render any other precautions useless.

Table 2.2 National and international guidelines for the acceptable microbial burden of selected hygiene indicators for irrigation and domestic water use

Organisation/Government	**Water use**	**Bacteriological quality** Limit value/range
South African Department of Water Affairs (DWAF)	Irrigation water applied to minimally-processed produce	≤ 1 *E. coli*/100 ml (DWAF, 1996)
	Drinking water	Water 0-100 heterotrophs/ml 0-5 total coliforms/100 ml 0 faecal coliforms/100 ml (DWAF, 1996)
World Health Organisation (WHO)	Unrestricted irrigation of crops (including produce eaten uncooked)	≤1000 faecal coliforms /100 ml (WHO, 2006)
	Drinking water	0 faecal coliforms/*E. coli*/ 100 ml (WHO, 2011)
Canadian Council of Ministers of the Environment (CCME)	Irrigation water applied to vegetables usually eaten uncooked	<1000 total coliforms/100 ml <100 *E. coli*/100 ml (CCME, 2003)
United States Government (Guidelines differ between states)	Spray irrigation guidelines	2.2-200 faecal coliforms/100 ml (Blumenthal et al.,2000)
	Surface irrigation guidelines	10-1000 faecal coliforms/100 ml (Blumental et al., 2000)
	Irrigation of foods consumed raw (California and Colorado Government)	<2.2 total coliforms/100 ml (Blumenthal et al., 2000; USEPA/USAID, 1992)

(adapted from Gemmell and Schmidt, 2013)

2.21 The Control of Contamination

Microbial contamination is particularly difficult to control once it is present and so prevention is the most effective means of ensuring the food safety of fresh produce. By applying the Hazard Analysis Critical Control Point (HACCP) and Good Agricultural Practices (GAP), fresh produce hygiene and quality can be achieved (Gil et al., 2015). These are regarded as the Codex standards by the World Trade Organisation. HACCP focuses on preventing hazards relating to food safety and quality, and not the quality of the final product. HACCP has been gazetted in South Africa as part of the Foodstuffs, Cosmetics and Disinfectants Act (Fuller, 2007).

2.21.1 Food safety standards and regulations

Food safety is of utmost importance as there is a huge demand for high-quality and safe foods across the globe. Increased imports and exports, the increased standard of living and media exposure have illustrated the need for precautions to be taken against food-borne diseases (Taylor, 2011; Soon and Baines, 2013). Although countries will likely have their own set of regulations, international guidelines were developed by the World Health Organisation (WHO), alongside the FAO of the United Nations, namely, the Codex Alimentarius and the ISO 22000, which are used as the baseline to ensure food safety and quality (Kruse, 2015; Chivandi and Maziriri, 2017).

Food hygiene and quality regulations are generally less stringent in developing countries and, as a result, they require more scrutiny. In South Africa, the importation and production of foods are governed by the Foodstuffs, Cosmetics, and Disinfectants (FCD) Act No. 54 of 1972. This legislation regulates the manufacturing, sale, and importation of food products within the country. There are currently two regulations under this Act that govern the microbiological standards for food items, namely R.1555 and R.692 (DoH, 2002). Ready-to-eat products are not stipulated under either of these regulations. This gap in the existing legislation highlights the absence of specific food regulations for such products. The rule of thumb is that microbiological organisms that may be present should not cause harm to humans upon consumption (DoH, 2002). In Table 2.3 below, examples of the national and international guidelines for ready-to-eat fruits and vegetables are shown, with reference to Canada, the European Union (EU), the German Society for Hygiene and Microbiology (DGHM) and Hong Kong. It is worth noting that there are currently no regulations governing the acceptable number of microbial pathogens in raw fruit and vegetables in South Africa and, as a result, many companies make use of international regulations. There is still a need to create clear and stringent guidelines for microbial pathogen monitoring to effectively reduce outbreaks (Beharielal et al., 2018).

Table 2.3 Microbiological limits for raw fruit and vegetables (ready-to-eat) in accordance with the South African, EU, DGHM and Hong Kong regulations or guidelines

Microorganism	Canadian Limits (cfu/g)	European Limits (m/M)	DGHM (m/M)	Hong Kong (m/M)
Total coliforms	-	-	-	-
Yeasts and Moulds	-	-	<10000/g (Yeasts only)	-
***E. coli* strains**	0/25 g	100/1000 cfu/g	100/1000 cfu/g	20/100 cfu/g
***Salmonella* spp.**	0/25 g	0/25 g	0/25 g	0/25 g

(adapted from: CCME, 2011; European Commission, 2007; DGHM e. V. 2012; Hong Kong CFS, 2014)

2.22 Summary

Urban agriculture is growing across urban cities and may have a role to play in improving food security. However, succeeding as an agricultural entrepreneur demands more than just being technically competent in production skills. It requires having the capability to comprehend market dynamics and excel in effective marketing, often characterised as possessing the 'spirit of entrepreneurship’. Some of the things that entrepreneurs face includes financial, land, technical, social and psychological risks. In addition to these challenges, entrepreneurs have to operate in a water-scarce and difficult policy space that often impedes the success of new entrants. Furthermore, water quality is very important when it comes to fresh produce, as it can have a direct impact on market access opportunities, food safety and quality. Water, particularly wastewater, has the potential to introduce food-borne diseases into processing plants and/or to be detrimental to human health, which therefore highlights the importance of smallholder farmers’ making use of good hygienic practices during the pre- and post-harvest periods. Limited access to resources and a lack of essential knowledge can pose barriers for smallholder farmers when they are trying to access markets to sell their produce. Understanding the socio-economics of smallholder farmers may offer some insight into how they can be assisted when it comes to capacity-building and providing them with essential knowledge, so that they can become self-sufficient in the production of fresh produce and, ultimately, so that they can gain market access.

CHAPTER 3: STUDY METHODOLOGY

3.1 Introduction

This section presents a description of the research process. It provides information concerning the methods that were used for undertaking this research, as well as the justifications for using them. It also describes the various stages of the research, including the selection of participants, the data collection process, and the process of data capturing and analysis.

3.2 Description of the Study Areas

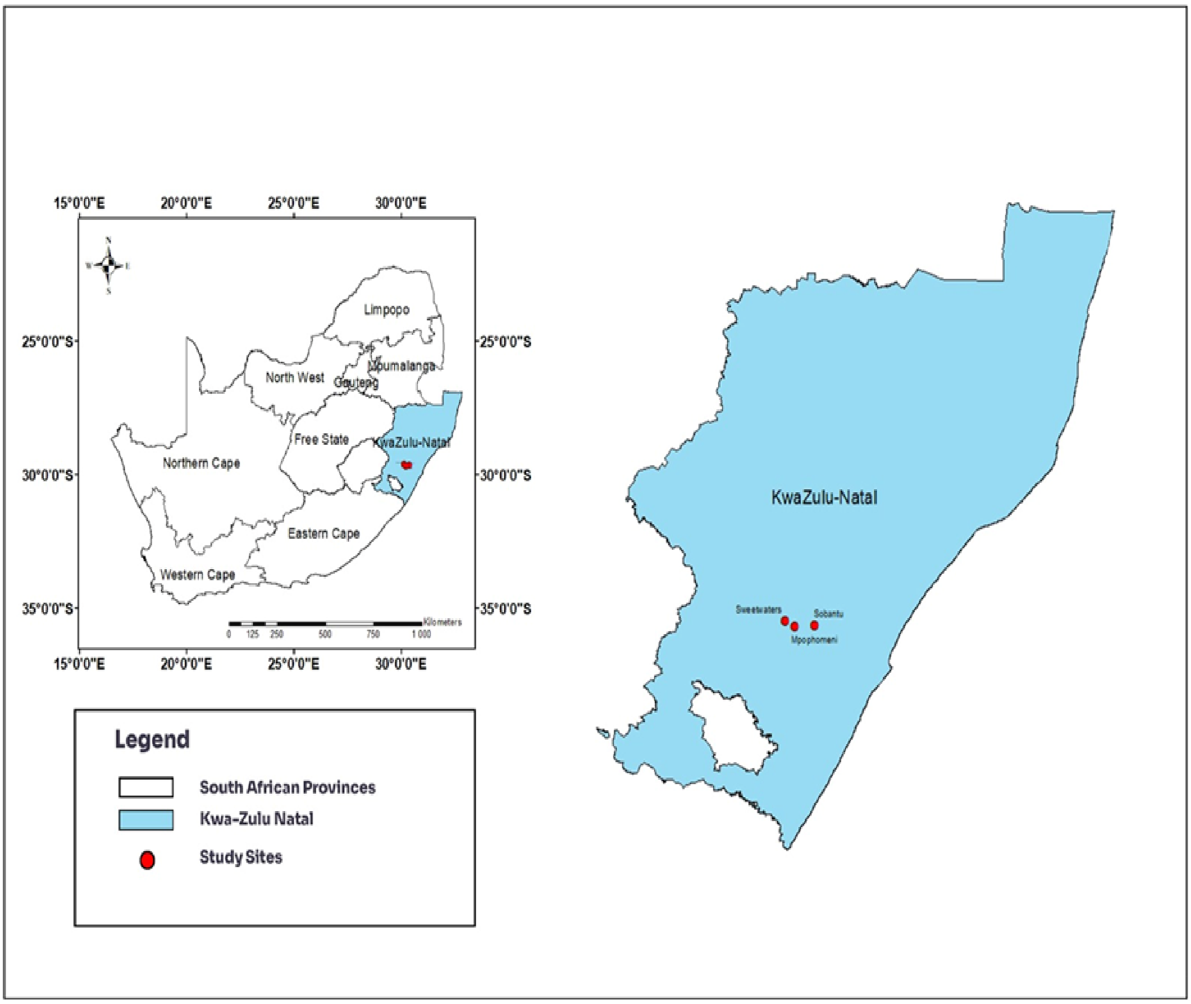


Figure 3.1: Geographic delineation of study areas within the KwaZulu-Natal Province

The Sobantu township is located close to the city of Pietermaritzburg in the Province of KwaZulu-Natal. Most employed people in this township earn an income at the nearby factories. Two rivers run through the township, and there are a number of floodplains associated with the rivers. Both rivers are used as a source of irrigation for smallholder agriculture and the river water is also used for other human activities, such as fishing. Agricultural activities include several community gardens and small individual production units (Cebekhulu, 2016). The Sobantu community is comprised of formal and informal residential areas and is located toward the lower reaches of the Baynespruit River. Moreover, the uMsunduzi River is also surrounded by factories, including three animal-feed factories and the New England Road landfill, which has in recent years been considered as an environmental and health concern. The companies themselves range in size, from small to large; some are independent, while others are subsidiaries of national or even multi-national operations. The factories manufacture a range of products, including carpets, chemicals, food and toilet paper, for both domestic consumption and export purposes. Sobantu residences and the nearby formal and informal settlements that require water from the Baynespruit for irrigation purposes contribute to, and suffer from, litter and sewage pollution problems.

Sweetwaters is a semi-urban area that is located on the outskirts of Pietermaritzburg. It is 18 km wide and is under the authority of a Chief and *IziNduna* (headmen), who govern the area. Sweetwaters is located in the uMsunduzi Local Municipality, under the uMgungundlovu District. It covers an area of approximately 12.94 km^2, with a population size of approximately 14 417 (Integrated Development Plan, 2011/2012). Approximately half of the households in Sweetwaters are involved in subsistence and smallholder farming. Their major problems are the high rate of unemployment and poverty and that the people lack the capacity to produce enough food (Integrated Development Plan, 2011/2012).

This study was also conducted in Mpophomeni, a peri-urban township in the KwaZulu-Natal Province. Mpophomeni means ‘home of the falls’, and it is located outside Howick, which is 28.3 km from the centre of the town of Pietermaritzburg. The population is estimated to be about 35 000 people, and it had an unemployment rate of more than 18% in 2018. Those who are formally employed work in and around the Howick area, Hilton, the Mpophomeni shopping centre and Pietermaritzburg. Mpophomeni is marketed as part of the ‘Zulu tourism experience’, is surrounded by waterfalls and is close to the Midmar Dam (Mathambo and Richter, 2007). The area is mostly populated with households that are subsistence farmers and a very small proportion who are smallholder farmers. The challenges that the communities face are high unemployment, as well as pollution in the area, which causes the degradation of the quality of the water which comes from the rivers, dams and springs in the area and is used for irrigation. The Mpophomeni township was purposefully selected for the study, as there is a high incidence of poverty, a high unemployment rate and a high dominance of urban agriculture and home gardens, as well as pollution, which is attributed to the deterioration of the water quality in the catchment areas. Mpophomeni has a wastewater treatment plant that is located adjacent to the Mthinzima River, which has historically treated domestic wastewater. This wastewater and the river encompass a range of issues, including the presence of solid waste in and around watercourses and the state of damaged and insufficient sewage infrastructure in Mpophomeni.

Community access processes were initiated after reaching out to Pietermaritzburg's urban township of Sobantu. Access was granted via a structure of the local government called a ‘war room’, where representatives from all levels of government, as well as from organisations involved in development and research, convened with the local authorities. The entrance to the war room was initially made possible by contacting the agricultural Extension Officer. The Secretariat for Community Development was contacted, and permission was requested to present the project to representatives of various stakeholders. The first meeting was held on November 12, 2020, after the Covid lockdown.

The purposive selection of the three sites was done by using the WRC’s project requirements, and this study was part of assessing the entrepreneurial risks that are linked to water quality, water security for urban-based farming and agro-processing. The WRC project seeks ways of linking water quality to urban farming and evaluating the entrepreneurial risks related to urban-based farming in urban farms and home gardens, to address food security at a household level. The sampling is critical for the study, because the researcher chooses the participants for the study (Williams, 2007). The targeted population for the study were the household members and key informants within the municipalities that were engaged in urban agriculture.

- The selection of the urban farmers was based on the following criteria:
- The farmer is located in areas that are close to rivers or water sources;
- The farmer is in close proximity to the markets;
- The farmer has other non-farm or off-farm economic activities;
- The farmer has fewer social conflicts and is already exposed to the urban farming methods;
- The farmer has water user rights.

The key considerations when choosing the farmers were the diversity of the farmers and their potential for growth. These farmers were surrounded by businesses, including factories, schools, and industries, that buy their products. The remaining goods were distributed to local residents, supermarkets in the area and local *Spaza* stores. The farmers were also close to Pietermaritzburg and Howick, the two towns closest to the selected sites.

Three focus group meetings and a workshop were held prior to the start of this study to determine the farmers' water sources. It was discovered that the farmers in Sobantu were utilising water from the uMsunduzi and Baynespruit Rivers; however, additional inquiries revealed that these rivers were not the only sources of water that they utilised, as they also made use of taps, boreholes, and community water supplies. In addition, it was discovered that the Mpophomeni farmers were employing taps, springs, and rainfall collection, while the farmers in Sweetwaters were also using water from the taps and nearby streams. The farmers from all the study areas revealed that they were paying for the water that they used from the taps; however, those using the river water did not have the water rights to do so. The discussions revealed that the farmers were unaware of the quality of the water that they were using, as they had never had it tested, even though Duzi-uMngeni Conservation Trust (DUCT) conducts regular water-quality checks and ensures that the health of the river is maintained.

3.3 Research Design and Approach

The study adopted a mixed-methods research design by using both qualitative and quantitative methods for data collection and analysis. The total number of farmers who participated in the three sites were (n=157) using multi-staged sampling. The qualitative research methods enabled researchers to study social and cultural phenomena, and to observe the feelings, thoughts, behaviours and beliefs of the society (Hussein, 2009). Qualitative data sources also included observations, interviews and questionnaires, as well as the researcher's impressions and reactions (Graue 2015).

3.4 Sampling

The overall sampling approach of participants in the three areas was multi-stage purposive sampling. According to Obilor (2023), multi-stage sampling is a type of cluster sampling which encompasses two or more stages in the selection of the sample. This sampling method was appropriate for the study due to the criteria of being an urban farmer for several years, using various water sources in the urban setting and having market participation. The participants had to meet the set criteria.

3.5 Data Collection Procedure and Tools

The data collection was multi-staged where various data was collected at different stages of the crop, water flow intervals and the stages of farmers readiness for markets and enterprise development. The water data was based on seasonality and allowing multiple samples for variance of water flow and time intervals. The initial stage of data collection was over a period of five days (one week) in Sobantu (October) followed by Mpophomeni and Sweetwater's in November 2021. Telephonic follow up were also conducted for data verification. This stage was largely for demographic data and laid the based to subsequent stages of data collection. The survey questions were pre-tested on 10 randomly selected smallholder farmers who were not selected to be part of the study. The questionnaires were administered in one-on-one interviews in isiZulu, as most of the respondents could not understand the questions that were asked in English. Questions that were not clear during the questionnaire pre-testing were modified, to clarify them for the respondents.

3.5.1 Structured questionnaires

The initial steps of the survey were to ask the respondents questions and receive their responses by using standardised questionnaires. The study used a survey questionnaire to learn more about the farmers' perceptions of the business risks related to the quality and security of the water supplied to urban farmers. The structured questionnaires were created to collect information on their market access, farming entrepreneurship, farming methods, livelihood strategies and demography and water sources. The structured questionnaires were pre-tested on 10 Sobantu homes that were not involved in the actual survey.

3.5.2 Focus groups

Focus Group Discussions (FGDs) were then conducted with the urban farmers, and key informants were interviewed (i.e. Extension Officers, Hello-Choice, UMEDA, etc.). These FGDs were employed to generate meaningful discussions to gain an understanding of the social capital and knowledge systems (Meinzen-Dick et al., 2004). Focus groups are a form of in-depth group interviews, which provide information on topics that are specified by the researchers (Noble and Smith, 2015).

3.5.3 Key informant interviews

Key informant interviews aimed to obtain a general idea regarding the knowledge systems used by farmers within, and outside of, their communities and how they acquire and share knowledge. Each of the interviews was conducted face-to-face by the researcher, and the COVID-19 regulations were observed.

3.5.4 Water quality and microbial burden assessment

River water samples were collected directly from the uMsunduzi River and from the water tanks utilised for storing river water on the field. In addition, soil samples and fresh produce samples were collected as well as tap water samples from smallholder farmers' plots. Water samples were generally collected between 8:00 am and 11:00 am, using sterile 500 ml Schott bottles. The river water samples were collected at a fast-flowing point of the river, slightly below the surface of the water. In the case of tap water collected from the hosepipe, 0.1 ml of $Na_2S_2O_3$ x 5 H_2O (18mg/ml) was added per 100 ml of the sample volume prior to autoclaving the sampling bottles to neutralise the free chlorine (Murray et al., 2018). The soil samples were collected in a sterile jar from a depth of about 15 cm below the soil surface.

Specific methods related to analysing the physicochemical water quality (e.g. pH, COD) and microbial burden (e.g. APC, hygiene indicators) will be outlined in Chapter 5 while Chapter 4 was an assessment of the Microbial Burden of Irrigation Water – Field Approach.

3.6 Laboratory Data

Samples to be analysed were transported on ice, and a laboratory analysis as specified in Chapter 5 was carried out within two hours. Water samples were used directly or diluted tenfold, by aseptically pipetting 1 ml of the sample into 9 ml of sterile peptone water (1 g peptone and 8.5 g of NaCl per 1 L of distilled water, pH 7.0), typically up to a decimal dilution of up to 10^{-6} using the same diluent, while for soil 10 g of the sample was added to a sterile Erlenmeyer flask containing 90 ml of sterile peptone water. The flask was gently shaken for a maximum of 10 minutes at ambient temperature, prior to preparing decimal dilutions that were typically up to 10^{-6}.

The temperature of the water samples was measured in the field by using a waterproof pocket pH tester (Hanna Instruments, HI98108, Italy). The Chemical Oxygen Demand (COD) was determined by using the Merck NOVA 60 system (Germany) and a Merck COD test kit (25-1500 mg/L, Merck, Germany) according to the manufacturer's instructions. Temperature data were obtained from Accuweather (2022), and rainfall data were obtained from Weather SA (2021).

3.7 Data Analysis

The Statistical Package for Social Science (SPSS) was used to analyse the descriptive statistics and the content analysis of the 157 participants. The responses to the closed-ended questions were coded and subject to a descriptive analysis by using SPSS software package. The focus group conversation and the open-ended questionnaire questions were analysed for common themes and occurrences. The data were analysed by using tests for the principal component analysis and descriptive statistics. Utilising a modified version of the Household Food Insecurity Access Scale instrument, (HFIAS) the level of water insecurity (access pillar) for the categorised water samples was determined. The HFIAS is one of the commonly used experience-based food insecurity scales (Coates et al., 2007). It was developed by the USAID-funded Food and Nutrition Technical Assistance II (FANTA) project. It has been used in various ways in research. In this study, the approach used by Brewis et al. (2021) and Sinyolo et al. (2014) was chosen because it could be used to study all four aspects of food security, namely, access, anxiety, as well as the inadequate quality and quantity of the food supply (Mango et al., 2014). The higher the adapted Household Water Insecurity Access Score, the higher the water insecurity status of that household was.

Table 3.1: Summary of project objectives and methodology

Objective	Data to be collected	Tools	Analysis
1 Detailed literature review on entrepreneurial risk associated with water quality and security supplied to urban based farming and related agro-processing; equity among water users and water recycling.	Entrepreneurial risk associated, water quality and security urban based farming, agro-processing; equity among water users and water recycling.	Desktop analysis, secondary data	Summary, themes and key concepts
2 A description and analysis of the current status quo on water quality, water access, urban farming, agro-processing, and the nature and roles of stakeholders on entrepreneurial risk in urban farming.	Water quality, water access, urban farming, agro-processing, the nature and roles of stakeholders on entrepreneurial risk in urban farming. Political Environmental, Social, Technical, Economic and Legal stakeholder data	Questionnaires, Focus Groups, Key informant interviews, Microbial Burden Counts, Ph, Chemical Oxygen Demand (COD). PESTEL	Descriptive analysis, PESTEL
3 Assessment of water quality through quantification of microbial burden of the irrigation water, pH, water temperature and the chemical oxygen demand (COD).	Water quality; water pH, water temperature COD.	Microbial Burden Count; COD. pH meter	Microbial Burden Counts; pH, COD.
4 Assessment of water use security. An index-based assessment of water availability, accessibility, utilisation (incl. safety) and supply stability to all	Water use security domains (availability, accessibility, utilisation (incl. safety) and supply stability	Water Use Security (Water Insecurity Access Scale)	Water Insecurity Access Scale

Objective	Data to be collected	Tools	Analysis
water users and how this enables or is a barrier.			
5 Produce guidelines on best practices on establishing and strengthening an Urban Farming; Agro-processing-Water Use.	Summaries of methods and approaches in the project	Thematic and desktop review of the project document	Thematic and desktop review of the project document

CHAPTER 4: POLITICAL, ENVIRONMENTAL, SOCIAL, TECHNICAL, ECONOMIC AND LEGAL (PESTEL) ENVIRONMENT OF URBAN FARMING AND AGRO-PROCESSING

4.1 Introduction and Contextualisation

More than 66% of the population live in urbanised areas in South Africa (Plecher, 2020). Unemployment remains one of the most persistent socio-economic challenges in urban areas (Davis and Thurlow, 2010; Gar and Rodger, 2020), and it is defined as "a point at which individuals actively work in search of jobs and mentally prepare themselves to work at any wage level that already exists" (Maqbool et al., 2013). High unemployment threatens the livelihoods of urban dwellers because they do not have an income source, yet they require food daily (Uwayezu and de Vries, 2020). Food insecurity and unemployment remain pressing problems in many parts of Sub-Saharan Africa (Mougeot, 2005; UN Habitat, 2007), especially in and around the major urban centres (Mougeot, 2005). Garrett (2000) suggests that urban-based sustainable livelihood analyses need to be treated with caution, since most urban dwellers depend almost entirely on their income to purchase their food, rather than producing it themselves. Consequently, traditional livelihood approaches, which often explore factors like the link between land tenure and food security (Keovilignavong and Suhardiman, 2020), are less relevant in urban regions. Urban poverty is also increasing in South Africa, and across Africa in general (UN Habitat, 2007), as is evidenced by increases in the poor-quality housing in environmentally degraded areas. Hence, Urban Agriculture, as defined by Wagstaff and Wortman (2015), is "all forms of agricultural production that exist within or around cities that seems to provide a realistic and pragmatic solution to urban poverty and food insecurity" (Mougeot, 2005).

Studies indicate that urban agriculture is an important source of food throughout the developing world and that it is a critical food security strategy for poor urban households (Salomon et al., 2020; Wang et al., 2021). Urban agriculture strengthens many ecosystem services, and it also improves human health and contributes to food security, incomes, and jobs, along with economic prospects. Urban agriculture also improves the aesthetical value and beauty of a city, education about farming and community resilience. After the apartheid era in South Africa, urban agriculture has been promoted in various policies as a coping strategy for income-generation and food security for unemployed urban dwellers (Tornton, 2008; Paganini and Lemke, 2020). Furthermore, urban agriculture has social and ecological benefits because it boosts biodiversity, reduces waste, improves natural resource efficiency and human health, and it also has rural and urban links and educational benefits that contribute to urban sustainability (Lovel, 2010; Surls et al., 2015; Kingsley et al., 2021). Although there are considerable links between the rural and urban areas in Africa (and elsewhere), and urban residents may have access to land in the country, it is increasingly being understood that urban problems are different to those that are experienced in rural areas (Mkwambisi et al., 2010; Singirankabo and Ertsen, 2020). The rural-urban connections also include the flow of labour from rural areas to work on small gardens in urban centres (Baffoe et al., 2021). Another link that could be significant is the supply of agricultural produce from rural and peri-urban areas to urban areas, while extension programmes are designed in urban areas and delivered to rural areas through development partners, such as Non-Governmental Organizations. These links can affect both rural food production and urban food systems, in that many urban residents retain their land in rural areas, which is used to produce food and to retain secure land ownership rights by using cheap labour (Mutea et al., 2021). As noted by Baker (2005), a significant portion of income in rural areas is not directly derived from agriculture but rather comes from off-farm and non-farm income sources that are linked to urban centres.

Studies in Africa, such as those of Gallaher (2017:180) on ‘sack gardeners’ in the Nakuru slums of Kenya, Hovorka (2005, 2006) on chicken farmers in Gaborone, Botswana, and Slater (2001) on ‘food gardening’ in Cape Town, South Africa, all posited that economically marginalised women can become financially, socially and politically empowered as a direct result of urban agriculture. Paradoxically, some case studies have found that urban agriculture is empowering, while others argue that it only makes the rich richer; this suggests that an intervening variable has not been considered. NGOs appear to be one such variable. In each of the abovementioned success stories, NGOs have invested considerable time and resources into training cultivators and integrating them into supportive networks. South Africa is urbanising rapidly, and this has resulted in an increase in its peri-urban population (Statistics SA, 2017a). Due to the limited economic activities, many turn to urban agriculture to obtain a basic livelihood in the form of cash crops, by becoming subsistence farmers (Thamaga-Chitja and Hendricks, 2008; Baiphethi and Jacobs, 2009; Mdluli et al., 2014). Urban agriculture, especially agro-ecology, is gaining prominence as a panacea for addressing food insecurities for the most vulnerable households in South Africa (Rudolph et al., 2020). Engaging in productive agriculture demands substantial water resources. Nevertheless, South Africa, being a water-scarce country often plagued by droughts, utilises the available, but poor-quality surface water (such as river water) for irrigation (Gemmell and Schmidt, 2012; Schreiner et al., 2018).

4.2 Methodology and Description of the Study Area

The following section gives a description of the area of study, and it also describes the methods used for data collection and analysis. The data collected in this report were qualitative. A participatory approach was employed to collect these qualitative data, and it was the overarching process guiding the research, where the stakeholder assessments and facilitation was conducted. The specific analytical framework and tool used for the analysis was to characterise the stakeholder resources, followed by Power, Environment, Social, Technical, Economic and Legal (PESTEL), as employed by Wu (2020), for understanding the macro-factors that influence the availability, access, utilisation (safety and quality) and stability of the water supply. The analysis further helps the managers to identify the future macroeconomic variables of interest in the construction of different scenarios, to ensure the proper development and sustainability of businesses by using the policy initiatives (Abdulla, 2020). It requires that an organisation must consider the external environment before starting a project and that it must ensure that it has captured all the potential risks and issues. Workshop discussions were conducted with various stakeholders for understanding the key issues, and this was supported by expert interviews with relevant key role players, particularly the market-related stakeholders. The data that were collected by using PESTEL were supplemented by a Porter's Five Forces Analysis of the Market in Agriculture (Adem et al., 2018; Muzahidul et al., 2020)

4.3 Study Area Description

Sobantu, Sweetwater and Mpophomeni are located on the outskirts of Pietermaritzburg in the Province of KwaZulu-Natal. The main employment for people in this township is at nearby factories. Two rivers run through Sobantu township and there are several floodplains associated with them. Sobantu has a comparatively flat topography, is well-drained and surrounded by the uMsunduzi and Baynespruit Rivers. Farmers use both rivers as a source of irrigation for smallholder agriculture, as well as for various other human activities, such as fishing. Kirkpatrick (2007) indicated that the Sobantu township is located on a floodplain and that further housing development is limited. Nevertheless, based on the good soils located at the 50-year flood-line, the area has a high agricultural potential. The noted agricultural activities include several community gardens and small individual production units (Cebekhulu, 2016). The Sobantu community is comprised of formal and informal residential areas and is located toward the lower reaches of the Baynespruit River. Both historically and currently, the community uses the floodplains for agriculture and its interest has increased in initiatives to develop the floodplains for further agricultural purposes (Govender, 2016).

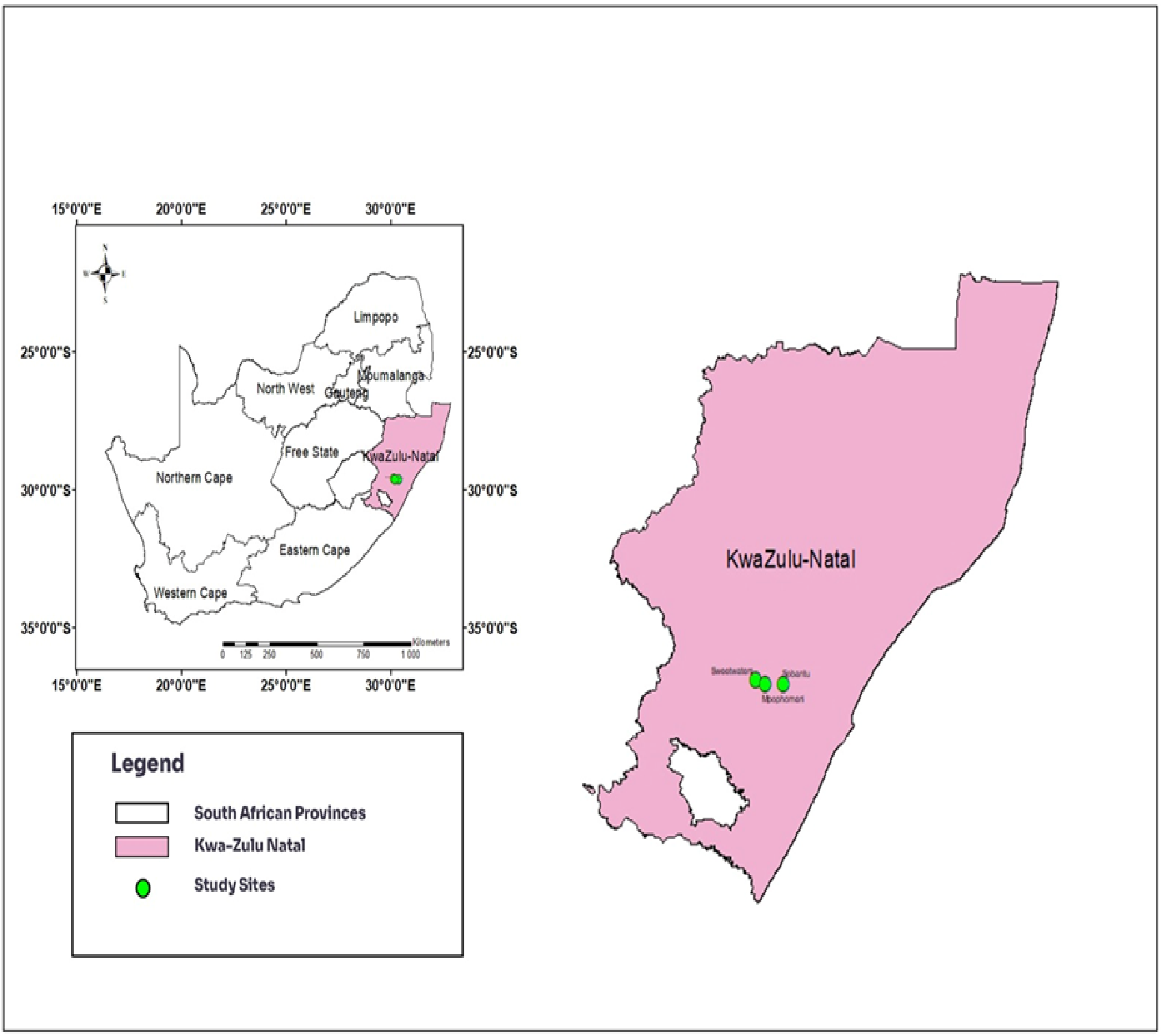


Figure 4.1: **Geospatial representation delineating study areas within the Mgungundlovu District**

Figure 4.2: Workshop where a focus group discussion was conducted with the farmers in urban Sobantu

Figure 4.3: Workshop where a focus group discussion was conducted with the farmers in urban Sobantu

4.4 Findings and Analysis of PESTEL

4.4.1 PESTEL analysis and Porter's Five Forces analysis of the market in agriculture

This section addresses the various elements that affect the environment. The objective of this analysis is to evaluate the internal and external environment of the business. One of the models that is used to analyse the competitive environment in industry, and to formulate strategies on a competition basis, is the Porter's Five Forces Model (Abinsay, 2020). To gain a competitive advantage, the competitors offer consumers greater value by lowering their prices or providing greater benefits and services that justify the high prices (Maciejczak, 2007). The root of competition is in the principle of economic and competitive forces beyond one's competitors, and trying to gain more of the market share, (Abinsay, 2020). There is a fundamental idea that the company operates on a network of buyers, suppliers, substitutes, new entrants, and competition that is still valid (Dalken, 2014). Porter's five distinct forces must be considered when determining the attractiveness of a specific industry (Larry et al., 2014). Where attractiveness refers to the profitability that the industry offers its entrants, the concept of profitability should be thought of as reasonable, or it should be avoided before entering the industry (Abinsay, 2020).

Competition has been proved to be a critical force in the operation of numerous organisations, irrespective of the industry (Indiatsy et al., 2014). Having a competitive strategy is fundamental in searching for a favourable position in the industry where competition occurs (Maciejczak, 2007). One can employ several tools to analyse a competitive environment, such as the Porters Five Forces model, the Game plan, the Value Chain model, the PESTEL model and a Strategic group analysis, of which the Porter's Five Forces model has been categorised as the best (Dalken, 2014). This model is an illustration of how the five competitive forces can be used to explain low profitability and entry into an industry (Hill and Jones, 2007). The model constitutes the threat of new entrants, the threat of substitute products or services, the bargaining power of buyers, as well as the bargaining power of suppliers and competitive rivalry. The level of these five forces greatly determines the mean expected level of profitability in an industry, and having an in-depth understanding, both individually and in combination, it is beneficial for making decisions on what industries to enter and for evaluating how an industry can improve its competitive position (McGanan, 1997; Indiatsy et al., 2015). The strength of each of the five forces is inversely proportional to the price and profits, so that a weak competitive force may serve as an opportunity, while a strong one may serve as a threat (Hill and Jones, 2007). Competition between industries is affected by undeniable forces that shape the market structure (Wulandari et al., 2021). The market structure mostly affects the attractiveness of an industry and it is also one of the factors that influences the behaviour of the market players (Dalken, 2014). Attractiveness means the profitability of an industry's offerings; its profitability must be considered before entering, or avoiding, the market (Johnson, 2014). Figure 4.4 illustrates the interrelationship between the forces within an industry.

