ENVIRONMENTAL MANAGEMENT OF URBAN FARMING AND WATER QUALITY: IMPLICATIONS FOR FOOD SECURITY

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ABSTRACT

Urban farming, in its small scale comprises of various production systems and practices that can lead to poor soil conditions, water pollution and the extension of climate change impacts. Moreover, smallholder farmers are in turn challenged by climate change impacts including heavy rainfall, high temperatures, hailstorms and pests exacerbated by the lack of knowledge, institutional support, governance framework, limited financial resources and technology. As a result, farmers are vulnerable to urban farming and environmental risks that affect the farmers' food and nutrition security. On the other hand, if done well, urban farming (UF) can benefit the urban environment through flood water mitigation, water infiltration and greening of the environment, while improving food security. The study was conducted in the communities of Sobantu, Sweetwaters and Mpophomeni, in KwaZulu-Natal. This study employed a mixed-methods research approach, which combines quantitative and qualitative analysis. The quantitative approach used a survey questionnaire to elicit responses from 78 urban and periurban smallholder farmers who were purposefully selected to participate in the study. Focus group discussions and field observations were used to collect in-depth qualitative data about the challenges urban farmers faced in urban farming. Additionally, the logit regression model was used to identify factors that influence the farmers adoption of urban farming management practices. The study revealed that the majority of the farmers were faced with environmental problems including poor soil conditions, water quality and access problems and climate change impacts, of which had an impact on crop yield and farm profit. Furthermore, results showed that 69.2% of farmers were aware of the environmental implications of urban farming. However, it was found that due to the farmers limited financial resources, farmers identified urban farming mainly as a source of income and a strategy to obtain extra food and less for the benefit of the environment. The study found that market availability (p=0.003), training on soil management (p=0.0011) and access to credit (p=0.097) were significant factors in the adoption of urban farming practices. The study further revealed that the farmers adoption of urban farming and water quality management practices were challenged by socio-economic and institutional factors such as the lack of knowledge, farmer training, access to markets, access to credit and poor extension support. An environmental management framework was provided to address the challenges that hinder the smallholder farmers adoption of urban farming and water quality management practices.

Key words: urban farming, environmental management, food security, climate change impacts.

PREFACE

The research contained in this dissertation was completed by the candidate while based in the School of Agricultural, Earth and Environmental Sciences of the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Pietermaritzburg Campus, South Africa. Under the supervision of Prof Joyce Chitja and Dr Ojo Temitope.

The contents of this work have not been submitted in any form to another university and, except where the work of other0s is acknowledged in the text, the results reported are due to investigations by the candidate.

Signed: … [redacted]…………….. Date: 23 March 2022
Nqobile Mthuli (Candidate)

As supervisors of the candidate, we agree to the submission of this dissertation.

Signed: …………………………………….. Date: ………………………...
Prof Joyce Chitja (Supervisor)

Signed: …………………………………….. Date: ………………………...
Dr Ojo Temitope (Co-Supervisor)

DECLARATION-PLAGIARISM

I, Nqobile Mthuli declare that:

1. The research reported in this dissertation, except where otherwise indicated, is my original research.
2. This dissertation has not been submitted for any degree or examination at any other university.
3. This dissertation does not contain other persons' data, pictures, graphs or other information unless specifically acknowledged as being sourced from other sources.
4. This dissertation does not contain other persons' writing unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted then:
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Signed: ……[redacted]………………………. Date: …23 March 2022……….
Name: Nqobile Mthuli

As research supervisor, I agree to submission of this dissertation for examination:

Signed: ………………………………………. Date……………………………………...…

Name: Prof. Joyce Chitja

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ABBREVIATIONS

DA: Department of Agriculture

DEA: Department of Environmental Affairs

DEAT: Department of Environmental Affairs and Tourism

DP: Development Planning

DWA: Department of Water Affairs

EIA: Environmental Management Impact

FAO: Food and Agricultural Organization

GHGs: Greenhouse gas emissions

IDP: Integrated Development Plan

MSA: Municipal Structures Act (No 117 of 1998)

NC: National Constitution (Act No 108 of 1996)

NEMA: National Environmental Management Act

NWA: National Water Act (No 36 of 1998)

PESTEL: Political, Economic, Social, Technology/technical, Environmental, Legal

SA-GAP: South African Good Agricultural Practices

SDGs: Sustainable Development Goals

SPSS: Statistical Package for Social Sciences (IBM SPSS Version 27)

SSA: Sub-Saharan Africa

UDM: uMgungundlovu District Municipality

UF: Urban Farming

UNDESA: The United Nations Department of Economic and Social Affairs

CHAPTER ONE: GENERAL INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Urbanization is rapidly increasing as people migrate to cities and towns as urban centers are perceived to provide better livelihood opportunities (Bisaga *et al.*, 2019). This has resulted in the high rate of migration of rural dwellers, including the youth and small-scale farmers, thus changing the face of rural and urban environments. Orsini *et al.* (2013) indicated that 55% of the world population is projected to live in urban areas and will increase to 60 and 70 percent in 2030 and 2050, respectively. The United Nations Department of Economic and Social Affairs (2016) stated that over 50% of the population in South Africa alone resides in cities and towns. These numbers are projected to increase to 60% by 2030 (UNDESA, 2016).

These urbanization trends have led to a significant shift in rural to urban poverty which has resulted to an expansion of informal settlements with poor living conditions that lack the basic provision of services, thus contradicting the common perceptions of what constitutes an "urban" area. Orsini *et al.* (2013) stated that the urbanization process exacerbates political, economic, social, and environmental issues, threatening people's well-being and livelihoods. These include increasing urban poverty and unemployment levels, expansion of informal settlements with poor living conditions, exerting pressure on cities and their limited land and water resources of which extends climate change impacts and challenges sustainability (Orsini *et al.*, 2013; Bisaga *et al.*, 2019). Bisaga *et al.* (2019) further states that urban farming has been adopted as a strategy to alleviate urban poverty, improve food and nutrition security for the growing and urbanizing population while providing environmental benefits such as flood water mitigation, water infiltration and urban greening.

Despite the opportunities of urban farming, urban farmers are often influenced by institutional and environmental factors that affect the sustainability of the practice. Trigo *et al.* (2021) stated that urban farming can be an environmentally destructive practice that contributes to depleting arable land and environmental pollution, including water quality deterioration which extends climate change impacts. These environmental issues are challenging the sustainable development goals (SDGs) that aim to alleviate poverty and hunger as well as providing clean water and sanitation. Therefore, environmental issues need to be addressed as environmental quality and the provision of ecosystem services is crucial for economic, social and environmental development.

According to the Department of Environmental Affairs and Development Planning and Department of Agriculture of the Western Cape government (DEA, DP & DA) (2018), the Western Cape government stated that "farming lies in the heart of sustainable social and economic development in the region and its people". Therefore, the urban farming environment and water quality must be utilized and managed wisely to sustain the farmers' well-being and livelihood (DEA, DP & DA, 2018). Henceforth, this study adds to the body of knowledge, practice and policy by identifying urban farming and water quality management practices aimed at addressing poor water quality and the environmental implications of urban farming.

1.2 GENERAL RESEARCH OBJECTIVE

The main objective of the study was to investigate the environmental management of urban farming and water quality: implications for food security

1.2.1 Specific objectives

1. Exploring the challenges of urban farming
2. Exploring the implications of urban farming on the environment and water quality: implications for food security
3. Identifying the environmental management practices adopted by the urban farmers
4. Determining the challenges around the state of the environmental management framework associated with urban farming and water quality: towards an environmental management framework associated for food and nutrition security

1.3 PROBLEM STATEMENT

The intensification of farming practices to meet the demands of the increasing population has negative implications on the environment such as soil and water pollution, soil erosion, water depletion and pest outbreaks. Moreover, these farming practices are exacerbating environmental constraints such as climate change impacts that are affecting crop production, threatening food security. Poor urban smallholder farmers are increasingly vulnerable due to poor response mechanisms resulting from socio-economic variables including the lack of institutional support, poor financial resources and the lack of information services. Further, there is limited knowledge amongst smallholder farmers about environmental management practices associated with urban farming and water quality. Information needs to be presented to farmers to enhance the adoption of urban farming and water quality management practices that can reduce the impacts of farming activities on the environment and the environmental constraints on crop production. Therefore, this research study does not only provide insight on the challenges of urban farming and its impact on the environment but promotes sustainable farming by identifying urban farming and water quality management practices adopted in the study.

1.4 SIGNIFICANCE OF THE STUDY

Statistics South Africa (2019) has revealed that food insecurity continues to be a threat to at least a third of the population with the majority residing in poor rural and peri-urban areas where subsistence farming is the main source of sustaining a livelihood. Climate change, poor soil and water quality are some of the environmental constraints that affect crop production and crop yields, threatening the farmers food security. This study sheds more light and understanding about the environmental impacts of urban farming and challenges that hinder its growth in the Sobantu, Sweetwaters and Mpophoneni communities. It is a significant study because it further promotes sustainable farming by identifying urban farming and water quality management practices that can reduce the environmental impacts of urban farming on the environment. Moreover, it adds to policy and practice by outlining the initiatives and roles that can be taken to address the socio-economic factors that hinder the farmers capacity to respond to environmental impacts and constraints, thus improving food security.

1.5 STUDY LIMITATIONS

The study only covered a purposively selected sample of smallholder farmers in the communities of urban Sobantu, semi-urban Sweetwaters and semi-urban Mpophomeni. Therefore, the findings cannot be generalized as the sampled farmers were not a representation of the entire population.

1.6 STUDY ASSUMPTIONS

The study assumed that all the participants in the study answered all the questions asked truthfully and that the given time frame was enough to conduct the data needed to complete the study.

1.7 ORGANIZATION OF THE DISSERTATION

This dissertation comprises of six (6) chapters. Chapter one consists of the problem and setting. The second chapter presents the literature review, the third chapter covers the overall methodology that was used to conduct and analyze data. It also outlines the description of the study area and sample farmers, the research design, sampling technique and sample size as well as the data analysis. Chapters four and five present the research results, and finally chapter six outlines the conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents an overview of literature and concepts in relation to the study. The concepts of urban farming, environmental management, food security and climate change impacts will be discussed in this chapter. The literature is based on the challenges of urban farming, environmental constraints on crop production, environmental implications of crop production and the implications for food security is presented. Moreover, environmental management practices associated with farming and water quality as well as factors that influence the farmers adoption of environmental management practices is discussed.

2.2 CONCEPTS AND DEFINITIONS

2.2.1 Urban farming

The term urban farming as adopted in this study is defined as an industry located within or on the fringe of a town or city which grows, processes, and distributes a diversity of agriculture products, using mainly human, land, and water resources (Hoornweg and Munro-Faure, 2008). Peri-urban farming is another term often used to refer to the production of food in and around cities (Davies et al 2021), however, for the purpose of this study, the term urban farming will be used throughout. Urban farming can occur through various land uses, including community and rooftop gardening, in the form of both smallholder and/or subsistence and commercial farming (Sarker *et al.*, 2019). While urban households generally engage in urban farming to obtain extra food or to sell produce in formal and informal urban markets, it also offers various environmental benefits such as flood water mitigation, water infiltration and urban greening in cities.

2.2.2 Environmental management

Kotze *et al*. (2009) further stated that one cannot manage the environment, water, or climate and pollution, but one can manage people's thoughts and actions because it is people's behavior that impacts the environment. Barrow (2005) suggested that in order to understand what environmental management means, the two terms need to be defined separately. The term “environment” refers to the surroundings in which humans and other organisms exist. It is used in its broadest sense to consist of biophysical, social, and economic aspects and the linkages within and between these components (Barrow, 2005). The term management is defined as "the execution of planned controls so as to achieve a desired outcome" (Fuggle *et al.*, 1992:3). Kotze *et al.* (2009) defined environmental management as a governance strategy that derives its authority from a well-established legal mandate aimed at regulating the effects of human activities, products and services on the environment to preserve and improve its natural state and its components such as soil, water and landscape.

In relation to the study, management in agriculture is defined as environmental management associated with agricultural production. It involves the "management of activities, relations and impacts of diverse agrarian (farm managers, resource owners) and non-agrarian (businesses, consumers, and residents) agents" (Bachev 2013:10). Environmental management involves policies and regulations including the constitution of South Africa - Section 24 of the South African Constitution which strongly advocates for the protection of the environment as a human right. The White Paper on Environmental Management Policy (1997) and the National Environmental Management Act (1998) consisting of various tools including the Environmental Impact Assessment (EIA) are key regulatory frameworks used to ensure that the management of activities and mitigation measures of the impacts of new developments are taken into consideration. In addition, the EIA process requires the integration of social, economic and environmental aspects that influence the planning, implementation and evaluation of decisions to ensure sustainability (Department of Environmental Affairs and Tourism report, 2014).