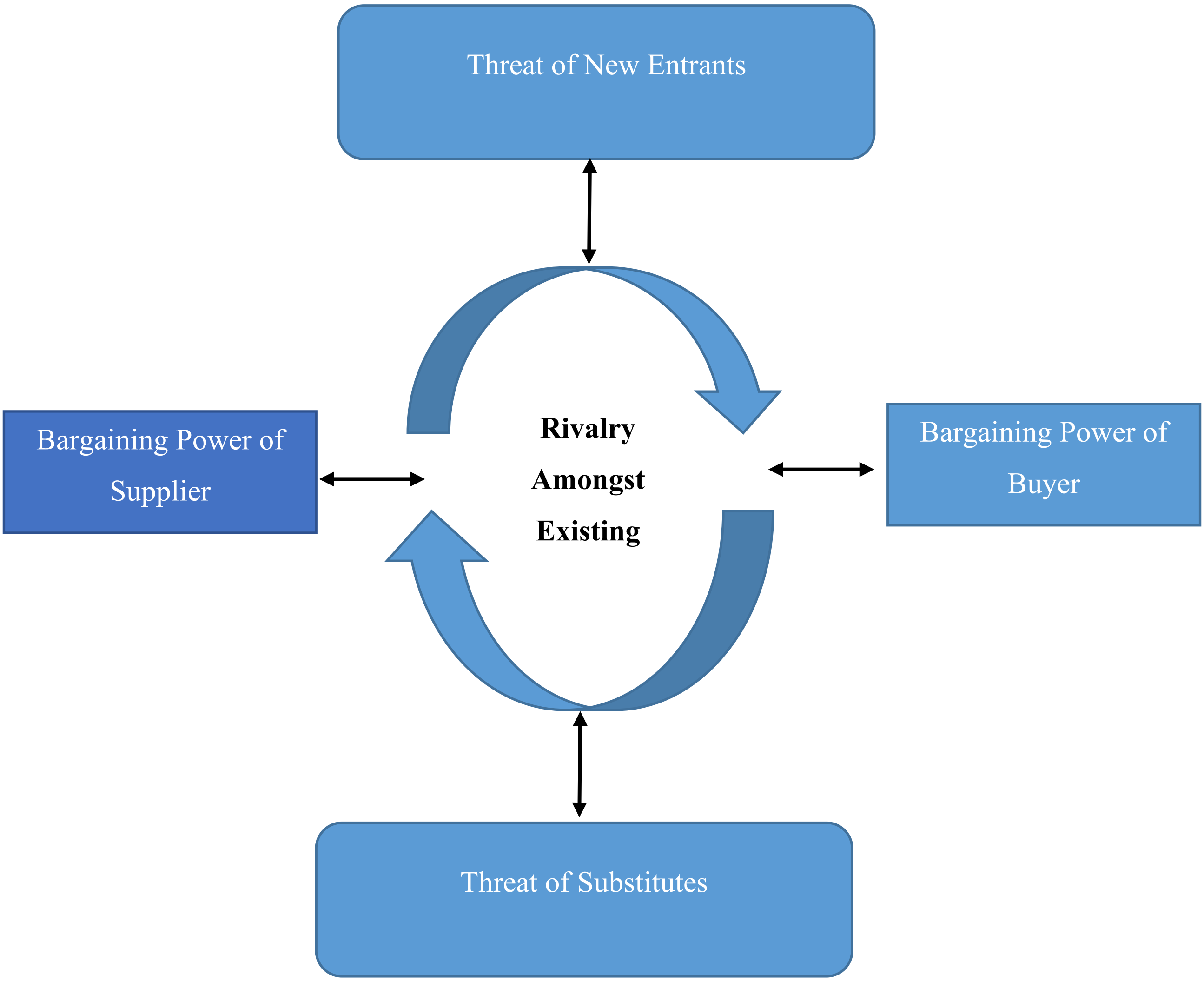


Figure 4.4: The five forces influencing competition within an industry (Ireland et al., 2009)

4.4.2 The threat of new entrants

a) Threats of new entrants

The first force examines how easy or difficult it is for competitors to join the marketplace in the particular industry that is being examined. The competitor's ability to enter the marketplace depends on whether or not the risk of the market share is depleted (Abinsay, 2020). The profitability of the market with a high yield on returns increases the attractiveness of the industry (Porter 2008; cited by Henses and Ostman, 2011). The number of new entrants in the market leads to decreased profitability, and unless entry is blocked, the profit rate will fall to a competitive level (Henses and Ostman, 2011). Abinsay (2020) also found this to be accurate, as an organic food perspective in developing countries showed that new entrants could pose a barrier. Current businesses that expand their activities could be a potential barrier for new entries. The entry barriers in the market can change, depending on governmental regulations and licensing; however, the competitiveness of the new entrants in the market depends largely on the difficulties experienced by the existing manufacturers (Abinsay, 2020; Wanyonyi et al., 2021). According to Deshpande (2013), the graph shape of a relatively new business with fewer competitors is bell-shaped, due to external inhibiting factors, such as regulations, high capital requirements, etc.

The profitability curve for the threat of new entrants is likely to be a polynomial curve, as seen in Equation 4.1:

$$Y = Ax2 + Bx + C \quad (4.1)$$

Where Y represents the probability of new entrants, and x represents the businesses in the agricultural sector, where good profits are driven by a particular crop in that year, which then motivates other farmers to plant that crop in the following ploughing season (and vice versa), thus, creating market crashes and market booms for a particular crop. The typical experience is that there is always a lag in information between the farmers and the market. This is because of issues such as the existence of barriers to entry (i.e. patents, rights, etc.), the economies of the different products, brand equity, switching costs or sunk costs, capital requirements, access to distribution, absolute cost advantages, learning curve advantages and government policies (Henses and Ostman, 2011).

b) Threats of substitutes

The second force is threatening the producers when buyers can easily find a substitute with attractive prices or of a better quality and they switch from one product or service to another, at little to no cost (Abinsay, 2020). This force indicates how easily consumers change from one product or service to that of a competitor. The existence of close product substitutes increases the tendency of consumers to switch to an alternative, in response to a price increase (Porter 2008; cited by Henses and Ostman, 2011). The issues that must be evaluated are the buyer's propensity to substitute, the relative price performance of the substitutes, the buyer's switching costs and the perceived level of the product differentiation. Substitutes are products that are similar in use to existing products (Abinsay, 2020). The existence of substitutes is because of the competition in the market, which thus influences the innovative nature of the producers in the market and helps them to gain the upper hand, i.e. to gain a competitive advantage over the other players (Deshpande, 2013).

c) The bargaining power of buyers

The third force refers to the ability of the buyers to control the producers' or suppliers' ability to be profitable. Thus, it is driven by having many buyers in the market, the importance of each buyer to the organisation, and the cost to the buyer of switching from one supplier to another (Abinsay, 2020). In agriculture, the main buyers are the grain merchants and handlers, the livestock producers and renewable/industrial energy users. These customers have the critical role of storing the grains for a few months and consuming them over the year, once they are harvested (Bechdol et al., 2010). The firms are typically private companies and traditional farmer cooperatives; nowadays, there is a substantial concentration of remote grain handling and merchandising companies (Bechdol et al., 2010). According to Henses and Ostman (2011), the main issues that need to be evaluated in this force are the buyer-to-firm concentration ratio, the bargaining leverage, the buyer volume, the buyer switching costs relative to the firm's switching costs, the availability of buyer information, and the availability of the existing substitute products, buyer price sensitivity and different advantages of the industry products. The quantity of the product also gives consumers power, as large volumes of the product drive the price down while the opposite is also true. The number of buyers determines the price on the market, and farmers tend to be price-takers when there are a limited number of buyers. The farmers settle for a price that is not always proportionate to the investment (both monetary and physical); however, food scarcity can be an exception.

Equation 4.2 illustrates the buyer curve:

$\Delta Y = \Delta A \, \Delta X$; an upward sloping curve (4.2)

Where:

Y: Bargaining power of the buyer

X: Number of businesses in the sector

A: Number of suppliers

d) The bargaining power of suppliers

The fourth force is an assessment of how easy it is for suppliers to drive up the prices. The bargaining power of suppliers typically tends to be directly proportional to the number of players in the industry (even though the correlation may not be 1:1). The number of buyers is a determinant of the price on the market, as a large number means that the suppliers are the price-makers.

The supplier curve is downward sloping, which is illustrated by Equation 4.3:

$$\Delta Y = \Delta X \, \Delta A \quad (4.3)$$

In the agricultural sector, a relatively large number of farmers are frequently exploited by the suppliers of inputs such as seeds, fertilisers, pesticides, etc. due to the adverse bargaining power of suppliers. According to Abinsay (2020), a more substantial bargaining power allows suppliers to sell lower-quality products at higher prices. Input suppliers are primarily those that supply grain and seeds, which are concentrated mainly on large agribusiness companies that compete vigorously for the farmers' business (Bechdol et al., 2010). The suppliers may also refuse to work with a firm or charge excessively high prices for unique resources (Henses and Ostman, 2011). The monetary and physical investment required to breed and engineer new crop varieties and traits is significant for regulatory approval (Bechdol et al., 2010).

e) The intensity of rivalry amongst competitors

The fifth force of competitive rivalry describes how the other four are interlinked with the shape and structure of competition in the industry (Abinsay, 2020). Agricultural production is characterised by a high degree of competitive rivalry. Efforts to develop branded or specialised products are quickly and effectively copied and meaningful differentiation is difficult to achieve. The competitive rivalry plays out most clearly when bidding for productive resources. Considering the impact of these forces, the level of competition and the profit potential is determined, as well as the overall attractiveness and performance of the industry (Abinsay, 2020). The agriculture industry is primarily characterised by a high degree of competitive rivalry (Bechdol et al., 2010). The issues that need to be evaluated are as follows: the number of competitors and diversity of the competitors, the rate of growth in the industry, the intermittent industry overcapacity, the exit barriers, the fixed cost per allocation per value-added, the economies of scale and the sustainable competitive advantage through improvisation (Abinsay, 2020).

4.5 PESTEL Analysis

The external environment of a business can be evaluated by using the PESTEL analysis, which is the standard tool that is generally used. PESTEL was initially published in 1960 by Jeremy McCarthy and focused on the political, economic, socio-cultural, technological, environmental, and legal aspects (Walstoom, 2004). According to Friend and Zehle (2009), the factors are uncontrollable for a firm, as they reveal how many external environment factors influence a business's performance. In Table 4.1, an overview of the different aspects of each element of the PESTEL is given.

Table 4.1: PESTEL analysis of water quality, water access, urban farming and entrepreneurship roles

Stakeholder	Role
Technical	**-Water Quality** The Department of Agriculture does not check the water quality. Farmers can do this if they are in partnership with a research project. **-Water Access** None have been identified at present. Farmers' access to river water or municipal water **-Urban Farming Policy and Programme** The Department of Agriculture has an Extension Officer who is responsible for facilitating the knowledge, information, etc. to advance farming in Sobantu. This Department facilitated contact with Local Government Secretariat in Sobantu. This facilitated a participatory workshop where the project team was present to identify the organisational/institutional, social, technical and financial issues, as well as the necessary processes and activities to investigate UA. This is being used to guide further engagement. This project first engaged the Department of Agriculture's extension services, in order to partner with, and to access, Sobantu. **-Urban farming entrepreneurship** A workshop was held in the Sobantu Village Hall. About half the participants were women who belonged to the community. Twelve people were members of the Sobantu Agricultural Co-operative, which was the implementing group and the main beneficiary of the urban farming project that is being developed. Community organisations concerned with childcare and the environment were also represented. The workshop was conducted in both the Zulu and English languages, and the need for fluency in Zulu was emphasised by those who would be directly involved in the project. **-What capacity-building interventions exist?** Training and assistance with implements **-What agro-processing training support exists?** None

Political-Local Government/Municipality	**Water Quality** The uMsunduzi Municipality checks the water quality of the rivers. Water samples are taken to identify if there is any possible spillage from the factories and if the water is safe to use for agricultural purposes or human activities. **-Water Access** The municipality provides tap water to the households. There are also strict rules that restrict the dumping of waste into the rivers and residents are also not allowed to build too close to the riverbanks. **-Urban Farming Policy and Programme** None **-Urban farming entrepreneurship** None
Social	**-What agro-processing training support exists?** None
Technical	Weak technical report
Environmental	**Water quality** DUCT checks the water quality and ensures that the rivers are healthy. They also help in the removal of some of the 'artificial' barriers, such as the lack of an enforcement threat or satisfaction with the status quo, which hold other stakeholders back (particularly those in industry, as well as in regulatory agencies and parastatals) and prevents what would otherwise be powerful incentives to prevent pollution from being effective. **-Water Access** Water is always released from the Henley Dam for the canoe races in Pietermaritzburg **-Urban Farming Policy and Programme** None. Water quality contributes to produce quality in agriculture. **-Urban farming entrepreneurship** None **-What agro-processing training support exists?** None
Legal	Farmers are loosely organised into 'co-operatives', families and individuals. The farmers are not bound by any constitution. Opportunities for governmental support may be missed due to the lack of formalisation.

4.6 PESTEL Analysis Report on the Sobantu Smallholder Farmers

A workshop for the stakeholders and urban farmers in Sobantu was held on 13/05/2021. The workshop was conducted to establish a PESTEL environment for urban farming and agro-processing in Sobantu. This tool was used to identify the external environmental factors that have an impact on the performance and activities of urban farming and agro-processing in Sobantu. The workshop participants were urban farmers from the Sobantu area who were either involved in cooperatives or who worked individually. Stakeholders from the government, including an Extension Officer who operates in the area, were also present. The workshop also included a production coordinator who works within the uMsunduzi Local Municipality, which provides smallholder farmers with production assistance and access to markets, including supermarket stores such as Boxer and Checksave. Moreover, a representative was present from Agri-seta, which is involved in assisting the farmers to access markets such as hospitals and schools, to become active participants in the economy and to contribute to the improvement of food security. The presence of the stakeholders was intended to bridge the communication gap between the farmers and the stakeholders, while providing solutions to the challenges that urban farmers are facing.

4.7 Challenges Identified by the PESTEL Analysis Tool

4.7.1 Politics

The local government is politically active and it is accessible in Sobantu. It provided a Gate-keeper's letter and makes the hall available each time the project and farmers need room for workshops and meetings. However, the farmers themselves are not organised to impact the market. Some are farming as families, which is effective, but there needs to be co-operation at a marketing level. The farmers nevertheless showed a good level of participation in this facilitation, as well as in the investigative part of the project. All the farmers reside within the same ward and have been governed by the same councillor for the past five years.

- The farmers claim that there are no political issues or disputes that affect urban farming; however, they do acknowledge that there may currently be political issues at play that they are not aware of.
- It was also mentioned that land invaders had once vandalised the farms that were allocated by the municipality, hence displacing several farmers.
- The farmers stated that no new changes affecting business growth, in any form, have been made by the current authority.
- In terms of the existing policies, the farmers stated that there are no implemented policies that hinder or prohibit the growth of urban farming.

4.7.2 Environment

Over 30 farmers who are engaged in farming showed interest in being part of the study. The data on the various crops they plant are presented in figure 4.5 below 4.2.

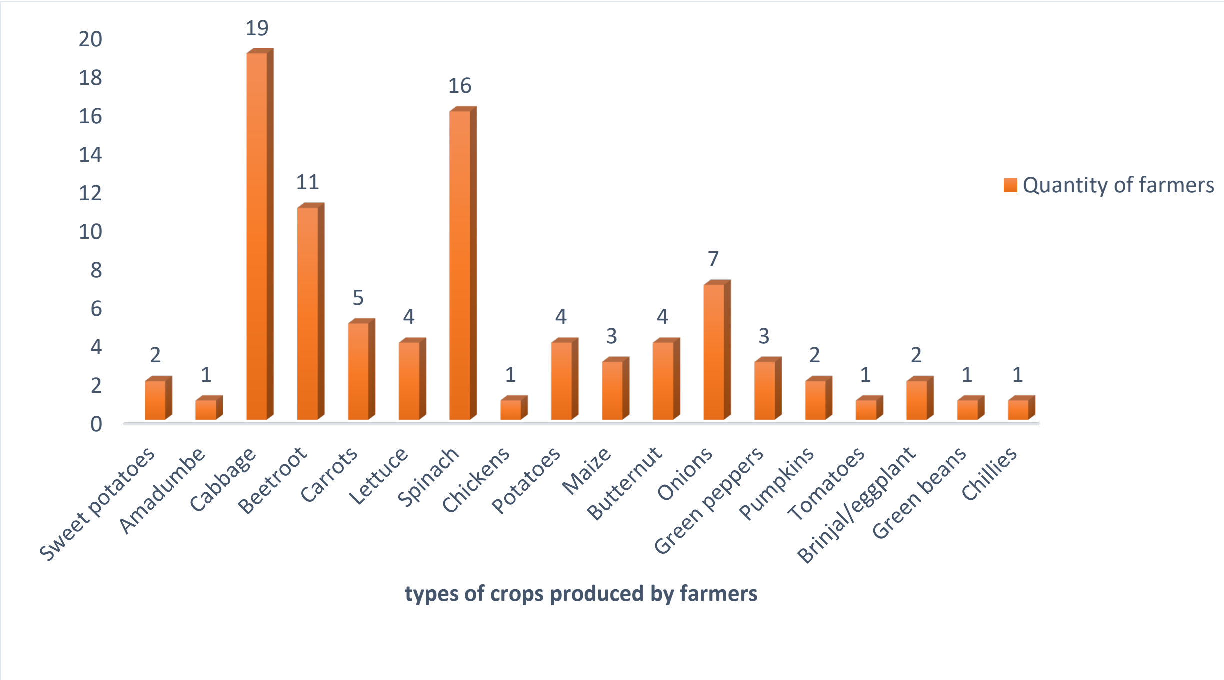


Figure 4.5: Illustration depicting the diversity of crops cultivated by farmers

- The farmers had made use of one of the river sources in Sobantu for irrigation; however, they were forced to stop utilising this particular source of water, as it was situated in close proximity to a waste drain. The farmers stated that the river showed visible signs of contamination although they are still awaiting water quality results from scientific tests that have been conducted on the river.
- The farmers said that their farming locations were viable for producing crops and that there have been no environmental conditions that hinder their productivity. However, they did mention how the heavy rains have made it difficult to plant other crops, as the crops would drown from the immense amount of water.
- The farmers alluded to the fact that the water they use for irrigation is often polluted by a sewage system that is located upstream, as the river is on the lower side of the topography. This affects the utilisation pillar of food security, which depends mainly on food safety and quality. It may disqualify the farmers from trading their produce on the market if no remedial action is conducted, as it is one of the markets' requirements for certification. According to the South African Good Agricultural Practice (SA-GAP), food produced with wastewater should only

have a certain number of contaminants in it before it can be sold on the market, and food irrigated with water that has been in contact with any excreta materials is prohibited.

4.7.3 Analysis of environmental and agricultural threats

A workshop was held at the Sobantu Community Hall on 31/05/2021 to obtain information from each individual farmer with which to compile a farmer data base. The collected data included the crop type, the area under cultivation (m/m^2), the planting and harvesting period, the expected quantity/production to be sold at the market, the target market, the farm-gate price, and the likely challenges expected/experienced during the production of each crop. The questions were administered to 20 farmers who availed themselves and worked either as individual farmers, in pairs or as co-operatives, with more than two members. A total number of 17 different food crops were identified to be produced and sold by the farmers. From the outset, it was clear that three crops (cabbages, spinach, and beetroot) were the most produced and sold to the target market, namely, the community members of Sobantu. The data accumulated in the workshop also revealed that there were several potential environmental and agricultural threats, with water quality issues and pests remaining a common challenge among the farmers. Agriculture is the most extensive and environmentally disruptive land-use practice, as it has the highest water usage capacity which is required for irrigation, and it contributes to environmental degradation, which results in soil and vegetation loss (Orsini, 2013). However, agricultural performance and activities are, in turn, threatened and influenced by external environmental factors.

The data sheet responses revealed that three out of the 20 farmers were currently facing water supply and quality issues. Several studies have reported that both the uMsunduzi and Baynespruit Rivers, which are a vital source of water for the farming community in Sobantu, are heavily polluted. For example, Neysmith and Dent (2010) and Ramburran (2014), have revealed that the poor water quality of the Baynespruit River is caused by illegal waste discharge from industrial institutions, a poor sewage infrastructure and the illegal dumping of waste by the members of the community who reside near the river. Furthermore, the Sobantu community is surrounded by several factories, as well as the New England Road landfill site, which has been considered an environmental and health concern in the past. This is an indication of the level of air, land and water pollution that the Sobantu community is subjected to, that threatens the quality of the produce that is cultivated by the farmers and that could possibly lead to a decline in their agricultural productivity.

The farmers also mentioned that the river was situated in close proximity to a waste drainage system, which has forced them to stop utilising the river as it was no longer safe to use for irrigation, although that some farmers still seem to be making use of it. The farmers had previously stated that the river showed visible signs of contamination, although they are still awaiting the water quality results from scientific tests that were conducted on the river. According to Becerra-Castro et al. (2015), polluted water has implications for environmental and agricultural productivity, as it elevates soil salinisation, which inhibits crop growth and reduces the crop quality and yields.

Out of the 20 farmers interviewed, 19 of them cultivated cabbages and 17 cultivated spinach, mostly a number of times per year and usually on the same dates each year, which is an indication that cabbage and spinach are a staple food crop in Sobantu. Furthermore, 12 of the farmers stated that the crops were to be sold to the community members, which indicates that competition exists within the market, and that there is pressure to produce more staple food crops of a high standard and quality. Spinach requires a substantial amount of water; however, considering the existing water issues in Sobantu, the competition for the already-polluted water sources is exacerbated by the increasing number of households, and as the rural-urban migration intensifies, this will put a lot more pressure on the water sources. This excessive abstraction of water from the river will not only result in the degradation of the water sources, but it will also pose the risk of resource depletion, ultimately threatening environmental and agricultural productivity, if appropriate management measures are not taken.

As people expand their households in peri-urban or urban communities, the rapid rural-urban migration into the uMsunduzi Municipal areas is likely to cause inappropriate development and land degradation. The farmers have expressed their concern over land invasion and vandalism on land that has been allocated to them by the municipality for agricultural purposes. This is likely to increase the chances of soil compaction, which will result in stormwater run-off. Ramburran (2014) stated that as the Sobantu community is located on a floodplain (the lower region of the Baynespruit River) it is likely to be susceptible to flooding. However, the fact that it is located on a floodplain also means that the area has a high agricultural potential.

The data also revealed that some farmers may be leaving their land plots bare, without any cultivation or vegetation cover, for lengthy periods of time. One farmer revealed that he has not cultivated any crops this year, while others have set a calendar to produce specific crops on specific dates, in order to supply the target market. However, the lack of crop cover encourages soil compaction and degradation, as soil is lost through wind and water erosion. The reduced water- and nutrient-holding capacity of soil will result in poor growing conditions for crops, which will lead to them being susceptible to pests. Furthermore, one farmer is currently cultivating only one crop type (spinach), which is an indication that the farmer may have adopted a monoculture cropping system, which is known to have a vast environmental and agricultural impact, including soil loss through wind and water erosion, as well as poor soil quality.

However, most of the farmers still adopt an intercropping farming system, by cultivating diverse food crops (see Figure 4.5) at different times of the year on different farm plots. This suggests that the farmers are aware of climate change and the changing of seasons and the benefits of cultivating certain crops during certain periods. This is highly beneficial, in terms of improving the soil fertility, and it prevents the occurrence of weeds and prohibits soil erosion by providing a persistent vegetation cover.

The persistent occurrence of pests on each of their cultivated crops was noted by the majority of the farmers, which suggests that there is a lack of pest control management and the lack of finances to purchase pesticides, which was confirmed by some of them. Previous findings have also revealed that some of the farmers lack access to information on the appropriate pesticides required for each of their cultivated food crops. The pests are damaging crops by leaving holes on their leaves, which changes their physical appearance, hence lowering the quality standards of the produce. The farmers will soon require the intense application of pesticides in order to maintain their productivity, but this often results in soil degradation and the exposure of the surrounding environment and groundwater to high levels of pesticides.

Despite the environmental threats surrounding the Sobantu community, most of the farmers claim that there are no water challenges, no pests or land issues prohibiting their agricultural and/or environmental productivity, and they also state that the crops that grow and reach maturity are still of good quality. Ramburran (2014) mentioned that the soils in the Sobantu community have high agricultural potential, considering its location on the floodplain. Furthermore, the urban farmers in Sobantu contribute to the sustainability of urban farming and the reduction of greenhouse gas emissions, as they are located in close proximity to their markets and sell their produce directly from their farms, which allows for fresh produce to be transported and/or sold with the limited use of energy, which has less of a negative impact on the environment.

4.7.4 Social

Socio-cultural issues are related to the shared beliefs and attitudes of a population, which reflect its national identity; these are linked to its attributes, such as population growth, age distribution, health consciousness, and career attitudes (Abbas et al., 2020). Social issues, such as the general attitude to having a career, influence the degree to which a society considers urban agriculture and entrepreneurship to be a career option that they can do well at. This determines whether society at large supports the idea of urban agriculture and entrepreneurship (Grebitus et al., 2017; Granzow and Jones, 2020). An overview of the socio-cultural attitude of the farmers in the study area can be found below:

- The farmers mentioned that their consistency in producing food crops, such as spinach and cabbages, which are clearly considered to be staple food crops in Sobantu, motivates the community members to purchase from them.
- The lack of fencing has resulted in a common problem of crop theft. However, the farmers admitted that there is only a certain degree of crime here.
- Covid-19 put a stop to crop production training programmes that were implemented in Sobantu specifically for the youth.
- The fact that crop theft is a common issue faced by the farmers indicates that there is a lack of purchasing power, and hence unemployment, which is ultimately affecting the progress of urban farming.
- Furthermore, the farmers expressed that unemployed community members, especially the youth, do not understand how farming can be turned into a business for income-generation.
- The farmers also stated that the lack of interest in urban farming by the youth has hindered the ageing and retiring urban farmers from passing on their knowledge and skills, which is threatening the growth and sustainability of urban farming.
- One farmer mentioned that her produce is only for subsistence purposes and is not utilised as a source of income. This is an indication that some of the farmers feel compelled to provide food for their households, rather than selling it and generating an income. This is a threat to the growth and sustainability of urban farming and it also perpetuates the perception that urban farming cannot be turned into a business, or become an income source.

4.7.5 Technology

The development of technology is driven by an increasing demand for alternative energy and for it to be integrated into the needs of the market (Harrell, 2016). This indirectly favours government support, which encourages innovation initiatives and technological change (Dockaliva and Kashi, 2014). The Sobantu farmers are engaging a basic, conventional, external-input production system, which may not be the most appropriate system, given that their resources are limited. A regenerative production system, based more on an agro-ecological system, would be most suitable as it relies less on external physically purchased inputs, such as fertilisers. Innovations in marketing and accessing consumers is an urgent need in Sobantu. Information on the type of produce and produce scheduling, as informed by market intelligence, is urgently required in Sobantu in order to align the farmers with the markets. Farmers have explained that "if we knew what the market wanted, some of us would plan to use the whole area that is available to us. At present we are afraid our efforts will be futile and the produce could rot in the field, instead of going to the markets, as in the past."

- The majority of the farmers do not own smartphones and any electronic devices that use the Internet.
- Despite some farmers having cell phones with Internet, they are still unable to access information, particularly on the markets, as the elderly are often not technologically up-to-date. This is where the youth should assist, but there were only two young members in attendance, which is a clear indication of the widening gap between the youth and farming, and the uncertain future for urban farming in Sobantu.

4.7.6 Economy

The performance of the economy, such as the rate of inflation, has a direct impact on the purchasing power, the supply power and also the attractiveness of a country's direct foreign investment (Rastogi and Trivedi, 2016), and the number of unemployed people can also affect the economic performance of a country (Koumparoulis, 2013). For instance, lower interest rates would enhance the ability of small, micro and medium enterprises (SMME) to invest, as the cost of capital would generally be lower and more affordable, while higher interest rates will reduce the propensity to invest and generally increase the prospects of failure because there is an inadequate working capital to enhance a business. The South African Rand is the national currency in South Africa.

- The farmers use their own funds from social grants to finance their farming inputs, such as seedlings. Furthermore, the farmers mentioned that they do not make sufficient profit after the market commission is deducted by the market agents; therefore, they are usually unable to create jobs, as they do not have the capital for it.
- No micro-finance institutions are working with the farmers.
- The farmers stated that the market agents usually deduct a higher percentage of market commission than was initially agreed upon. This has evoked feelings of discouragement among the farmers, as they feel that they are being underpaid (with no profit) for their own produce.

4.7.7 Legal

The factors related to the legal environment in which companies operate are labour law, competition law and consumer rights (Yuksel, 2012). It is important to consider these legal factors, especially if there are changes in the coverage and depth of the law (Francisca and Lantu, 2014).

- The farmers stated that they are often required to provide certification (i.e. SA-GAP certification) to ensure that the food safety and quality standards that are set by the markets are met. The farmers stated that they are unable to get this certification, which has created a barrier for them and their ability to trade freely in the markets. This often results in the farmers' produce (no matter the quantity they provide) being sold at low prices, with little to no profits made.

Some of the existing challenges that were identified by the urban farming community of Sobantu were the lack of transportation (which is exacerbated by their inability to afford transportation costs), the lack of information-sharing and the lack of unity amongst the urban farmers. Some of the issues mentioned, such as the lack of transportation, should never have occurred, as the stakeholders from Agri-seta mentioned that part of their programme was to provide the farmers with trucks to transport their produce, which was to be free-of-charge. This indicates a lack of communication between the farmers and the stakeholders where links to information should have been easily provided and shared. Some of the farmers also mentioned struggling to get rid of pests, which is a further indication of the lack of communication with, and support from, the appointed Extension Officer. However, considering all the challenges discussed in the workshop, it was made clear that the main problem that should be treated as a matter of urgency, is the lack of market access.

4.8 PESTEL and Entrepreneurial Opportunities and Risks for Farmers in Sobantu

Several opportunities are available to farmers in the Sobantu area, particularly in entrepreneurship, as they are a closely-knit community. If they decide to sell their produce at the traditional markets, they save on their transaction costs. The informal markets and the online platform for selling produce bring about a reduction in production costs for the farmers. However, all the farmers sell almost the same products, grown on relatively small plots, which makes it challenging to generate greater profits and difficult to acquire more buyers who want rather large quantities. Their production method makes them prone to becoming 'price-takers' in the market.

According to the data collected from the farmers in Sobantu, they all produce almost the same products, i.e. cabbages, potatoes, spinach, carrots, green peppers, beetroot and pumpkins. They run the risk of having their produce spoiling in the garden (or farm), as the overproduction of such commodities in the market results in a surplus. According to the economic theory of supply and demand, a surplus in the market means the price must drop to the level of a new equilibrium, to account for the price that the consumer is willing to pay for the commodity and the price at which the producer is ready to produce, without making a loss. The production trends of the farmers show that they do not time their production according to the seasons, i.e. when there is a shortage in the market and they could generate a high-income during the harvest season. The way to achieve this would be for farmers to conduct market research by observing the trends of products in the market; they could then use this information to time the planting/harvesting period to ensure that they maximise their sales when there are shortages in the market.

Having contractual agreements between the producer and the buyer will also allow the farmers to ensure that their product has a buyer at the end of the harvesting season. The existence of contracts, such as Future and Forwards contracts, will be highly beneficial to smallholder farmers (SHFs), as they have primarily diversified their crops. Challenges in improving the status quo and the risk of unforeseen changes, for instance, regarding important policies, the political framework and internal security, require careful risk management on the part of farmers. One way of mitigating the risks that a smallholder farmer faces is through diversification. Agribusiness firms also need to look for local strategies that could help to reduce their exposure to risks; such strategies include collective action with other farmers, who have a better understanding of the local PESTEL situation, who know how to interact with local authorities and who contribute to a dense social network (Mhlanga, 2010). Bodie et al. (2012) explained how collective action is helpful for portfolio diversification, as producing only one or two crop types causes the farmer's wealth to be tied up in a highly volatile crop. For example, farmers that are part of the Sobantu Agricultural Co-operation have a verbal contractual agreement with Umgibe Farming Organics and Training Institute, which provides them with a market that purchases their produce, i.e. carrots, butternuts, beetroots and cabbages. Another suggestion would be to have agreements and contracts with neighbouring schools, hospitals, firms and other informal markets (e.g. Spaza shops) to buy their farm products. One farmer stated that they sometimes supply neighbouring firms, while another said he provides the school kitchen and sometimes the hospital (Northdale Hospital). If transactions are done regularly, based on a contractual agreement between the farmers (the producers) and the entities (the buyers of their commodities), it would ensure that there is a continued supply of good nutrition to the community and an increase in their household income.

Farmers in Sobantu reported that they rarely have access to the Extension Officer's services, which would help to mitigate the unknown risks, for example, the prices, weather, labour, diseases, and pests that require several strategies for risk management, as they can never be fully protected from risk. The Extension Officers have access to information that farmers who are not technologically adept, do not necessarily have. Information on prices, for example, is one of the leading determinants for how much profit the farmer makes. The Sobantu farmers are mostly prices-takers, as there are a limited number of buyers for their products. For example, some normally sell their spinach for R10/bunch, but they will reduce their price if the buyer says they have less money, all for the sake of making a sale on that particular day. This has resulted in farmers' settling for a price that is not always proportionate to their investment (both monetary and physical) as the buyer, in this instance, has the power to bargain for a price below the market range. The farmers also revealed that they struggle to get inputs, as the suppliers are the price-makers, thus presenting challenges for those farms with pests due to the high price of pesticides. Furthermore, there is an apparent lack of information on effective agro-ecological practices that may require limited or no inputs.

There are also financial risks, as farmers cannot access the appropriate financial institutions and have to use their pension grants to buy inputs, such as seedlings, fertiliser, pesticides, etc., which results in less money for the household. Even though government entities offer some financial assistance in the form of vouchers for the purchase of inputs, these limit the farmers' bargaining power as they are given a list of suppliers from which they can buy their inputs. This makes the farmers susceptible to household food insecurity, as funds that should be directed towards purchasing food for the household are now used to buy inputs. They do, however, have an opportunity to create their own financial institutions; the farmers have started a *Stokvel* account within their community, from which they can draw funds to buy inputs, without offsetting their pensions. Another method of financing their businesses would be to reinvest 25% of the income that they generate from the sale of their produce.

4.9 Summary

This report was based on the stakeholder workshop, with the aim of establishing a PESTEL environment for urban farming and agro-processing in Sobantu, Pietermaritzburg. A participatory approach was employed to collect the qualitative data, which was the overarching process guiding this research, in which the assessment and facilitation of the stakeholders was conducted. The specific analytical framework and tool that was used to characterise the stakeholder resources was the PESTEL method for understanding macro-factors that influence water availability, access, utilisation (safety and quality) and stability of supply. Workshop discussions were conducted with various stakeholders for understanding the key issues, and these were supported by expert interviews with relevant key role players, particularly market-related stakeholders. The data that were collected by using the PESTEL model were supplemented by a Porter's Five Forces Analysis of the Market in Agriculture. The PESTEL model has provided a pathway for this study to evaluate an environment that impacts the water quality, water access, urban farming and role of entrepreneurship to help the market participation of farmers in Sobantu, as well as in similar localities in South Africa. The strategy was formulated by keeping in mind the various socio-cultural and political factors in the country. The main aim of this report was to identify the PESTEL-related barriers in urban farming and, together with the stakeholders and the farmers, to resolve them so that the farmers can participate sustainably in the appropriate mainstream and niche markets.

The results of the PESTEL model have revealed some of the following challenges faced by the Sobantu farmers. From a political perspective, the local government is active in Sobantu and it is accessible. In terms of the existing policies, the farmers stated that they are not aware of implemented policies that hinder or prohibit the growth of urban farming, despite the fact that the uMsunduzi Municipality does not have an urban farming policy. However, a development agency at a district level (UMEDA) locates agriculture, including urban agriculture, in the mix of its economic growth strategies. Furthermore, the farmers themselves are not organised enough to impact the market, as most of them are farming as small families, which seems effective from a primary production perspective, but there is a need for co-operation at a marketing level. In the same vein, from an environmental point of view, it was observed that land invaders had once vandalised the farms allocated by the municipality to several farmers, hence displacing them. The farmers had also made use of one of the river sources in Sobantu for irrigation; however, they were forced to stop utilising this source of water as it flows in close proximity to a waste drainage system. It was also observed that the river showed visible signs of contamination, although they are still awaiting water quality results from scientific tests that were conducted on the river.

The farmers said that their farming location was viable for producing crops and that there have been no environmental conditions that hinder their productivity. However, they mentioned that heavy rains have made it difficult to plant other crops, as the crops have drowned from the large amount of water. The farmers alluded to the fact that the water they use for irrigation is polluted by the upstream sewage system. As the river is on the lower side of this sewage system, it affects the utilisation pillar of food security, which depends mainly on food safety and quality, and it automatically eliminates these farmers from trading their produce in the marketplace, since one of the requirements of the market is that they need certification. According to the South African Good Agricultural Practice (SA-GAP), food produced with wastewater should have a certain contaminant limit before it can be sold at a market, and food that is irrigated with water that has been in contact with any excreta material is prohibited.

In order to analyse the environmental and agricultural potential and threats of urban farming and agro-processing in the study area, a workshop was held at the Sobantu Community Hall. This workshop was conducted to obtain information from each individual farmer, in order to compile a farmer database. The information included the crop type, the area under cultivation (m/m^2), the planting and harvesting period, the expected quantity/production to be sold at the market, the target market, the farm-gate price and the likely challenges expected/experienced during the production of each crop. The result showed that a total of 17 different food crops were produced and sold by the farmers, with three crops (cabbages, spinach and beetroot) being predominantly produced and sold to the target market, namely, the community members of Sobantu.

The findings of the stakeholder analysis also revealed several potential environmental and agricultural threats, with water quality issues and pests being the most common challenges among the farmers. Agriculture is considered to be the most extensive and environmentally disruptive land-use practice, with the highest water usage capacity required for irrigation, which contributes to environmental degradation and results in soil and vegetation loss. However, the agricultural performance and activities are also threatened and influenced by external environmental factors. Rapid rural-urban migration into the uMsunduzi Municipal area is likely to cause inappropriate development and land degradation, as people expand their households in the peri-urban or urban communities. The farmers mentioned the occurrence of land invasion and vandalism on land that was allocated to them by the municipality for agricultural purposes.

It is commendable that a country like the Maldives, which is described in its constitution as a "sovereign, independent, democratic state", has introduced positive policy reforms and initiatives for developing the Maldives Agricultural Sector. However, it has been noted that there are still threats that impede the achievement of these goals. The results of PESTEL show that the legal and regulatory framework in relation to food security, water security and urban farming vis-à-vis agri-preneurship products need to be strengthened further, in order to give a chance to local agricultural communities to fully utilise and benefit from the policy initiatives taken by the government. The regulatory bodies need to strengthen the links between the farmers and consumer markets to ensure sustainable local food production and, at the same time, to reduce the dependency on food imports.

In addition, the data showed that some farmers may be leaving their land bare without cultivation of vegetation cover for lengthy periods of time for various reasons. Other farmers heeded extension advice and their own knowledge by setting a calendar to produce specific crops on specific dates, in order to supply a target market. For fallow land with no crop cover, soil compaction and soil degradation through wind and water erosion were common. On the other hand, most, farmers still adopted an intercropping farming system including a variety of crops and planting at different times while also using various plots. This practice indicates that farmers were aware of climate change of the seasons and the benefits of crop rotating and times of planting.

Education, knowledge, training, and skills are the foundation of any sector. The analysis shows that the lack of development in this area is adversely affecting the way farming practices are carried out which, in turn, affects the productivity of farming as well as future agricultural business practices. It shows the necessity of incorporating appropriate training, extension services or affordable consulting services and making them available to all the farmers throughout the year. Teaching farming practices, market practices and the management of small agriculture business enterprises would greatly reduce the problems that farmers face. There is a need for a farmers' network to bring the farmers from all over Sobantu onto a platform where they can stay connected, contribute to the development of the sector, and collaborate in order to improve their livelihoods and have a greater impact. This report was followed by a detailed survey and in-depth focus groups to collect data on the PESTEL variables and other aspects of the markets, food security, water access and safety and agro-processing.