A number of strict environmental laws apply to environmental management in South Africa, including the polluter pays principle in which the polluter is required to provide monetary compensation for the development impacts imposed on the environment (Griffin et al, 2015). Additionally, the precautionary principle is also a well-known and practiced regulatory principle where decision-makers adopt mitigation measures to prevent uncertain developmental impacts (DEAT, 2014). The implementation of these regulatory principles depends on the type of development and/or activity and varies significantly in different contexts, in this case, between high and low-income urban farmers.

2.2.3 Food security

According to the Committee on Food Security of the Food and Agriculture Organization (FAO, 2012), food security exists when all people at all times have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Havas and Salman (2011) mentioned that food security is a multidimensional topic that addresses the availability of food and its cost, source, and production practices used in the cultivation and harvesting of the food products. Food security comprises of four pillars: food availability, accessibility, utilization, and stability (Statistics SA, 2019). According to the FAO, food security objectives can only be realized when all four pillars have been fulfilled simultaneously.

South Africa is a food secure country at the national level, however, challenges are more experienced at the individual and household level where insufficient access to resources to obtain food in sufficient quantities and of good quality are prevalent. Food insecurity is defined as the lack of access to adequate, affordable, and nutritious food by individuals and households. It is a major issue in South Africa and globally with all four pillars affected, thus resulting to hunger and famine mostly within poor individuals and households (FAO, 2018).

2.2.4 Climate change

According to Ubisi *et al*. (2017) climate change effects are identified as changes in the variability of rainfall and high temperatures over a period of time often resulting to floods and drought which reduces crop production and productivity. This is often attributed to natural processes and anthropogenic activities that emit greenhouse gases including methane and carbon dioxide into the atmosphere (Collier et al., 2008). This often results to the urban heat island phenomenon where urban areas give off higher temperatures compared to rural areas and other places located at the outskirts of cities (Ackerman *et al.*, 2014; Campbell, 2017). The KwaZulu-Natal province has long since been experiencing extreme weather events, particularly heavy rainfall, floods, heat waves, drought, hailstorms and cold spells (Hlahla and Hill, 2018). In the years 1987 and 1989, the province of KwaZulu- Natal faced the worst floods which killed an estimated 388 people, with 68 000 more homeless and hailstorms (uMgungundlovu District Municipality, 2013). Poor smallholder farmers are the most vulnerable to climate change due to low adaptation capacity as a result of the poor socioeconomic variables such as financial resources, education and technology (Nyong, 2006; Hlahla and Hill, 2018).

2.3 THE CONTEXT OF URBAN FARMING AND SMALLHOLDER FARMERS: OPPORTUNITIES AND CHALLENGES

Although agriculture is more prominent in rural areas, it has become a common practice in urban areas aimed at addressing unemployment, urban poverty, food and nutrition insecurity and climate change impacts (Prain and Dubbeling, 2011; Orsini, 2013; Van Wyk and Dlamini, 2018). Moreover, some urban dwellers engage in urban farming to not only obtain extra food and income but to gain control of the organic quality of the food they consume, to restore degraded urban land plots, and to address deficiencies in micro-nutrients (Moglia, 2014; Thamaga-Chitja and Morojele, 2014). Feola *et al.* (2020) state that urban farming can offer various environmental benefits including flood water mitigation, water filtration and the greening of the urban environment which has a positive impact on the mitigation of climate change impacts. Several authors (Prain and Bubbeling, 2011; Brinkley, 2012; Feola *et al.*, 2020) attest that urban farming aims to achieve a sustainable urban environment with reduced greenhouse gas emissions (GHGs) and contribute to climate change mitigation while meeting food demands for the growing population. The proximity of the urban farmers to consumers and market outlets has reduced transportation for distribution which has alleviated the accumulation of GHGs and prolonged the longevity of fresh produce (Prain and Dubbeling, 2011), ultimately contributing to urban environmental management.

Although agriculture is a popular practice in South Africa, people are still food insecure, the challenge is that over 90% of the locally produced food is done by smallholder farmers who cultivate in small plots of land with outdated farming tools, depend heavily on rainfall and have limited access to financial resources (Khapayi and Celliers, 2016). This entails that certain barriers will eventually result in losses in production and hinder farmers in producing sufficient amounts of food to enable surplus which will be traded in formal and informal markets for people to access. Farming, whether subsistence or commercial and whether dependent on rain or irrigation will always be associated with environmental and socioeconomic barriers that threaten the successful production of food crops, thus threatening food security.

Krishnan et al. (2016) state that the PESTEL, an acronym for political, economic, social, technological, environmental and legal, analysis model can be used to generate and analyze the challenges in an organizations' external environment. The term was developed from ETPS (Economic, Technical, Political and Social) as originally presented by Aguilar (1967). Organizations that continuously evaluate their environment for external factors that present challenges provide the organization with a competitive advantage as it helps improve organizational performance (Matovic, 2020; Buye, 2021). Therefore, this study adopted the PESTEL analysis model to identify and analyze external environment factors that challenge the growth and performance of urban farming, thus the sustainability of urban food systems and the livelihoods of the farmers.

2.3.1 Political Factors

Politically, an outline of the government's influence and the extent of its role in the performance of urban farming is considered. Archer *et al* (2008) state that political dynamics have a direct and indirect influence on farming systems such as through implemented policies in the case of direct influences. While the indirect political influences are experienced through the markets when the government invests in public infrastructure and development such as administering of subsidies and incentives aimed at, for instance, increasing food production or encouraging the adoption of environmentally friendly ways of farming (Archer et al., 2008). According to Chikazunga *et al* (2012) subsidies and incentives have resulted in the significant growth in the agricultural economy in the United States of America and Europe, while in South Africa the implementation challenges have seen supported smallholder farmers still struggling. Despite the established and implemented policies and programs meant to uplift poor smallholder farmers in South Africa, there is still little improvement to show that these interventions are effective (Khapayi and Celliers, 2016).

Agricultural departments exclude urban farming from their primary mandate in favor of rural farming and development. According to (Anderson *et al*., 2016; Von Loeper et al., 2016; Clark and Tilman., 2017) one key barrier to the sustainability of urban farming is that this concept is politically overlooked in favor of rural agriculture, commercial farming and other types of developments by urban decision-makers and national governments. This could be attributed to the perception that it is only rural people who are involved in agriculture and the fact that the urban farming sector is not adequately integrated into agricultural policies and urban planning. The lack of policy and programming support especially for urban farming has hindered the effectiveness of this practice (Cele, 2016). Smallholder urban farmers are lacking in support mechanisms, basic agricultural resources and infrastructure, dismissing the potential in creating employment and affordable food for the urban poor (Prain and Dubbelling, 2011).

Poor extension services are a common problem as attested by Davis and Terblanche (2016) in their study. This means that the ineffectiveness of urban farming policies has resulted in many smallholder farmers in South Africa lacking the capacity to access relevant information, services and opportunities implemented by the government.

Additionally, this lack of interest and support from the government has hindered the relevance of urban farming, contributing to the lack of research conducted, which has piled up the inadequacy in skills, knowledge, and awareness on how to identify and address various challenges in the urban farming sector (Anderson *et al*., 2016; Clark and Tilman, 2017). This is evident through the fact that smallholder farmers are lacking in market access related information while the government emphasizes on providing subsidies and incentives to improve agricultural production and yields (Khapayi and Celliers, 2016). According to Khapayi and Celliers (2016) smallholder farmers who lack of access to formal markets are often challenged by various institutional factors including the lack of institutional support, poor infrastructure, lack of land ownership and high formal market requirements such as providing certification to ensure food safety and health standards have been met. This suggests that although the government plays some role in developing smallholder urban farmers, the lack of thorough research conducted has affected the degree of political responses.

2.3.2 Economic Factors

Economic factors, including the lack of credit and inadequate purchasing power exacerbated by inflation where food prices increase pose a significant threat to the farmers' ability to sustain farm operations. A study conducted by Mpandeli and Maponya (2014) state that smallholder farmers often lack financial resources that hinder their purchasing power to access farm inputs such as seedlings, accessing tractors and farm labor. Although urban smallholder farmers are in proximity to both formal and informal markets, transaction costs to transport and distribute produce are still high due to market changes. This influences the farmer's ability to increase food production and productivity which lowers the chances of actively participating in market trade. Therefore, decreasing investment opportunities, further reducing farm profit and credit access. This limits the farmer's ability to turn their farming activities into a lucrative business which will enable them to compete with commercial markets.

According to Van Wyk and Dlamini (2018), factors such as poverty associated with unemployment and high food prices make it difficult for vulnerable households to sustain their livelihoods. The increase in the prices of food commodities in South Africa and globally during the years 2006 to 2008 had adverse impacts on poor households, which left the population extremely vulnerable to food insecurity (Van Wyk and Dlamini, 2018). Considering the high and continuously increasing food prices exacerbated by low monthly income, low farm input generated and the lack of access to credit, poor smallholder farmers often have to utilize some of the produce for household consumption to obtain extra food. It is clear that for poor smallholder urban farmers to overcome their low socio-economic background, they need to ensure the sustainability of urban farming.

2.3.3 Social Factors

Social factors outline the shared beliefs and attitudes the population has acquired, giving it an identity (Matovic, 2020). These include age distribution, gender dynamics, career attitudes, and crime levels amongst many of which can influence the population's perceptions of urban farming. According to Schroeder and Smaldone (2015), social factors such as age and gender dynamics play a significant role in the practice of urban farming. The largest concentration of active smallholder farmers in Sub-Saharan Africa are female and are usually the older generation (Food and Agricultural Organization, 2001; Thamaga-Chitja and Morojele, 2014; Cele, 2016). Female farmers play a significant role in the production, processing, marketing and preparation of food in the household and thus should be included in assessing their influence on the changing farming systems (Food and Agricultural Organization, 2001; Archer *et al*., 2008).

Female farmers particularly in rural areas are often at a disadvantage in terms of accessing resources such as land due to gender inequalities supported by cultural beliefs (Myeni *et al.*, 2009). Female smallholder farmers often lack sufficient arable land for production and are subjected to cultivating food crops in small quantities which limit their participation in selling their produce in formal markets (Raney *et al.*, 2011; Food and Agricultural Organization, 2015). According to Cele (2016) the youth does not have an interest in smallholder farming due to the lack of economic gains, and thus often commute to city centers in search of job opportunities in non-farming sectors. This is concerning because smallholder farming systems are vulnerable to the slow disappearance of indigenous knowledge systems as the aging farmers retire (Archer et al., 2008).

Furthermore, poverty and unemployment are also crucial factors when assessing farming systems. According to the Food and Agricultural Organization (2001) allocating resources to the most vulnerable communities continues to be a common challenge in developing countries. Poor smallholder farmers often lack access to adequate resources including access to formal education, health facilities, purchasing power to access sufficient farm inputs and access to credit (Sanusi *et al.,* 2015).

2.3.4 Technological Factors

According to Fadeyi et al. (2022) smallholder farming is a significant strategy to address the high rates of poverty, unemployment, to improve food security as well as to mitigate climate change. However, in Africa there is a low adoption of new technology which has influenced the low production and productivity of agriculture. Technology introduces new ways of producing and distributing food and communicating with consumers and other farmers, which is significant for meeting the increasing demands for more food especially during a global pandemic. Moreover, the increasing and urbanizing population is accompanied by a high demand for more food. Therefore, strategies are needed to increase food production, and innovation and technology can offer to sustain these efforts. However, the poor and older generation of smallholder farmers in Africa are at a disadvantage as they do not have the capacity to invest in new technology. A study by Yende (2020) revealed that smallholder farmers lacked in technological early warning systems for climate change. Fadeyi *et al.* (2022) attested to this stating that poor smallholder urban farmers often find themselves at a disadvantage in terms of investing in new technology due to their lack of financial resources, age, education and access to extension support.

Considering that the world is shifting into a new era that is more dependent on the use of technology, introducing smallholder farmers to such platforms will enable them to communicate and sell their produce to a wider audience in a sustainable manner. Therefore, farmers will not only easily access lucrative markets but will generate enough profit to sustain their livelihoods and households. In this study, the farmers' lack of access to technology limited their ability to participate in a well-known digital trading and market-place named, *Hello choice,* that connects farmers selling fresh produce with prospective consumers. This was attributed to the farmers low socio-economic status and inadequate farm characteristics.