CHAPTER 5: A DESCRIPTION OF THE FARMING SYSTEMS, STAKEHOLDERS AND WATER QUALITY AND THE MICROBIAL BURDEN OF IRRIGATION WATER IN THE STUDY AREAS

5.1 Introduction and Contextualisation

The COVID-19 lockdown, among other pressures, has directed more attention to the growing of food in urban areas, as well as in the townships. Prior to the lockdown, there was evidence that urbanisation resulted in an increase in the peri-urban population in South Africa (Statistics SA, 2017a). Many citizens have turned to urban agriculture to obtain a basic livelihood in the form of cash crops, and they have become subsistence farmers (Thamaga-Chitja and Hendricks, 2008; Baiphethi and Jacobs, 2009; Mdluli et al., 2014). However, the practice of agriculture for home consumption and surplus requires large amounts of water (Freres et al., 2011). Considering how South Africa is frequently faced with droughts and that it has already scarce water resources, accessible surface water of poor quality (i.e. river water) is now being used for irrigation (Gemmell and Schmidt, 2012; Schreiner et al., 2018). Effluent from industrial plants has previously been associated with the poor quality of river water in South Africa (Edokpayi et al., 2017; Madikizela and Chimuka, 2017). In addition, sewage spills from wastewater treatment plants, due to their inadequate infrastructure and capacity, have also been shown to increase the microbial burden of the nearby receiving rivers (Taing et al., 2019). The recent cholera outbreak in Hammanskraal in South Africa highlighted the substantial health risks associated with declining water quality and failing water treatment infrastructure. Coupled with the fact that smallholder farmers tend to rely on overhead irrigation, microbial pathogens can be introduced directly onto the surface of fresh produce (Pachepsky et al., 2011; Mdluli et al., 2013; European Union, 2017), which increases the risk of food-borne illnesses that might result in infections and the possible death of susceptible YOPI citizens such as young children (0-14 years) by enteric pathogens, such as *Salmonella* spp.

In South Africa, the second most common reason for death of children age 1-14 is infectious intestinal illnesses (Statistics SA, 2021). Along with children, the elderly, pregnant, and immuno-compromised community members are typically more susceptible to food-borne illnesses. Many recent food-borne pathogen outbreaks have been associated with fresh leafy vegetables that are consumed raw, such as lettuce and spinach, and in many cases, irrigation water has been regarded, or even identified, as a possible origin of the contamination present on the fresh produce (Uyttendaele et al., 2015; IFSAC, 2022). Water quality is typically assessed targeting appropriate hygiene indicator organisms such as *Escherichia coli* (Uprety et al., 2020) while the quantification of heterotrophic bacteria is a way of determining the general microbial burden of water (Bartram et al., 2003). Therefore, selected water quality parameters were monitored to assess the microbial quality of irrigation water associated with smallholder farming in Sobantu, Pietermaritzburg, KwaZulu-Natal.

5.2 Description of the Water Quality Assessment and Stakeholder Assessment

Table 5.1, below, provides an overview of the involvement of the various stakeholders with regard to water quality and its impact on the Sobantu urban farmers and community.

Table 5.1 Stakeholder assessment for water quality, water access, urban farming and entrepreneurship roles

Stakeholder	Role
Department of Agriculture	**-Water Quality** The Department of Agriculture does not check the water quality. Farmers can do this if they are in partnership with a research project. -**Water Access** None identified at present. Farmers access river water or municipality water -**Urban Farming Policy and Programme** The Department of Agriculture has an Extension Officer who is responsible for the facilitation of knowledge, information, etc. to advance farming in Sobantu. The Department of Agriculture facilitated contact with the Local Government Secretariat in Sobantu. This facilitated a participatory workshop where the project team was present to identify the organisational/institutional, social, technical and financial issues, as well as the processes and activities necessary to investigate urban agriculture. This is being used to guide further engagement. This project first engaged the Department of Agriculture's extension services to partner with, and to access, Sobantu. -**Urban farming entrepreneurship** A workshop was held in the Sobantu Village Hall. Approximately half of the participants were female members from the local community. Twelve people were members of the Sobantu Agricultural Co-operative, which is the implementing group and main beneficiary of the urban farming project being developed. Community organisations concerned with childcare and the environment were also represented. The workshop was conducted in both the Zulu and English languages, and it emphasised the need for fluency in Zulu by those that would be directly involved in the project What capacity-building interventions exist? Training and assistance with implements. -**What agro-processing training support exists?** None

Stakeholder	Role
Local Government/ Municipality	**-Water quality** The uMsunduzi Municipality checks the water quality of the rivers. Water samples are taken to identify any possible spillage from factories and to see if the water is safe to use for agricultural purposes or human activities. **-Water access** The municipality provides tap water to the households. There are also strict rules that restrict the dumping of waste into the rivers and residents are also not allowed to build too close to the riverbeds. **-Urban farming policy and programme** None **-Urban farming entrepreneurship** None **-What agro-processing training support exists?** None
Department of Social Development	**-Water quality** The department does not check water quality. **-Water access** None **-Urban farming policy and programme** None **-Urban farming entrepreneurship** None. Various community members receives social grants. Are some being used for inputs in agriculture? **-What agro-processing training support exists?** None
Department of Health	**-Water quality** The department does not check for water quality. **-Water access** None **-Urban farming policy and programme** In Sobantu, the Department of Health implements programmes to improve nutrition and to screen for cancer. Farmers are community members; a knowledge of the theory of health is important. Nutrition security for farmers through consumption. **-Urban farming entrepreneurship** None **-What agro-processing training support exists?** None

Stakeholder	Role
Duzi-uMngeni Conservation Trust (DUCT)	-**Water quality** DUCT checks the water quality and ensures that the rivers are healthy. They also help in the removal of some of the 'artificial' barriers, such as the lack of the enforcement of threats or satisfaction with the status quo, holding other stakeholders back (particularly those in industry, but also in regulatory agencies and parastatals) and preventing what would otherwise be powerful incentives to reduce pollution from being effective. -**Water access** Water is always released from the Henley Dam for the canoe races in Pietermaritzburg. -**Urban farming policy and programme** None. However, ensuring water quality contributes to water safety this water is also used for agriculture. -**Urban farming entrepreneurship** None -**What agro-processing training support exists?** None
Umgeni water	**Water quality** Umgeni water regularly checks the water quality of local rivers.
Farmers	**Water quality** Through local knowledge, farmers check the water quality by using the 'naked eye'. They look at the colour of the water and if fish are in the water. -**Water access** Farmers access water from the tap and for irrigating their crops, they access water from the river. Farmers can use as much river water as required but they must not pollute the river. -**Urban farming policy and programme** None -**Urban farming entrepreneurship** None -**What agro-processing training support exists?** None

In the past, the Department of Agriculture has facilitated a participatory workshop to identify the organisational, institutional, social, technical and financial issues and the processes and activities that are necessary for initiating an urban agriculture project. By focusing on the economic benefits of urban agriculture, the main body of previous studies has overlooked the complex way in which urban agriculture empowers economically marginalised people (Gallaher, 2017; Oliver, 2019).

Some case studies have paradoxically revealed that urban agriculture is empowering, and others argue that it only makes the rich richer However, entrepreneurial capability and capacity needs attention as it is often not considered well by NGOs (Oliver, 2019). The objective of the project was to improve the lives of the community by creating employment, improving the nutrition levels, and increasing the participation of women in income-generating activities. A wide range of established and novel workshop techniques were used to draw on the knowledge and analytical potential of the participants and to generate both ownership and self-belief in their ability to confront problems, reducing reliance on external assistance. Additionally, capacity-building training was offered on how to utilise various tools and implements.

As reflected in the findings, enhancing the capacity of people to manage change by developing their cognitive ability to learn, to improve problem situations and to communicate effectively is premised on the idea of system-thinking agriculture. System agriculture draws on the concept of experiential learning and on system-thinking and practice, scientific methods that encourage intuitive and creative activity, as well as logical, systematic thinking. The complex interaction between the stakeholders requires a system-thinking approach. In Sobantu, many residents depend directly on the water harvested from these often highly polluted streams and rivers for drinking, cooking and irrigation. The water has the potential to directly impact on lives, and on occasions, may result in negative health implications. Thus, there is an urgent need for researchers to attend to these problems, and it is imperative to reorient agricultural research programmes from using an individualistic enterprise approach to using a holistic approach in the agricultural system.

According to the uMsunduzi Integrated Development Plan (IDP, 2018/19), agriculture provides 3% of the GDP of the municipality. However, subsistence and smallholder farmers in many surrounding Municipalities within the uMgungundlovu Municipality supply their produce directly to the markets. In Sobantu, the uMsunduzi Municipality supplies free tap water to the community and oversees the quality of local river water. This quality monitoring is conducted both by Umgeni Water and the Municipal Environmental Health Section. Almost without exception, this monitoring indicates the poor and continuously declining water quality, with important resources being classified as being unsuitable for human consumption without treatment, and, to a large extent, unsuitable for recreational use. Numerous residents rely on water from polluted sources for various purposes, impacting their daily lives and sometimes leading to severe health problems. However, the local municipality has not yet provided support for the smallholder urban farmers in order to enhance their urban farming entrepreneurship and agro-processing activities. The Department of

Social Development (DSD) has been involved with social issues in the community of Sobantu, some of which include HIV and Aids, crime, unemployment, and Gender-Based Violence (GBV).

The Department of Health (DoH), in collaboration with the Health Sciences Faculty of UKZN, is working alongside the clinics in the community to provide an awareness of cancer in the area. This is also likely to be useful, since the dumpsite, which is less than a kilometre away from the community, is likely to affect not just the health of the people but also their market access, as consumers may not want to purchase produce that they regard as being unsafe, particularly if the Sobantu groups try to enter the farmers' markets. In the past, the DoH has implemented programmes to raise awareness of nutrition within the community.

The DUCT has been responsible for raising the awareness of the community and schools on the health of the river by means of engagement events and research case studies. DUCT has also been actively involved in the maintenance of sewage and gutters in the Sobantu area. The farmers in the community of Sobantu are smallholders and have difficulty securing markets to sell their produce. Production inputs, such as seeds and water, are available to them, but the main constraint that they face is accessing the markets. Some of the farmers have been trained in the production aspects of urban farming; however, they have received little to no support on urban farming entrepreneurship and agro-processing.

5.3 Methodology and Description of the Study Area

The following section will describe the methods used for data collection and analysis in the study area.

5.3.1 Study area description

The study area is the Sobantu township, which is located on the outskirts of Pietermaritzburg in the Province of KwaZulu-Natal. Most employed people in this township earn an income at the nearby factories. Topographically, Sobantu is a comparatively flat area; it is well-drained and surrounded by the uMsunduzi and Baynespruit Rivers. Both rivers are used as a source of irrigation for smallholder agriculture and the river water is also used for various other human activities, such as bathing and fishing. Neysmith (2008) reported that the Sobantu township is located on a floodplain, which limits further housing developments. However, it has been found that the area has high agricultural potential, based on the excellent fertility of the soils located on the 50-year flood-line. Current agricultural activities include several community gardens and individual small production units (Cebekhulu, 2016). The Sobantu community is comprised of formal and informal residential areas and is located toward the lower reaches of the Baynespruit River. The community members have shown great interest in using the floodplains for urban agriculture, and their interest in the initiatives to develop the potential of the floodplains for agricultural purposes has increased (Govender, 2016). The study area is depicted in Figure 5.1 below.

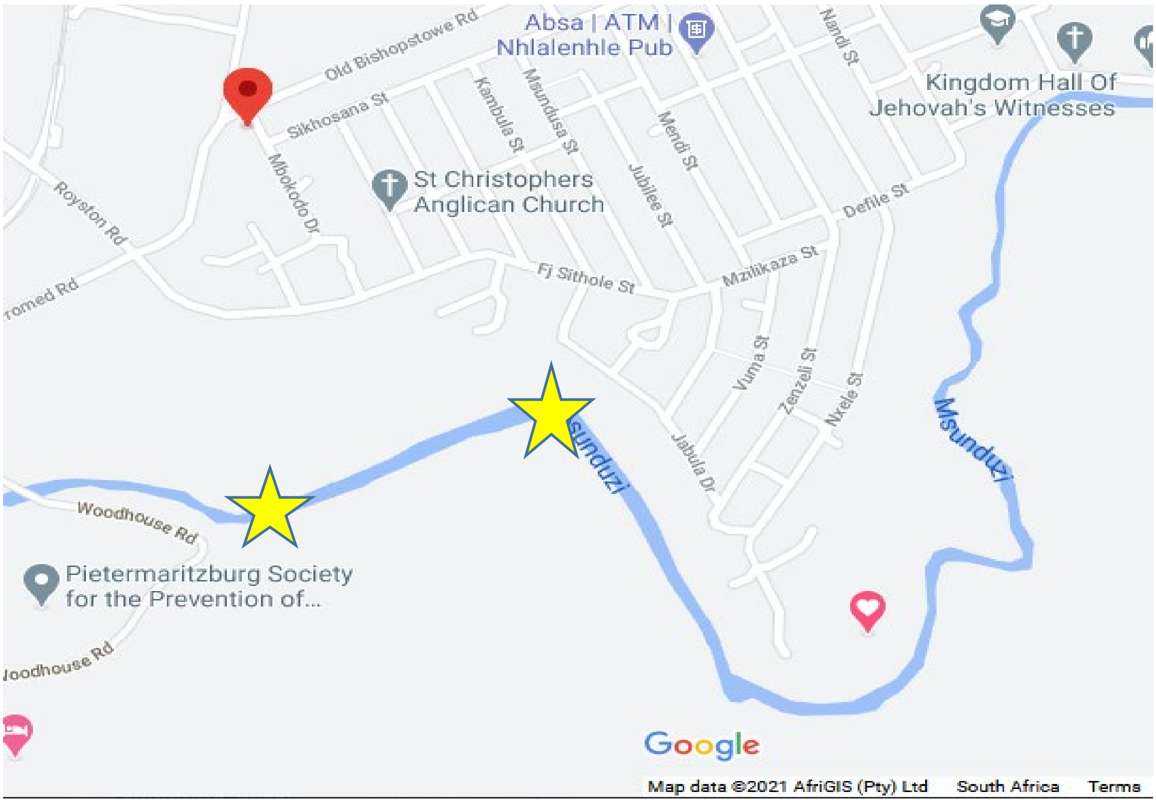


Figure 5.1: Location of Sobantu in Pietermaritzburg. The sampling sites are indicated on the map by yellow stars

5.3.2 Materials and methods for water quality and fresh produce assessment

The GPS coordinates of -29.603905, 30.422966 and -29.597923, 30.415895 depict the Sobantu township study area in Pietermaritzburg, KwaZulu-Natal. River water samples were collected directly from the uMsunduzi River and from the water tanks that store river water in the fields prior to use. In addition, tap water samples were collected from a hosepipe on one of the smallholder farmer's plots, as well as soil samples and fresh produce (Figure 5.2).

Figure 5.2: The locations where the samples were collected for subsequent analysis.

A. Open water tank on the farmer's plot

B. Tap water (e.g. hosepipe) sampling location

C. Soil-sampling location

D. uMsunduzi River water-sampling site

Water samples were generally collected between 8:00 am and 11:00 am, using sterile 500 ml Schott bottles. The river water samples were collected at a fast-flowing point of the river, slightly below the surface of the water. In the case of the tap water collected from a hosepipe, 0.1 ml of $Na_2S_2O_3$ x 5 H_2O (18 mg/ml) was added per 100 ml of the sample volume, prior to autoclaving the sampling bottles, to neutralise the free chlorine (Murray et al., 2018). The soil samples were collected in a sterile jar from a depth of about 15 cm below the soil surface. The samples were transported on ice, and a laboratory analysis was carried out within two hours. Water samples were used directly, or diluted tenfold by aseptically pipetting 1 ml of sample into 9 ml of sterile peptone water (1 g peptone and 8.5 g of NaCl per 1 L of distilled water, pH 7.0), typically up to a decimal dilution of 10^{-6}, using the same diluent. 10 g of the soil sample was added to a sterile Erlenmeyer flask containing 90 ml of sterile peptone water. The flask was gently shaken for a maximum of 10 minutes at an ambient temperature prior to preparing decimal dilutions, typically up to 10^{-6}.

Fresh produce samples of not less than 50 g were aseptically collected into sterile plastic bags. Samples were collected from more than three plants to ensure a representative sample. Thereafter, the samples were transported on ice to the laboratory and analysed within two hours.

The temperature of the water samples was measured in the field using a waterproof pocket pH tester (Hanna Instruments, HI98108, Italy). The Chemical Oxygen Demand (COD) was determined by using the Merck NOVA 60 system (Germany) and a Merck COD test kit (25-1500 mg/L, Merck, Germany) according to the manufacturer's instructions. Temperature data were obtained from Accuweather (2021) and rainfall data were obtained from Weather SA(2021)).

Aerobic plate counts were done to determine the total number of viable heterotrophs in the water, produce and soil samples, and these were carried out by using Plate Count agar (PCA) (Oxoid) with 100 µl samples obtained from decimal dilutions spread-plated in duplicate, according to SANS 4823 (SANS, 2007). The enumeration of total and faecal coliforms and *E. coli* from the irrigation water (e.g. river, tap and tank), fresh produce and soil was carried out by using the MFHBP-19 procedure (Health Canada, 2002), as previously described (Mdluli et al., 2013; Beharielal et al., 2018). The fresh produce was cut aseptically into smaller portions, using sterilised scissors, not exceeding 1-2 cm for leafy produce samples. An amount of 25 g of each produce sample was transferred aseptically into 225 ml of sterile buffered peptone water. The flasks were resealed and shaken gently for 10 min at an ambient temperature, prior to establishing the decimal dilutions, using the same diluent (typically up to 10^{-6}). An initial presumptive test using Lauryl Sulphate Tryptose broth (LST) (Merck) was followed by confirmatory testing for total coliforms using Brilliant Green Lactose Bile broth (BGLB) (Oxoid), and the quantification of faecal coliforms was done by using EC broth (Oxoid). Confirmation of presumptive *E. coli* isolates was carried out by using Eosin Methylene Blue (EMB) and Tryptone Bile X-glucuronide Agar (TBX) (Oxoid) plates as well as the GIMViC procedure and PCR targeting gadA as reported previously (Gemmell and Schmidt, 2013, Beharielal et al., 2018). The MPN results are expressed as MPN per 100 ml or MPN per gram and were established according to de Man (1983).

The detection of *Salmonella* spp. in the irrigation water, soil and fresh produce samples was carried out by using the ISO 6579 procedure (2002). Sterile buffered peptone water (Oxoid) was incubated at 37°C for 24 hours as a pre-enrichment, followed by selective enrichment in the Mueller-Kaufmann Tetrathionate-novobiocin broth (Oxoid) and Rappaport Vassiliadis Soy broth (Oxoid), and lastly, by plating-out the samples on Xylose Lysine Desoxycholate (XLD) (Oxoid) and Brilliant Green agar (BGA) (Oxoid). The results were expressed as the presence/absence of *Salmonella* spp. in 25 g or 25 ml for each respective sample. Additional confirmation of *Salmonella* spp. isolates was carried out by using Rambach chromogenic agar (Sigma), while the prescribed biochemical testing according to ISO 6579 and the confirmatory PCR (using the established invA primers) were also carried out.

The detection of *Enterococcus* spp. in the irrigation water, soil and fresh produce samples was carried out by using the ISO 7899-2 procedure (2002). Thus, 10 g of the soil sample was suspended in 90 ml sterile Buffered Peptone Water (BPW) at an ambient temperature for a maximum of 10 minutes to perform the quantification of intestinal enterococci. The 25 g of the fresh produce sample was suspended in 225 ml sterile BPW at an ambient temperature for a maximum of 10 minutes. 100 µl of decimal dilutions of the soil and fresh produce sample were spread-plated onto Slanetz and Bartley agar (SB, Merck), and the individual colonies were transferred onto the Bile Esculin Azide agar (BEA, Oxoid) for confirmation. The membrane filtration method was used for the water samples, where 100 ml of the irrigation water samples (or decimal dilutions thereof) were filtered through a sterile 0.45 µm membrane filter. After that, the membrane filters were initially transferred onto SB agar and subsequently onto BEA agar (Oxoid), to confirm colonies formed on SB agar as intestinal enterococci. Representative, confirmed *E. coli* isolates were subjected to antimicrobial susceptibility testing (AST) according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST, 2021) disk diffusion method using Mueller-Hinton agar (Oxoid) and ready to use antibiotic susceptibility test disks (Oxoid), as reported previously (Beharielal et al., 2018). *Escherichia coli* ATCC 25922 was used as quality control. *E. coli* isolates selected for AST were grown on nutrient agar overnight at 37±1°C. Tubes containing sterile 0.85% saline were inoculated with the isolates to obtain a density of 0.5 McFarland standard. Sterile cotton swabs were used to inoculate and evenly spread the inocula on the surface of Mueller-Hinton agar (MH) (Oxoid). Four antibiotic disks were aseptically placed onto the agar plate using forceps within 15 minutes of inoculation. Plates were inverted and incubated aerobically at 35±1°C for 18±2 hours. The zone of inhibition was measured using a digital Vernier calliper to the nearest mm, recorded and interpreted according to the EUCAST breakpoint tables (v12) (EUCAST, 2022).

5.4 Results

This project was concerned with the water quality, water access, urban farming and agro-processing, as well as the potential impact of water quality on the entrepreneurial risk in urban farming and food security. The deliverable provided valuable baseline information on the irrigation water quality, which affects the entrepreneurial risk of urban farming.

5.4.1 Physico-chemical parameters

A basic physico-chemical analysis of the samples collected in the Sobantu township was carried out. According to DWAF, the acceptable pH of water used for irrigation should be within the range of 6.5-8.4 (DWAF, 1996), while the European Union suggests a range of 6.5-9.5 for drinking water (EC, 2020). While all river water samples met these DWAF requirements at the time of sampling (e.g. a pH ranging from 7.26-8.17) the tank water samples exceeded a maximum pH of 8.4 on most occasions and the hosepipe water sample on six occasions, but they did not exceed a pH value of 9.5. Mdluli et al. (2013) reported the highest pH value of 7.79 for tap water collected in KwaZulu-Natal. During the rainfall season, from December 2020 to March 2021, the pH values of river water samples were higher (e.g. $\geq$7.87), which might be a result of the run-off of industrial effluent into the uMsunduzi River. The pH values for the uMsunduzi River water ranged from 7.26-8.17, matching values reported for the same river in an earlier study (Gemmell and Schmidt, 2013). Marie and Lin (2018) reported a pH range of 6.00-9.04 for water collected at a sampling site located near an industrial area along the Umhlanga River in KwaZulu-Natal. The elevated pH and COD values observed in the water tanks could be due to the practices of the smallholder farmers in the specific area, such as the addition of chemical agents. However, this requires additional analyses.

The tap water samples collected from the hosepipe had elevated COD values ranging from 74-154 mg/L O_2 (Table 5.4), exceeding the acceptable value (75-100 mg/L O_2) according to the South African irrigation water guidelines on four occasions (Table 5.4). The uMsunduzi River water COD ranged from 44-124 mg/L O_2 (Table 5.2) during the sampling period, thereby matching the values reported in an earlier study for the same river and the nearby Baynespruit River (Gemmell and Schmidt, 2012), while Marie and Lin (2018) reported COD values of up to 269 mg/L for the Umhlanga River water in KwaZulu-Natal, and Mdluli et al. (2013) recorded COD values of up to 36 mg/L for the IsiJodi River in KwaZulu-Natal. The water tanks had a COD ranging from 48-137 mg/L O_2 (Table 5.3).

5.4.2 Microbiological analysis

a) Irrigation water

The microbiological quality of the water and produce samples was assessed by determining the Most Probable Number (MPN) for the total and faecal coliforms and *E. coli*, aerobic plate counts, counts for intestinal enterococci and the presence of the pathogen *Salmonella* spp. The counts for the total coliforms in the uMsunduzi River water samples ranged from 24 000-4 900 000 MPN/100 ml and those for faecal coliforms from 7 900-420 000 (Table 5.2). The DWAF threshold for the safe use of irrigation water (i.e. <1 *E. coli*/100 ml, DWAF, 1996) was exceeded on each sampling occasion, as the uMsunduzi River had an *E. coli* burden ranging between 1700-240 000 MPN/100ml. International guideline values were also exceeded on all sampling occasions; the suggested value for safe irrigation with direct contact to the plant is 100 *E. coli*/100 ml (EC, 2017), now reduced to only 10 *E. coli*/100ml (EU, 2020), and 1000 *E. coli*/100 ml (WHO, 2006).

Gemmell and Schmidt (2013) obtained a maximum value of 350 000 faecal coliforms/100 ml for the uMsunduzi River and recorded the highest counts for total and faecal coliforms during March. The uMsunduzi River water is therefore still unsuitable for the irrigation of minimally-processed produce. As expected, the collected tap water was below the detection limit for total coliforms, faecal coliforms and *E. coli* throughout the sampling sessions. The water tank exhibited lower counts than the river water for the total and faecal coliforms and *E. coli* throughout the sampling sessions, thus far meeting the acceptable range of <1000 MPN/100 ml stipulated by the WHO for safe irrigation (WHO, 2006) and the even stricter 100 *E. coli* per 100 ml threshold suggested by the European Union (EC, 2017). The reduction of the counts in the water containers is most likely due to the exposure to ultraviolet radiation, which can cause a die-off of microorganisms, as these tanks are exposed to the sun over long periods (Turtoi, 2013). In addition, rainfall might have had a dilution effect and a certain die-off due to cell starvation might have occurred.

The higher rainfall reported in December 2020 (50-100 mm) compared to that in November 2020 (25-50 mm) (Table 5.10) may have resulted in a dilution effect lowering the microbial burden of the river water, as lower counts for total coliforms were recorded. In contrast, moderate temperatures of around 25˚C and the low rainfall (10-25 mm) recorded in late March resulted in considerably higher total and faecal coliform abundances of 4 900 000 and 220 000 MPN/100 ml, while the first sampling occasion in September 2021 with similarly low rainfall yielded the lowest counts for total and faecal coliforms and *E. coli*. Hence, rainfall and temperature do not consistently correlate with the counts observed.

Salmonella spp. has thus far been detected in the uMsunduzi River water during two sampling sessions, which was confirmed by the typical growth detected on the XLD and Rambach agar plates (Table 5,2), and biochemical confirmation according to ISO 6579. The presence of *Salmonella* spp. may be due to faecal contamination introduced into the river, possibly due to sewage leaking into the river, as *Salmonella* spp. was frequently detected in the same river in an earlier study (Gemmell and Schmidt, 2013). At the same time, intestinal enterococci were detected in the water samples, with counts ranging between 205-323 cfu/100 ml, thereby exceeding the recommended threshold level of ≤100 faecal enterococci per 100 ml for irrigation water intended for full contact irrigation of ready to eat produce (DIN 19650, 1999) on all sampling occasions (Table 5.2). However, there are currently no national recommendations on the acceptable intestinal enterococci counts for irrigation water. Nevertheless, intestinal enterococci were detected at counts lower than 100 cfu/100 ml in the water tanks on all sampling occasions (Table 5.3). The absence of *Salmonella* spp. in most water samples, with the exception of the river water on two occasions, meets the national and international guidelines for safe irrigation water as *Salmonella* spp., a pathogen, should be absent (WHO, 2006; EC, 2017). While a similar study by Beharielal et al. (2018) reported the absence of *Salmonella* spp. in the Mnini River water samples, an earlier study of the uMsunduzi River found that *Salmonella* spp. was detected when faecal coliform counts were high and exceeded the WHO guidelines for safe irrigation (Gemmell and Schmidt, 2013).

Finally, the heterotrophic plate counts for the river, tank and tap water (hosepipe) exceeded the DWAF guidelines for domestic use of a maximal 100 cfu/ml on all sampling occasions for river and tank water and on four sampling occasions for the tap water collected from the hosepipe, which was probably due to the contamination of the hosepipe (Tables 5.2, 5.3 and 5.4) (DWAF, 1996). As observed on the farm in Sobantu, the hosepipe may be exposed to contamination via soil contact, due to improper storage and the lack of cleaning before and after use. There are currently no guidelines that specify the acceptable aerobic heterotroph counts to govern safe water use for irrigation purposes (DWAF, 1996; WHO, 2016; EC, 2017). However, the heterotrophic plate counts indicate the amount of nutrients present in a given water sample and indicate the possible infiltration of water distribution systems. At the same time, high aerobic plate counts indicate the potential for microbial pathogens that are present to grow in the same sample, due to nutrients available. Total heterotrophic counts were similar to the data reported in a study by Nevondo and Cloete (1999) for the Tshwane River, as well as a study analysing the Baynespruit River in Sobantu (Gemmell and Schmidt, 2012).

b) Soil and fresh produce

Soil samples contained up to 2 400 *E. coli*/g, which matches the reported values for soil sampled in a peri-urban community in KwaZulu-Natal (Beukes and Schmidt, 2022). This result might originate, to some degree, from river water irrigation, but it could also originate from other known and previously-reported sources (Mdluli et al., 2013; Beukes and Schmidt, 2022). The testing of fresh produce was carried out to determine the microbial burden. Spinach reached the highest burden for total and faecal coliforms with 18 000 and 7 000 MPN/g, respectively, although very low counts (<4.5 MPN/g) for *E. coli* were detected on all sampling occasions (Table 5.6). The results for cabbage showed that a burden of up to 220 *E. coli*/g was present on one occasion, which exceeded the benchmark value "m" specified by the European Union for ready-to-eat vegetables, but it stayed well below the critical value of "M" (EC, 2005). Similarly, *E. coli* was detected at 110 MPN/g for spring onion on one occasion (Table 5.9). However, according to the now-outdated DoH Guidelines (2002), the fresh produce samples, particularly spinach and cabbage, were frequently not acceptable, given that they exceeded the stipulated value of 200 total coliforms per gram on several occasions and that *E. coli* was detected.

All presumptive *E. coli* isolates that were identified by using EMB agar were confirmed by employing TBX agar, with all the isolates being found to be β-glucuronidase positive. Additional confirmation was obtained via biochemical testing (GIMViC) and PCR as reported previously (Gemmell and Schmidt, 2013). Fresh produce was also tested for the presence of intestinal enterococci and *Salmonella* spp. However, while intestinal enterococci were detected on one occasion in spinach (12 cfu/g) and three occasions in cabbage samples (24-67 cfu/g) (Tables 5.6 and 5.8), *Salmonella* spp. was not detected in any of the fresh produce samples analysed (Tables 5.6, 5.7, 5.8, 5.9). Therefore, the fresh produce meets the European Union guidelines for ready-to-eat vegetables, as the pathogen *Salmonella* spp. should not be detected in a 25 g sample (EC, 2005). Similarly, the now-outdated guidelines of the DoH (2002) specify that *Salmonella* spp. should not be detected in 25 g fresh produce.

Finally, the heterotrophic plate counts were also determined for fresh produce and were within the expected range for fresh produce reported by an earlier study in the Sobantu township (Gemmell and Schmidt, 2012). The spinach samples that were analysed had aerobic plate counts of $2.5 \times 10^3 – 9.2 \times 10^5$ cfu/g, cabbage samples $1.4 \times 10^3 – 2.89 \times 10^5$ cfu/g, green peppers $7.4 \times 10^4 – 8.7 \times 10^5$ cfu/g and spring onions $3.4 \times 10^3 – 7.9 \times 10^4$ cfu/g. However, due to the COVID-19 pandemic and the implementation of a strict lockdown, we experienced sampling delays and sampling cancellations.

Out of 90 confirmed and tested *E. coli* isolates obtained from the uMsunduzi River, 11 showed resistance against ampicillin, 6 against norfloxacin and cefotaxime and 5 against ciprofloxacin. While not antibiotic resistant *E. coli* isolates were obtained from spinach, cabbage and green pepper, *E. coli* isolates resistant against at least one of the above-mentioned antibiotics were obtained from spring onion, potentially indicating a transfer of river borne antibiotic-resistant *E. coli* onto fresh produce via irrigation. The presence of *E. coli* exhibiting resistance against clinically relevant antibiotics such as norfloxacin and ciprofloxacin (e.g. fluoroquinolones) in river water used for irrigation might cause the spread of resistance genes within the farm-to-fork chain and is therefore a potential health concern. However, this is not unexpected, as the presence of antibiotics such metronidazole in the uMsunduzi River (Matongo et al., 2015) was reported, and a recent study highlighted that European wastewater treatment plants are releasing clinically relevant antibiotics, such as ciprofloxacin, into receiving rivers (Rodriguez-Mozaz et al., 2020). Thus, a similar scenario might apply to local South African WWTPs. Furthermore, the presence of antibiotic-resistant pathogens such as *Klebsiella pneumoniae* in samples from a local wastewater treatment plant releasing effluent into the uMsunduzi River was demonstrated (King et al., 2020).

Table 5.2: uMsunduzi River physico-chemical and microbiological results for water samples collected in the months of November 2020 through to September 2021

Msunduzi River									
Date	Water temperature (˚C)	pH	COD (mg O_2/L)	APC (cfu/ml)	Total coliforms (MPN/100 ml)	Faecal coliforms (MPN/100 ml)	*E. coli* (MPN/100 ml)	*Salmonella* spp.	Intestinal Enterococci (cfu/100 ml)
16/11/2020	-	-	-	-	160 000	28 000	24 000	-	-
10/12/2020	25.0	8.15	44	$2.33x10^4$	64 000	46 000	17 000	n.d	213
26/02/2021	26.0	7.87	61	$9.20x10^5$	130 000	79 000	11 000	n.d	283
17/03/2021	21.5	8.14	91	$6.00x10^4$	79 000	49 000	17 000	n.d	210
30/03/2021	25.0	8.17	72	$8.27x10^5$	4 900 000	220 000	130 000	n.d	205
13/04/2021	23.6	7.26	61	$7.00x10^3$	170 000	79 000	17 000	n.d	323
20/04/2021	20.1	7.83	69	$2.40x10^6$	2400 000	330 000	240 000	positive	298
12/05/2021	25.0	7.35	71	$1.15x10^4$	110 000	70 000	2 800	n.d	205
26/05/2021	15.0	7.56	73	$1.19x10^5$	79 000	49 000	22 000	n.d	213
17/06/2021	16.0	7.50	87	$8.45x10^5$	170 000	27 000	6 800	positive	270
05/08/2021	18.0	7.45	124	$5.70x10^4$	33 000	13 000	2 400	n.d	286
25/08/2021	20.1	7.74	108	$4.50x10^4$	49 000	24 000	3 500	n.d	274
13/09/2021	19.5	7.58	78	$6.40x10^4$	24 000	7 900	1 700	n.d	262
27/09/2021	22.5	7.62	82	$8.10x10^5$	1 100 000	420 000	3 400	n.d	245

-: Samples not takes, n.d: below limit of detection

Table 5.3: Water container physico-chemical and microbiological results for water samples collected in the months of December 2020 through to September 2021

Water container									
Date	Water Temperature (˚C)	pH	COD (mg O_2/L)	APC (cfu/ml)	Total coliforms (MPN/100 ml)	Faecal coliforms (MPN/100 ml)	*E.coli* (MPN/100 ml)	*Salmonella* spp.	Intestinal Enterococci (cfu/100 ml)
10/12/2020	29.0	8.82	78	$1.8x10^3$	46	33	7.8	n.d	2
26/02/2021	31.0	8.82	48	$1.6x10^4$	33	11	2	n.d	n.d
17/03/2021	23.0	7.75	114	180	110	4.5	4.5	n.d	n.d
30/03/2021	29.0	8.06	73	$5.5x10^5$	<1.8	<1.8	<1.8	n.d	72
13/04/2021	26.0	9.35	48	$9.0x10^3$	<1.8	<1.8	<1.8	n.d	n.d
20/04/2021	19.8	8.30	112	$1.6x10^5$	14	9.2	<1.8	n.d	12
12/05/2021	29.0	9.35	79	170	140	27	<1.8	n.d	25
26/05/2021	15.1	9.05	104	$8.3x10^3$	330	79	<1.8	n.d	7
17/06/2021	14.8	9.14	134	$8.6x10^3$	240	79	<1.8	n.d	30
05/08/2021	16.7	8.60	125	$1.0x10^5$	26	4.5	<1.8	n.d	2
25/08/2021	20.1	9.04	137	$2.1x10^3$	13	7.8	<1.8	n.d	18
13/09/2021	21.4	8.80	108	$2.1x10^3$	79	4.5	<1.8	n.d	n.d
27/09/2021	25.3	9.11	126	$6.4x10^3$	4.5	<1.8	<1.8	n.d	36

n.d: below limit of detection

Table 5.4: Tap water physico-chemical and microbiological results for samples collected in the months of December 2020 through to June 2021

Tap water									
Date	Water Temperature (˚C)	pH	COD (mg O_2/L)	APC (cfu/ml)	Total coliforms (MPN/100 ml)	Faecal coliforms (MPN/100 ml)	*E.coli* (MPN/100 ml)	*Salmonella* spp.	Intestinal Enterococci (cfu/100 ml)
10/12/2020	33.0	8.78	154	n.d	<1.8	<1.8	<1.8	n.d	n.d
26/02/2021	31.0	8.09	87	620	<1.8	<1.8	<1.8	n.d	n.d
17/03/2021	33.0	7.61	139	480	<1.8	<1.8	<1.8	n.d	n.d
30/03/2021	33.0	8.43	87	560	<1.8	<1.8	<1.8	n.d	n.d
13/04/2021	27.0	8.33	87	180	<1.8	<1.8	<1.8	n.d	n.d
20/04/2021	23.0	8.60	84	n.d	<1.8	<1.8	<1.8	n.d	n.d
12/05/2021	33.0	6.97	78	n.d	<1.8	<1.8	<1.8	n.d	n.d
26/05/2021	20.0	8.46	113	n.d	<1.8	<1.8	<1.8	n.d	n.d
17/06/2021	22.0	7.80	76	n.d	<1.8	<1.8	<1.8	n.d	n.d
05/08/2021	18.0	8.10	98	n.d	<1.8	<1.8	<1.8	n.d	n.d
25/08/2021	17.0	7.90	126	n.d	<1.8	<1.8	<1.8	n.d	n.d
13/09/2021	18.6	8.43	69	n.d	<1.8	<1.8	<1.8	n.d	n.d
27/09/2021	23.0	8.41	74	n.d	<1.8	<1.8	<1.8	n.d	n.d

n.d: below limit of detection

Table 5.5: Soil physico-chemical and microbiological results for samples analysed in the months of December 2020 through to June 2021

Soil Samples							
Date	pH	APC (cfu/g)	Total coliforms (MPN/g)	Faecal coliforms (MPN/g)	*E.coli* (MPN/g)	*Salmonella* spp.	Intestinal Enterococci (cfu/g)
16/11/2020	-	-	-	-	-	-	-
10/12/2020	7.18	$3.90x10^5$	4 900	3 300	350	n.d	81
26/02/2021	7.62	$8.20x10^5$	280	270	<1.8	n.d	n.d
17/03/2021	8.17	$4.20x10^5$	11 000	7 000	2 200	n.d	180
30/03/2021	9.25	$1.70x10^5$	79 000	13 000	2 400	n.d	270
13/04/2021	8.45	$1.30x10^6$	24 000	13 000	330	n.d	9
20/04/2021	8.20	$4.20x10^5$	13 000	4 900	1 100	n.d	9
12/05/2021	6.46	$1.70x10^5$	14 000	4 600	1 400	n.d	27
26/05/2021	8.84	$8.30x10^3$	24 000	4 900	250	n.d	n.d
17/06/2021	8.20	$8.60x10^3$	490	33	23	n.d	n.d
05/08/2021	8.60	$5.40x10^4$	790	170	7.8	n.d	n.d
25/08/2021	8.34	$4.20x10^3$	3 500	1 700	79	n.d	20
13/09/2021	8.75	$1.31x10^5$	4 60	35	<1.8	n.d	n.d
27/09/2021	8.23	$2.07x10^5$	79	17	14	n.d	n.d

-: Sample not taken, n.d: below limit of detection

Table 5.6: Spinach microbiological results for samples collected in the months of April 2021 through to September 2021

Date	APC (cfu/g)	Total coliforms (MPN/g)	Faecal coliforms (MPN/g)	*E. coli* (MPN/g)	*Salmonella* spp.	Intestinal Enterococci (cfu/g)
20/04/2021	7.50×10^4	18000	7000	<1.8	n.d	n.d
12/05/2021	2.90×10^5	180	11	4.5	n.d	n.d
26/05/2021	7.78×10^4	2300	150	<1.8	n.d	12
17/06/2021	9.20×10^5	350	23	<1.8	n.d	n.d
05/08/2021	4.90×10^3	230	7.8	<1.8	n.d	n.d
25/08/2021	2.50×10^3	<1.8	<1.8	<1.8	n.d	n.d
13/09/2021	1.72×10^4	<1.8	<1.8	<1.8	n.d	n.d
27/09/2021	1.80×10^4	<1.8	<1.8	<1.8	n.d	n.d

n.d: below limit of detection

Table 5.7: Green peppers microbiological results for samples collected in the months of April 2021 through to June 2021

Sampling Date	APC (cfu/g)	Total coliforms (MPN/g)	Faecal coliforms (MPN/g)	*E. coli* (MPN/g)	*Salmonella* spp. (25 g sample)	Intestinal Enterococci (cfu/g)
20/04/2021	7.4×10^4	110	7.8	<1.8	n.d	n.d
12/05/2021	1.6×10^5	13	9.2	4.5	n.d	n.d
26/05/2021	1.34×10^4	17	7.8	<1.8	n.d	12
17/06/2021	8.7×10^5	<1.8	<1.8	<1.8	n.d	n.d

n.d: below limit of detection

Table 5.8: Cabbage microbiological results for samples collected in the months of April 2021 through to September 2021

Date	APC (cfu/g)	Total coliforms (MPN/g)	Faecal coliforms (MPN/g)	*E. coli* (MPN/g)	*Salmonella* spp.	Intestinal enterococci (cfu/g)
20/04/2021	$9.60x10^3$	1300	26	<1.8	n.d	n.d
12/05/2021	$6.10x10^4$	24000	6.8	<1.8	n.d	n.d
26/05/2021	$1.84x10^5$	13000	2300	220	n.d	67
17/06/2021	$2.89x10^5$	23	13	<1.8	n.d	n.d
05/08/2021	$1.90x10^4$	<1.8	<1.8	<1.8	n.d	32
25/08/2021	$2.40x10^3$	240	130	<1.8	n.d	24
13/09/2021	$1.75x10^5$	13	<1.8	<1.8	n.d	n.d
27/09/2021	$1.40x10^3$	24	<1.8	<1.8	n.d	n.d

n.d: below limit of detection

Table 5.9 Spring onion microbiological results for samples collected in the months of April 2021 through to September 2021

Date	APC (cfu/g)	Total coliforms (MPN/g)	Faecal coliforms (MPN/g)	*E. coli* (MPN/g)	*Salmonella* spp.	Intestinal Enterococci (cfu/g)
05/08/2021	$6.4x10^3$	4900	700	110	n.d	n.d
25/08/2021	$2.0x10^4$	17	<1.8	<1.8	n.d	n.d
13/09/2021	$3.4x10^3$	170	22	7.8	n.d	n.d
26/09/2021	$7.9x10^4$	2300	330	45	n.d	n.d

n.d: below limit of detection

Table 5.10 Ambient weather and rainfall data on the sampling sessions*

Monthly sampling dates	Ambient Temperature (°C)	Rainfall (mm)
16 November 2020	21-27	25-50
10 December 2020	21-26	50-100
26 February 2021	20-26	25-50
17 March 2021	22-26	10-25
30 March 2021	19-25	10-25
13 April 2021	17-26	0-10
20 April 2021	18-24	0-10
12 May 2021	14-29	0-10
26 May 2021	15-32	0-10
17 June 2021	13-24	0-10
05 August 2021	8-24	0-10
25 August 2021	11-24	10-25
13 September 2021	14-25	10-25
27 September 2021	19-34	25-50

*The rainfall data were obtained from weather SA (https://www.weathersa.co.za/home/historicalrain) the temperature data from Accuweather (https://accuweather.com/en/za/pietermaritzburg.

5.5 Discussion

The analysis of the uMsunduzi River water samples showed that the recommended irrigation water quality value of 1000 faecal coliforms/100 ml (WHO, 2006) for safe irrigation was always exceeded by the samples that were analysed. This result matches that of earlier studies in this region, which showed that the water from local rivers used for irrigation by farmers in Sobantu was frequently of an inadequate microbiological quality (Gemmell and Schmidt, 2012; 2013), except for the water stored in water containers, which probably allowed for the sufficient die-off of microbial contaminants. On all sampling occasions, the water container samples met both the WHO and European Union guidelines for safe irrigation water (WHO, 2006; EC, 2017), as the levels for *E. coli* were below 1000 and 100 per 100 ml. Thus far, the results have demonstrated that the microbial contamination of the uMsunduzi River relating to the *E. coli* levels has not improved but has further declined, matching a recent report highlighting that the river is a potential health risk to domestic and recreational users (Ngubane et al., 2022).

At the same time, it appears that the water from the tanks was of a better microbiological quality and could be a potential substitute for river water, due to its lower microbial burden, as simply trying to switch to tap water may not be possible for some of the farmers. Furthermore, since the farmers practise overhead irrigation, there is a likelihood that pathogenic bacteria that are present in irrigation water will be transferred onto the fresh produce (Pachepsky et al., 2011; Uyttendaele et al., 2015). By simply changing the irrigation method and using a form of drip irrigation, the microbial burden could be reduced significantly (Uyttendaele et al., 2015). However, drip irrigation might not be feasible and affordable for the farmers, given the underlying costs and the need for maintenance and monitoring.

Thus, it is imperative that farmers use water sources that are safe for overhead irrigation, that are both cost-effective and accessible. This safe water usage will result in a better quality of fresh produce, it will improve the food security of the farmers and the community and it will enable access to the highly-regulated markets. The agro-processing practices of the farmers will also benefit as they currently lack knowledge of basic water hygiene; therefore, there is room for them to grow in that respect. Gemmell and Schmidt (2013) previously found that *Salmonella* spp. and *Staphylococcus aureus* were present in the uMsunduzi River water that was used by farmers for overhead irrigation when the *E. coli* counts were high. Therefore, our data might indicate some improvement regarding its water quality, as *Salmonella* spp. has only been detected on two out of 13 sampling occasions.

The testing of fresh produce on all sampling occasions has shown no obvious *Salmonella* spp. carry over from the river water. However, this remains to be confirmed by additional sampling in the future, given that additional contamination scenarios, such as the transfer of pathogens by wind and animal faeces are known (Iwu and Okoh, 2019; Nag et al., 2021). Tham et al. (2021) showed that the transfer of *Salmonella* spp. from irrigation water onto fresh produce did occur, even when the *E. coli* counts were below the detection levels. This scenario highlights that hygiene indicators are an excellent river water quality tool, even though the presence of specific pathogens cannot be excluded when hygiene indicator levels are low.

Furthermore, the presence of bacterial pathogens will deter market access and the market opportunities that are available to the farmers, as stringent market access barriers call for safe fresh produce of good quality, which means that the farmers may need to find an alternative irrigation source, if they are to participate in such markets. Access to good quality water that is safe for irrigation can have an impact on the resilience of food systems and food production. Should there be a drought, more farmers may have to rely on the river water as a means of sustaining their irrigation, in order to generate cash crops and/or a food basket at an elevated contamination risk (Schreiner et al., 2018; Vilakazi et al., 2019).

5.6 Summary

This project investigated the knowledge and understanding of entrepreneurial risk that is linked to water quality and water security for urban-based farming and agro-processing. The status quo report was based on a selected study site, the Sobantu township, which is located on the outskirts of Pietermaritzburg in the Province of KwaZulu-Natal. The overall project employed a mixed-method approach, incorporating both social and economic data collection and utilising qualitative and quantitative data analysis methods. The result of the stakeholder assessment indicated that there was a lower level of engagement by the government, at both a provincial and municipal level, for water access, water quality and entrepreneurship. Farmers are primarily self-reliant, while opportunities for improvement can be pursued for the development of a more niche-market and for skills development.

The stakeholder involvement in water quality, water access, urban farming and entrepreneurship roles indicates a poor water quality level, with important resources being classified as being unsuitable for human consumption without treatment and largely unsuitable for recreational use. The study also revealed that many residents depend directly on the water harvested from these highly polluted streams and rivers for drinking, cooking and irrigation, which has a direct impact on their livelihoods, and on occasions, severe health implications. The study posited that water management is improved when different stakeholders acknowledge their shared water risks. An analysis of the river water samples showed that the recommended irrigation water quality value of 1 000 faecal coliforms/100 ml for safe irrigation was exceeded by the uMsunduzi River water samples on all sampling occasions. The risk for the agricultural use of the rivers was above the tolerable risk values applicable for wastewater re-use that are at present recommended by the World Health Organisation (WHO).

As revealed in the preliminary findings, current and future water quantity and quality challenges may result in slower economic and urban growth, if adequate planning is not undertaken. This calls for a re-evaluation of the policies governing surface water quality assessments vis-à-vis the planned subsequent monitoring of water samples to confirm whether the water extracted from the river and stored in tanks on-site is suitable for irrigation. In the same vein, the results call for education in hygienic practices and other tested protocols that can improve the water quality, which will result in lower entrepreneurial risks related to food safety and market access barriers. Further testing is necessary to monitor the extent of the poor quality of the uMsunduzi River water to safeguard that farmers are able to make informed irrigation water usage decisions.

CHAPTER 6: AN ASSESSMENT OF WATER SECURITY DEFINED AS AVAILABILITY, ACCESSIBILITY, UTILISATION AND STABILITY

6. 1 Introduction and Contextualisation

Food and nutrition security are threatened by the ever-increasing demand for nutritious food, which is driven by many factors, including the human population which, it is estimated, will reach 9 billion by 2050 (Hall et al., 2017). On the other hand, smallholder agriculture has been shown to contribute to the alleviation of household food insecurity, while also generating an income and allowing for economic development through the sale of food products (Beharielal et al., 2018). Globally, approximately 925 million people experienced undernourishment in 2010. According to a UN Report (2015), the proportion of undernourished people in the world has decreased from 15% in 2000-2004 to 8.9% in 2019. However, after declining steadily for a decade, world hunger is on the rise and is now affecting 9.9% of the global population. The number of undernourished people increased by up to 161 million between 2019 and 2020. According to the World Summit on Food Security, there will be nearly 10 billion people worldwide by 2050, and there will be approximately three billion more mouths to feed than in 2010, which has implications for all resources, as more energy will be required to produce food (FAO, 2010; Nikmaram and Rosentrater, 2019).

Water scarcity is occurring in many parts of the world and it affects the health, aquatic systems and food security of people (Falkenmark, 2013); therefore, water is important for food and nutrition security. Water security is defined as "the consistent availability of an acceptable quantity and quality of water for health, livelihoods and production, and it is combined with a suitable level of water-related risks" (Grey and Sadoff, 2007). The agricultural sector consumes the highest quantity of water, compared to other industries, and there is an ever-increasing demand for production (Sajid and Rahman, 2021). Nevertheless, water scarcity is a concern for current and intending players in the agricultural sector (Sutcliffe et al., 2021). It must be noted that there is a demand for water, not only for agriculture, but also from other sectors. It is predicted that there will be an increase of up to 40% for manufacturing, and agro-processing fits into this space. In the study area, the urban township of Sobantu is surrounded by large manufacturing companies, including sugar warehouses, such as. Illovo, Unilever Best Foods, the Napp factory shop, Metcan Manufacturing, Tiger Brands and Meadow Feeds. It is therefore relevant in urban agriculture to investigate water demand and water use by other role players.

Agriculture in South Africa is characterised by commercial farmers and smallholder farmers, which make up the majority and minority, respectively (Baiphethi and Jacobs, 2009; Mdluli et al., 2013). Although South African households rely largely on cash to acquire their food, many poor households in rural South Africa continue to produce extra food for their own consumption (STAT SA General Household Food Security Survey, 2012). Smallholder farmers who participate in the market require water, not only to increase their yield, but also for their produce to be of an acceptable market quality. Water is also utilised in the agro-processing value chain to wash and sanitise agricultural produce, and to wash equipment and machinery (Rodda et al., 2011; Nikmaram and Rosentrater, 2019). There is a strong correlation between water scarcity, poverty and access to land. Furthermore, populations that are under water stress may soon reach a threshold where their water requirements can no longer be met (Falkenmark, 2013).

Smallholder farmers in the economy are often limited to the informal sector, mainly due to their lack of access to markets, their transaction costs and the poor infrastructure. In comparison, commercial farmers are generally more successful and occupy both the export and local food markets (Khoza et al., 2019). Exacerbating factors, such as climate change, urbanisation and population growth have also led to the scarcity of freshwater resources, which impacts food security, as freshwater is required during the initial production and processing of food products (Kirby et al., 2003; Jansen, 2012).

Agriculture is growing in urban areas, but it remains an informal sector activity within the Southern African Development Community (SADC) region, compared to other areas in the world; for example, in Chinese cities, where urban farmers are more common than rural farmers (van der Merwe, 2003; Wang et al., 2021). Access to safe and available water for food production on a sustainable basis is critical for the success of urban farming. Given the rapid urbanisation across Africa, which is leading to an increase in informal settlements and food insecurity, urban agriculture could be a veritable tool to alleviate poverty (de Bon et al., 2010); it may contribute to the reduction of unemployment, to improving incomes, to decreasing food insecurity, to the availability of localised food and environmental benefits, as well as to the reduction of organic waste through composting (Heather, 2012; Agamile, 2022).

Agriculture requires a large portion of the global domestic water footprint (Tuyishimire et al., 2022). Considering that South Africa already has limited freshwater sources, most of which are generally polluted, this applies further pressure on the viable freshwater sources (Rodda et al., 2011). Subsequently, smallholder farmers tend to rely on water of inadequate quality, which could likely result in the contamination of their fresh produce. The introduction of contaminants can occur at any stage of fresh produce preparation, from the inputs to the processing thereof, into other food products (Gemmell and Schmidt, 2010). Water sources may be contaminated with heavy metals, resulting from industrial effluent being released into rivers, which can subsequently have an adverse effect on fresh produce and the humans who consume it (Allende and Monaghan, 2015; Alves et al., 2016). The water that is utilised in agro-processing is susceptible to heavy-metal leakage and the introduction of microbial pathogens, which can have an adverse effect on the environment on consumer health. Sedimentation, run-offs and the leaching of chemicals can also negatively impact water systems that are often used for irrigation (Oberholster and Botha, 2014). Effluent from industrial plants, such as pesticides and dyes, may also introduce endocrine-disrupting chemicals, which can have an adverse effect on the human body. Industrial activity also contributes to pollution, which can change the soil composition and can, in turn, affect the growth of crops (Britz et al., 2007; Oberholster and Botha, 2014; Nikmaram and Rosentrater, 2019). The use of greywater by smallholder farmers is another potential resource, although it has both advantages and disadvantages; for example, it may contain the essential nitrogen and phosphorus required by plants, but it could potentially contribute to water insecurity. Furthermore, there are microorganisms present on the skin and in faecal matter and urine which, when consumed, possess the potential to cause disease (Rodda et al., 2011).

Moreover, improper farming practices, such as the over-use of antimicrobials in livestock farming, result in the emergence of antimicrobial-resistant pathogenic microbial species, such as pathogenic strains of *Escherichia coli* and the pathogen *Salmonella* spp., which have been reported worldwide (Abubakar et al., 2019; Mthembu et al., 2019). The use of unsuitable irrigation water sources contaminated by faecal matter from sewage or animal manure can also result in the introduction of pathogens into the human gastrointestinal tract, leading to serious illness (Britz et al., 2007; Oberholster and Botha, 2014; Uyttendaele et al., 2015). Furthermore, pathogenic strains can attach themselves to fresh produce and can penetrate the plants via their roots and stomata. The socio-economic factors that influence smallholder farming are the level of education, age and training of farmers, which can significantly impact food production (Ramaila et al., 2011). A lack of knowledge regarding food production hygiene may result in smallholder farmers using already-contaminated materials. This may lead to poor quality of their produce, which prevents them from entering the lucrative markets (Mdluli et al., 2013).

6.2 Water Security

Water is essential in our daily lives; it is used for cleaning, cooking and drinking, among other things. Water is a source of balance because the human body consists of 75% water (Roland, 2019), and it also plays an important role in agriculture, which uses 50%-63% of the available water (Bonthuys, 2018). The quality of the water is also important because it can have a significant impact on the health of consumers, as well as their food and nutritional status. South Africa is a water-scarce country, which causes problems for the agricultural sector, which is heavily reliant on water for irrigation and crop growth (Hassan and Thurlow, 2011). The same is true for urban agriculture, which is at a greater disadvantage because water allocation in cities is more focused on the industrial sector (Haysom et al., 2012). Despite being labelled as the champion of water supply development, South Africa faces enormous challenges in this sector. The patrons once lived in an era when the responsibility for supplying water was fragmented and there was no government department in charge of its management, which resulted in different levels and quality of service between the White and Black areas (Folifac, 2007). According to William (2018), one of the pillars of water allocation is the water allocation reform strategy, the targets of which have been set and are expected to be met by 2024. According to the Department of Water and Forestry (2008), about 60% of water allocation should go to the Black population, with half of that going to Black women. The 1997 Department of Water Affairs (DWAF) policy and functions were primarily concerned with irrigation and forestry, with millions of people living without access to water and basic sanitation (William, 2018). New non-racial reforms in water allocation were implemented after 1994, to address the social ills of the past, and these policies include the following:

a) **The Water Service Policy (White Paper) 1994:** It addresses the country's backlogs in water service, and the institutions and mechanisms that are needed to remedy these backlogs.

b) **The Republic of South Africa Constitution (Act 108 of 1996):** It establishes the human right of access to an adequate and sustainable water supply and service, which is enshrined in the Bill of Rights.

c) **The Water Service Act (WSA) of 1997 (Act 108 of 1997):** It ensures the right of access to an essential water supply and sanitation, and also provides a regulatory framework and the establishment of water service institutions, such as water boards and water services.

d) **The National Water Policy of 1997 (DWAF 1997):** It redefined ownership and the allocation of water, declaring that all water, irrespective of where it occurs in the hydrological cycle, is public water and that the national Government will act as its trustee.

e) **The National Water Act of 1998 (Act 36 of 1998):** is founded on two pillars, i.e. sustainability and equity, and amongst other resources, it requires the establishment of a national water resource strategy to set out a national framework for managing the water resources.

f) **The National Water Resource Strategy (DWAF, 2004):** It provides the national implementation framework for the management of water resources and divides the country into 19 water management areas (WMA).

g) **The National Water and Sanitation Programme:** This is an international partnership that is aimed at enhancing an accessible, safe and affordable water supply and sanitation for the poor.

Water is necessary for life on earth and is critical for achieving SDG 6, i.e. providing clean water and sanitation to all (Vilakazi et al., 2019). High-quality and abundant water is critical for food security and agricultural production. Unsustainable water use endangers livelihoods that are based on agriculture and water. Agriculture has the largest global water footprint, as water is used for fishing, livestock and crop production, as well as for the processing of raw materials into foods and products, which makes agriculture one of the causes of water scarcity. Furthermore, agricultural water use jeopardises its availability because it is polluted by excessive fertiliser and pesticide use. Droughts are a recurring problem in South Africa, and they have a significant impact on agricultural production and on how the country functions (Baudoin et al., 2017). Water-scarce areas typically have a high population density and low water availability, which is most likely due to the high rate of urbanisation and immigration. In this chapter, an investigation is undertaken into various aspects of water security: its availability, accessibility, utilisation and stability. These aspects are examined alongside indicators related to agency and empowerment as socio-economic proxies. The chapter also delves into the utilisation of water quality in the context of urban farming and agro-processing, aiming to shed light on strategies for enhancing developmental capacity within the urban environment. In addition, the socio-economic factors that govern water use will also be explored to determine how food security is hindered, as well as their overall impact on the access to markets and the associated entrepreneurial risks.

6.3 Methodology and Research Design

6.3.1 Data collection approach

In this section, the global design and approach includes a case study that uses mixed-methods research and both qualitative and quantitative methods for data collection. The study employed a multi-stage sampling methodology (n=157) across the three sites. The participants were specific (urban farmers and their small farms), with intense participatory data collection over several seasons (Leite and Marks, 2005). This study used a mixed methodology for conducting the research, which involved collecting, analysing and integrating quantitative and qualitative research in a single study (Creswell, 2005). The first phase involved informal interviews and a transect walk through the gardens. The transect walks and informal interviews were instrumental in identifying and locating the farmers' gardens and collecting their information to create a database for all the cases. The case study methodology was deemed to be suitable because it enables researchers to conduct an in-depth investigation into various phenomena, within a specific context (Rashid, 2019). Since urban farming is an emerging area of research in KwaZulu-Natal, this information was used to develop questions for the farmers' households in each case. The second stage of the study focused on creating structured questionnaires, which included both open- and closed-ended questions. Moreover, Focus Group Discussion questions were also prepared, which were randomly conducted with active farmers, to gain an in-depth understanding of the study area. FGDs were then conducted with the urban farmers and key informants were interviewed (i.e. Extension Officers). The structured questionnaire was designed to capture the demographics, the type of farming, the livelihood strategies, the farming techniques, the water quality, entrepreneurship in farming, as well as market access. The structured questionnaire was pre-tested on 10 cases in Sobantu that were not part of the actual survey; it was then modified, finalised and administered in the study.

6.3.2 Data analysis

The SPSS version 27 and STATA 18 software was used to analyse the descriptive statistics and the content analysis of the 157 participants. The responses to the closed-ended questions were coded and subject to a descriptive analysis. The open-ended questions from the questionnaire and the FGDs were then analysed for themes and incidences of commonality. Descriptive statistics and Principal Component Analysis tests were used to analyse the data. The assessment of water insecurity, specifically pertaining to access, for the sampled and categorised groups, was conducted by employing a modified Household

Food Insecurity Access Scale (HFIAS) instrument designed to gauge the status of food security, as described in 3.7, was similarly used to gauge the status of water insecurity. This method was employed by Sinyolo et al. (2014) and Brewis et al. (2021), because of its ability to capture all four areas of food security, namely, access, anxiety, as well as the inadequate quality and quantity of the food supply (Mango et al., 2014). The higher the adapted Household Water Insecurity Access score, the higher the water insecurity status of that household was.

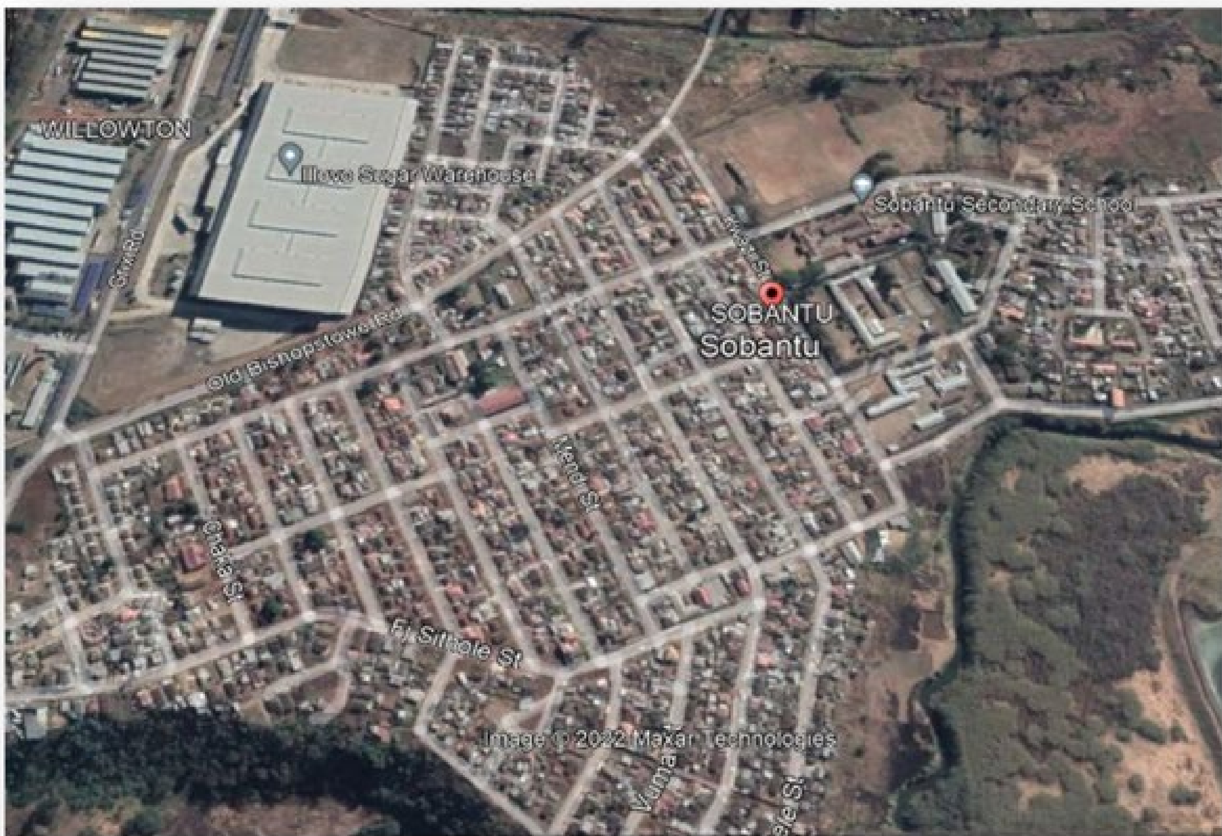


Figure 6.1: Sobantu area in Pietermaritzburg, KwaZulu-Natal Province

6.3.3 Study sites

This section gives a brief overview of the study areas, i.e. the Sobantu, Sweetwaters and Mpophomeni townships, each of which are described individually below. The study consisted of 157 urban farmers from the abovementioned three townships in and around Pietermaritzburg.

a) Sobantu township

The Sobantu township (Figure 6.1) is served by a water-borne sewage system (Kirkpatrick, 1994). Topographically, Sobantu is a comparatively flat area, it is well-drained and surrounded by the Ramaala uMsunduzi and Baynespruit Rivers. These two rivers run through the township and there are several flood-plains associated with them. Several studies have reported that both the uMsunduzi and Baynespruit Rivers are a vital source of water for the farming community in Sobantu. Both rivers are used as a source of irrigation for smallholder agriculture, and the river water is also used for various other human activities, such as bathing and fishing; however, the community relies heavily on the municipal water supply (tap water). The uMsunduzi Municipality and Umgeni Water both play a critical role in the monitoring and enforcement of water pollution. The most active NGO working on water quality issues in civil society is the Duzi-uMngeni Conservation Trust (DUCT), which was founded by recreational users of the three local watercourses. Along the lower reaches of the Baynespruit River, the main stakeholders include industries, particularly edible oil producers and others, which discharge effluent into the sewers and stormwater drains along the river. Studies by Neysmith and Dent (2010) and Ramburran (2014) revealed that the poor water quality of the Baynespruit River is caused by illegal waste discharge from industrial institutions, a poor sewage infrastructure and the illegal dumping of waste from the members of the community who reside in close proximity to the river. Farmers in Sobantu alluded to the fact that they used water from the uMsunduzi River to irrigate their crops, but that it was polluted by an upstream sewage system. Moreover, the uMsunduzi River is also surrounded by factories, including three animal-feed factories and the New England Road landfill site, which has been considered to be an environmental and health concern in recent years. The companies themselves range in size, from small to large; some are independent, while others are subsidiaries of national, or even multi-national, operations. The factories manufacture a range of products, including carpets, chemicals, food and toilet paper, for both domestic consumption and for export. Sobantu and the nearby formal and informal settlements that require water from the Baynespruit River for irrigation purposes contribute to, and suffer from, the litter and sewage pollution problems.

b) The Sweetwaters township

Sweetwaters is a semi-urban area located on the outskirts of Pietermaritzburg. It is 18 km wide and is under the authority of a Chief and iNduna who govern the area. Sweetwaters is located in the uMsunduzi Local Municipality, under the uMgungundlovu District. It covers an area of approximately 12.94 km^2, with a population size of approximately 14 417 (Integrated Development Plan, 2020/2021). Approximately half of the households are involved in subsistence and smallholder farming in Sweetwaters. The major problems that are faced are the high rate of unemployment and poverty and the fact that the people lack the capacity to produce enough food (Integrated Development Plan, 2011/2012). The Sweetwater community relies heavily on municipal taps for their household water supply, but harvested rainwater is integrated during the rainy season, and nearby streams and river sources are also used during municipal water outages.

c) The Mpophomeni township

Mpophomeni is located under the uMngeni Local Municipality, in the uMgungundlovu District of Pietermaritzburg. Its area coverage is approximately 4.58 km², with a population size of 25 732. Mpophomeni has a significant historical background as it was first a place of solace for the Black community in the apartheid era when segregation was imposed by the government. The area is mostly populated with subsistence households and a very small proportion of smallholder farmers. The greatest problem within the community is its high unemployment rate. This community depends heavily on municipal taps for its domestic water supply, but it also integrates harvested rainwater during the rainy season and uses nearby streams and rivers during municipal water outages.

6.4 Farmers' Demographics

The results in Table 6.1 show that the majority of the farmers interviewed (79.5%) were female and 20.5% were male. Studies by Azam and Banumathi (2015) and Kerdsriserm and Suwamaneepong (2020) provided empirical evidence that female farmers are the most likely to adapt to urban farming management practices, as they are often concerned about the nutritional aspect of the food that households consume.

Table 6.1 reveals a nuanced distribution of individuals across different age groups, with each group characterized by varying frequencies and percentages. In the youngest age bracket (20-30 years), there were three individuals, representing 2% of the total population. The 31-40 age group comprised six individuals, accounting for 3.6% of the population. The 41-50 age group exhibited 24 individuals, representing 15.7% of the population. In the 51-60 age group, 60 individuals were identified, constituting 38.3% of the total population. Notably, the age group over 60 (≥61) included 63 individuals, making up 40.4% of the population. These findings confirm the existing trend which highlights that the elderly are more interested and involved in farming, compared to the youth (Cele, 2016); Beharielal *et al.,* 2022). This means that if the youth are not encouraged to participate in farming activities, the indigenous knowledge systems will disappear from the area. It also means that the older farmers are less likely to access and incorporate new technology and innovations in order to improve their farm management operations in urban farming, due to their lack of credit and knowledge, and it is also less likely that the older generation will be thinking about future investments.

Table 6.1 also shows the results of the farmers' level of formal education. A substantial portion of the respondents, constituting 43.6%, have attained a secondary level of education, indicating a prevalent level of basic schooling within the surveyed cohort. This suggests a foundational level of literacy and numeracy, essential for engaging in various socio-economic activities and accessing higher education opportunities.

Following closely, individuals with primary education represent 39.7% of the population, underscoring the significance of foundational education in shaping individuals' cognitive abilities and socio-economic prospects. This observation highlights a considerable emphasis on primary education attainment within the demographic. Moreover, 9% of respondents report having tertiary education, indicating a minority with advanced educational qualifications. This subset likely possesses specialized skills and knowledge, potentially enhancing their employability and socioeconomic status. Notably, individuals with no formal education comprise a smaller proportion of the population, with some being able to read and write despite lacking formal schooling. While this subgroup represents only 3.8% each, their presence underscores the importance of literacy and numeracy skills in facilitating socio-economic participation and empowerment.

However, it is noteworthy that no respondents indicate vocational training as their highest level of formal education. This absence may suggest limited opportunities or uptake for vocational education within the surveyed population, highlighting a potential area for targeted skills development initiatives.

Although these results contradict the common trend that highlights the illiteracy amongst smallholder farmers in South Africa, the large majority of farmers in the study are unable to access higher education institutions that disseminate theoretical and practical knowledge, which would enhance their capacity to understand more about innovative and environmentally sound management concepts relating to urban farming and water quality. Siulemba and Moodley (2014) and Sapbmer and Thammachai (2021) stated that sustainable agriculture is knowledge-intensive and that for the farmers to understand, perceive and adapt to environmentally-friendly ways of food production, it is important for them to be environmentally aware. Furthermore, farmers who have a higher level of formal education have the capacity to access information from various sources and are more likely to be more open to new and sustainable technology and innovations.

The analysis reveals significant disparities between farmers who have undergone agricultural training and those who have not. Among the participants, a total of 26 farmers reported receiving agricultural training, while 130 farmers indicated no participation in training programs. Farmers who have undergone training exhibit higher levels of knowledge regarding modern agricultural techniques, such as improved crop management practices, pest control strategies, and soil conservation methods. Moreover, trained farmers demonstrate a greater propensity to adopt these practices in their agricultural operations, leading to improved productivity and yield outcomes compared to their non-trained counterparts.

Table 6.1: The distribution of the gender, age and formal education levels of the farmers

Demographic	Category	Frequency	Percentage (%)
Variable		(n=156)	
Gender	Female	124	79.5
	Male	32	20.5
Age	20-30	3	2
	31-40	6	3.6
	41-50	24	15.7
	51-60	60	38.3
	<61	63	40.4
Level of formal education	No Formal education, and can't read & write	6	3.8
	No Formal education, but can read & write	6	3.8
	Primary	62	39.7
	Secondary	68	43.6
	Tertiary education	14	9
	Vocational training	0	0
	Other	0	0
Agricultural training	No	130	83.9
	Yes	26	16.1

As demonstrated in Table 6.2, The presented data delineates the distribution of monthly income sources among the surveyed population, indicating distinctive trends over the specified period.

Old Pension grants emerge as the predominant income source, constituting 40.4% of the total, exhibiting a substantial reliance on retirement benefits within the demographic. Government grants follow closely behind, comprising 11.5% of the overall income pool. This observation underscores the significance of state support systems in augmenting individuals' financial stability. Moreover, farm income and wages both contribute significantly, each representing 16% and 12.8% of the total income, respectively. This finding suggests a diversified economic landscape, with individuals deriving income from both traditional agricultural activities and wage-based employment opportunities. This was to be expected, since the majority of the active farmers in this study were over the age of 60 years, which is the standard age of eligibility to receive a monthly R1 890 old-age pension grant in South Africa. The farmers stated that this was not enough to sustain their households and that they therefore participated in urban farming to obtain extra food, while generating an income from selling the surplus. However, the average income earned by farmers' selling their frequently-cultivated crops was below R300 per month. The farmers' inconsistency in keeping farm records, in book-keeping and in measuring the produce that they sell (per kg) has made it difficult to provide accurate calculations of the average amount of money they earn from selling their produce. The farmers stated that they were faced with various constraints that hindered their ability to make an adequate profit, such as the lack of access to markets, their inability to acquire certification to meet the market standards and their low bargaining power. This indicates that they do not have the purchasing power to afford the constant need for synthetic chemicals, and therefore, they are more likely to adopt to organic methods of crop production, which do not require much agricultural input.

The data presented illustrates the accessibility of credit among the surveyed population, highlighting distinct trends and disparities in credit availability. A notable observation is the prevalence of limited access to credit, with 84% of respondents indicating a lack thereof. This finding suggests significant barriers to financial inclusion. Conversely, 16% of respondents report access to credit, indicating a subset of the population with the means to leverage financial resources beyond their immediate income. This minority with access to credit likely benefits from greater financial flexibility, enabling them to invest in productive assets, smooth consumption patterns, or mitigate financial shocks.

Table 6.2: The farmers' monthly source of income and main livelihood strategy

Demographic variable	Category	Frequency (n=156)	Percentage (%)
Monthly source of income	1. Government grant	18	11.5
	2. Old Pension grant	63	40.4
	3. Remittance	10	6.4
	4. Wages	20	12.8
	5. Farm income	25	16
	6. Non-farm income	20	12.8
Access to credit	1. Yes	25	16
	0. No	131	84

The following sections will assess water security and its components of availability, access, utilisation and stability, and they will also discuss water security as it is related to entrepreneurship risks and agro-processing.