2.3.5 Environmental Factors

Sen (1976) on food entitlement stated that the concept of food insecurity has more to do with social, economic and political causes of vulnerabilities (insufficient government support, lack of access to credit, issues around the empowerment of marginalized groups including women in agriculture) and less of environmental issues. While these are important factors that influence the persistence of food insecurity in developing countries, environmental issues have become at the forefront in the last decade (Matovic, 2020). This is due to the alarming scarcity of natural resources, poor water quality standards, depleting arable land, climate change impacts as well as the sustainability and carbon footprint targets set by governments. Environmental constraints such as limited arable land and poor water quality exacerbated by climate change impacts such as heavy rainfall, floods, heat waves and hailstorms influence the availability and accessibility of food. (Abera *et al*. 2017; Battersby and Hayson, 2019; Siborurema, 2019). Climate change impacts are already undermining the production of major crops, threatening food and nutrition security (Calicioglu, 2019; Feola et al., 2020).

2.3.6 Legal Factors

These factors outline all the legal matters, such as laws about labor, discrimination, safety, and consumer rights (Matovic, 2020). Legal aspects are significant as they ensure that farmers comply with the law, such as upholding health and safety measures, product labeling, and product safety. Farmers in South Africa are required to provide the South African Good Agricultural Practice (SA-GAP) certification, to ensure that food safety and quality standards set by the markets have been met. This is a determinant for product quality and value, which is a significant driver for the marketability of food products hence the generation of sufficient profit and ultimately the growth of farming as a lucrative business. However, considering the lack of access to resources, including information, many poor and smallholder urban farmers may not meet these standards.

2.4 FARMING AND THE ENVIRONMENT: THE ENVIRONMENTAL IMPLICATIONS OF URBAN FARMING

Industrialization and the growing and urbanizing population have led to a competition for natural resources including water. According to the Food and Agricultural Organization (2015), a 70 percent increase in food production to match the 9 billion increases in the global population by 2050 is required. South Africa has adopted a market-oriented agricultural economy with major productions and export of various food commodities such as deciduous and subtropical fruits, sugar, citrus, some vegetables, and livestock. The commercial sector has since grown significantly over the years due to population growth and rural-urban migration, influencing dietary shifts towards certain food commodities such as processed food items and meat, which have high ecological footprints (Campbell, 2017).

The government is most likely to provide more incentives and subsidies particularly to smallholder farmers promoting high-input farming as its primary development tool to ensure food demands of the growing population are met. However, the intensification of agricultural production to meet the food demands of the projected population growth will undoubtedly exert more pressure on the environment and its elements, thus extending climate change impacts and challenging sustainability (FAO, 2012; Clark and Tilman, 2014; Laurence *et al.*, 2014; Springmann *et al.*, 2016; Campbell, 2017). According to Orsini (2013) agriculture is considered the most extensive and environmentally disruptive land use practice, contributing to environmental degradation such as soil and vegetation loss. Campbell *et al.* (2017:12) further state that "agricultural activities contribute to 25-33% of greenhouse gas emissions; occupy 40% of earth's land surface and account to more than 70% of freshwater abstractions". More than 40% of water in South Africa is used for irrigation (Campbell et al., 2019).

Moreover, urban farming, despite its small- scale form with reduced transportation and food waste during distribution can be environmentally destructive with more significant climate change impacts compared to rural farming (Orsini, 2013; Orsini, 2020; Tharrey *et al.*, 2020; Dorr *et al.*, 2021). Inappropriate farming methods including heavy use of industrialized machinery, water and agricultural chemicals can result to water depletion, air, soil and water pollution (De Veries et al., 2003; Orsini, 2013; Bachev, 2014; Clark and Tilman, 2014; Reynolds *et al.*, 2015; Springmann *et al.*, 206; Campbell, 2017; Orsini, 2020).

The study adopted a value chain approach developed by Gomez *et al.* (2011) to highlight the environmental constraints compromising crop production and the impact of farming activities on the environment at three stages of the food crop value chain:

2.4.1 PRE-PRODUCTION

This stage of the crop value chain outlines the decisions and activities farmers make before the actual cultivation of crops. It is the planning and preparation stage where farmers decide on the type and diversity of crops to plant, whether they will be selling the produce or for household consumption and the cropping technique to be employed (Reynolds et al., 2015). Furthermore, farmers also decide on the types and amount of farming inputs they will use during production and how these inputs will be managed to reduce environmental impacts (Reynolds *et al.*, 2015).

However, it is also important to note that these decisions will depend on the size and quality of the land to be used for production as well as the farmers financial capacity. The smallholder farmers in developing countries, particularly in South Africa are socially and economically motivated to farm as it is a strategy used to address the high rates of unemployment, poverty and high food prices in formal market outlets. Smallholder farmers who want to improve their household food security and to generate an income often expand production land and intensify crop production. Although smallholder farming is usually done on a small-scale area with low farm inputs, certain cropping decisions influenced by socio-economic variables can have an impact on the environment.

The removal of weeds and soil tillage using heavy machinery in preparation of the production of crops can have adverse impacts on the soil structure and quality while contributing to air pollution through the emission of green-house gases (Reynolds *et al.,* 2015; MacLaren *et al.,* 2020). These land preparation practices expose the soil to erosion, compaction and thus reduces the soil capacity to retain water. Subsistence farmers who only farm for household consumption have a tendency to focus on one type of crop and only for one season of the cropping calendar. This exposes the soil to wind and water erosion, especially on farms situated on steep slopes.

2.4.2 PRODUCTION

The production stage is where crops have been planted and where farmers are exposed to various environmental challenges such as pest and disease outbreaks, drought, high weather temperatures, heavy rainfall, flooding and hailstorms that affect crop yield and quality (Reynolds et al., 2015). To address these environmental challenges farmers often have to intensify irrigation, apply chemical fertilizers, pesticides and herbicides. However, these solutions themselves are harmful towards the environment and can affect crop yield, threatening food security. The lack of financial resources and knowledge about effective management and adaptive practices can increase the farmers vulnerability to crop losses and reduced farm profit.

Production activities at this stage such as the application of chemical fertilizers release toxic gases that accumulate air, soil and water pollution and applying more than the recommended amount and under unfavorable environmental conditions can contribute to ecosystem fragmentation and the acidification and eutrophication of natural environments (De Veries *et al.,* 2003; Atreya *et al.,* 2012; Orsini, 2013; Campbell, 2017; Chandini *et al.*, 2019). Agricultural chemicals not only can kill organisms that were not a target but can also get lost in different ways such as surface and groundwater flow, drainage and irrigation systems during the rainy season (De Veries *et al.*, 2003; Khodapanah *et al*., 2009; Heather, 2012; Griffin *et al.*, 2014; Oshunsanya, 2014; Chandini *et al.*, 2019; Reynolds *et al.*, 2019).

The excessive application of fertilizers on the same soil for a long time, form and accumulate salts in the soil to such an extent that crops cannot extract sufficient amount of water from the salty soil solution (Chandini *et al.,* 2019). Soil acidification extends soil quality issues, increases pests resulting to stunted crop growth and poor crop quality as come fertilizers contain toxic chemicals that can enter the food chain through absorption by soils. According to the FAO (2002), it is estimated that about 1.9 hectares of land was already affected by soil degradation as a result of agricultural activities. Therefore, there is a need for proper management of agricultural chemicals to reduce their environmental impacts. According to Oshunsanya (2014), water quality is a term used to describe the physical, chemical and biological characteristics of water, usually in respect to its suitability for an intended purpose.

The presence of fertilizers from nearby agricultural grounds can result to the eutrophication of water which is the over-enrichment of nutrient leading to uncontrolled growth of algae and aquatic weeds (Lee, 2004; Griffin *et al*., 2014; Khan, 2014). According to Reynolds et al. (2015) the impact of water used for irrigation depends on the location between the farm and the water source. The presence of algae turns water to a green color, impairs water clarity which causes taste and severe odor problems, thus reducing the quality of the water which would have been considered safe to utilize to consume. Excessive fertilization due to agricultural activities is one of the major drivers of eutrophication along with sewage, industrial and other urban discharges. It is for these reasons that agricultural chemicals have been met with intense scrutiny in regard to their use and application. While agricultural chemicals are significant to restore soil quality and enhance crop growth, it is equally important to ensure that they are applied at the recommended amount.

2.4.3 POST-PRODUCTION

The post-production stage is where pollution occurs through harvesting, processing, storage and distribution (Reynolds *et al.,* 2015). Urban areas in Pietermaritzburg lack sufficient access to land plots where waste can be discarded ethically, exacerbated by urban population growth, poor municipal governance and service delivery (Integrated Development Plan, 2020/2021). This has contributed to the production of an unsustainable linear system of recycling in urban areas (Chandrasekaran *et al.*, 2010; Integrated Development Plan, 2020/2021). This has influenced the burning and illegal dumping of crop residues has resulted in severe air, land and water pollution. Moreover, the use of transportation for the distribution of food post-harvest was recorded to contribute to land, water, and air pollution in Southern Africa (Murungu, 2012). Chandini *et al.* (2019) further state that when crops are removed and harvested, there is a reduction of soil nutrients that can be corrected either through natural processes or by applying fertilizers. Additionally, inappropriate methods of harvesting, processing and storage can lead to produce spoilage of which can have adverse effects on the farmers profit. Smallholder farmers often do not have access to storage facilities and advanced technology.

2.5 THE IMPACT OF ENVIRONMENTAL DEGRADATION ON FOOD SECURITY

Although agriculture is a popular practice in South Africa, people are still food insecure. The challenge is that over 90% of the locally produced food is done by smallholder farmers who cultivate in small plots of land with minimum farm inputs and lack market access (Khapayi and Celliers, 2016). This entails that smallholder farmers are likely generating less income from the low crop yields accumulated especially when crop production is also constrained by environmental degradation. Environmental degradation is one of the major causes of food insecurity and is driven by natural and anthropogenic processes. According to Gupta (2018), environmental degradation is an umbrella term that is used to describe various environmental conditions such as air, soil, water pollution, variability of water supply, climate change variability and loss of vegetation. If these environmental conditions are severe, there is a temporary or severe decline in the productive capacity of the environment and in turn affect the availability, accessibility, utilization and stability of food security (Steenkamp *et al.*, 2021).

According to Havas and Salman (2011:9) “food systems are socio-ecological systems that enable human beings to provide appropriate nutrients from their environmental resources”. Thus, the diverse physical quantities and environmental parameters are significant forces that need to be protected from exploitation and degradation (Cullis *et al.*, 2019). Agriculture in Africa and South Asia is vulnerable to environmental constraints including climate change due to low adaptive capacity arising from socio-economic and political variables (Masipa, 2017; Aryal *et al.*, 2019; Ogundipe *et al.*, 2019). Climate change impacts have repeatedly threatened the progress of the Sustainable Development Goals and efforts to reduce poverty and hunger (Darkoh, 2009; Gupta, 2018). It is evident in the Southern African region where variable and extreme weather events, including droughts and floods, have adversely affected production yields and the sustainability of livelihoods. Studies focusing on crop yields in India have found that despite adaptation strategies, heat waves have reduced wheat and rice yields and rain-fed maize is projected to reduce by 3.3-6.4% in 2030 (Arshad et al. 2017; Gupta et. 2017; Tesfaye et al. 2017; Aryal et al. 2019).

The occurrence of severe droughts associated with the strong El Nino events in 2015 and 2016 gave rise to hunger and undernourishment in various countries as agricultural systems were affected (FAO, 2018). A report by the FAO (2017) revealed that the three main factors currently affecting food production include conflict, climate change, and economic slowdowns. Agriculture is site- specific to ecological and socio-economic settings, thus the success and failure of the production of crops will always be subjected to prevailing climatic conditions and production factors. In a study conducted by Mabhaudhi, Chimonyo and Modi (2017), a map of the agro- ecological zones of South Africa demonstrated that farming systems are mainly determined by the zones in which they exist in. According to the uMgungundlovu District Municipality (2013) major cash crops including a variety of fruits and vegetables were destroyed which posed a threat to the agricultural economy. A report drafted by Pienaar and Boonzaaier (2018) state that the drought event that occurred in the Western Cape province of South Africa during the period of 2017 and 2018 had a negative impact on households that depended on agriculture for their subsistence. This led to water cuts administered by the local government in several parts of the province.