6.5 An Assessment of Water Security in Urban Agriculture

6.5.1 Water accessibility

This study employed accessibility, availability, utilisation and stability as the food security dimensions in a step towards developing an index to measure the water security tools. In terms of water availability, the data were collected through FGDs (Table 6.3) that unpacked the four dimensions of water security (adopted measurements to understand if water is available for these urban farmers). In terms of water quality, the farmers indicated that they use rainwater; however, during the winter season they face challenges because there is less rain. Waiting for rain is not ideal for farmers who want to plant crops all year round. Other farmers indicated that they use private taps to acquire water, even though their access to municipal water was limited, as they had to pay more money, depending to their usage. Changes in hydro-chemical properties influence the access to water quality. These factors may present a challenge and affect a household's access to water resources. Van Deventer (2012) illustrated that water quality is an important factor when seeking to address food security at a farm level. Nevertheless, challenges arise due to sewage discharge from both commercial and domestic sewage systems, in addition to agricultural run-off and industrial effluent. These issues collectively pose a significant threat to surface water quality, consequently elevating health risks. The findings indicate that water scarcity and the lack of access to water for these farmers are caused by natural and financial factors. The lack of water and other resources, including finance, weakens farmers' ability to access and supply the markets throughout the year. In addition, many agro-processors require high-quality water for the washing of their fresh products.

Table 6.3: Focus group discussion on the challenges that affect the adoption of water quality and management practices

Themes	Concepts	Responses
Urban farming management practices	Motivation for farming	*Farmers are socially and economically-motivated to farm and less inclined to be concerned about the environment. It's been years doing farming, (years for farming experience). Although farmers were employing urban farming management practices, they did not identify these practices, but stated that they were practices that they had engaged in while growing up*.
	Hindrances to adopting urban farming management practices	*There is a lack of contact and communication with Extension Officers, poor information-sharing amongst other farming neighbours, as well as the lack of access to resources, such asfinances and technology. The farmers also lacked knowledge about environmental management practices.*
Water quality	Access to water	Rainwater: *"we are faced with a challenge during winter as there is not much rainfall"*. Private tap: *"sometimes there are water-cuts in this area"*, while others expressed that high water tariffs are a major limiting factor. Farmers explained that there are periods of not having access to water. Furthermore, the water sources and methods used by farmers to extract water for their crops also pose a health risk.
Management practices	Hindrances to adopting water quality management practices	*Farmers stopped using the uMsunduzi River, due to pollution. There was little knowledge about water quality management practices. The perception is that the local government should be managing the quality of the river source in Sobantu, as farmers are not equipped to carry out such practices.*

6.5.2 Water availability

The questionnaires identified that smallholder farmers make use of municipal tap water, borehole water, greywater, rivers/streams and stored water, e.g. rainwater (Figure 6.2). The analysis reveals that Tap water is the predominant source as 75% of the farmers stated that their main irrigation source is Tap water provided by the municipality. Rain harvest also play a significant role in with 16% of the farmers stating that they harvest rainwater. Other irrigation sources were rivers (5%) and other sources such as waste water accounted for 4%.

In discussion, the smallholder farmers revealed that making use of municipal water was limiting, as they had to pay more money for its usage. Not only that, sometimes they would be subject to water being unavailable, which would result in their using alternative water sources for irrigation, such as grey water and river water, which are generally at risk of contamination (Barnes et al., 2003; Britz et al., 2013). Irrigation water for fresh produce needs to be of a high-quality in order to maintain the safety and quality of food. The availability of irrigation water would lead to increased crop yields and crop quality, which would potentially promote food security.

Table 6.4 explores aspects related to the two water security pillars, namely, water availability and accessibility. The provided data outlines responses regarding the availability of water throughout the year within the surveyed population. The majority of respondents, comprising 60.9% of the total, indicated that water is not available consistently throughout the year. This predominant response suggests a prevalent challenge or perception within the demographic regarding the irregularity or insufficiency of water supply over time. Factors such as seasonal variations, climatic conditions, and infrastructure limitations may contribute to this perception of water scarcity or intermittency. These findings are supported by the results from the Focus Group Discussion (FDG) (Table 6.3), which state that, with regard to rainwater, "we are faced with a challenge during winter, as there is not much rainfall", and with regard to private tap water, that "sometimes there are water-cuts in this area", while others expressed high water tariffs as being a major limiting factor.

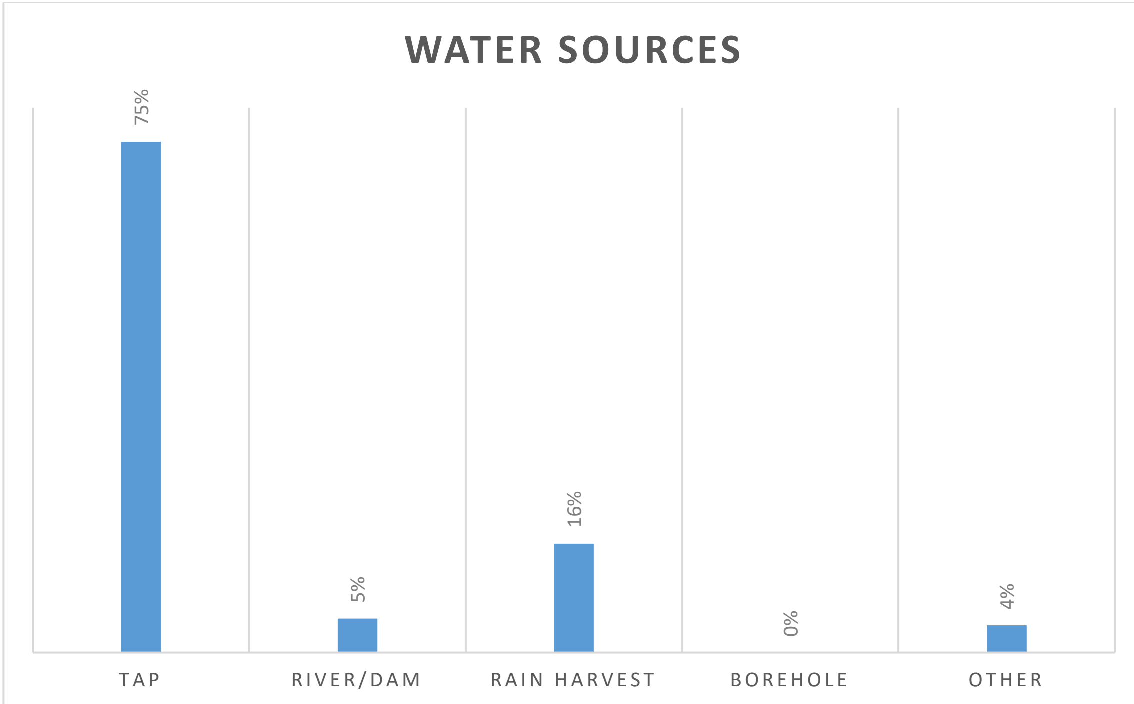


Figure 6.2: Different irrigation water sources (%) utilised by smallholder farmers in Study areas

Conversely, 39.1% of respondents affirmed that water is available consistently throughout the year. This minority response suggests a subset of the population that perceives water availability as stable and reliable across different seasons. This perspective may be influenced by factors such as access to well-maintained water infrastructure, adequate storage facilities, or geographical location with abundant water resources.

When questioned about their use of other water sources, some farmers mentioned that they used water harvesting techniques (e.g. *JoJo* tanks) during water-cuts and dry months when there was a limited water supply. Others mentioned that they used springs or boreholes as alternative water sources.

With regard to the method of water abstraction, a focus group discussion was conducted to explore the methods employed by farmers for water abstraction and irrigation. Findings revealed a diverse range of techniques utilized by farmers in their agricultural practices. Notably, farmers employed buckets, pipes, and watering cans for water abstraction, with a predominant reliance on manual methods. While drip irrigation was minimally adopted, it represented a notable departure from traditional techniques. This manual watering system has a great impact on these urban farmers, especially in terms of their gender and age, where most urban farmers are women and elderly who suffer from poverty because of their household responsibilities. Furthermore, the water sources and methods used by farmers to extract water for their crops also pose a health risk in table 6.3 above. More specifically, the quality of the water containers is undesirable and they are not always cleaned before refilling them with water for crop irrigation, which results in mixing clean water with dirty water, which could have hazardous effects. Therefore, the treatment and constant quality control of the water sources, as well as the methods that these urban farmers use, requires ongoing monitoring, i.e. cleaning. In a study by Murungani and Thamaga-Chitja (2018), it was found that the reduced water quality results in a reduction in the quality of farmers' products at the market, because it affects the growth of the plants.

Table 6.4: Access to water, the type of water source used to irrigate crops, and the irrigation systems used to abstract water

Water Source	Category	(n=156)	%
Access to water all year round	1. Yes	61	39.1
	0. No	95	60.9
Type of main watersource	2. tap	117	75
	3. River	~~90~~ 8	5.13
	4. Rainwater	1 25	16.03
	5. Borehole	~~60~~ 0	3.85

6.5.3 Stability of the water supply

From the results of Table 6.4 on the availability and accessibility of water to farmers, the study further analysed the stability of the water security, by investigating the stability pillar of water security. Farmers irrigate their crops based on the availability and the utilisation of water. In line with the results of Table 6.5, high numbers of farmers rely on manual irrigation systems; however, more than half (51.3%) of the farmers in Table 6.5 assumed that the crops should be irrigated when the temperatures are high. This is followed by 24.4% of farmers who irrigated their crops every other day and 19.2% who irrigated their crops twice per day. Knowing when to irrigate their crops, and how much water to use, is crucial for maximising their yields, and for accessing and supplying the market. These results showed that there is a need to educate farmers and to equip them with knowledge on irrigation so they will be able to produce on a bigger scale and access more markets. This refers to the two additional food security pillars, namely, sustainability and agency (Clapp et al., 2022). Given the limiting factors, including the constant water-cuts and high water tariffs, poor smallholder farmers require cost-effective, but reliable, water sources.

Farmers were asked to state the sustainable water sources that they had adopted to limit intensive irrigation. Approximately 77% use harvested rainwater stored in *JoJo* tanks and other large water containers as an alternative, and 5% adopted the alternative mulching technique, which involves covering the soil surface around the crops with organic matter (the respondents mainly used grass) to prevent water loss. Soil cover, such as cover crops or mulch, can help to prevent soil and nutrient losses and has additional benefits, in terms of soil moisture conservation. About 5% of the farmers used wastewater, while the remaining 12.8% did not use any sustainable water sources. When farmers practise proper water management to avoid water wastage, the sustainable irrigation systems and water sources are improved. Increased and stable water supplies from all sources will help to expand sustainable irrigation on a small-, medium- and large-scale level. It has been reported that the majority of users of rainwater harvesting irrigation systems are women (Fuentes-Galván et al., 2018); however, these are labour-intensive techniques, which makes it burdensome for women farmers, who are constrained by the need to also perform all the household labour (Abdulla et al., 2021).

In order to determine whether the farmers were aware that water needs to be saved during crop production, they were asked whether their crop selection was based on the plants' water consumption requirements. A total of 73% of farmers agreed, while 27% of farmers disagreed. According to the findings, the majority of farmers are concerned about water conservation and avoiding its exploitation and depletion. This demonstrates that, while the majority of farmers have a reliable water source, there are other existing limiting factors, such as their uncertainty about the quality of the river source in Sobantu, as well as the water-cuts and high-water tariffs that are enforced across all the research sites. This inadvertently caused farmers to conserve water for the benefit of the environment. According to Bernstein (1997), water charges and tariffs are economic instruments that provide incentives to regulate the behaviour of water users and polluters who are in support of water use and pollution control. However, the study discovered that farmers are not saving water to address the country's water security issues, but rather, because they are influenced by the local government and their socio-economic constraints.

Table 6.5 The management practices used by farmers to save water for irrigation

Variables	Category	(n=156)	(%)
Frequency of irrigation?	1. Daily (twice)	15	19.2
	2. Every other day	19	24.4
	3. Only when weather temperatures are high	40	51.3
	4. Other	4	5.1
Sustainable water source	1. Rainwater harvesting	60	76.9
	2. Mulching	4	5.1
	3. Wastewater	4	5.1
	4. No employed practices	10	12.8
Crop selection is based on less water consumption	1. Strongly agree	27	34.6
	2. Agree	5	6.4
	3. Somewhat agree	25	32.1
	4. Somewhat disagree	5	6.4
	5. Disagree	6	7.7
	6. Strongly disagree	10	12.8

Figure 6.3 shows the water containers used by farmers for rainwater harvesting. All their containers are cut open on top as these urban farmers rely heavily on manual irrigation systems to collect and irrigate their crops. However, this has both a negative and positive impact, in terms of the water quality stored in these containers. The farmers have highlighted that birds drink the water and also drop their waste into the water, which adds to its microbial load.

Figure 6.3 Rainwater harvesting for sustainable water use by smallholder farmers

In Table 6.6, the study delves into the extent of government support for water sanitization initiatives and its influence on respondents' access to clean water and their perceptions thereof. Utilizing survey data, the research examines the frequency and percentage of respondents who report receiving support from the government for water cleaning efforts. Findings indicate that a significant proportion of respondents, comprising 23.7%, report receiving support, while the majority, constituting 76.3%, do not. This analysis sheds light on the role of government interventions in addressing water sanitation challenges, highlighting the need for continued efforts to expand access to clean water and enhance public perception of government initiatives. Thus, a significant finding was that there is a lack of communication between the government institutions and small farmers regarding sustainable water management, i.e. its quality and safety. Some farmers in Sobantu mentioned that some students and NGOs, such as DUCT, teach the communities about healthy environments and rivers around communities; however, they do not teach specifically for agricultural purposes, but for community activities. Farmers also mentioned that municipal employees came to take water samples, but there was a tendency not to provide feedback to the community. With regard to what management practices were adopted to prevent water pollution, 3.8% of the farmers indicated that they clean the area around the water source, while 94.9% were not adopting any practices. One farmer who used a spring water source (1.3%) specified that a protective zone was built around the source.

The low adoption of water quality management practices can be attributed to the fact that the majority of the farmers are dependent on tap water. This is because the farmers in Sobantu had access to the uMsunduzi River; however, they were forced to stop using this water source due to the visible signs of contamination, as well as the results of several studies, which declared that the river was unsuitable for use (Neysmith and Dent, 2010; Ramburran, 2014). The FGD (Table 6.3) revealed that there was also the perception that protecting the river source against pollution should be the responsibility of the local municipality, as the river was being contaminated by the factories located in proximity to it. In addition, the farmers alluded to the fact that the local government is better-equipped and skilled to test, monitor and protect the river from pollution.

These findings indicate a lack of knowledge about water management, as well as a lack of facilitation from agencies, such as the public, private, non-governmental and community-based organisations. Water policies are formed by the Department of Water and Sanitation (DWS) and are aimed at positively impacting the country and its people (Masindi and Dunker, 2016). Recent studies indicate that there is weak governance, a disconnect between the national budget and requirements for water and sanitation financing, a lack of finance to meet the requirements as a result of the fragile municipalities, weak monitoring and evaluation, as well as a lack of accountability and responsiveness to the communities (Masindi and Dunker, 2016).

Table 6.6: Various water quality management practices adopted by farmers

Water quality management variables	Category	Frequency (n=156)	Percentage (%)
Does the government monitor the quality of water used for irrigation?	1. Yes	37	23.7
	0. No	119	76.3
Prevent water pollution	1. Build protective zones around the farm	0	0
	2. Avoid washing farm implements in the river	0	0
	3. Clean the area around the water source	3	3.8
	4. None	74	94.9
	5. Other	1	1.3

6.5.4 The PCA analysis results for water quality

Twelve components were used to extract water quality indices, and only four Principal Components (PCs) were extracted that had Eigen values of greater than 1, as per the Kaiser Criterion. The four extracted PCs contributed 68% of the total variations of the variables used. The first component (PCW1) explained 35% of the variations and was found to be closely related to the water quality and health risks. According to Namara et al. (2010), access to agricultural water decreases temporary poverty at a farm level. Van Deventer (2012) illustrated that water quality is also an important factor in addressing food security at a farm level; however, sewage discharge from the sewage plant and commercial industrial effluent pose a threat to the surface water, thus resulting in health risks. The second component (PCwq2) explained 13% of the variations and was found to be closely related to the health risks of urban agriculture. Boischio et al. (2008) noted that risk management on the use of WW can significantly reduce health risks at a farm- and household level. The third component (PCwq3) explained 11% of the variations and was found to be closely linked with health risks. Dreschel et al. (2008) found that there were cases where the use of WW caused cholera among the respondents, and they also noted that some agricultural products were consumed raw. The fourth component explained 9% of the variations and was found to be closely-related to water quality. In a study by Murungani and Thamaga-Chitja (2018), it was found that reduced water quality results in reduced production quality at the market, and that it affects plant growth. Dreschel et al. (2008) and Boischio et al. (2008) also found that water treatment techniques could improve the quality, i.e. the careful collection of irrigation water, without disturbing the sediment, reduced the helminth egg count by 70%, while most of the removal of the helminth eggs took place on the first day of sedimentation, and that of faecal coliforms in the same three-day period was about 2 $\log_{10}$ units, due to natural die-off. Therefore, based on the PCA analysis, it can be reasonably concluded that the water quality poses risks to the entrepreneurial efforts and market access of farmers.

Table 6.7 Dimensions of water access, quality and use in urban agriculture

Variables	Principal Components			
	PC_1 (WW use)	PC_2 Health risk	PC_3 Health risk effects	PC_4 Water quality
1. Aware of the use of WW	0.029	0.485	-0.387	0.001
2. WW poses a health risk	-0.020	-0.081	0.118	0.848
3. Any health risk known to you	0.152	0.284	-0.482	0.181
4. Wastewater should be treated (WQ)	-0.370	0.280	0.040	0.158
5. Wastewater use in UA	0.432	0.089	0.126	0.160
6. WW be cooked before use/consumption	-0.297	0.422	-0.015	0.053
7. Crop type matters	-0.447	0.095	-0.023	-0.002
8. Would eat leafy vegetables	0 .434	0.126	0.097	0.110
9. Would eat roots and tubers	-0.391	0.128	-0.028	0.027
10. Know of WHO guides on WW use	-0.008	-0.528	-0.203	-0.211
11. Pre-wash vegetables before use	0.103	0.106	0.528	-0.315
12. Health risk examples (cholera, worms)	-0.108	0.286	0.505	-0.197
Eigen Value	4.21	1.54	1.34	1.10
Variance explained (%)	35	13	11	9
Cumulative % of variance	35	48	59	68

Note: Component loadings greater than |0.4| are included in the interpretation. KMO = 0.76 and the Bartlett test of sphericity Chi-Square = 425.46; p-value = 0.000

Although the illegal dumping of waste is a major contributor to the pollution of the uMsunduzi River, the farmers also have a role to play in caring for the environment through using environmentally friendly ways of production. Furthermore, the farmers in Sobantu stated that the local government does not monitor the water quality of the uMsunduzi and Baynespruit Rivers that run through their community. It was found that DUCT does take water samples of the Sobantu-Baynespruit River to identify spillage from factories surrounding the community, and that its reports are published on the Internet (DUCT, 2021). In addition, the local municipality has strict regulations that restrict the illegal dumping of waste into rivers, and residents are also not allowed to build close to the riverbeds. However, it should be noted that the results in Table 6.8 indicate that majority of the farmers are not aware of this information, which can be attributed to the lack of access to information services, such as extension services and technological resources. Despite the implemented policies, the surroundings of the uMsunduzi River were observed to be dirty and littered (Figure 6.4*)*. Studies argue that most rivers located near towns are more polluted, compared to the peripheral streams. It is difficult to disentangle all the human activities, i.e. the dumpsite, sewage pipes and industrial companies in the area, and to isolate the direct role of agrochemicals when determining the water quality in Sobantu.

Figure 6.4 Image showing the uMsunduzi River with litter

6.5.5 Utilisation

Food utilisation is an important pillar of food and nutrition security; it refers to how the body uses the various nutrients in food, and therefore, the safety of the food is important. The farmers' way of producing food, especially fresh food, affects health, feeding practices, food preparation, and ultimately also the food diversity. A diverse diet at a household level is beneficial for human development and for improving the learning and health outcomes in children, as it reduces stunting (FAO, 2011). The following section will address the socio-economic factors that affect the utilisation pillar and that ultimately play a role in empowerment and agency.

6.6 Socio-Economic Factors Influencing Smallholder Farmers' Irrigation and Pre- and Post-Harvest Practices

The decision of farmers to practise irrigation and pre-and post-harvest is influenced by socio-economic characteristics, such as age, gender, the level of education and training exposure.

6.6.1 The hygiene practices used by farmers

The results of the hygiene practices in the study sites are presented in Table 6.8 and indicate that there is no statistically significant association between age and gender in this case. However, other findings have shown that the aged farmer population generally practices good hygiene (Mdluli et al., 2014). Despite the fact that the majority of farmers are older, no link appears to exist between their age and more hygienic farming practices. Similarly, Beharielal et al. (2018) found no significant association between the farmers' age and good hygiene practices. Smallholder farmers are part of a population that has limited resources, so they can only use certain inputs during pre-harvest practices. Washing fresh produce and education are nearly significant ($p=0.068$), which is critical because fresh produce education is necessary for farmers to access the commercial and formal markets. Education has the potential to improve the lives of farmers by increasing their productivity, because it helps them to have a better understanding of the appropriate practices as a result of their learning new skills (Quansah et al., 2020). However, it should be noted that the 'level of education', rather than just 'education', is a determinant of how well these improved farming practices are implemented. According to a previous study by Martins et al. (2012), farmers with a higher level of education are thought to have a more comprehensive knowledge of good farming practices, in contrast to those who have only had a primary level education. Babalola et al. (2010) found that farmers with secondary level education can easily grasp the dynamics of farming for business purposes and can be trained with minimal difficulty; they can also appreciate and use the majority of the available post-harvest technologies effectively (Babalola et al., 2010).

6.6.2 Potential contamination sources

As can be seen in Table 6.8, the awareness of strict food safety standards is positively associated with the farmers' groups at p=0.003. This is expected, as those farmers who have been members of farm-based organisations have learnt how to ensure water security on their plots and how to implement the recommended practices. The positive association of farm groups and their awareness of hygienic practices may be traceable to the fact that farmers who have experienced water problems in the past, have become optimistic regarding water security in the study area. This result conflicts with the study of Sinyolo et al. (2014) who found a negative relationship between the duration of membership in an irrigation scheme and water security in South Africa. Farmers who identified compost as a potential source of contamination had received at least partial training, and an association was noted (p=0.004). Furthermore, the results based on the potential contamination source show that, while the training on soil contamination is not sufficient, it is critical because food safety is an important factor for market access (whether it is for household use, to be eaten raw, or for commercial use), and the amount of soil present during and after harvesting may pose a risk of contamination.

6.6.3 A knowledge of food safety

The smallholder farmers in this study also lacked a knowledge and/or awareness of the strict food and hygiene standards imposed by many fresh produce markets. The problems linked to farm safety and health, particularly among older farmers, remain largely apparent and unexplored (Hernandez-Peck, 2001). Education on strict food safety standards is almost statistically significant, which implies that a lack of education could be a constraint to the market requirements for safety. According to studies on the effects of education on farming practices, education increases the likelihood of farmers' adopting improved practices because it improves their ability to acquire, understand and efficiently implement the prescribed methods, which substantiates that the education level correlates with good hygiene practices (Mdluli et al., 2014; Kilpatrick, 2000; Kilpatrick and Johns, 2003; Beharielal et al., 2022).

Table 6.8 Relationships between hygiene practices and awareness and knowledge of food safety and socio-economic factors

	p-value				
	Farmer group	Age	Gender	Education level	Training
Hygiene practices					
Washing of fresh produce	0.811	0.698	0.183	0.068	0.136
Washing hands	0.313	0.789	0.598	0.628	0.965
Washing equipment	0.409	0.601	0.139	0.253	0.712
Washing boots and clothing	0.550	0.872	0.212	0.489	0.300
Potential contamination sources					
Water	0.758	0.300	0.260	0.524	0.593
Soil	0.610	0.222	0.542	0.365	0.061
Compost	0.435	0.182	0.513	0.410	0.004*
Equipment	0.094	0.655	0.575	0.416	0.471
Do not know	0.003*	0.515	0.575	0.346	0.852
Knowledge of food safety					
Awareness of strict food safety standards	0.003*	0.881	0.477	0.051	0.555
Outbreaks linked to fresh produce	0.734	0.234	0.155	0.337	0.555

* Indicates significance ($p < 0.05$)

6.7 Farming Methods Practised by Urban Smallholder Farmers in the Study Sites

6.7.1 The type of fertiliser used by urban farmers

The results showed that only one statistically significant association existed between farmers' educational level and pre-harvest practices, namely, the compost that is used. The results also showed that the farmers were educated in the use of composting as a means of enriching their farming plots ($p=0.018$). However, when comparing the pre-and post-harvest practices, there was no significant relationship with the farmer's age, gender or training.

6.7.2 Type of irrigation

There appears to be a significant relationship between the farmer groups and the use of river water as an irrigation source ($p=0.001$). In addition, there was also a significant relationship between gender and stored water. The results showed that women were more likely to make use of stored irrigation water, because most of the farmers were women ($p=0.018$). This highlights the lack of resources that farmers face in their use of alternative irrigation water sources. Each irrigation subsystem, i.e. collection, replenishment, storage, conveyance, distribution off- and on-farm, as well as on-farm application, involves a process that has great potential to compromise the microbiological integrity of the irrigation water in unique ways. For instance, the transport of irrigation water via irrigation ditches and canals involves its interaction with the microbial reservoirs of bottom sediments, bank soils, algae and periphyton, whereas water transport via pipes involves its interaction with biofilms in the transport pipes. The storage method of irrigation water can have a profound effect on pathogen transmission. For example, certain studies have demonstrated that water quality is rapidly degraded in storage ponds and tanks, due to the inputs from avian species or other wildlife. Sewage discharge, septic tank contamination, stormwater drains, wild- and livestock defaecation, run-off from contaminated fields, as well as industrial and municipal effluent, can all potentially contaminate the surface waters.

Table 6.9 Relationship between pre-and post-harvest practices and socio-economic factors

	p-value				
	Farmer group	Age	Gender	Education level	Training
Farming method practiced	0.602	0.709	0.936	0.573	0.802
Type of fertiliser used					
Animal	0.361	0.474	0.351	0.205	0.258
No fertiliser	0.488	0.296	0.147	0.525	0.976
Compost	0.075	0.162	0.136	0.018*	0.938
Store fertiliser	0.454	0.888	0.087	0.859	0.394
Type of irrigation					
Borehole	0.734	0.881	0.477	0.337	0.087
Tap water	0.825	0.938	0.065	0.255	0.096
Grey water	0.964	0.109	0.192	0.281	0.199
Stored water	0.182	0.169	0.018*	0.796	0.643
River water	<0.001*	0.703	0.717	0.076	0.976

* Indicates significance ($p<0.05$)

6.8 Microbiological Quality Analysis and Physico-Chemical Parameters

The microbiological quality of the water was assessed by determining the Most Probable Number (MPN) for total and faecal coliforms and *E. coli*, aerobic plate counts, as well as intestinal enterococci and the presence of *Salmonella* spp.

6.8.1 The uMsunduzi River as water source used by farmers

Salmonella spp. was detected in the uMsunduzi River water during two sampling sessions, and it was confirmed by the growth on the XLD and Rambach agar (Table 6.10) as well as the prescribed biochemical tests (ISO 6579). The presence of *Salmonella* spp. may be due to faecal contamination that is introduced through sewage leaking into the river. Furthermore, it was frequently detected in the same river in an earlier study (Gemmell and Schmidt, 2013). At the same time, intestinal enterococci were detected in the uMsunduzi River water samples, with counts ranging between 205-323 cfu/100 ml, while counts below 100/100 ml were detected in water tanks (Tables 6.10 and 6.11). The absence of *Salmonella* spp., a pathogen, in most water samples, with the exception of the river water on two occasions, meets the national and international guidelines for safe irrigation water (WHO, 2006; European Commission, 2007). A similar study by Beharielal et al. (2018) reported the absence of *Salmonella* spp. in the Mnini River water samples, and an earlier study of the uMsunduzi River found that *Salmonella* spp. was detected when the faecal coliform counts were high and exceeded the WHO guidelines for safe irrigation (Gemmell and Schmidt, 2013). There are currently no national recommendations on the acceptable intestinal enterococci counts for irrigation water, even though for full contact irrigation the level of intestinal enterococci should not exceed 100 per 100 ml irrigation water (DIN 19650, 1999). Alarmingly, the results demonstrated that the microbial contamination of the uMsunduzi River, with regard to its *E. coli* levels, has not improved but has substantially deteriorated when compared to an earlier study (Gemmell and Schmidt, 2013).

Table 6.10 uMsunduzi River physico-chemical and microbiological analysis for the months of November 2020 through to September 2021

uMsunduzi River

Date	Temperature (°C)	pH	COD (mg O_2/ L)	APC (cfu/ml)	Total coliforms (MPN/100 ml)	Faecal coliforms (MPN/100 ml)	*E.coli* (MPN/100 ml)	Salmonella spp.	Intestinal Enterococci (cfu/100 ml)
16/11/2020	-	-	-	-	160 000	28 000	24 000	-	-
10/12/2020	25	8.15	44	$2.33x10^4$	64 000	46 000	17 000	n.d	213
26/02/2021	26	7.87	61	$9.2x10^5$	130 000	79 000	11 000	n.d	283
17/03/2021	21.5	8.14	91	$6x10^4$	79 000	49 000	17 000	n.d	210
30/03/2021	25	8.17	72	$8.27x10^5$	4 900 000	220 000	130 000	n.d	205
13/04/2021	23.6	7.26	61	$7x10^3$	170 000	79 000	17 000	n.d	323
20/04/2021	20.1	7.83	69	$2.4x10^6$	2 400 000	330 000	240 000	positive	298
12/05/2021	25	7.35	71	$1.15x10^4$	110 000	70 000	2 800	n.d	205
26/05/2021	15	7.56	73	$1.19x10^5$	79 000	49 000	22 000	n.d	213
17/06/2021	16	7.50	87	$8.45x10^5$	170 000	27 000	6 800	positive	270
05/08/2021	18	7.45	124	$5.7x10^4$	33 000	13 000	2 400	n.d	286
25/08/2021	20.1	7.74	108	$4.5x10^4$	49 000	24 000	3 500	n.d	274
13/09/2021	19.5	7.58	78	$6.4x10^4$	24 000	7 900	1 700	n.d	262
27/09/2021	22.5	7.62	82	$8.1x10^5$	420 000	1 100 000	3 400	n.d	245

-: samples not taken, n.d: below limit of detection

6.8.2 Tap water and harvested water (tanks and containers) used by urban farmers

As expected, the collected tap water was below the detection limit for total coliforms, faecal coliforms and *E. coli*. for all the sampling sessions. The tank water exhibited lower counts than river water for total (<1.8-330 MPN/100 ml) and faecal (<1.8-79 MPN/100 ml) coliforms and *E. coli* (<1.8-7.8 *E. coli*/100 ml) throughout the sampling sessions, thus far meeting the acceptable range of <1000 MPN/100 ml stipulated by the WHO for safe irrigation (Tables 6.11 and 6.12) (WHO, 2006). The reduction in the water container counts is probably due to exposure to ultraviolet radiation, which can cause a die-off of microorganisms, as these tanks are exposed to the sun for long periods (Turtoi, 2013). On most sampling occasions, the heterotrophic plate counts for the uMsunduzi River and tank water exceeded the DWAF guidelines for domestic use of a maximal 100 cfu/ml, with counts for the tap water exceeding this value on four occasions (Tables 6.10 and 6.12) (DWAF, 1996). As observed on the farm in Figure 6.5, the hosepipe was exposed to contamination through contact with the soil, due to improper storage and a lack of cleaning before and after use. It also appears that the stored tank water was of a better quality and could be a potential substitute because it has a lower microbial burden, and simply trying to switch to tap water may not be possible for some of the farmers, without incurring additional financial costs.

The fact that urban farmers practise overhead irrigation could also enable transfer of pathogenic bacteria that are present in the irrigation water onto the fresh produce. By simply changing the irrigation method and using a form of drip irrigation, the microbial burden could be reduced significantly (Uyttendaele et al., 2015). However, drip irrigation might not be feasible for the farmers, given the underlying cost. Thus, it is imperative they use water sources that are safe for overhead irrigation, while being both cost-effective and accessible, to alleviate water insecurity in the study area. Hence, an improvement in water security will not only result in the improved quality of fresh produce, but it will also improve the livelihoods of the farmers and the community and it will enable them to access the highly-regulated markets. The agro-processing practices of the farmers would also benefit, as they currently lack knowledge about basic water hygiene.

Table 6.11 Water container physico-chemical and microbiological analysis for the months of December 2020 through to September 2021

Water container									
Date	Temperature (°C)	pH	COD (mg O_2/L)	APC (cfu/ml)	Total coliforms (MPN/100 ml)	Faecal coliforms (MPN/100 ml)	*E.coli* (MPN/100 ml)	*Salmonella* spp.	Intestinal Enterococci (cfu/100 ml)
16/11/2020	-	-	-	-	-	-	-	-	-
10/12/2020	29	8.82	78	$1.8x10^3$	46	33	7.8	n.d	2
26/02/2021	31	8.82	48	$1.6x10^4$	33	11	2	n.d	n.d
17/03/2021	23	7.75	114	180	110	4.5	4.5	n.d	n.d.
30/03/2021	29	8.06	73	$5.5x10^5$	<1.8	<1.8	<1.8	n.d	72
13/04/2021	26	9.35	48	$9x10^3$	<1.8	<1.8	<1.8	n.d	n.d
20/04/2021	19.8	8.3	112	$1.6x10^5$	14	9.2	<1.8	n.d	12
12/05/2021	29	9.35	79	14	170	27	<1.8	n.d	25
26/05/2021	15.1	9.05	104	$8.3x10^3$	330	79	<1.8	n.d	7
17/06/2021	14.8	9.14	134	$8.6x10^3$	240	79	<1.8	n.d	30
05/08/2021	16.7	8.6	125	$1.0x10^5$	26	4.5	<1.8	n.d	2
25/08/2021	20.1	9.04	137	$2.1x10^3$	13	7.8	<1.8	n.d	18
13/09/2021	21.4	8.8	108	$2.1x10^3$	79	4.5	<1.8	n.d	n.d
27/09/2021	25.3	9.11	126	$6.4x10^3$	4.5	<1.8	<1.8	n.d	36

-: samples not taken, n.d: below limit of detection

Table 6.12 Tap water physico-chemical and microbiological analysis for the months of December 2020 through to September 2021

Tap water

Date	Temperature (˚C)	pH	COD (mg O_2/L)	APC (cfu/ml)	Total coliforms (MPN/100 ml)	Faecal coliforms (MPN/100 ml)	*E.coli* (MPN/100 ml)	Salmonella spp.	Intestinal Enterococci (cfu/100 ml)
16/11/2020	-	-	-	-	-	-	-	-	-
10/12/2020	33	8.78	154	n.d.	<1.8	<1.8	<1.8	n.d	n.d
26/02/2021	31	8.09	87	620	<1.8	<1.8	<1.8	n.d	n.d
17/03/2021	33	7.61	139	480	<1.8	<1.8	<1.8	n.d	n.d
30/03/2021	33	8.43	87	560	<1.8	<1.8	<1.8	n.d	n.d
13/04/2021	27	8.33	87	180	<1.8	<1.8	<1.8	n.d	n.d
20/04/2021	23	8.6	84	n.d.0	<1.8	<1.8	<1.8	n.d	n.d
12/05/2021	33	6.97	78	n.d.0	<1.8	<1.8	<1.8	n.d	n.d
26/05/2021	20	8.46	113	n.d.0	<1.8	<1.8	<1.8	n.d	n.d
17/06/2021	22	7.8	76	n.d.0	<1.8	<1.8	<1.8	n.d	n.d
05/08/2021	18	8.1	98	n.d.0	<1.8	<1.8	<1.8	n.d	n.d
25/08/2021	17	7.9	126	n.d.0	<1.8	<1.8	<1.8	n.d	n.d
13/09/2021	18.6	8.43	69	0	<1.8	<1.8	<1.8	n.d	n.d
27/09/2021	23	8.41	74	0	<1.8	<1.8	<1.8	n.d	n.d

-: samples not taken, n.d: below limit of detection

Figure 6.5 Farm site showing an irrigation system used by smallholder farmers (a hosepipe)

6.9 Perceptions of Farmers on Produce and Environmental Hygiene Conditions on the Farms and the Market

According to the findings in Table 6.13, 1.3% of the respondents were somewhat aware of the World Health Organisation (WHO) recommendations on the use of wastewater, owing to a training course that they had attended on irrigation techniques. Their awareness did not imply that they were only producing with WW. This was also demonstrated by the fact that, despite receiving training on the use of WW, farmers rarely use it. The majority (98.7%) of farmers indicated that they pre-wash their vegetables before selling them to their customers, which demonstrates their recognition of the importance of meeting consumer expectations regarding the visual appeal and cleanliness of the product. Farmers who practise mixed farming (92.3%) practised safe animal husbandry by building a fence between their livestock and crop production sites. However, FGDs on the environmental effects of this revealed that some members of the community would destroy or even go as far as stealing farmers' produce once it was ready for harvest, despite the farmers' fences, which would result in human risk and indicates the communities' struggle with social cohesion.

In addition to selling from their farms, the farmers mentioned that they have an informal community market at which they sell their produce. However, they may not have access to rest-room facilities because these markets are informal, and some farmers may not have such facilities in their fields, which may be far from their homes. The findings showed that the majority of farmers (91%) used public toilets, while 7.7% used their neighbours' toilets and only 1.3% used the open fields. This demonstrates an understanding of the health implications if the proper facilities are not used, which could also affect the number of potential customers.

The majority of farmers (72%) indicated that tap water was their water source at the markets and on the farms, while 28.2% said they would buy water at the market. The findings also showed that the majority of farmers (79.5%) were converting their organic waste into compost for their fields, which can be viewed as a less expensive alternative when preparing the land, because it is both cost-effective and good for the soil. However, some farmers (10.3%) disposed of their organic waste by throwing it away, which also reflects their level of knowledge about the benefits of using organic waste in their fields.