Households' dependent on farming had to adjust agricultural production systems by ceasing cultivating any crops that required excessive amounts of water and/or prioritize specific types of crops (Pienaar and Boonzaaier, 2018). Such cases result in a change of dietary patterns as producers are forced to cultivate food crops that require less water and land use, hence disrupting production yields for staple crops such as maize and rice that are significant in meeting food and nutrition security objectives in developing countries. Poor farming households become vulnerable to food and nutrition insecurity as they have to rely on market outlets that sell processed foods at high prices to maintain their well-being (FAO, 2018; Pienaar and Boonzaaier, 2018). The profitability of urban farming in the research study is likely to decline due to environmental constraints, thus making it difficult for farmers who are highly dependent on agriculture as a main source of income to sustain their livelihoods. Gupta (2018) reported that the lack of economic profitability lowers the chances of employing farm labor, hence challenges the sustainability of farming. This was further attested by Cullis *et al.* (2019) stating that the performance and activities of farming are dependent on the physical- biological and economic dimensions.

The persistent threat of environmental risks to agriculture will reduce incentives to invest in farming systems which will not only challenge the efforts to ensure food security but sustainability as well (Gupta, 2018). The Food and Agriculture Organization state that although food production is set to increase by 70 percent in order to feed the growing population, it is also required that the food is nutritious. However, given the deteriorating environmental quality, this will be a challenge. According to Mallick (2013) contaminated soil and water resources have adverse impacts on the quality of crops and the health of human beings, especially in cases where polluted water resources are breeding grounds for water- borne diseases, further reducing surface water access. Contaminated water resources have an impact on the health of the water users often resulting in waterborne diseases such as cholera and diarrhea, which can be contagious (Cullis *et al.*, 2018).

Vilakazi *et al.* (2019) further stated that any significant alterations in water quality could result in long-term resource degradation and a reduced capacity to provide ecosystem services and sufficient food required to feed the growing and urbanizing population. A study conducted by Bisaga *et al*. (2019) identified high levels of contamination in the Msunduzi River which inhibited the performance of farming activities in some parts of the region. Additionally, food crops cultivated within urban areas by urban farmers are usually not as healthy and fresh as one would expect due to air pollution. There are high concerns on the chances that fresh produce may contain a high concentration of heavy metals that may result in health risks (Tuijl, Hospers and Van den Berg, 2018). In addition, contaminated soil often lose the nutrients that are required for the nourishment of the crops grown. Therefore, producers run the risk of not only utilizing contaminated water for irrigation but poor soil which will inhibit crop growth and quality, thus violating food safety standards. In this case, the utilization pillar of food security is affected as the nutrients from the soil and water will be lost making them nutrition insecure.

In overall, environmental constraints threaten the production and productivity of food, disrupts market prices and pressurizes the purchasing power of poor households. Therefore, the four pillars of food security namely, availability, accessibility, utilization and stability are affected in the sense that poor households characterized by poor socio-economic variables do not have the resilience to recover from the vulnerabilities of food insecurity. The global, regional and local communities are currently faced with rising food prices and poor households affected by unemployment and poverty are becoming more food insecure. According to Khapayi and

Celliers (2016) smallholder farmers still live below the poverty line. The national minimum wage in South Africa is R3 643 per month, while the food poverty line is R624 per month (Pietermaritzburg Economic Justice and Dignity, 2022; Statistics South Africa, 2021). The cost for household food basket for Pietermaritzburg is R4 253.07 since the beginning of January 2022, while the urban food basket is R977.57 as of June 2021 (PMBEJD, 2022; National Marketing Council, 2021). This entails that given the environmental constraints on food production, the market disruptions, low socio-economic variables exacerbated by the food poverty line, household food basket and urban food basket, poor households dependent on agricultural production are vulnerable to food insecurity.

The global, regional and local cases of environmental degradation due to anthropogenic activities are an indication of the manner in which human beings interact with the environment. It is estimated that climate variations will continue to undermine the production of major crops and more poor households will struggle to obtain sufficient food of good quality and diversity for a nutritious diet (FAO, 2018). Therefore, controlling measures need to be adopted. Resource users and polluters especially farmers need to be aware of the relationship that exists between farming and the environment, the environmental impacts of farming and the consequences on food security. This will influence farmers adoption of environmental management practices that will protect the already scarce natural resources for future generations.

2.6 URBAN FARMING AND WATER QUALITY MANAGEMENT PRACTICES: SUSTAINABLE FARMING

According to Chandrasekaran et al. (2010), sustainable farming is the successful management of resources for agriculture to satisfy changing human needs while maintaining and/or enhancing the quality of the environment and conserving natural resources. The goal of sustainable farming as per the definition of sustainable development in the Brundtland Commission (1987) is to achieve "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Sustainable farming can be understood in two parts. That is sustainable production, which needs to ensure that the supply side of the production system focuses on environmental performance. In crop production, management measures for reducing the risk of environmental degradation due to organic and inorganic fertilizers and pesticides can be achieved through limiting and optimizing the type, amount and timing of applications to crops (Chandrasekaran *et al.*, 2010). The second part of which is sustainable consumption addresses the demand side, which looks into how the goods and services required to meet basic needs and improve quality of life such as food, leisure and mobility can be delivered in ways that reduce the burden on the environment's carrying capacity.

An effective way of reducing farming impacts on the environment while supplying food for the growing population is understanding the linkages between food security, production activities and the environment. Several studies state that if farmers are aware of the impacts of farming on the environment, they are more willing to protect the environment by adopting the sustainable development concept (Story and Forsyth, 2008; Perepeckzo, 2011; Hyland *et al.*, 2015; Chandini *et al.,* 2019; Sulewski and Golas, 2019). Realizing the environmental impacts of agriculture constitutes the first step in the overall assessment of the sustainability of agriculture and how its activities should be managed. According to Jepthas and Swanepoel (2019), farming activities can be managed in different forms, including the voluntary activity of a farmer, private contracts with interests associated with that of the farmer, collective action with other affected stakeholders as well as public order such as enforcing environmental management regulations and taxation.