There remains cause for concern, because some farmers (37.2%) were unwilling to implement environmentally friendly techniques, such as using fewer pesticides on their crops. Approximately 78.2% of the farmers stated that they use animal manure on their production sites, which can be considered an environmentally friendly technique. The use of animal manure is motivated by a variety of factors, including the market price of compost, the suitability of manure for the soil, as well as its benefits for their crops.

Regarding environmental risk assessment, approximately 83.3% of respondents believed that there is sufficient land available to cultivate food for the entire population. However, when asked if they believe that engaging in urban agriculture can mitigate the effects of climate change, only 53.8% concurred, while others exhibited a lack of awareness concerning the negative or positive impacts of climate change. This revelation is significant as it highlights a disparity: while 84.6% of respondents agreed that humans are abusing the environment, only a small percentage were aware of the negative effects of climate change as well as the primary causes of climate change, namely human activities. The farmers' responses indicated a lack of knowledge about the environmental risks; their knowledge about climate change, its causes and how to mitigate its effects. According to Gainnin et al. (2017), climate change has an impact on the agricultural yield of commodities such as maize, rice, sorghum and millet. This was demonstrated in the early 1970s global food crisis for example, when the worst global drought and famine in history culminated in a decrease in production related to the *El Nino* phenomenon in 1972/73 (Gerlach, 2015). The effects of drought are expected to be more severe in leafy vegetables as they have high water requirements, thus making vegetable growers vulnerable to the effects of climate change (Gainnin et al., 2017; Hlahla and Hill, 2018).

The farmers were also asked if they had insurance, in the case of a disaster, and none of them did. While 85.8% thought that insurance was important, only 67.9% said that they would get insured if they had the money (i.e. from finance institutions that have such facilities). The responses show that, while the majority of farmers are aware of the risk(s) of climate change to their businesses, they are not considering ways of mitigating its effects, or even reducing the cost of damage caused by natural disasters.

Table 6.13 Risk perception of farmers in relation to the environment and their production sites

Factors influencing farmers' risk perception of the environment		Percentage (%)
Knowledge of WHO recommendations on the use of WW		1.3
Pre-wash their crops before selling at the market		98.7
Practise safe animal husbandry		92.3
Lavatory facilities at farm/market	Public toilets	91.0
	Open Fields	1.3
	Neighbours' toilet	7.7
Source of drinking water at farm or market	Store bought	28.2
	Tap water	71.8
	River/dam	-
Discarding organic waste	Throw away	10.3
	Burn	3.8
	Make compost	79.5
	Throw in dumpsite	6.4
Discarding animal waste (manure)	Use in vegetable farming	78.2
	Sell to neighbours	16.7
	Throw in dumpsite	5.1
Use of chemicals		37.2
Believe that environment has enough land for everyone		83.3
UA can mitigate climate change effects		53.8
Humans abusing the environment		84.6
The use of vacant land and abandoned buildings to mitigate climate change and to address food insecurity		73.1
Have insurance, in case of hazards (drought, fire, hailstorm or floods)		-
See hazard insurance as vital		85.9
Would acquire hazard insurance		67.9

In summary, it is clear that the communities depend heavily on municipal taps for their domestic water supply, but they also integrate harvested rainwater during the rainy season and use nearby streams and rivers during municipal water outages. However, tap water, the main source of water, is not sustainable and needs to be improved as a key water source for urban agriculture, due to the high cost of municipal water. Other water harvesting and retention technologies will have to be applied, in order to improve productivity and to produce a surplus that can be sold. The following section addresses the role of water security. An index of water security is important and the data have been collected and computed by using the adapted HFIAS and are presented in Figure 6.6.

6.10 The Entrepreneurial Risk Factors that Affect Urban Agriculture

The aim of this study was to assess how water access, availability, as well as the utilisation and stability of the supply pillars, determine water security. However, there are also risk factors in urban agriculture that affect its profitability, production yield and quality. Production risk, price/market risk, financial risk, institutional risk, and human or personal risk are the five currently-known risk factors in agriculture that impact the production yield and quality. Louw and Jordaan (2016) found that smallholder farmers are less likely to take on risk along the formal value chain, but that they rather opt for the low-value formal markets.

6.10.1 Human or personal risk and off-farm effects on entrepreneurship in urban agriculture

In this category, the components of the environmental hygiene conditions were used to extract the entrepreneurial risk indices in the environmental hygiene conditions category in Table 6.14, where six indices were extracted and only two categories had Eigen values greater than one, according to the Kaiser criterion. The two extracted principal components account for 63% of the total variations of the variable. The first component (PC-EHC1) was found to be closely-related to human/personal risk and explained 42% of the variations. According to Korir (2011), human/personal risk has been linked to the principal's injury, death or illness (farm). The second component (PC-ECH2) explained 23% of the variations and was found to be closely related to human risk as improper organic waste disposal. Van Deventer (2012) observed that proper waste disposal increases food and nutrition security at the market or on the farm, as it can have a significant impact on the health of workers and residents in the area.

Table 6.14 PCA for human or personal risk on- and off-farm effects on entrepreneurship in UA

Variables	Principal Components			
	PC-Hygiene in farm/market	PC-Discarding waste at farm/market		
1. Place of ease at farm or at the market	0.502			
2. Mode of discarding animal waste	0.425			
3. Source of H_2O at market/farm				
4. Vegetables sold at the market (e.g. leafy, roots)	0.361	-0.770		
5. Mode of discarding organic waste	0.563	0.600		
6. Use of chemicals in fields				
Eigen Value	2.928	1.612		
Variance explained (%)	42	23		
Cumulative % of variance explained (%)	42	65		
Keiser-Meyer-Olkin (KMO)	0.633			
Measure of sampling adequacy	Bartlett Test of Sphericity	Chi-Square	Sig	d.f
		30	0.000	21

6.10.2 Market risk effects on entrepreneurship in urban agriculture

Ten components of entrepreneurial risk were used to extract market risk indices and only four Principal Components (PCs) were extracted with Eigen values greater than 1 as per the Kaiser Criterion, which contributed 68% of the total variation of the variables used in Table 6.15. The first component (PC-Mrkt1) explained 35% of the variations and was found to be close to market access. According to Murangai and Thamaga-Chitja (2018), market access was found to reduce the poverty of smallholder farmers at a household level; however, concerns about the market prices, the trustworthiness of agents at the market and among farmers, as well as the excessive agents' fees, all have an impact on the farmers' income-generating capacity. The second component (PC-Mrkt2) explained 22% of the variations and was found to be closely linked to the threat of substitutes at the market. According to Abinsay (2020), the availability of substitutes on the market reduces the consumers' risk by allowing them to switch from one alternative to another in response to price increases. The third component (PC-Mrkt3) accounted for 15% of the variations and was discovered to be closely related to the buyer's bargaining power, i.e. the ability of buyers to control the producer's or supplier's ability to be profitable. According to Bechdol et al. (2010), the quantity of products produced influences the market prices, and farmers tend to be price-takers when there are only a few buyers. The fourth component (PC-Mrkt4) accounted for 10% of the variations and was discovered to be closely related to the number of producers in the market when determining the price. According to Abinsay (2020), the number of suppliers in an industry is usually directly proportional to the number of players. Bechdol et al. (2010) and Abinsay (2020) found that a large number of farmers are exploited by input suppliers, for example, in relation to fertilisers, seeds and pesticides, due to the farmers' low bargaining power.

Table 6.15 PCA for market (price) risk effects on entrepreneurship in UA

Variable	Principal Components			
	PC_1 (Market entry)	PC_2 (Substitutes)	PC_3 (Switch buyers)	PC_4 (Producers in market)
1. Switch from one buyer with ease	0.489			
2. Able to sell to markets	0.456			
3. Readily-available substitutes at market			0.666	
4. Keep records of produce	0.471			
5. High enough degree of competition			0.651	
6. Sold at the FPM	0.481			
7. Enough producers in the market for price determination		0.368		0.750
8. Consider their business successful		0.392		-0.633
9. Ease of market entry		0.591		
10.Give customers credit		0.589		
Eigen Value	3.509	2.258	1.489	1.019
Variance explained (%)	35	22	15	10
Cumulative % of variance explained (%)	35	57	72	83
Keiser-Meyer-Olkin (KMO)	0.687			
Measure of sampling adequacy	Bartlett test of sphericity	Chi-Square	Sign.	d.f
		421.32	0.000	45

6.10.3 Production risk effects on entrepreneurship in urban agriculture

The PCA derived from the entrepreneurial risk, i.e. the financial and institutional risk indices, are reported in Table 6.16. The Bartlett's Test of Sphericity and the KMO measure of sampling adequacy indicated that the data were appropriate for PCA. The results in Table 6.16 indicated the significance of the Bartlett test (1%) and suggested that the variables were inter-correlated. Moreover, the KMO measurement (0.7) was greater than 0.5, which indicated the suitability of PCA. Twelve components of the financial and institutional risk were used to extract the indices, and only four principal components had Eigen values above 1, as per the Kaiser Criterion. The four extracted PCs contributed 71% of the total variations of the variables used. The first component (PC-F1) explained 32% of the variations and was found to be closely-related to the awareness of contracting as a risk management strategy.

According to Kahan (2013) and Korir (2011), risk management strategies in agriculture are vital as there is a high variability in the agricultural sector, thus strategies such as contracting, price stabilisation and information, and credit subsidies are employed to minimise the uncertainty. The second component (PC-EC) explained 18% of the variations and was found to be closely linked to climate change. According to Hlahla and Hill (2018), the effects of climate change can be clearly seen among the urban poor (i.e. women, children and the elderly), doubling their vulnerability due to the climate-related risk and poverty. The third component explained 14% of the variations and was found to be closely linked to an awareness of the environment. According to Giannini et al. (2016), there is a link between climate change and food security, which can be positive, provided that the farmers understand the complexities of climate variability and how it can be managed better. The fourth component explained 10% of the variations and was found to be closely linked to urban agriculture for mitigating the impacts of climate change. Studies by Khalil and Najar (2012), Hallet et al. (2016) and Steele (2017) found that urban farming can reduce the carbon footprint, depending on the species planted, as some fruit, such as strawberries, were found to be contribute more to GHG emissions.

Table 6.16 Production risk effects on entrepreneurship in UA

Variable	Principal Components			
	PC_1 (Risk aware)	PC_2 (Climate impact)	PC_3 (Environ. Aware)	PC_4 (UA mitigate)
1. Know organisation for UA		0.445		
2. Have access to extension services		0.423		
3. Importance of crop insurance	0.499		0.641	
4. Would take contracting to diversify risk	-0.415			
5. Part of UA organisation	0.513	0.576	0.610	
6. UA mitigates climate change	0.411			
7. Use of vacant spaces to feed poor insurance on crops				
8. Humans abuse environment		-0.481		0.638
9. Insurance on crops		-0.413		
10. Environment has enough land			-0.580	
11. Would acquire crop insurance	0.401			0.471
12. Aware of contracting				0.520
Eigen Value	3.579	2.113	1.682	1.197
Variance explained (%)	32	18	14	10
Cumulative % of variance explained (%)	32	47	62	71.4
Keiser-Meyer-Olkin (KMO)	0.672			
Measure of sampling adequacy	Bartlett test of sphericity	Chi-Square	Significance	df
		384.42	0.000	66

6.10.4 The psychological capital dimensions of entrepreneurship in urban agriculture

The PCA derived from the entrepreneurial risk, i.e. the financial and institutional risk indices, are reported in Table 6.17. The Bartlett's Test of Sphericity and the KMO measure of sampling adequacy indicated that the data were appropriate for the PCA. The results in Table 6.17 indicate the significance of Bartlett's test (1%) and suggest that the variables are inter-correlated. Moreover, the KMO measure (0.6) was greater than 0.5, which indicated that the PCA can be applied to the dataset. In the same vein, the multidimensionality of Likert scale questions on psychological capital was reduced with the aid of PCA. The first three principal components with an Eigen value above 1 were retained. The three extracted PCs contributed 57% of the total variations of the variables used. The first component of (PC- Opt_Agr) explained 23% of the variations and was found to be closely linked to the farmers' being optimistic about the future of urban agriculture, as they believe that the constraints are minor and can be addressed easily. The second component explained 18% of the variations and was found to be closely linked to the hope and resilience of the farmers. It was found that the farmers were still willing to continue farming, even though they faced several constraints, such as inadequate access to finance (Zaca et al., 2021). The third component explained 16% of the variations and was found to be closely linked to the willingness of the farmers to take on risk, i.e. to take on other business opportunities. The farmers were open to exploring farming business opportunities; however, capital farming constraints and the lack of resources made it difficult for them, which made them risk-takers.

Table 6.17 The effects of psychological capital dimension on entrepreneurship in UA

Variables	Principal Components		
	PC_1- Hope and Resilience.	PC_2- Optimistic	PC_3- Risk taking
1. Poor yields, capital constraints and struggling to make ends meet would not be motivation enough to quit UA.	.744		
2.Trust other farmers	.625	.463	
3.Enjoy new challenges	.557		-.546
4.Willing to take on risk in comparison to other farmers	-.510		
5. Do not give up easily (low yields and constraints are temporary)		.825	
6.Optimistic about the future of UA, even when faced with constraints		-.551	
7. Cope with shocks, such as droughts and natural disasters			.831

Variables	Principal Components			
Eigen Value	1.587	1.244	1.123	
Variance explained (%)	22.67	17.78	16.04	
Cumulative % of variance	22.67	40.446	56.50	
Keiser-Meyer-Olkin (KMO)	0.671			
Measure of sampling adequacy	Bartlett test of sphericity	Chi-Square	Significance	df
		60.55	0.000	44

6.11 The Distribution of the Water Security Status Among Smallholder Vegetable Farmers

The continuous measurement of the level of food insecurity (access) was obtained by using an adapted HFIAS to measure the water security status, as can be seen in Figure 6.6. The method was employed by Sinyolo et al. (2014) and Brewis et al. (2021) because of its ability to capture all four areas of food security, namely, access, anxiety, inadequate quality and the quantity of the food supply (Mango et al., 2014). Thus, a higher score indicates a water insecure household (Maziya et al., 2017; Brewis et al., 2021). The food security status distribution of smallholder vegetable farmers indicated that 45% of the total population was water insecure, 27% was mildly water insecure, 22% was moderately water insecure, while 6% reported being water secure. Generally, these findings suggest that smallholder vegetable farmers are water insecure.

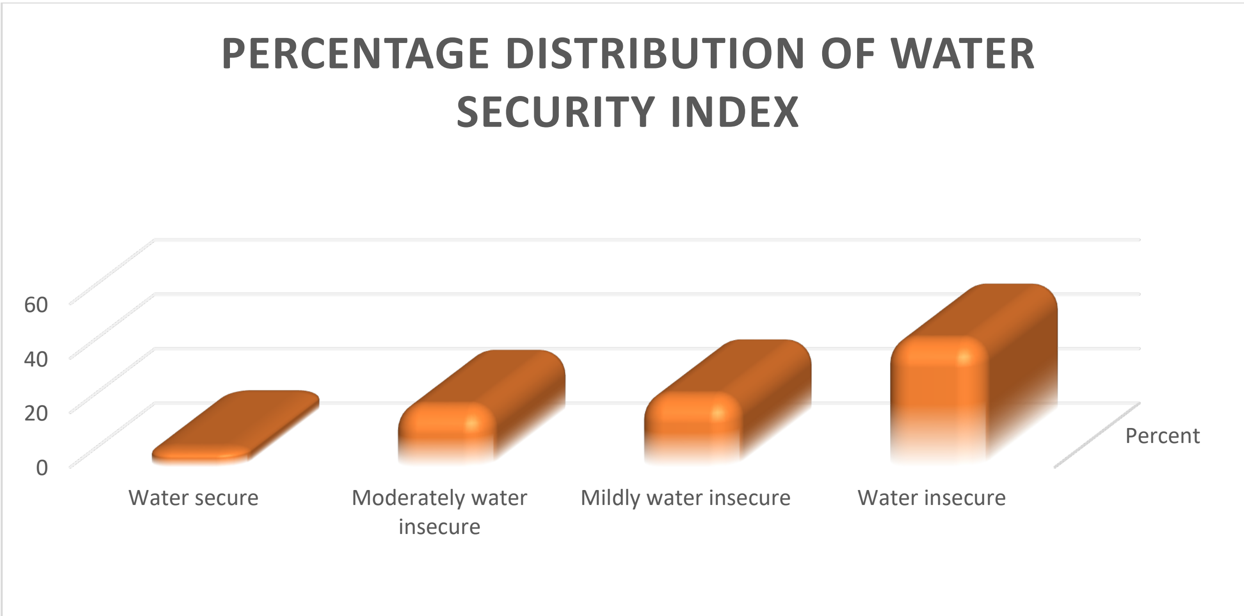


Figure 6.6 Percentage distribution of the water security index

As shown in Table 6.18, the farmer's age plays a positive role in influencing the perceived water security level of smallholder vegetable farmers. Age is an expression of experience and wisdom in handling the water challenges, thus, it has a positive influence on water security. This result is in tandem with the study of Sinyolo et al. (2014), who found that the farmers' age had a positive influence on water security in South Africa. It is not unexpected that having a high off-farm income increased the water security. An increased off-farm income shows the ability to pay for water without fail, which hence improves the water security, especially in the areas that pay for water, where municipal water is the most common water source. Therefore, having a higher off-farm income, which is tantamount to being able to afford to pay for water, increases the likelihood that households will practise different agricultural enterprises, compared to water insecure households, which may focus on limited food options and agricultural enterprises that do not require more water. This finding agrees with the study of Ningi et al. (2021), who stated that being able to afford to pay for water decreases the probability of high food insecurity.

The coefficient of access to training was positive and statistically significant in influencing water security in the study area. As the farmers receive agricultural and irrigation training, the likelihood of improved water security is expected. The implication of this result shows that the more the farmers have access to agricultural and irrigation training, the higher their water security status will be. This is evident in the marginal analysis depicted in Table 6.18, which shows that a unit increase in access to training leads to a 25% increase in the water security level.

Table 6.18 Poisson regression of the factors influencing water security

Water security	Coef.	Std err.	P-value	dy/dx	Std. err	P-value
Gender	0.086	0.064	0.177	1.404	1.041	0.178
Age	0.154	0.045	0.001***	2.511	0.736	0.001***
Education	0.032	0.034	0.343	0.527	0.556	0.343
Training	0.153	0.067	0.023**	0.250	0.101	0.023**
Income	0.065	0.016	0.000***	1.063	0.264	0.000***
Experience	0.085	0.026	0.001***	1.387	0.427	0.001***
Land Ownership	0.022	0.042	0.606	0.356	0.690	0.606
Constant	2.403	0.205	0.000***			
Pseudo r-squared	0.068					
Chi-square	41.349					
Akaike crit. (AIC)	579.449					
Bayesian crit. (BIC)	598.302					
Number of obs	78.000					
Prob > chi2	0.000					

*** p<0.01, ** p<0.05, * p<0.1

6.12 Conclusions

Water security was found to be low, as the main source that is relied upon was costly and unreliable. Although tap water was easily accessible and available, its use was unsustainable due to the cost of municipal water. The river water was abundant during most of the year, but was often contaminated, which posed a risk to the safety of the produce. The findings indicated that water scarcity and the lack of access to water for these farmers were due to natural and financial factors, which weakened the farmers' ability to explore market access and supply these markets throughout the year. The farmers need to be empowered in the technologies of water harvesting and retention. This knowledge is available in the Sobantu field schools, where mulching and water safety are being taught to reduce the microbial load. These results show that there is a need for improved human developmental training to educate the farmers and to provide them with more knowledge about irrigation.

The study results indicate that the farmers are more socially- and economically motivated to engage in farming and less inclined to be concerned about the environment. It was therefore expected that these farmers would not adopt environmental management practices, as they would be less aware of and concerned about the environment, but more concerned about the immediate need to obtain extra food and to generate enough profit to sustain their households and livelihoods. It was also found that many agro-processors have a need for high-quality water; for instance, to wash their fresh products.

As a result, the treatment and consistent quality control of the farmers' water sources and their washing practices require constant monitoring. A study by Murungani and Thamaga-Chitja (2018) found that reduced water quality results in reduced production and access to the market. Hence, irrigation water for fresh produce needs to be of a high quality, in order to maintain the safety and quality of food. The availability of irrigation water may lead to increased crop yields and crop quality, which will potentially promote food security.

Knowing when to irrigate crops and how much water to use is crucial for maximising vegetable yields. To educate the farmers and provide them with knowledge of irrigation, human developmental training is imperative for improved productivity and enhanced access to market. Consequently, the two additional food security pillars, namely, sustainability and agency are improved. Given the limiting factors, including the constant water-cuts and high-water tariffs, poor smallholder farmers need cost-effective, but reliable, water sources.

Furthermore, the results on the potential contamination sources show that, while soil contamination training does not seem significant, it is essential, because food safety is an important market access factor (for household, raw and commercial products), and the amount of soil present during and after harvesting may pose a risk of contamination. It was found that farmers are not saving water to address the country's water security issues, but rather they are influenced by the local government and their socio-economic constraints. The low adoption of water quality management practices can be attributed to the fact that the majority of the farmers are dependent on tap water. The reason for this is that, although the Sobantu farmers had access to the uMsunduzi River, they were forced to stop using the water source due to visible signs of contamination and several findings declaring that its water was unsuitable for use.

The effects of climate change are expected to be more severe in crops of leafy vegetables, as their water requirements are high, thus making vegetable growers vulnerable to the effects of climate change. Hence, there is a need to address the risk factors of agriculture holistically and to focus mainly on generating an income for the smallholder urban farmers.

Based on the PCA analysis, it can therefore be reasonably concluded that water quality is a probable risk for entrepreneurial efforts and also impedes farmers' access to markets. The third component explained 16% of the variations and was found to be closely linked to the willingness of the farmers to take on risks, i.e. other business opportunities. The farmers were open to exploring farming business opportunities; however, capital farming constraints and the lack of resources made it difficult for them and made them risk-takers. Farmers are faced with various constraints, such as the lack of access to markets, inability to acquire certification to meet the market standards, as well as their low bargaining power, which all hinder their ability to make an adequate profit. This indicates that they do not have the purchasing power and cannot afford the constant need for synthetic chemicals; therefore, they are more likely to adopt organic methods of crop production, which do not require much agricultural input. In summary, this study has presented factors that enhance water security among smallholder vegetable farmers in the study area. In particular, the study highlighted the importance of strengthening the agricultural training of farmers and their involvement in off-farm income activities as a panacea for the enhanced water security status of smallholder vegetable farmers in KwaZulu-Natal Province of South Africa.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This study assessed the entrepreneurial risk linked to water quality, water security for urban-based farming and agro-processing in Sobantu, Mpophomeni and Sweetwaters of KwaZulu-Natal Province. Climate change is an important issue to consider in agriculture, including urban agriculture, and particularly in KwaZulu-Natal where flooding has been an issue. Given the fast expansion of urbanisation in the world, including South Africa, the need for nutritious food will increase further, putting more strain on the urban food system. Urban agriculture has the potential to mitigate poverty and enhance food and nutrition security. However, entrepreneurial endeavours in overpopulated areas may be impeded by poor water quality, and limited profitability, land, and access to markets. However, there are growing benefits of urban agriculture including social urban and environmental renewal (Yuan, 2022). The study had several objectives to fulfil: a detailed literature review on the entrepreneurial risks associated with the quality and security of water supplied to urban-based farming and related agro-processing, as well as equity among the water users and water recycling. The second objective considered the assessment of the stakeholders, water quality, water access, urban farming, agro-processing, and the nature and role of stakeholders, on the entrepreneurial risks in urban farming. In the same vein, the third objective explored the stakeholder workshop to establish a Political, Environmental, Social, Technical, Economic and Legal (PESTEL) environment for urban farming and agro-processing, while the fourth objective assessed the microbial burden of irrigation water. The last objective critically assessed the water security, using the lens of availability, accessibility, utilisation, and stability of water supply.

7.2 Conclusion

Typically, most smallholder capacity to supply consistently the market is challenged by an inadequate supply of water and other resources including such finances. The field schools in Sobantu were valuable in capacity building on mulching and the safe use of water, in order to minimise the microbial burden. The process contributed to ongoing empowerment of the farmers with regard to water use and water retention. To increase productivity and gain access to new markets, farmers need to receive training in human development skill including communication, group management, business principles while technical skill in appropriate irrigation and crop disease and pest management ned ongoing enhanced.

This will support the two new additional pillars of food security – sustainability and agency. Because of their constraints, such as the constant water-cuts and the high price of water, poor smallholder farmers require an affordable, yet reliable, water supply such as climate smart water harvesting. Furthermore, training on the potential sources of contamination remains still important because food safety is crucial for market access (for household, raw and commercial products). For example, simple practices of removing excess soil from crops at harvest and after harvesting may increase the risk of contamination. It was positive to observe that, although limited, some farmers are conserving water through JoJo tanks for their own use as a response to their own socio-economic condition due to high water costs.

It is important for agricultural risks related to water safety and contamination must be addressed with a focus on urban farmers since, agriculture is a livelihood option and an avenue for entrepreneurship. generates income for them. There are a number of challenges that prohibit farmers from making an adequate profit when they produce a surplus, including their limited market access, their lack of the necessary certification to meet the market standards and their inadequate bargaining power. Urban farmers need institutional arrangements that make it possible for them to supply constantly and have meaningful market supply.

From the study, it can be concluded that market participation can be enhanced by increasing market information sources to the urban farmers through appropriate market-focused extension services. Enhancing access to market information through various means such as including radio (focused radio programmes), television, social media and applications such as WhatsApp and Facebook App.

7.3 Recommendations

The study recommends various policy and programmatic interventions that will yield agency and empowered farmers. The findings demonstrate the need to enhance farmers' knowledge and behaviour regarding irrigation practices through human developmental training, which will enable them to produce on a larger scale and to gain access to markets. This will likely add to food security by improving access and availability. Given the limiting factors, including the constant water-cuts, high water tariffs, and climate change effects such as flooding, poor smallholder urban farmers require cost-effective, but reliable water sources.

The findings also revealed that the lack of access to water and water scarcity experienced by farmers affected entrepreneurial endeavours. Their capacity to investigate market access and supply throughout the year is weakened by a shortage of water and other resources including storage and packing facilities. For example, small agro-processors have a significant need for a physical facility and quality water for washing their fresh items. Furthermore, good agricultural practices and hygiene awareness are important because they are crucial for decreasing pre- and post-harvest microbial contamination and for market access.

The results further indicated that the low adoption of water quality management practices can be attributed to the fact that the majority of the farmers are dependent on tap water provided by the local municipality. However, there are local government limitations on tap water use for agricultural purposes, while the quality of alternative water sources is not actively monitored.

Due to their high need for water, leafy vegetables are predicted to experience the consequences of climate change and water scarcity more severely, which makes vegetable growers more susceptible to climate change effects. Because urban farmers are exposed to various risks, regardless of the type of enterprise, there is therefore a need to address the risk factors of urban agriculture holistically including appropriate production systems.

Further the study recommends the involvement of the youth for sustainability of farming, innovation for sustained urban farming participation. The study recommends urban policies and programs by various stakeholders that strengthen market training activities and form farmer group and co-operatives to improve market participation among smallholder urban farmers as co-operation addresses prevailing scale issues.

Entrepreneurship is vital for livelihoods, particularly in a low job market such as South Africa. For urban farming has is positive for both improving access to improves nutrition and possible extra income is well supported. Therefore, the study recommends a business-driven action learning (BDAL) process for urban farming entrepreneurs to determine internal and external factors for the success of urban farming. In addition, the study recommends that water security is ensured through improved access and smart water use. Local government needs to play a more attentive water safety role needs attention to ensure food safety. Recommendations regarding the strengthening of urban farming and agro-processing include entrepreneurial capacity-building of farmers and physical market entry to encourage produce aggregation for market access and to enable distribution.

REFERENCES

Abbas, S, Zakar, R and Fischer, F. 2020. Qualitative study of socio-cultural challenges in the nursing profession in Pakistan. *BMC Nursing*, 19, 1-7.

Abdulla, N. 2020. PESTEL analysis of Maldivian agricultural system to improve agricultural management. Online Publication. Available at: https://dspace.dsau.dp.ua/bitstream/123456789/3506/1/PESTEL%20Word%20%28pdf.io%29.pdf. (Accessed 22 November 2023).

Accuweather 2021. Available Online https://accuweather.com/en/za/pietermaritzburg. Accessed Date, November 2021)

Ackerman, K, Conard, M, Culligan, P, Plunz, R, Sutton, MP and Whittinghill, L, 2014. Sustainable food systems for future cities: The potential of urban agriculture. The economic and social review, 45(2, Summer), 189-206.

Adem, A, Çolak, A and Dağdeviren, M. 2018. An integrated model using SWOT analysis and Hesitant fuzzy linguistic term set for evaluation occupational safety risks in the life-cycle of a wind turbine. *Safety Science*, 106, 184-19.

Alcalde-Sanz, L. and Gawlik, B.M., 2017. Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge: *Towards a legal instrument on water reuse at EU level*. JRC Science for Policy Report, EUR 28962 EN.

Alegbeleye, O, Sant'Ana, AS. 2023. Microbiological quality of irrigation water for cultivation of fruits and vegetables: An overview of available guidelines, water testing strategies and some factors that influence compliance. Environmental Research, 220, 114771.Allah, MA and Nakhaie, H. 2011. Entrepreneurship and risk-taking. In *International Conference on E-business, Management and Economics*,25, 77-79.

Alegbeleye, O.O., Singleton, I. and Sant'Ana, A.S., 2018. Sources and contamination routes of microbial pathogens to fresh produce during field cultivation: A review. *Food microbiology*, *73*, pp.177-208.

Aljoudi, A.S., Al-Mazam, A. and Choudhry, A.J., 2010. Outbreak of food borne Salmonella among guests of a wedding ceremony: the role of cultural factors. *Journal of Family and Community Medicine*, *17*(1), p.29.

Amoah, LNA. 2021. Water scarcity and food security in Ngqeleni locality in the Eastern Cape Province-South Africa. African Journal of Hospitality, Tourism and Leisure, 10(1), 40-53.

Angelillo, I.F., Viggiani, N.M., Rizzo, L. and Bianco, A., 2000. Food handlers and foodborne diseases: knowledge, attitudes, and reported behavior in Italy. *Journal of food protection*, *63*(3), pp.381-385.

Antwi-Agyei, P, Peasey, A, Biran, A, Bruce, J. and Ensink, J. 2016. Risk perceptions of wastewater use for urban agriculture in Accra, Ghana. *PloS one*, *11*(3), e0150603.

Arndt, C, Davies, R, Gabriel, S, Harris, L, Makrelov, K, Robinson, S, Levy, S, Simbanegavi, W, Van Seventer, D and Anderson, L, 2020. Covid-19 lockdowns, income distribution, and food security: An analysis for South Africa. Global food security, 26, 100410.

Augustin, M.A., Riley, M., Stockmann, R., Bennett, L., Kahl, A., Lockett, T., Osmond, M., Sanguansri, P., Stonehouse, W., Zajac, I. and Cobiac, L., 2016. Role of food processing in food and nutrition security. *Trends in Food Science & Technology*, *56*, 115-125.

Baffoe, G., Zhou, X., Moinuddin, M., Somanje, A.N., Kuriyama, A., Mohan, G., Saito, O. and Takeuchi, K., 2021. Urban-rural linkages: Effective solutions for achieving sustainable development in Ghana from an SDG interlinkage perspective, Vol. 16,1341-1362. Springer Japan

Baiphethi, M and Jacobs, P, 2009. The contribution of subsistence farming to food security in South Africa. Agrekon, 48, 459-482.

Balali, G.I., Yar, D.D., Afua Dela, V.G. and Adjei-Kusi, P., 2020. Microbial contamination, an increasing threat to the consumption of fresh fruits and vegetables in today's world. *International journal of microbiology*, *2020*.

Bartram, J, Cotruvo, JA, Exner, M, Fricker, C and Glasmacher, A. (eds.). 2003. Heterotrophic plate counts and drinking-water safety. The significance of HPCs for Water Quality and Human Health. IWA Publishing.

Bartz FE, Lickness JS, Heredia N, Fabiszewski de Aceituno A, Newman KL, Hodge DW, Jaykus LA, García S, Leon JS. Contamination of Fresh Produce by Microbial Indicators on Farms and in Packing Facilities: Elucidation of Environmental Routes. Appl Environ Microbiol. 2017 May 17;83(11):e02984-16. doi: 10.1128/AEM.02984-16. PMID: 28363965; PMCID: PMC5440716.

Battersby, J, Haysom, G, Kroll, F, Tawodzera, G and Marshak, M. 2015. Looking beyond urban agriculture: Extending urban food policy responses. South African Cities Network Programme, Sustainable Cities.

Baudoin, M.A. and Ziervogel, G., 2017. What role for local organisations in climate change adaptation? Insights from South Africa. Regional Environmental Change, 17, 691-702.

Baumgartner, B and Belevi, H. 2001. A systematic overview of urban agriculture in developing countries. EAWAG/SANDEC, Dübendorf, 1-34.

Becerra-Castro, C., Lopes, A.R., Vaz-Moreira, I., Silva, E.F., Manaia, C.M. and Nunes, O.C., 2015. Wastewater reuse in irrigation: A microbiological perspective on implications in soil fertility and human and environmental health. *Environment international*, *75*, pp.117-135.

Beharielal, T, Thamaga-Chitja, J and Schmidt, S. 2018. Pre-and post-harvest practices of smallholder farmers in rural KwaZulu-Natal, South Africa: Microbiological quality and potential market access implications. Food Control, 92, 53-62.

Beharielal, T.; Thamaga-Chitja, J.; Schmidt, S (2022). Socioeconomic Characteristics Associated with Farming Practices, Food Safety and Security in the Production of Fresh Produce – A Case Study including Small-Scale Farmers in KwaZulu-Natal (South Africa). Sustainability 2022, 14, 10590. https://doi.org/10.3390/ su141710590.

Bélanger, L., Garenaux, A., Harel, J., Boulianne, M., Nadeau, E. and Dozois, C.M., 2011. Escherichia coli from animal reservoirs as a potential source of human extraintestinal pathogenic E. coli. *FEMS Immunology & Medical Microbiology*, *62*(1), pp.1-10.

Beukes, LS and Schmidt, S. 2022. Manual emptying of ventilated improved pit latrines and hygiene challenges – a baseline survey in a peri-urban community in KwaZulu-Natal, South Africa. International Journal of Environmental Health Research, 32(5), 1043-1054.

Bicudo, J.R. and Goyal, S.M., 2003. Pathogens and manure management systems: a review. *Environmental technology*, *24*(1), pp.115-130.

Bintsis, T., 2017. Foodborne pathogens. *AIMS microbiology*, *3*(3), p.529.

Bizari, D.R. and Cardoso, J.C., 2016. Reuse water and urban horticulture: alliance towards more sustainable cities. Horticultura Brasileira, 34, 311-317.

Boischio, A., Clegg, A. and Mwagore, D., 2006. Health risks and benefits of urban and peri-urban agriculture and livestock (UA) in Sub-Saharan Africa: resource papers and workshop proceedings. *Urban Poverty and Environment series; 1*.

Bold, J. and Rostami, K., 2011. Foodborne, food related illness and role of the healthcare professionals. *Gastroenterology and hepatology from bed to bench*, *4*(1), p.1.

Bonthuys, J., 2018. In-depth study sheds light on irrigated farming areas, water use. *Water Wheel*, *17*(4), 26-29.

Brewis, A., Roba, K.T., Wutich, A., Manning, M. and Yousuf, J., 2021. Household water insecurity and psychological distress in Eastern Ethiopia: Unfairness and water sharing as undertheorized factors. *SSM-Mental Health*, *1*, p.100008.

Brooks, J. 2016. "Food security and the Sustainable Development Goals", in Love, P. (ed.), Debate the Issues: New Approaches to Economic Challenges, OECD Publishing, Paris, Available at: https://doi.org/10.1787/9789264264687-27-en. (Accessed 22 November 2023).

Brooks, S., 2013. Investing in food security? Philanthrocapitalism, biotechnology and development. *Philanthrocapitalism, Biotechnology and Development (November 1, 2013). SWPS*, *12*.

Buechler, S. and Scott, C., 2006. *Wastewater as a controversial, contaminated yet coveted resource in South Asia* (No. HDOCPA-2006-36). Human Development Report Office (HDRO), United Nations Development Programme (UNDP).

Bui, H. and Baruch, Y., 2010. Creating learning organizations: a systems perspective. The Learning Organization, 17(3) 208-227.

Calow, R.C., Robins, N.S., MacDonald, A.M., MacDonald, D.M., Gibbs, B.R., Orpen, W.R., Mtembezeka, P., Andrews, A.J. and Appiah, S.O., 1997. Groundwater management in drought-prone areas of Africa. *International Journal of Water Resources Development*, *13*(2), pp.241-262.

Camino Feltes, M.M., Arisseto-Bragotto, A.P. and Block, J.M., 2017. Food quality, food-borne diseases, and food safety in the Brazilian food industry. *Food Quality and Safety*, *1*(1), pp.13-27.

Carlitz, R.D. and Makhura, M.N., 2021. Life under lockdown: Illustrating tradeoffs in South Africa's response to COVID-19. *World development*, *137*, 105168.

Carstens, C.K., Salazar, J.K. and Darkoh, C., 2019. Multistate outbreaks of foodborne illness in the United States associated with fresh produce from 2010 to 2017. *Frontiers in microbiology*, *10*, p.2667.

CCME (Canadian Council of Ministers of the Environment). 2020. Public Health Notice: Outbreak of *Salmonella* infections linked to red onions imported from the United States. CCME. Available at : https://www.cdc.gov/salmonella/newport-07-20/index.html. (Accessed 22 November 2023).

Cebekhulu, LM. 2016. Understanding the experiences of young widows in rural KwaZulu-Natal (Doctoral dissertation, University of KwaZulu-Natal). Available at : https://ukzndspace.ukzn.ac.za/bitstream/handle/10413/13173/Cebekhulu_Lindiwe_Millicent_2015.pdf?sequence=1&isAllowed=y. (Accessed 22 November 2023).

Chakona, G. and Shackleton, C.M. 2019. Food insecurity in South Africa: To what extent can social grants and consumption of wild foods eradicate hunger? *World Development Perspectives*, *13*, 87-94.

Chaminuka, N. and Dube, E., 2017. Urban agriculture as a food security strategy for urban dwellers: A case study of Mkoba residents in the city of Gweru, Zimbabwe. *PEOPLE: International Journal of Social Sciences*, *3*(2), 26-45.

Chauret, C., 2011. Survival and control of Escherichia coli O157: H7 in foods, beverages, soil and water. Virulence, 2(6), 593-601.

Cheteni, P. and Umejesi, I., 2022. Sustainability of agriculture development in South Africa: Towards Vision 2030. *Economics, Management and Sustainability*, *7*(1), 70-85.

Chitja, J., Mthiyane, C.C.N., Mariga, I.K., Shimelis, H., Murugani, V.G., Morojele, P.J., Naidoo, K. and Aphane, O.D., 2016. *Empowerment of Women Through Water Use Security, Land Use Security and Knowledge Generation for Improved Household Food Security and Sustainable Rural Livelihoods in Selected Areas of Limpopo: Report to the Water Research Commission*. Water Research Commission. Cirelli, G.L., Consoli, S., Licciardello, F., Aiello, R., Giuffrida, F. and Leonardi, C., 2012. Treated municipal wastewater reuse in vegetable production. *Agricultural Water Management*, *104*, 163-170.

Chivandi, A. and Maziriri, E.T., 2017. An evaluation of ISO 22000 food safety standards awareness and implementation in Zimbabwean branded fast food outlets: customer, employee, and management perspectives. *African Journal of Hospitality Tourism and Leisure*, *6*(2), pp.1-24.

Coates, J, Swindale, A & Bilinsky, P (2007) Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide (v. 3). Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Cofie, O.O., Van Veenhuizen, R. and Drechsel, P., 2003. Contribution of urban and peri-urban agriculture to food security in sub-Saharan Africa. *Africa Day of the 3rd WWF in Kyoto*, *3*.

Colvin, C., Muruven, D., Lindley, D., Gordon, H. and Schachtschneider, K., 2016. Water facts and futures: rethinking South Africa's water future, WWF-SA 2016 Water Facts and Futures, 2-96.

Contador, T., Rendoll-Cárcamo, J., Gañan, M., Ojeda, J., Kennedy, J., Convey, P., & Rozzi, R. 2023. Underwater with a hand lens: ecological sciences and environmental ethics to value freshwater biodiversity. In Field environmental philosophy: education for biocultural conservation. 53-69. Cham: Springer International Publishing.

Cosgrove, W.J. and Loucks, D.P., 2015. Water management: Current and future challenges and research directions. *Water Resources Research*, *51*(6), 4823-4839.

Cosgrove, W.J. and Rijsberman, F.R., 2014. World water vision: making water everybody's business. Routledge.

Cosgrove, W.J. and Rijsberman, F.R., 2014. *World water vision: making water everybody's business*. Routledge.

Dälken, F., 2014. *Are porter's five competitive forces still applicable? a critical examination concerning the relevance for today's business* (Bachelor's thesis, University of Twente).

Danso, G., Hope, L. and Drechsel, P., 2014. *Financial and economic aspects of urban vegetable farming* (No. 612-2016-40551).

De Man, J. 1983. MPN tables, corrected. European Journal of Applied Microbiology and Biotechnology, 17, 301-305.

Delaquis, P., Bach, S. and Dinu, L.D., 2007. Behavior of Escherichia coli O157: H7 in leafy vegetables. *Journal of food protection*, *70*(8), pp.1966-1974.

Department of Agriculture Land Reform & Rural Development (2021). A profile of the South African beef Market Value Chain. Pretoria.

Dickin, S.K., Schuster-Wallace, C.J., Qadir, M. and Pizzacalla, K., 2016. A review of health risks and pathways for exposure to wastewater use in agriculture. Environmental Health Perspectives, 124(7), 900-909.

DIN (Deutsches Institut für Normung) 19650. Bewässerung – Hygienische Belange von Bewässerungswasser. 1999. Normenausschuss Wasserwesen im Deutschen Institut für Normung e.V., Berlin.

DoH (Department of Health). 2002. Guideline for environmental health officers on the interpretation of microbiological analysis data of food [Online]. Available from: http://www.DoH.gov.za/docs/factsheets/microguide.pdf

Du Toit, A., 2011. Nasruddin's key: poverty measurement and the government of marginal populations. Institute for Poverty, Land and Agrarian Studies, University of the Western Cape. Available at: https://repository.uwc.ac.za/xmlui/handle/10566/4479. (Accessed 22 November 2023).

Dubbeling, M., van Veenhuizen, R. and Halliday, J., 2019. Urban agriculture as a climate change and disaster risk reduction strategy. *Field Actions Science Reports. The Journal of Field Actions*, (Special Issue 20), pp.32-39.

DWAF (Department of Water Affairs and Forestry), 1993. South African water quality guidelines: Volume 3-Industrial use. Department of Water Affairs and Forestry.

DWAF (Department of Water Affairs and Forestry), 1996. South African water quality guidelines (second edition). Volumes 1 and 4: Domestic use and agricultural water use. CSIR, Environmental Services. Pretoria, South Africa. Available at: http://www.iwa-network.org/filemanageruploads/WQ_Compendium/Database/Future_analysis/080.pdf.

DWAF (Department of Water Affairs and Forestry), 1997. White Paper on a National Water Policy for South Africa. Department of Water Affairs and Forestry, Pretoria, South Africa.'

DWAF (Department of Water Affairs and Forestry), 2004. Department of Water Affairs: Revision of General Authorisations in Terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998). South African Government Gazette, (26187).

Ebner, P.D., Deering, A., Mojadady, M., Rahimi, Z., Amini, R., Popal, M., Eshaqzai, N., Barak, S., Amini, S., Azizi, E. and Morshid, E., 2018. Capacity building through water quality and safety analyses in Herat, Afghanistan. *Journal of food protection*, *81*(9), pp.1467-1471.

Economic Research Service (ERS), 2020. Risk in Agriculture. Available at :https://www.ers.usda.gov/topics/farm-practices-management/risk-management/risk-in-agriculture/. (Accessed 18 October 2023).

Edokpayi, J.N., Odiyo, J.O. and Durowoju, O.S. 2017. Impact of wastewater on surface water quality in developing countries: A case study of South Africa. Intech Open. Published: January 18th, 2017. DOI: 10.5772/66561.

Eisazadeh, S., Naghdi, A. and Nemati, A., 2015. Urban Agriculture as an Entrepreneurship Opportunity: Its Opportunities and Challenges. Research Journal of Fisheries and Hydrobiology (1). pg 639-648

ELamin A. and Saeed, A.B., 2019. Impact of using treated wastewater for irrigation on soil chemical properties, plant growth and forage yield. University of Khartoum Journal of Agricultural Sciences, 16(1) 75-87.

Eppinger, M., Mammel, M.K., Leclerc, J.E., Ravel, J. and Cebula, T.A., 2011. Genomic anatomy of Escherichia coli O157: H7 outbreaks. *Proceedings of the National Academy of Sciences*, *108*(50), pp.20142-20147.

European Commission (EC). 2005. Commission regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. 2005/L338/1.

European Commission (EC). 2017. Commission notice on guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene. 2017/C 163/01.

European Commission (EC). 2020. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption. 2020/L 435/63.

Falkenmark, M., 2013. Growing water scarcity in agriculture: future challenge to global water security. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 371(2002), p.20120410.

FAO, 1997. Higher Agricultural Education and Opportunities in Rural Development for Women. Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy. Food and Agriculture Organization

FAO, 2002. The state of food insecurity in the World 2001. Rome, Italy: FAO Available at: (www.fao.org/3/y6000en/Y6000EN.pdf). (Accessed 22 November 2023).

FAO, 2007. Profitability and sustainability of urban and peri-urban agriculture. Agricultural Management, Marketing, and Finance Occasional Paper, 19. Food and Agriculture Organization of the United Nations (FAO): Rome, Italy. Food and Agriculture Organisation

FAO, 2020. Tracking Progress on Food and Agriculture-Related SDG Indicators 2020. Available at: (www.fao.org/3/cb6872en/cb6872en.pdf). (Accessed 22 November 2023).

FAO,2018a. World Livestock: Transforming the Livestock Sector through the Sustainable Development Goals. FAO, Rome, Italy, 222.Retrieved from. http://www.fao.org/3/CA1201EN/ca1201en.pdf.

Fereres, E., Orgaz, F. and Gonzalez-Dugo, V. 2011. Reflections on food security under water scarcity. *Journal of Experimental Botany*, 62, 4079-4086.

Folifac, F.A., 2007. National Water Policies and Water Services at the extremes: What Challenges must be faced in bridging the gap? Learning from the South Africa Experience. *African Water Journal*, *1*(1), 5-22.

Food and Agriculture Organisation: Global Forest Resources Assessment, 2010. Available online: https:www.fao.org. Accessed date October 2021.

Fraval, S., Hammond, J., Bogard, J.R., Ng'endo, M., van Etten, J., Herrero, M., Oosting, S.J., de Boer, I.J., Lannerstad, M., Teufel, N. and Lamanna, C., 2019. Food access deficiencies in sub-Saharan Africa: prevalence and implications for agricultural interventions. Frontiers in Sustainable Food Systems, 3, 104.

Friend, G. and Zehle, S., 2009. Guide to business planning (pp. 31-35). *London: The Economist Newspaper Ltd*.

Fuller, D.Q., 2007. Contrasting patterns in crop domestication and domestication rates: recent archaeobotanical insights from the Old World. *Annals of Botany*, *100*(5), pp.903-924.

Gallaher, C.M., 2017. Regreening Kibera: how urban agriculture changed the physical and social environment of a large slum in Kenya. In Global urban agriculture 171-183. Wallingford UK: CABI.

Gar, R.A. and Rodgers, R.A. 2020. Challenges in Tackling Poverty and Unemployment: Analysis of Youth Employment in Agriculture Program in Alkaleri, Duguri and Gar Rural Communities of the Bauchi State, Nigeria. In: the Palgrave Handbook of Agricultural and Rural Development in Africa (pp. 199-215). Palgrave Macmillan, Cham.

Garrett J.L. 2000. Achieving urban food and nutrition security in the developing world. Online Overview Paper for a 2020 Vision for Food, Agriculture and the Environment. Focus 3. Brief 1 of 10. Available at: http://www.ifpri.org/2020/focus/focus03/focus03.pdf [Accessed on 24 September 2006].

Gassner, A., Harris, D., Mausch, K., Terheggen, A., Lopes, C., Finlayson, R.F. and Dobie, P., 2019. Poverty eradication and food security through agriculture in Africa: Rethinking objectives and entry points. Outlook on Agriculture, 48(4) 309-315.

Gemmell, M. and Schmidt, S. 2012. Microbiological assessment of river water used for the irrigation of fresh produce in a sub-urban community in Sobantu, South Africa. Food Research International, 47, 300-305.

Gemmell, M. and Schmidt, S. 2013. Is the microbiological quality of the uMsunduzi River (KwaZulu-Natal, South Africa) suitable for domestic, recreational and agricultural purposes? Environmental Science and Pollution Research, 20(9), 6551-6562.

Gerasymenko, N. and Zhemoyda, O.V., 2009. *New challenges for risk management in agri-food industry* (No. 698-2016-47895).

Gerlach, C., 2015. Famine responses in the world food crisis 1972-5 and the World Food Conference of 1974. European Review of History: Revue européenne d'histoire, 22(6), 929-939.

Ghaleh MR., 2019. Ecological, Social and Economic Benefits of Urban Agriculture. Available at:https://www.tehrantimes.com/news/438142/Ecological-Social-and-Economic-Benefits-of-Urban-Agriculture. Tehran Times, (Accessed 19 October 2023).

Ghosh, P., Hossain, M., & Sarkar, S. (2023). Inequality among social groups in accessing improved drinking water and sanitation in India: a district-level spatial analysis. The Professional Geographer, 75(3) 361-382

Ghosh, S., 2023. Integrating urban agriculture in design and planning for built environments. Encyclopedia of Sustainable Technologies.

Gil, M.M., Quezada, M.S., Revello, R., Akolekar, R. and Nicolaides, K.H., 2015. Analysis of cell-free DNA in maternal blood in screening for fetal aneuploidies: updated meta-analysis. *Ultrasound in obstetrics & gynecology*, *45*(3), pp.249-266.

Gomiero, T., Paoletti, M.G. and Pimentel, D., 2008. Energy and environmental issues in organic and conventional agriculture. Critical Reviews in Plant Sciences, 27(4) 239-254.

Gomiero, T., Pimentel, D. and Paoletti, M.G., 2011. Environmental impact of different agricultural management practices: conventional vs. organic agriculture. *Critical reviews in plant sciences*, *30*(1-2) 95-124.

Gomiero, T., Pimentel, D. and Paoletti, M.G., 2011. Environmental impact of different agricultural management practices: conventional vs. organic agriculture. *Critical reviews in plant sciences*, *30*(1-2) 95-124.

Govender, J. 2016. An assessment of the water quality of the Baynespruit River and its linkages to the health of the Sobantu community. Master's dissertation, University of KwaZulu-Natal.

Grace Ning Yuan, Gian Powell B. Marquez, Haoran Deng, Anastasiia Iu, Melisa Fabella, Reginald B. Salonga, Fitrio Ashardiono, Joyce A. Cartagena, 2022. A review on urban agriculture: technology, socio-economy, and policy, Heliyon, Volume 8, Issue 11. ISSN 2405-8440. https://doi.org/10.1016/j.heliyon.2022.e11583.

Grammer, H., 2019. *Framing the Western Cape water crisis: an analysis of the reporting of five South African publications in 2017 and 2018* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Granzow, M. and Jones, K.E. 2020. Urban agriculture in the making or gardening as epistemology. Local Environment, 25(5) 381-396.

Graue, C., 2015. Qualitative data analysis. *International Journal of Sales, Retailing & Marketing*, *4*(9), pp.5-14.

Grebitus, C., Printezis, I. and Printezis, A. 2017. Relationship between consumer behaviour and success of urban agriculture. Ecological Economics, 136, 189-200.

Grey, D. and Sadoff, C.W., 2007. Sink or swim? Water security for growth and development. Water policy, 9(6), pp.545-571.

Gupta, R.P.S., de Wit, M.L. and McKeown, D., 2007. The impact of poverty on the current and future health status of children. Paediatrics & child health, 12(8) 667-672.

Gustat, J., O'Malley, K., Luckett, B.G. and Johnson, C.C., 2015. Fresh produce consumption and the association between frequency of food shopping, car access, and distance to supermarkets. *Preventive Medicine Reports*, *2*, pp.47-52.

Haileamlak, A., 2014. Millennium development goals: Lessons learnt and the way forward. Ethiopian Journal of Health Sciences, 24(4) 284-284.

Hall, D.M., Camilo, G.R., Tonietto, R.K., Ollerton, J., Ahrné, K., Arduser, M., Ascher, J.S., Baldock, K.C., Fowler, R., Frankie, G. and Goulson, D., 2017. The city as a refuge for insect pollinators. Conservation Biology, 31(1), pp.24-29.

Hallett, S., Hoagland, L. and Toner, E., 2016. Urban agriculture: Environmental, economic, and social perspectives. *Horticultural Reviews Volume 44*, *44*, pp.65-120.

Harris, D.R. and Fuller, D.Q., 2014. Agriculture: definition and overview. Encyclopedia of global archaeology, 104-113.

Haysom, G., 2015, September. Food and the city: Urban scale food system governance. In *Urban Forum* (Vol. 26, No. 3, 263-281). Dordrecht: Springer Netherlands.

Haysom, G.G.D., 2007. *Project proposal for transforming Grabouw, Western Cape, into a sustainable community* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Hazell, S., Delbridge, V. and Conradie, B., 2015. Food gardening in Lavender Hill, Cape Town: using adoption rates to estimate the perceived benefit. *UR@ UCT: Undergraduate Research*, *1*(1).

Health Canada. 2002. MFHPB-19. Enumeration of coliforms, faecal coliforms and of E. coli in foods using the MPN method. Ottawa, Canada.

Hendriks, S.L., 2005. The challenges facing empirical estimation of household food (in) security in South Africa. Development Southern Africa, 22(1) 103-123.

Herrero, M., Thornton, P.K., Bernués, A., Baltenweck, I., Vervoort, J., van de Steeg, J., Makokha, S., van Wijk, M.T., Karanja, S., Rufino, M.C. and Staal, S.J., 2014. Exploring future changes in smallholder farming systems by linking socio-economic scenarios with regional and household models. Global Environmental Change, 24, 165-182

Hovorka, A.J., 2004. Entrepreneurial opportunities in Botswana:(re) shaping urban agriculture discourse. Journal of contemporary African studies, 22(3) 367-388.

Hussain, I., Raschid, L., Hanjra, M.A., Marikar, F. and Van Der Hoek, W., 2002. Wastewater use in agriculture: Review of impacts and methodological issues in valuing impacts.

Hussein, A., 2009. The use of triangulation in social sciences research: Can qualitative and quantitative methods be combined?. *Journal of comparative social work*, *4*(1), pp.106-117.

Indiatsy, C.M., Mucheru, S.M., Mandere, E.N., Bichanga, J.M. and Gongera, E.G. 2014. The application of Porter's five forces model on organisation performance: A case of Cooperative Bank of Kenya Ltd. Kenya

Integrated Development Plan (IDP)For 2018-2019; Available online: http://www.msunduzi.gov.za, Accessed date October 202.

Inter-agency Food Safety Analytics Collaboration (IFSAC). 2022. Food-borne illness source attribution estimates for 2020 for Salmonella, Escherichia coli O157, Listeria monocytogenes, and Campylobacter using multi-year outbreak surveillance data, United States. GA and D.C.: U.S. Department of Health and Human Services, Centres for Disease Control and Prevention, Food and Drug Administration, U.S. Department of Agriculture's Food Safety and Inspection Service.

ISO 16075, 2015. Guidelines for Treated Wastewater Use for Irrigation Projects. International Organization for Standardization, Geneva, Switzerland.

ISO 6579, 2002. Microbiology of food and animal feeding stuffs: horizontal method for the detection of Salmonella spp. International Organisation for Standardization, Geneva.

ISO 7899-2, 2000. Water quality: detection and enumeration of intestinal enterococci. International Organisation for Standardization, Geneva.

ISO 7899-2, 2000. Water quality: detection and enumeration of intestinal enterococci. International Organisation for Standardization, Geneva.

Iwu, C.D. and Okoh, A.I. 2019. Preharvest transmission routes of fresh produce associated bacterial pathogens with outbreak potentials: a review. International Journal of Environmental Research and Public Health, 16(22), 4407.

Jacobs, P. and Xaba, T., 2008. Women in urban and peri-agriculture: Sustaining livelihoods in the Cape Metropolitan Area. Agenda, 22(78) 186-197.

Jaffee, S., Henson, S., Unnevehr, L., Grace, D. and Cassou, E., 2018. *The safe food imperative: Accelerating progress in low-and middle-income countries*. World Bank Publications.

Jaramillo, M.F. and Restrepo, I., 2017. Wastewater reuse in agriculture: A review about its limitations and benefits. Sustainability, 9(10) 1734.

Joe Stevens and Barbara van Koppen., 2015. Trends and Outlook: Agricultural Water Management in Southern Africa COUNTRY REPORT SOUTH AFRICA. Southern Africa Regional Program of the International Water Management Institute (IWMI).

Joint, F.A.O., World Health Organization and WHO Expert Committee on Food Additives, 2017. *Evaluation of certain contaminants in food: eighty-third report of the Joint FAO/WHO Expert Committee on Food Additives*. World Health Organization.

Kahan, D., 2013. Economics for farm management extension (p. 97). Rome, Italy: Food and Agriculture Organization of the United Nations.

Kaufman, J.L. and Bailkey, M., 2000. Farming inside cities: Entrepreneurial urban agriculture in the United States ,1-124. Cambridge, MA: Lincoln Institute of Land Policy.

Keovilignavong, O. and Suhardiman, D. 2020. Linking land tenure security with food security: Unpacking farm households' perceptions and strategies in the rural uplands of Laos. Land Use Policy, 90, 104260.

Kerr, W. and Nanda, R., 2009. *Financing constraints and entrepreneurship* (No. w15498). National Bureau of Economic Research.

Kgari, T., Van Wyk, Y., Coetzee, H. and Dippenaar, M., 2016. Mine water approach using tracers in South African abandoned coal mines. Mining meets water – conflicts and solutions, pp.410-416.

King, D.L., Delfabbro, P.H., Billieux, J. and Potenza, M.N., 2020. Problematic online gaming and the COVID-19 pandemic. Journal of behavioral addictions, 9(2), pp.184-186.

Kingsley, J., Egerer, M., Nuttman, S., Keniger, L., Pettitt, P., Frantzeskaki, N. and Marsh, P. 2021. Urban agriculture as a nature-based solution to address socio-ecological challenges in Australian cities. Urban Forestry and Urban Greening, 60, 127059.

Kirk, M.D., Pires, S.M., Black, R.E., Caipo, M., Crump, J.A., Devleesschauwer, B., Döpfer, D., Fazil, A., Fischer-Walker, C.L., Hald, T. and Hall, A.J., 2015. World Health Organization estimates of the global and regional disease burden of 22 foodborne bacterial, protozoal, and viral diseases, 2010: a data synthesis. *PLoS medicine*, *12*(12), e1001921.

Kirkland, T.M., Kemp, R.J., Hunter, L.M. and Twine, W.M., 2013. Toward improved understanding of food security: a methodological examination based in rural South Africa. Food, Culture & Society, 16(1) 65-84.

Komarek, A.M., De Pinto, A. and Smith, V.H., 2020. A review of types of risks in agriviticulture: What we know and what we need to know. Agricultural Systems, 178, 102738.

Korir, L.K., 2011. Risk management among agricultural households and the role of off-farm investments in Uasin Gishu County, Kenya (No. 634-2016-41499).

Korir, S.C., Rotich, J.K. and Mining, P., 2015. Urban agriculture and food security in developing countries: A case study of Eldoret municipality, Kenya.

Kristiansen, P., Taji, A. and Reganold, J., 2006. Organic agriculture: opportunities and challenges. Organic Agriculture: A Global Perspective. CSIRO Publishing, Australia 421-441.2z0

Kroupitski Y, D Golberg, E Belausov, R Pinto, D Swartzberg, D Granot, S Sela. 2009. Internalization of Salmonella enterica in leaves is induced by light and involves chemotaxis and penetration through open stomata. Appl. Environ. Microbiol. 75(19):6076-6086.

Kruse, P., 2018. Review on water quality sensors. *Journal of Physics D: Applied Physics*, *51*(20), p.203002.

Labadarios, D., Mchiza, Z.J.R., Steyn, N.P., Gericke, G., Maunder, E.M.W., Davids, Y.D. and Parker, W.A., 2011. Food security in South Africa: a review of national surveys. Bulletin of the World Health Organization, 89(12) 891-899.

Lal, R., 2020. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. *Food security*, *12*(4) 871-876.

Leddy, A. M., Weiser, S. D., Palar, K., & Seligman, H. (2020). A conceptual model for understanding the rapid COVID-19-related increase in food insecurity and its impact on health and healthcare. The American journal of clinical nutrition, 112(5) 1162-1169.

Lin, W., Zhang, X., Tan, Y., Li, P. and Ren, Y., 2019. Can water quality indicators and biomarkers be used to estimate real-time population? *Science of the Total Environment*, *660*, pp.603-610.

Liu, L., Oza, S., Hogan, D., Perin, J., Rudan, I., Lawn, J.E., Cousens, S., Mathers, C. and Black, R.E., 2015. Global, regional, and national causes of child mortality in 2000-13, with projections to inform post-2015 priorities: an updated systematic analysis. The lancet, 385(9966) 430-440.

Lomazzi, M., Borisch, B. and Laaser, U., 2014. The Millennium Development Goals: experiences, achievements and what's next. Global health action, 7(1) 23695.

Lone, S.A. and Ahmad, A., 2020. COVID-19 pandemic – an African perspective. Emerging microbes & infections, 9(1) 1300-1308.

Louw, A. and Jordaan, D., 2016. Supply chain risks and smallholder fresh produce farmers in the Gauteng province of South Africa. Southern African Business Review, 20(1) 286-312.

Lovell, S.T., 2010. Multifunctional urban agriculture for sustainable land use planning in the United States. Sustainability, 2(8),pp.2499-2522. Lupia, F. and Pulighe, G., 2015. Water use and urban agriculture: Estimation and water saving scenarios for residential kitchen gardens. Agriculture and agricultural science procedia, 4 50-58

Luna-Guevara, J.J., Arenas-Hernandez, M.M., Martínez de la Peña, C., Silva, J.L. and Luna-Guevara, M.L., 2019. The role of pathogenic E. coli in fresh vegetables: Behaviour, contamination factors, and preventive measures. *International journal of microbiology*, *2019*.

Lund, C., Fortnow, L., Karloff, H. and Nisan, N., 1992. Algebraic methods for interactive proof systems. *Journal of the ACM (JACM)*, *39*(4), pp.859-868.

Lynch, K., Binns, T. and Olofin, E., 2001. Urban agriculture under threat: The land security question in Kano, Nigeria. Cities, 18(3) 159-171.

Machado-Moreira, B., Richards, K., Brennan, F., Abram, F., & Burgess, C. M. 2019. Microbial contamination of fresh produce: what, where, and how?. Comprehensive reviews in food science and food safety, 18(6) 1727-1750.

MacLeod, N.D., McDonald, C.K. and Van Oudtshoorn, F.P., 2008. Challenges for emerging livestock farmers in Limpopo province, South Africa. African Journal of Range and Forage Science, 25(2) 71-77.

Madikizela, L.M. and Chimuka, L. 2017. Occurrence of naproxen, ibuprofen, and diclofenac residues in wastewater and river water of the KwaZulu-Natal Province in South Africa. *Environmental Monitoring and Assessment*, 189(7) 348.

Mango, N., Zamasiya, B., Makate, C., Nyikahadzoi, K. and Siziba, S., 2014. Factors influencing household food security among smallholder farmers in the Mudzi district of Zimbabwe. *Development Southern Africa*, *31*(4), pp.625-640.

Manyi-Loh, C.E., Mamphweli, S.N., Meyer, E.L., Makaka, G., Simon, M. and Okoh, A.I., 2016. An overview of the control of bacterial pathogens in cattle manure. *International journal of environmental research and public health*, *13*(9), p.843.

Maqbool, M.S., Mahmood, T., Sattar, A. and Bhalli, M.N. 2013. Determinants of unemployment: Empirical evidence from Pakistan. Pakistan Economic and Social Review, 51, 191-208.

Marie, V. and Lin, J. 2018. Microbial indicators and environmental relationships in the Umhlangane River, Durban, South Africa. Open Life Sciences, 13(1) 385-395.

Marsden, T. and Sonnino, R., 2008. Rural development and the regional state: Denying multifunctional agriculture in the UK. Journal of Rural Studies, 24(4), pp.422-431.Masuku, M., Selepe, M. and Ngcobo, N., 2017. Small scale agriculture in enhancing household food security in rural areas. Journal of Human Ecology, 58(3) 153-161.

Martínez-Vaz, B.M., Fink, R.C., Diez-Gonzalez, F. and Sadowsky, M.J., 2014. Enteric pathogen-plant interactions: molecular connections leading to colonization and growth and implications for food safety. *Microbes and environments*, *29*(2), pp.123-135.

Mason-D'Croz, D., Bogard, J.R., Sulser, T.B., Cenacchi, N., Dunston, S., Herrero, M. and Wiebe, K., 2019. Gaps between fruit and vegetable production, demand, and recommended consumption at global and national levels: an integrated modelling study. *The Lancet Planetary Health*, *3*(7), pp.e318-e329.

Mateo-Sagasta, J., Zadeh, S.M. and Turral, H. eds., 2018. More people, more food, worse water?: a global review of water pollution from agriculture.

Mathambo, V. and Richter, L., 2007. " We are volunteering": endogenous community-based responses to the needs of children made vulnerable by HIV and AIDS.

Matongo, S., Birungi, G., Moodley, B. and Ndungu, P., 2015. Pharmaceutical residues in water and sediment of Msunduzi River, KwaZulu-Natal, South Africa. Chemosphere, 134, pp.133-140.

Maziya, M., Mudhara, M., & Chitja, J. (2017). What factors determine household food security among smallholder farmers? Insights from Msinga, KwaZulu-Natal, South Africa. Agrekon, 56(1) 40

McAllister, T.A. and Topp, E., 2012. Role of livestock in microbiological contamination of water: commonly the blame, but not always the source. *Animal Frontiers*, *2*(2), pp.17-27.

McDougall, R., Kristiansen, P. and Rader, R., 2019. Small-scale urban agriculture results in high yields but requires judicious management of inputs to achieve sustainability. Proceedings of the National Academy of Sciences, 116(1) 129-134.

Mdluli, F., Thamaga-Chitja, J. and Schmidt, S. 2013. Appraisal of Hygiene Indicators and Farming Practices in the Production of Leafy Vegetables by Organic Small-holder Farmers in uMbumbulu (Rural KwaZulu-Natal, South Africa). International Journal of Environmental Research and Public Health, 10, 4323-4338.

Mdluli, F., Thamaga-Chitja, J., Schmidt, S. and Shimelis, H. 2014. Production hygiene and training influences on rural small-holder organic farmer practices: South Africa. Journal of Consumer Sciences, 42, 17-23.

Meemken, E.M. and Bellemare, M.F., 2020. Smallholder farmers and contract farming in developing countries. Proceedings of the National Academy of Sciences, 117(1) 259-264.

Meinzen-Dick, R., DiGregorio, M. and McCarthy, N., 2004. Methods for studying collective action in rural development. Agricultural systems, 82(3) 197-214.

Meissner, H.H., Scholtz, M.M. and Palmer, A.R., 2013. Sustainability of the South African livestock sector towards 2050 Part 1: Worth and impact of the sector. South African Journal of Animal Science, 43(3) 282-297.

Mekonnen, M.M. and Hoekstra, A.Y., 2016. Four billion people facing severe water scarcity. Science advances, 2(2), p.e1500323.

Michetti, M., Raggi, M., Guerra, E. and Viaggi, D., 2019. Interpreting farmers' perceptions of risks and benefits concerning wastewater reuse for irrigation: a case study in Emilia-Romagna (Italy). Water, 11(1) 108.

Miller-Robbie, L., Ramaswami, A. and Amerasinghe, P., 2017. Wastewater treatment and reuse in urban agriculture: exploring the food, energy, water, and health nexus in Hyderabad, India. Environmental Research Letters, 12(7), p.075005.

Misra, A.K., 2014. Climate change and challenges of water and food security. International Journal of Sustainable Built Environment, 3(1), pp.153-165.

Mkwambisi, D.D. 2008. Urban agriculture in Malawi: poverty reduction, waste management and institutional barriers. School of Earth and Environment, Sustainability Research Institute. Leeds, University of Leeds. PhD.

Molle, F. and Berkoff, J., 2009, February. Cities vs. agriculture: A review of intersectoral water re-allocation. In *Natural Resources Forum* (Vol. 33, No. 1, pp. 6-18). Oxford, UK: Blackwell Publishing Ltd.

Moss, B., 2008. Water pollution by agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491) 659-666.

Mougeot, L.J.A. 2005. Introduction: Urban agriculture and the millennium development goals. In AGROPOLIS: The Social, Political and Environmental Dimensions of Urban Agriculture, Mougeot LJA (ed.). Earthscan Publication: London; 1-30.

Msunduzi Municipality Integrated Development Plan 2011/2012

Murray, A.L., Kumpel, E., Peletz, R., Khush, R.S. and Lantagne, D.S. 2018. The effect of sodium thiosulfate dechlorination on faecal indicator bacteria enumeration: laboratory and field data. Journal of Water and Health, 16(1) 70-77.

Murray, R.T., Rosenberg Goldstein, R.E., Maring, E.F., Pee, D.G., Aspinwall, K., Wilson, S.M. and Sapkota, A.R., 2018. Prevalence of microbiological and chemical contaminants in private drinking water wells in Maryland, USA. *International Journal of Environmental Research and Public Health*, *15*(8), p.1686.

Murugani, V.G. and Thamaga-Chitja, J.M., 2018. Livelihood assets and institutions for smallholder irrigation farmer market access in Limpopo, South Africa. International Journal of Water Resources Development, 34(2), 259-277.

Mutea, E., Rist, S. and Jacobi, J. 2020. Applying the Theory of Access to Food Security among Smallholder Family Farmers around North-West Mount Kenya. Sustainability, 12(5), 1751.

Muzahidul, M., Akter, L., Pervez, A.K., Nabi, M.N., Uddin, M.M. and Arifin, Z., 2020. Application of combined SWOT and AHP for strategy development: evidence from pottery industry of Bangladesh. Asian Journal of Agriculture and rural Development, 10(1), pp.81-94.

Myeni, L., Moeletsi, M., Thavhana, M., Randela, M. and Mokoena, L., 2019. Barriers affecting sustainable agricultural productivity of smallholder farmers in the Eastern Free State of South Africa. Sustainability, 11(11) 3003.

Nag, R., Monahan, C., Whyte, P., Markey, B.K., O'Flaherty, V., Bolton, D., Fenton, O., Richards, K.G. and Cummins, E. 2021. Risk assessment of Escherichia coli in bio-aerosols generated following land application of farmyard slurry. Science of the Total Environment, 791, 148-189.

Nevondo, T.S. and Cloete, T.E. 1999. Bacterial and chemical quality of water supply in the Dertig village settlement. Water SA, 25, 215-220.

Neysmith, J and Dent, M. 2010. Non-statutory barriers and incentives for stakeholder in reducing water pollution: A South Africa case study. Water SA. 36(5) 577-588.

Neysmith, J. 2008. Investigating non-regulatory barriers and incentives to stakeholder participation in reducing water pollution in Pietermaritzburg's Baynespruit (Doctoral dissertation, University of KwaZulu-Natal).

Ngqangweni, S., Mmbengwa, V., Myeki, L., Sotsha, K. and Khoza, T., 2016. Measuring and tracking smallholder market access in South Africa. *National Agricultural Marketing Council Working Paper (NAMC/WP/2016/03)*.

Ngqangweni, S., Tempia, N. and Lubinga, M.H., 2020. 28 Importance of small rural markets in the transformation of Southern African agriculture. *Transforming Agriculture in Southern Africa*, p.250.

Ngubane, Z., Bergion V., Dzwairo, B., Troell, K., Amoah, I.D., Stenström, T.A., and Sokolova, E. 2022. Water quality modelling and quantitative microbial risk assessment for uMsunduzi River in South Africa. J. Water Health, 20, 641.

Nikmaram, N. and Rosentrater, K.A., 2019. Overview of some recent advances in improving water and energy efficiencies in food processing factories. Frontiers in nutrition, 6, p.20.

Noble, H. and Smith, J., 2015. Issues of validity and reliability in qualitative research. Evidence-based nursing, 18(2) 34-35.

Nolasco, J., 2011. Sustainable water management for urban agriculture: Planting justice, Oakland, 1-12, CA: Working Paper Pacific Institute.

Nyambo, D.G., Luhanga, E.T. and Yonah, Z.Q., 2019. A review of characterization approaches for smallholder farmers: Towards predictive farm typologies. The Scientific World Journal, 2019.

Nzimande, P., 2013. Does Urban Agriculture Create Job Opportunities (Post Graduate Diploma Report, University of KwaZulu Natal). Available at: https://doi.org/10.13140/RG.2.2.33210.18882. (Accessed 22 November 2023).

Oberholster, P.J. and Botha, A.M., 2014. The Importance of water quality to the food industry of South Africa. Understanding the Food Energy Water Nexus, 1-16.

Obilor, E.I., 2023. Convenience and purposive sampling techniques: Are they the same. *International Journal of Innovative Social & Science Education Research*, *11*(1), pp.1-7.

Oduniyi, O.S., Rubhara, T.T. and Antwi, M.A., 2020. Sustainability of livestock farming in South Africa. outlook on production constraints, climate-related events, and upshot on adaptive capacity. Sustainability, 12(7) 2582.

Olivier, D.W. and Heinecken, L., 2017. The personal and social benefits of urban agriculture experienced by cultivators on the Cape Flats. Development Southern Africa, 34(2) 168-181.

Olivier, D.W., 2018. A cropping system for resource-constrained urban agriculture: Lessons from Cape Town. Sustainability, 10(12), 4804.

Olivier, D.W., 2019. Urban agriculture promotes sustainable livelihoods in Cape Town. Development Southern Africa, 36(1) 17-32.

Orsini, F., Kahane, R., Nono-Womdim, R. and Gianquinto, G. 2013. Urban agriculture in the developing world: a review. Agronomy for Sustainable Development, 33(4) 695-720.

Pachepsky, Y., Shelton, D.R., McLain, J.E.T., Patel, J. and Mandrell, R.E. 2011. Irrigation waters as a source of pathogenic microorganisms in produce: A review. In: D.L. Sparks (Ed.), Advances in Agronomy, Vol. 113, Burlington: Academic Press, 73-138. ISBN: 978-0-12-386473-4.

Paganini, N. and Lemke, S. 2020. "There is food we deserve, and there is food we do not deserve" Food injustice, place and power in urban agriculture in Cape Town and Maputo. Local Environment, 25(11-12) 1000-1020.

Partanen, P., Hultman, J., Paulin, L., Auvinen, P. and Romantschuk, M., 2010. Bacterial diversity at different stages of the composting process. *BMC microbiology*, *10*(1), pp.1-11.

Pawlak, K. and Kołodziejczak, M., 2020. The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production. Sustainability, 12(13), 5488.

Pezzuto, A., Belluco, S., Losasso, C., Patuzzi, I., Bordin, P., Piovesana, A., Comin, D., Mioni, R. and Ricci, A., 2016. Effectiveness of washing procedures in reducing Salmonella enterica and Listeria monocytogenes on a raw leafy green vegetable (Eruca vesicaria). *Frontiers in microbiology*, *7*, p.1663.

Pienaar, L. and Traub, L., 2015. Understanding the smallholder farmer in South Africa: Towards a sustainable livelihoods classification.

Pijnacker, R., Dallman, T.J., Tijsma, A.S., Hawkins, G., Larkin, L., Kotila, S.M., Amore, G., Amato, E., Suzuki, P.M., Denayer, S. and Klamer, S., 2019. An international outbreak of Salmonella enterica serotype Enteritidis linked to eggs from Poland: a microbiological and epidemiological study. *The Lancet Infectious Diseases*, *19*(7), pp.778-786.

Pinkovetskaia, I.S., Sverdlikova, E.A. and Lebedev, A.V., 2019. Estimating entrepreneurial risk in Russian small and medium-sized enterprises. Journal of Contemporary Issues in Business & Government, 25(1).

Piperno, D.R., 2011. The origins of plant cultivation and domestication in the New World tropics: patterns, process, and new developments. Current anthropology, 52(S4) S453-S470.

Plecher, H., 2021. South Africa: Urbanization in South Africa from 2009 to 2019. New York, NY: Statista Inc. Retrieved, 12.

Postel, S., Polak, P., Gonzales, F. and Keller, J., 2001. Drip irrigation for small farmers: A new initiative to alleviate hunger and poverty. *Water International*, *26*(1), pp.3-13.

Prain, G. and De Zeeuw, H., 2007. Enhancing technical, organisational and institutional innovation in urban agriculture. Urban Agriculture Magazine, 19(7).

Puech, C., Baudry, J., Joannon, A., Poggi, S. and Aviron, S., 2014. Organic vs. conventional farming dichotomy: does it make sense for natural enemies?. Agriculture, Ecosystems & Environment, 194,48-57.

Pulighe, G. and Lupia, F., 2020. Food first: COVID-19 outbreak and cities lockdown a booster for a wider vision on urban agriculture. Sustainability, 12(12), p.5012.

Ragaert, P., Devlieghere, F. and Debevere, J., 2007. Role of microbiological and physiological spoilage mechanisms during storage of minimally processed vegetables. *Postharvest biology and technology*, *44*(3), pp.185-194.

Rajwar, A., Srivastava, P. and Sahgal, M., 2016. Microbiology of fresh produce: route of contamination, detection methods, and remedy. *Critical reviews in food science and nutrition*, *56*(14), pp.2383-2390.

Ramburran, E. 2014. 1st draft to rehabilitate the Baynespruit River for increased water supply to improve the water quality, Msunduzi Municipality, Pietermaritzburg, South Africa. Salomon, M.J., Watts-Williams, S.J., McLaughlin, M.J. and Cavagnaro, T.R. (2020). Urban soil health: A city-wide survey of chemical and biological properties of urban agriculture soils. Journal of Cleaner Production, 275, 122900.

Randell, A.W. and Whitehead, A.J., 1997. Codex Alimentarius: food quality and safety standards for international trade. Revue Scientifique et Technique (International Office of Epizootics), 16(2) 313-321.

Redding, L., Chetri, D.K., Lamichhane, D.K., Chay, Y., Aldinger, L. and Ferguson, J., 2012. Animal production systems of small farms in the Kaski district of Nepal. Tropical animal health and production, 44, 1605-1613

Reganold, J.P. and Wachter, J.M., 2016. Organic agriculture in the twenty-first century. Nature plants, 2(2) 1-8.

Rodriguez-Mozaz S, Vaz-Moreira I, Varela Della Giustina S et al. (2020) Antibiotic residues in final effluents of European wastewater treatment plants and their impact on the aquatic environment. Environ Int 140:105733.

Roser, M. and Ortiz-Ospina, E., 2013. Global extreme poverty. Our world in data. Available at:https://ourworldindata.org/poverty?utm_source=United+Nations+Development+Programme&utm_campaign=5d5d9197b8-pip-%232&utm_medium=email&utm_term=0_e8640e0633-5d5d9197b8-139894821. (Accessed 22 November 2023).

Roy, S., Banna, L.N., Mamun, S.A. and Farukh, M.A., 2013. Effects of industrial wastewater reuse for crop production: A case study in Tejgaon metropolitan area of Dhaka, Bangladesh. *Journal of the Bangladesh Agricultural University*, *11*(452-2016-35607) 183-188.

Rudolph, M., Muchesa, E. and Kroll, F. 2020. Towards an Eco-social Food System: The Shift from Industrial Agriculture to Agro-ecology in South Africa. International Journal of Sustainable Development Research, 6(2), 22.

Rutten, M.M., 2013. What economic theory tells us about the impacts of reducing food losses and/or waste: implications for research, policy and practice. Agriculture & Food Security, 2(1) 1-13.

Saldías, G.S., Largier, J.L., Mendes, R., Pérez-Santos, I., Vargas, C.A. and Sobarzo, M., 2016. Satellite-measured interannual variability of turbid river plumes off central-southern Chile: Spatial patterns and the influence of climate variability. Progress in Oceanography, 146, pp.212-222.

Sallwey, J., Hettiarachchi, H. and Hülsmann, S., 2017. Challenges and opportunities in municipal solid waste management in Mozambique: a review in the light of nexus thinking. AIMS Environmental Science, 4(5).

SANS. 2007. Method 4833. Second Edition. Microbiology: General guidance for the enumeration of microorganisms – colony count technique at 30°C. South African Bureau of Standards, Pretoria.

Sarkar, A., Lehto, S.M., Harty, S., Dinan, T.G., Cryan, J.F. and Burnet, P.W., 2016. Psychobiotics and the manipulation of bacteria-gut-brain signals. *Trends in neurosciences*, *39*(11), pp.763-781.

Schreiner, B., Mungatana, E. and Baleta, H. 2018. Impacts of drought induced water shortages in South Africa: Economic analysis. Water Research Commission (WRC), WRC Report, 18.

Scott, A. and Storper, M., 2003. Regions, globalization, development. *Regional studies*, *37*(6-7), pp.579-593.

Scott, T., Mannion, R., Davies, H. and Marshall, M., 2003. The quantitative measurement of organizational culture in health care: a review of the available instruments. *Health services research*, *38*(3), pp.923-945.

Seed-Uno, 2014. Promoting food security with the climate-smart Umgibe vegetable growing system. Seed promoting Entrepreneurship for sustainable development. Available at: (https://www.seed.uno/enterprise-profiles/umgibe-farming-organics-and-training-institute.) (Accessed 27 June 2020).

Seufert, V., Ramankutty, N. and Foley, J.A., 2012. Comparing the yields of organic and conventional agriculture. Nature, 485(7397) 229-232.

Shaw, D.J., 2007. World food summit, 1996. In World Food Security: A History since 1945 (pp. 347-360). London: Palgrave Macmillan UK.

Shehane, S.D., Harwood, V.J., Whitlock, J.E. and Rose, J.B. 2005. The influence of rainfall on the incidence of microbial faecal indicators and the dominant sources of faecal pollution in a Florida river. Journal of Applied Microbiology, 98(5) 1127-1136.

Sihlobo, W., 2018. Brief Reflections on SA's agricultural labour market in the context of changing farm structures. Agricultural Business Chamber (Agbiz), Pretoria, South Africa.

Singh, R., 2017. Problems and prospects of women entrepreneurship with special reference to MSMEs in the state of Gujarat. Unpublished doctoral thesis, Gujarat Technological University, Gujarat, India. Retrieved from https://www. gtu. ac. in/uploads/Thesis129990992024. pdf.

Singirankabo, U.A. and Ertsen, M.W. 2020. Relations between Land Tenure Security and Agricultural Productivity: Exploring the Effect of Land Registration. Land, 9(5), 138. UN-Habitat. 2007. The State of the World's Cities, 2006/7. United Nations Centre for Human Settlements, Nairobi.

Sinyolo, S., Mudhara, M. and Wale, E., 2014. Water security and rural household food security: Empirical evidence from the Mzinyathi district in South Africa. *Food Security*, *6*, pp.483-499.

Skoufias, E., Vinha, K. and Conroy, H.V., 2011. The impacts of climate variability on welfare in rural Mexico. World Bank Policy Research Working Paper, (5555).

Smit, B., Pilfosova, O., Burton, I., Challenger, B., Huq, S., Klein, R.J.T., Yohe, G., 2001. Adaptation to Climate Change in the Context of Sustainable Development and Equity. In: McCarthy, J.J., Canziani, O.F. (Eds.), Working Group II: Impacts, Adaptation and Vulnerability, 879-906.

Soon, J.M. and Baines, R.N., 2013. Public and private food safety standards: facilitating or frustrating fresh produce growers?. *Laws*, *2*(1), pp.1-19.

South African Weather Service (2020). Weather. Online Document. Available at: https://www.weathersa.co.za/home/historicalrain.

South African Weather Service (2020). Weather. Online Document. Available at: https://www.weathersa.co.za/home/historicalrain.

South African Weather Service (2020). Weather. Online Document. Available at: https://www.weathersa.co.za/home/historicalrain.

Statistics SA (Statistics South Africa), 2019. Survey of Employers and the Self-employed (SESE), 2017. P0276

Statistics SA (Statistics South Africa), 2020. Results from Wave 2 survey on the impact of the COVID-19 pandemic on employment and income in South Africa. Report-00-80-03.

Statistics SA (Statistics South Africa), 2023. Statistical Release PO441. Gross Domestic Product Second Quarter. Pretoria: Statistics South Africa

Statistics SA (Statistics South Africa). 2017a. Poverty trends in South Africa: An examination of absolute poverty between 2006 and 2015. Pretoria: Statistics South Africa.

Statistics SA (Statistics South Africa). 2017b. Mortality and causes of death in South Africa: Findings from death notification. Pretoria: Statistics South Africa.

Statistics South Africa: Improving Lives through Data. Available online: https://www.statssa.gov.za, Accessed date October 2021.

Steele, K., 2017. Urban farming: An introduction to urban farming, from types and benefits to strategies and regulations. Vitalyst Health Foundation, Phoenix, AZ.

Stewart, R., Korth, M., Langer, L., Rafferty, S., Da Silva, N.R. and van Rooyen, C., 2013. What are the impacts of urban agriculture programs on food security in low and middle-income countries?. Environmental Evidence, 2(1) 1-13.

Sulla, V. and Zikhali, P., 2018. Overcoming poverty and inequality in South Africa: An assessment of drivers, constraints and opportunities (No. 124521, 1-148). The World Bank.

Sundström, J.F., Albihn, A., Boqvist, S., Ljungvall, K., Marstorp, H., Martiin, C., Nyberg, K., Vågsholm, I., Yuen, J. and Magnusson, U., 2014. Future threats to agricultural food production posed by environmental degradation, climate change, and animal and plant diseases – a risk analysis in three economic and climate settings. *Food Security*, *6*, pp.201-215.

Surls, R., Feenstra, G., Golden, S., Galt, R., Hardesty, S., Napawan, C. and Wilen, C., 2015. Gearing up to support urban farming in California: Preliminary results of a needs assessment. Renewable Agriculture and Food Systems, 30(1), pp.33-42.

Taing, L., Chang, C., Pan, S. and Armitage, N. 2019. Towards a water secure future: reflections on Cape Town's Day Zero crisis. Urban Water Journal, 16, 530-536.

Tack, D.M., Marder, E.P., Griffin, P.M., Cieslak, P.R., Dunn, J., Hurd, S., Scallan, E., Lathrop, S., Muse, A., Ryan, P. and Smith, K., 2019. Preliminary incidence and trends of infections with pathogens transmitted commonly through food – Foodborne Diseases Active Surveillance Network, 10 US sites, 2015-2018. *American Journal of Transplantation*, *19*(6), pp.1859-1863.

Tal, A., 2018. Making conventional agriculture environmentally friendly: moving beyond the glorification of organic agriculture and the demonization of conventional agriculture. Sustainability, 10(4) 1078.

Taylor, S.E., 2011. Social support: A review. *The Oxford handbook of health psychology*, *1*, pp.189-214.

Tenebe, I.T., Emenike, P.C., Nnaji, C.C., Babatunde, E.O., Ogarekpe, N.M., Dede-Bamfo, N. and Omole, D.O., 2020. Bacterial characterization and quantification of rainwater harvested in a rural community in Nigeria. Environmental Nanotechnology, Monitoring & Management, 14, 100370.

Tham, C.A.T., Zwe, Y.H. and Li, D. 2021. Microbial study of lettuce and agriculture water used for lettuce production at Singapore urban farms. *Food Control*, 126, 108065.

Thamaga-Chitja, S. and Hendriks, S. 2008. Emerging issues in smallholder organic production and marketing in South Africa. Development Southern Africa, 25, 317-326.

The Department of Water & Sanitation., 2019. Annual Report. South Africa, Pretoria.

Thomas, A., 2012. Urbanization before cities: lessons for social theory from the evolution of cities. Journal of World-Systems Research, 211-235.

Turtoi, M. 2013. Ultraviolet light potential for wastewater disinfection. Ann. Food Sci. Technol, 14(1), 153-164.

Uçar, A., Yilmaz, M.V. and Çakiroglu, F.P., 2016. Food safety – problems and solutions. *Significance, prevention and control of food related diseases*, *3*.

Uhunamure, S.E., Kom, Z., Shale, K., Nethengwe, N.S. and Steyn, J., 2021. Perceptions of smallholder farmers towards organic farming in South Africa. Agriculture, 11(11), p.1157.

United Nations. Department of Economic and Social Affairs. The Sustainable Development Goals: Report 2022. United Nations, 2022.

United Nations: The Millennium Development Goals Report 2015. Available online: https://www.un.org. Accessed date October 2021.

Uprety, S., Dangol, B., Nakarmi, P., Dhakal, I. and Sherchan, S.P. 2020. Assessment of microbial risks by characterization of Escherichia coli presence to analyse the public health risks from poor water quality in Nepal. International Journal of Hygiene and Environmental Health, 226, 113484.

US Environmental Protection Agency (USEPA). 1986. Bacteriological ambient water quality criteria for marine and fresh recreational waters. Office of Water Regulations and Standards, 1986 Washington, D.C.

Uwayezu, E. and de Vries, W.T.D. 2020. Access to Affordable Houses for the Low-Income Urban Dwellers in Kigali: Analysis Based on Sale Prices. Land, 9(3), 85.

Uyttendaele, M., Jaykus, L.A., Amoah, P., Chiodini, A., Cunliffe, D., Jacxsens, L., Holvoet, K., Korsten, L., Lau, M., McClure, P. and Medema, G., 2015. Microbial hazards in irrigation water: standards, norms, and testing to manage use of water in fresh produce primary production. Comprehensive Reviews in Food Science and Food Safety, 14(4), 336-356.

Van Beek, L.P.H., Wada, Y. and Bierkens, M.F., 2011. Global monthly water stress: 1. Water balance and water availability. Water Resources Research, 47(7).

Van Beilen, N., 2016. Effects of conventional and organic agricultural techniques on soil ecology. Center for Development and Strategy, 2016(1).

Van Marle-Köster, E. and Visser, C., 2018. Genetic improvement in South African livestock: can genomics bridge the gap between the developed and developing sectors? Frontiers in Genetics, 9, 331.

Van Tuijl, E., Hospers, G.J. and Van Den Berg, L., 2018. Opportunities and challenges of urban agriculture for sustainable city development. European Spatial Research and Policy, 25(2) 5-22.

Van Veenhuizen, R. ed., 2014. Cities farming for the future: Urban agriculture for green and productive cities. IDRC. Available at: https://ruaf.org/assets/2019/11/Cities-Farming-for-the-Future_compressed.pdf. (Accessed 22 November 2023).

Vilakazi, N., Nyirenda, K. and Vellemu, E. 2019. Unlocking Water Issues Towards Food. Security in Africa. In: Food Security in Africa. IntechOpen. DOI: 10.5772/intechopen.86788.

Visser, C., Van Marle-Köster, E., Myburgh, H.C. and De Freitas, A., 2020. Phenomics for sustainable production in the South African dairy and beef cattle industry. Animal Frontiers, 10(2) 12-1

Von Loeper, W., Musango, J., Brent, A. and Drimie, S., 2016. Analysing challenges facing smallholder farmers and conservation agriculture in South Africa: A system dynamics approach. South African Journal of Economic and Management Sciences, 19(5) 747-773.

Wagstaff, R.K. and Wortman, S.E. 2015. Crop physiological response across the Chicago metropolitan region: Developing recommendations for urban and peri-urban farmers in the north central US. Renewable Agriculture and Food Systems, 30(1), 8-14. https://doi. org/10.1017/S174217051300046X.

Wang, N., Zhu, L., Bing, Y., Chen, L. and Fei, S. 2021. Assessment of urban agriculture for evidence-based food planning: A case study in Chengdu, China. Sustainability, 13(6), 3234.

Wanyonyi, E.I., Gathungu, E.W., Bett, H.K. and Okello, D.O. 2021. Determinants of Porter's competitive strategy utilisation among agro-dealers in Kenya. Cogent Food and Agriculture, 7(1), 1865595.

Watkins, L.K.F., Winstead, A., Appiah, G.D., Friedman, C.R., Medalla, F., Hughes, M.J., Birhane, M.G., Schneider, Z.D., Marcenac, P., Hanna, S.S. and Godbole, G., 2020. Update on extensively drug-resistant Salmonella serotype Typhi infections among travellers to or from Pakistan and report of ceftriaxone-resistant Salmonella serotype Typhi infections among travellers to Iraq – United States, 2018-2019. *Morbidity and Mortality Weekly Report*, *69*(20), p.618.

Weam, B., Abraham, M., Doiphode, S., Peters, K., Ibrahim, E., Sultan, A. and Mohammed, H.O., 2016. Foodborne bacterial pathogens associated with the risk of gastroenteritis in the state of Qatar. *International journal of health sciences*, *10*(2), p.197.

Weather SA (2021). Available Online. https://www.weathersa.co.za/home/historicalrain. Accessed on November 2021.

Wheeler, T. and Von Braun, J., 2013. Climate change impacts on global food security. Science, 341(6145) 508-513.

WHO (World Health Organisation). 2006. Guidelines for the safe use of wastewater, excreta and greywater; Volume 1: Policy and regulatory aspects. World Health Organisation, Geneva, Switzerland. URL: whqlibdoc.who.int/publications/2006/9241546824_eng.pdf (Accessed on: 2021, May 14).

WHO (World Health Organisation). 2006. Guidelines for the safe use of wastewater, excreta and greywater; Volume 1: Policy and regulatory aspects. World Health Organisation, Geneva, Switzerland. URL: whqlibdoc.who.int/publications/2006/9241546824_eng.pdf (Accessed on: 2021, May 14).

Williams, C., 2007. Research methods. Journal of Business & Economics Research (JBER), 5(3). Pg 65-75

World Health Organization, 2019. *The state of food security and nutrition in the world 2019: safeguarding against economic slowdowns and downturns* (Vol. 2019). Food & Agriculture Org.

Wu, B., Tian, F., Zhang, M., Piao, S., Zeng, H., Zhu, W., & Lu, Y. (2022). Quantifying global agricultural water appropriation with data derived from earth observations. Journal of Cleaner Production, 358, 131891.

Wu, Y. 2020 (February 17). The marketing strategies of IKEA in China using tools of PESTEL, Five Forces Model and SWOT Analysis [Paper Presentation]. International Academic Conference on Frontiers in Social Sciences and Management Innovation, Beijing, China.

Yuan, G.N., Marquez, G.P.B., Deng, H., Iu, A., Fabella, M., Salonga, R.B., Ashardiono, F. and Cartagena, J.A., 2022. A review on urban agriculture: technology, socio-economy, and policy. Heliyon.

Zambrano-Monserrate, M.A., Ruano, M.A. and Sanchez-Alcalde, L., 2020. Indirect effects of COVID-19 on the environment. Science of the total environment, 728 138813.

Zhang, X., Zhang, F., Wang, D., Fan, J., Hu, Y., Kang, H., Chang, M., Pang, Y., Yang, Y. and Feng, Y., 2018. Effects of vegetation, terrain and soil layer depth on eight soil chemical properties and soil fertility based on hybrid methods at urban forest scale in a typical loess hilly region of China. PLoS. One, 13(10), p.e0205661.

Zhu, B. and Habisch, A., 2020. Smallholder farmers’ engagement in non-certified organic farming: a case from Southern China. British food journal, 122(2) 465-481.

APPENDIX A: STUDENT RESEARCH ABSTRACTS

GRADUATED & NEAR COMPLETION STUDENT RESEARCH ABSTRACTS (MASTERS, PhD, Post Doc)

Ms. Nqobile Mthuli's study investigates the environmental management of urban farming and its implications for food security in the communities of Sobantu, Sweetwaters, and Mpophomeni, located in KwaZulu-Natal, South Africa. Employing a mixed-methods research approach, combining quantitative survey analysis with qualitative data collection through focus group discussions and field observations, the study examines the challenges faced by urban and peri-urban smallholder farmers in the region. The quantitative analysis involved a survey questionnaire administered to 78 purposefully selected farmers, while qualitative data were gathered to provide deeper insights into the issues encountered in urban farming.

The findings reveal significant environmental challenges, including poor soil conditions, water quality and access issues, and impacts of climate change, which adversely affect crop yield and farm profitability. While a substantial portion of farmers (69.2%) demonstrate awareness of the environmental implications of urban farming, financial constraints lead many to prioritize income generation and food acquisition over environmental stewardship. Market availability, training in soil management, and access to credit emerge as critical factors influencing farmers' adoption of sustainable urban farming practices.

Socio-economic and institutional barriers, such as limited knowledge, inadequate training, constrained market access, credit limitations, and insufficient extension support, further hinder the adoption of environmentally sound farming practices. To address these challenges, the study proposes an environmental management framework tailored to the needs of smallholder farmers, aiming to enhance their adoption of sustainable urban farming and water quality management practices.

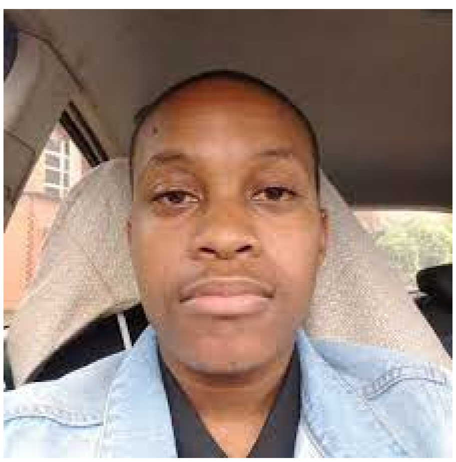
Through its comprehensive analysis and practical recommendations, this study contributes to the understanding of the complex dynamics between urban farming, environmental management, and food security in the context of peri-urban communities in KwaZulu-Natal. It underscores the importance of integrating environmental considerations into urban agricultural policies and interventions to ensure the long-term sustainability of food production systems and the well-being of urban communities.

Ms. Sinethemba Zakhona Ndwalane's study delves into the assessment of entrepreneurial risk and water quality in urban agriculture, with a focus on decision-making processes among urban farmers and their implications for income generation. Additionally, the research examines the existing water policies governing access, use, and quality, along with farmers' perceptions regarding the use of wastewater (WW) in urban agriculture (UA) and the role of UA in food and nutrition security. Employing a mixed-method approach, the study incorporates both qualitative and quantitative data collection methods, including structured questionnaire surveys, observations, and focus group discussions, among 78 urban households randomly selected through a multistage sampling technique.

The socio-demographic analysis reveals a predominance of female respondents with a mean age of 58, highlighting a scarcity of youth participants in the study. Findings underscore the presence of policies governing water access, use, and quality, although no specific regulations pertain to UA. Despite guidelines on water quality, urban farmers resort to alternative water sources, including rainwater and wastewater, due to urban water shortages. However, farmer perceptions indicate reluctance towards WW usage, despite awareness of its agricultural utility.

Moreover, the study identifies significant factors such as age, education, water quality, and entrepreneurial risks (production and price) that influence urban farmers' risk perception and income generation capacity. While many farmers engage in UA to secure household food and nutrition, economic challenges deter market-oriented farming endeavours. The study emphasizes the necessity of enhancing farmers' awareness regarding safe WW utilization and risk management strategies to foster sustained income generation and entrepreneurial engagement in UA.

In conclusion, the study advocates for targeted educational initiatives to improve farmers' knowledge on WW usage and risk management, particularly among youth, to invigorate their participation in UA. By addressing these gaps, the research underscores the potential to bolster UA's role in enhancing food and nutrition security while fostering entrepreneurial resilience within urban farming communities.



Sinethemba R. Dlamini's study investigates the intricate relationship between water use, water quality, and food security among smallholder farmers engaged in urban farming and agro-processing in KwaZulu-Natal, South Africa. The research aims to elucidate the socio-economic factors influencing water use practices, water quality during pre- and post-harvest processes, and their subsequent effects on food security. Through focus group discussions and questionnaires administered to 78 smallholder farmers in Sobantu, Sweetwaters, and Mpophomeni, the study explores farmers' attitudes, knowledge, and practices concerning water use, food safety, and entrepreneurship.

Descriptive statistics reveal a predominantly female (67%) and mature (87% over 40 years old) farming population, with a high percentage (99%) expressing the importance of achieving high-quality fresh produce despite lacking knowledge of food safety. Only a minority (26%) of farmers have received formal training in agriculture. Statistical analysis indicates that socio-economic factors such as income level, previous training, and farmer group membership significantly influence water use practices.

Microbiological analysis of water sources reveals contamination levels exceeding regulatory standards, particularly in the Msunduzi river water used for irrigation. While fresh produce samples show microbial burdens, they generally meet EU safety regulations for ready-to-eat vegetables. However, antibiotic resistance patterns observed in microbial isolates raise concerns about potential health risks associated with consumption.

The study underscores the critical role of socio-economic factors in shaping water use practices and highlights the need for context-specific agricultural training programs focusing on water use and quality. Furthermore, it emphasizes the importance of hygiene and food safety awareness for farmers to access better markets. The presence of antibiotic-resistant microbial pathogens poses significant risks to food security and public health, necessitating policy interventions and further research to address these challenges.

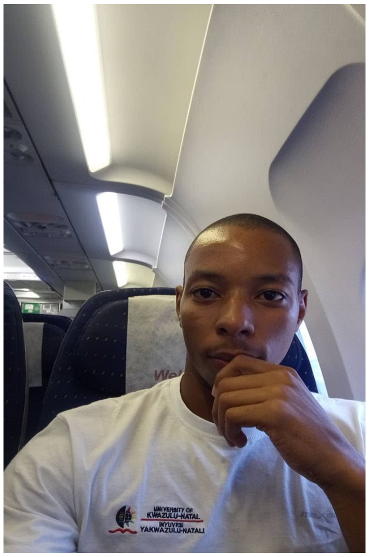
In conclusion, the study underscores the interplay between socio-economic dynamics, water management practices, and food security outcomes in urban farming contexts. By illuminating these relationships, the research contributes to the formulation of evidence-based policies and interventions aimed at promoting sustainable urban agriculture and safeguarding public health.

 **Busile Glory Lukhele's** study investigates the pivotal role of digital technology in agriculture and its impact on market access and household food security among smallholder farmers in Eswatini. Conducted in the Ntfonjeni community in the Hhohho region and the Sidvokodvo community in the Manzini region, the research employed a mixed-methods approach, combining surveys and key informant interviews. A sample of 100 active long-term smallholder vegetable farmers was selected using purposive sampling and interviewed face-to-face using a questionnaire, while two extension officers provided additional insights as key informants. The data was analysed using SPSS version 28.

Descriptive statistics revealed that the majority of farmers were male (56%) compared to female farmers (44%), with cabbage being the most commonly grown vegetable. Among the digital tools, a normal phone (23.58%) was the most owned digital tool among farmers, with phone calls being the most common means used for advertising. The study found that most farmers sold their produce at the farm gate, with the local community members being the most common market. Farmers primarily received market information from other agricultural cooperative members and extension officers through phone calls. However, a significant proportion of farmers (36.7%) indicated a lack of training on digital marketing.

Mobile money emerged as the most widely used digital platform for financial transactions among smallholder farmers, with most farmers obtaining farm credit from microfinance institutions, particularly Fincorp. The Household Food Insecurity Access Scale (HHFIAS) score revealed varying degrees of food insecurity among farmers, with 24% classified as food secure, 39% as moderately food insecure, 31% as mildly food insecure, and 6% as severely food insecure.

The findings underscore the need for policymakers and supporting organizations to develop programs aimed at empowering smallholder farmers by enhancing their social capital and human capital assets through education, training, and awareness creation on the role of digital technologies in market access. By addressing the gaps in digital literacy and access to training, policymakers can contribute to improving market access and enhancing household food security among smallholder farmers in Eswatini.



Phiwokuhle Ndlovu's study investigates market access, entrepreneurship, and the role of water security in urban based farming. The study was conducted in the Sobantu and Mphophomeni Townships that are located in the province of KwaZulu-Natal. The research aims to provide valuable insights on whether smallholder urban farmers can be successful entrepreneurs if they have access to markets and enough safe water for irrigation. The study looked at the drivers of market access and the determinates of participating in agricultural entrepreneurial activities within the smallholder urban farmers. Furthermore, the study explored the relationship between market access, entrepreneurship, and water security in urban-based farming. The innovativeness of the study comes from adopting a business-driven action learning (BDAL) process to strengthen entrepreneurial activities through forum and sharing network.

Gugulethu Mdluli's study examines the determinants of market access for urban smallholder farmers and their implications for household food security within the Msunduzi municipality, located in the uMgungundlovu district of Pietermaritzburg, KwaZulu-Natal. Despite the recognized potential of urban agriculture to enhance income and food security, smallholder farmers in Pietermaritzburg face challenges in accessing markets, particularly the Mkondeni market established in 1982. Higher transactional costs hinder their ability to reach this market, limiting their income opportunities and food security outcomes.

Through an examination of market access constraints from production to market levels, this research aims to provide valuable insights for local government structures and programs addressing food security within the Msunduzi municipality. By identifying and understanding the factors impeding market access for urban smallholder farmers, policymakers can develop targeted interventions to alleviate these constraints and enhance the socioeconomic well-being of urban farming communities.

The findings of this study are expected to inform evidence-based decision-making processes, guiding the formulation of more effective policies and interventions aimed at improving market access for smallholder farmers. By addressing market access challenges, local government structures can foster a more enabling environment for urban agriculture, thereby enhancing household food security and contributing to the overall resilience and sustainability of urban communities within the Msunduzi municipality.

Sinethemba Gwala's study investigates the intricate relationship between land and market access among urban farmers in Msunduzi Municipality, with a specific focus on its implications for household food security. Three primary objectives guide the research: firstly, to determine the sizes of land parcels held by urban farmers and the security of their land tenure; secondly, to explore the relationship between access to land and market access in the context of urban-based farming; and thirdly, to examine how limited access to land influences the household food security of urban farmers within the Msunduzi municipality.

Through a mixed-methods approach combining surveys and interviews, data was collected from urban farmers across various socio-economic strata and geographical locations within Msunduzi Municipality.

Ntombenhle Sithole's research delves into the critical issue of water access and its impact on the food and nutrition status of small livestock farmers in urban areas, focusing on the Sobantu and Mpophomeni townships in KwaZulu-Natal. In urban areas, where agriculture plays a significant role in livelihoods, limited access to water poses a significant challenge, exacerbated by high water tariffs and financial constraints faced by low-income communities, particularly in the context of high unemployment rates. To mitigate these challenges, families often turn to small livestock production as a means of improving their livelihoods and generating income. However, the implications of water scarcity on small livestock production remain poorly understood.

The study aims to address this gap through specific research objectives. Firstly, it seeks to characterize water availability and utilization patterns for small livestock farming in urban areas, shedding light on the challenges and constraints faced by farmers. Secondly, the research endeavours to explore the multifaceted role of water in small livestock production within urban contexts, highlighting its significance for animal health, productivity, and overall farm viability. Additionally, the study aims to document strategies employed by small livestock farmers to enhance water access, recognizing the importance of innovative approaches in overcoming water scarcity challenges.

Through a comprehensive examination of water access, utilization patterns, and the socio-economic dynamics of small livestock farming in urban areas, the study seeks to generate insights that can inform policy and interventions aimed at enhancing water access and promoting food security among small livestock farmers.

Nontobeko Gebashe's research delves into the gender dynamics of land use within urban agriculture settings, particularly focusing on the disparities between males and females and their implications for household food and nutrition security. Despite the recognized significance of urban agriculture in addressing food insecurity, there exists a noticeable gender gap in participation, with fewer men actively engaging in farming activities. Gebashe's study aims to uncover the underlying reasons for this disparity by investigating how males and females utilize land in urban areas for household food and nutrition security. The research objectives include exploring gender roles among urban farmers, investigating land use practices, and assessing the impact of these dynamics on household food security outcomes. Through a comprehensive mixed-methods approach, including surveys, and interviews, data will be collected to analyse patterns of land use and gender dynamics.

**Dr T. Beharielal,** study was focusing on "Pre- and post-harvest farming practices and the microbial quality of fresh produce – a comparison of different farming systems. High levels of fresh produce related foodborne disease outbreaks have led to the scrutiny of farming practices as a potential reason for microbial contamination of fresh produce. To understand the potential spread of microbial hazards and identify critical contamination sources, the farming practices of different farming systems (conventional; semi-conventional; semi-organic and organic) were analysed in KwaZulu-Natal, South Africa. Questionnaires and key-informant interviews illustrated that farming practices were influenced by financial constraints experienced by the farmer and in the case of informal semi-organic farmers', education and gender had the highest impacts on farming practices utilized. Established hygiene indicators (faecal coliforms, *E. coli*, *Enterococcus* spp.) were quantified in fresh produce and selected potential pre-harvest contamination sources (irrigation water, soil, and fertilizer). In addition, the presence of two selected foodborne pathogens in the same samples (*Salmonella* spp. and *Staphylococcus* spp.) was analysed. According to recommendations by the South African Department of Health, fresh produce samples frequently violated food safety recommendations. However, according to international guidelines fresh produce was most often found to be of satisfactory quality. *Salmonella* spp. although not detected fresh produce samples, was detected in an irrigation water and fertilizer sample from the semi-organic farm. Bacterial organisms isolated from fresh produce and other farming inputs sampled in the study displayed antimicrobial resistance and biofilm formation capabilities. Such resistances as displayed by the bacterial organisms may lead to health complications in consumers and may impact on the quality of fresh produce and thus saleability. Microbial contamination of fresh produce – potentially including antibiotic resistant and biofilm forming bacteria – within the production and processing environment highlights the need for good pre-and post-harvest hygiene practices and monitoring in view of food safety.

 **Dr Nthabeleng Tamako** study was "Assessing the impact of urbanization and climate change on urban food gardens and land access: A case study of Sobantu township, KwaZulu-Natal Province. Urban food insecurity and land scarcity are pressing issues exacerbated by the effects of urbanization and climate change. These phenomena have led to an increase in the frequency and intensity of extreme events, which have adverse consequences on food security and land degradation. The consequences of climate change have put the sustainability of food systems and the livelihoods of vulnerable populations at risk. The impact of climate change and urbanization on agriculture, particularly urban agriculture, is predicted to be detrimental, especially in areas of informal growth. The current study examines the consequences of urbanization and climate change on urban food gardens and land access, with a particular focus on water quality and soil fertility. It is crucial to understand the effects of climate change and urbanization on urban food gardens in order to comprehend urban food security and nutrition, given the rapid growth of the urban population and the consequent increase in demand for food. Urban agriculture faces a threat due to competition for land use and demand, and human activities such as urbanization, erosion, and pollution often result in significant changes to urban soils, which can lead to low soil fertility. Numerous studies have identified irrigation water as a source of pathogenic microorganisms in food production. To address this issue, a mixed-method approach was used, combining qualitative and quantitative data collection techniques, to survey 78 urban farmers in the Pietermaritzburg Townships of KZN Province. The research aimed to understand the impact of climate change and urbanization on urban food gardens and to identify potential solutions to mitigate its effects. The analysis of river water samples revealed that the uMsunduzi river water consistently exceeded the recommended standards for irrigation water quality, making it safe for use. Subsequent research showed that the stored water in the tanks had a lower microbial load and could potentially be used as a replacement. This study uncovered substantial variations in the soil nutrient

properties across different urban land uses, highlighting the intricate and diverse nature of urban soils, which are shaped by a multitude of management practices, environmental disturbances, and environmental factors.

CAPACITY BUILDING

Capacity Building through the life of this project was both from a an academic, technical and through soft skills.

a) **Early career research, academic & leadership skills**

Dr. Nthabeleng Tamako and Mr. Phiwo Ndlovu have been the post doctorate and doctoral students respectfully. Both have grown their academic and research prowess and gained valuable experience and skills in facilitating meetings and coordinating fieldwork activities including facilitating access to external stakeholder. The project leader's empowering style of mentorship fosters growth and confidence to germinate faster in such young professionals.

Technical skills acquired include research methods, data analysis, writing, presentation and publishing for all students. All research is written in manuscript format, thus position at least a publication from each Masters student and more from Doctoral & Post Doctoral candidates. The project runs at least two research and writing workshops per year in addition to other conferences students are encouraged to attend. Many of the students have presented & facilitated at UKZN Post graduate Research Innovation Symposium (PRIS) conference and international ones such as the Afri in South Africa & Namibia can Farm Management (AFMA), AEASA & African Agricultural Economics Association.

Business driven and participatory research skills to support farmers transformation towards business orientation in their operations.

With regards to **soft skills,** they and all students have acquired, effective communication among project stakeholders (all students, plan and execute field work themselves while supported by the project team, thus learning project management)

Following their involvement in the project, Dr. Nthabeleng Tamako working with the Project leader & the team transitioned to the role emerging research developmental editor in one of her roles in the project, leveraging her expertise to refine and enhance the project's research outputs. Mr. Phiwo Ndlovu, on the other hand sharpened skills in agricultural logistics, communication & stakeholder engagement. He further assumed the role of a Green Fellow Member, signifying his commitment to environmental sustainability and conservation efforts within the project.

I**nstitutional and community capacit**y building include hiring of Ms Thembelihle Memela as research assistant for a brief time in the project. Mr Phiwo Ndlovu is currently an Adhoch lecturer using transferring knowledge to young students.

At a community level, the demonstration/field plots allowed for farmers:

-be exposed to appropriate production and soil management (Project students & external Stakeholder Training on agro-ecological methods of production)

-be exposed to practical scientific method for water quality improvement

-exposure to market information and market-led production (HelloChoice Marketing Information Sharing).