Many authors (Francis *et al.*, 1990; Bavu, 2004; Martinez-Blanco *et al.*, 2013) highlight different urban farming management practices that will enhance soil biological properties, improve soil moisture content for soil fertility and quality which include the use of applying green manure, organic compost, avoiding excessive tillage, cultivating diverse crops all year round. Additionally, maintaining cover crops to protect the soil, employing the crop rotation and intercropping system will also help improve soil fertility and soil health. This will benefit the production and productivity of crops which means that the farmers will have access to fresh and good quality produce to improve household food security. According to Bhat et al. (2019) maintaining the cultivation of crops all year round, crop rotation, intercropping, applying grass and mulching, building windbreaks and avoiding excessive tillage can also help farmers prevent soil erosion from wind and water. The study found that the majority of the farmers were challenged by the persistent occurrence of pests and some of the strategies to control pests highlighted by (Coleman, 2021) include intercropping, planting crop repellents such as Legumes and herbs alongside main crops to disrupt the pest life cycle. Other strategies include improving soil quality through crop rotation, planting in the appropriate seasonality conditions.

According to Odiyo and Makungo (2012), the first step towards effective water quality management is fully acknowledging the current water quality status and the distribution patterns of any pollutant emissions in water sources. The persistent climate change impacts and environmental degradation such as poor water quality are a significant indicator of how human beings misuse the environment and its natural resources. Therefore, environmental management should focus on the control of human actions relative to the environment. The South African government has established various environmental laws, policies and regulations that have been presented in the form of frameworks which guide decision-makers viz; farmers in minimizing the negative impacts of farming activities on the water used for irrigation. In promoting sustainable water use in countries faced with limited water resources availability, farmers are encouraged to employ wastewater recycling and rainwater harvesting. Water harvesting has been a cost-effective and successful strategy in many parts of Africa and Asia (Kataoka, 2005; Denison & Wotshela, 2012). The implementation of the National Jar programme in Thailand in response to water supply from 1981 to 1990 improved rainwater collection in rural households which proved to be beneficial to farmers (Kataoka, 2005).

In overall, the responses need to focus on key drivers of agricultural intensification, limit the export of pollutants from farms, protect water bodies from agricultural pollutants and help restore water sources that are already contaminated. It is also crucial to establish information systems through training and research to transfer new knowledge and technologies to support the decision-making of water managers, policy makers and water users viz: farmers. Drescher (2003), suggested that reducing the use of intensive agro-inputs and conserving scarce resources as well as encouraging education plays an essential role in building support for agricultural land preservation. Atreya et al. (2012) attested to this stating that transforming the water user's perspectives towards the environment through education and empowerment will improve ecosystem health. A safe and healthy environment enables the provision of services required to achieve social, economic and environmental growth, thus sustaining livelihoods and enhancing human development (Davids et al., 2016).

2.6.1 POLICIES SUPPORTING SUSTAINABLE FARMING

As part of the first sustainable development goal which is to reduce food insecurity, a 70% increase in food production is required to feed the growing global population before 2050 and various alternatives are being discovered to achieve this goal (FAO, 2015). Smallholder farming is a significant strategy to achieve this goal as it offers many socio-economic and environmental benefits (Campbell et al., 2018). However, it needs to be done in a sustainable and regenerative manner and support from the government and other relevant institutions is essential. Sustainable farming policies and programs are essential as they have the capacity to control the decision-making environment of food producers, marketing agents and consumers (FAO, 2016). According to Khwidzhili and Worth (2017) although there is no final policy that has been finalized there are draft policies and legislations delivered by the provincial and local authorities to guide natural resources management and pollution prevention. The authors mentioned two of South Africa's key agricultural policies, including the white paper and South Africa's policy on agriculture sustainable development. These policies seek to promote sustainable agricultural practices throughout the nine provinces of the country.

The Comprehensive Africa Agricultural Development Programme (CAADP) has intended to address land and water management, market access, eliminate poverty and hunger through agriculture by investing portions of its financing into agriculture. Such interventions outlined in documents such as the National Development Plan (NDP) have aimed at rural and urban development by encouraging food insecure households to participate in productive agricultural activities in order to sustainably grow their own food which will help reduce food and nutrition insecurity. Studies have considered this strategy as a sustainable way of ensuring that households have access to food at all times. Efforts to build a sustainable food system in Europe has called for the European Commission to allocate at least 25% of the budget to climate change initiatives (European Investment Bank, 2020). Initiatives such as the European Green Deal aim to make economic growth sustainable by targeting industrial and the agriculture sector to reduce greenhouse gas emissions and adopt a healthy and environmentally-friendly food system (Fetting, 2020)

Addressing urban environmental issues is crucial for the achievement of the Sustainable development goal 11 of the United Nations 2030 Agenda for sustainable development, which aims to "make cities and human settlements inclusive, safe, resilient and sustainable". The SDGs also acknowledge the significance of water by demonstrating a specific water quality target in sustainable Goal 6, which aims to ensure availability and sustainable management of water and sanitation for all.

This plays a crucial role in influencing future policies aimed at providing adequate management practices to address water pollution. Regulatory instruments to support sustainable practices of urban farming and water management include but not limited to permitting and licensing of certain agro-chemicals, prohibitions on the direct discharge of pollutants, limits on the marketing and sale of dangerous agricultural inputs as well as restricting certain agricultural practices. Odiyo and Makungo (2012) further demonstrated that there are extensive and comprehensive policy, legal, technical and institutional frameworks that support water quality monitoring and management in South Africa. Some of these frameworks include the National Constitution (Act 108 of 1996), National Water Act (No. 36 of 1998) and Municipal Structures Act (No. 117 of 1998). According to the National Constitution (Act 108 of 1996), everyone has the right to access to clean water that is not harmful to health.

Therefore, stakeholders responsible for the provision of water to communities are obligated to monitor the quality of the water at the point of consumption. The National Water Act (No. 36 of 1998) is the principal legal instrument in South Africa and contains comprehensive provisions for the protection, use, development, conservation, management, and control of South Africa's water resources. It enables water users such as farmers to continue providing quality food for the growing population while promoting a safe and healthy environment with ecosystem services meant to strengthen resilience and sustainable food systems (Vilakazi et al., 2019). However, poor smallholder farmers lack knowledge about these environmental legislations and policies implemented by the government. Therefore, it is important to note that more focus should be on the actual urban farming practices instead of the policies and environmental regulations that the smallholder farmers may not be aware of.

According to Khwidzhili and Worth (2017) it is important to note that a collaborative action of many stakeholders including farmers is essential for the effective implementation of sustainable farming practices. These practices involve enhancing the farmers knowledge and skills in farm management including practices to reduce the use of chemicals and inappropriate methods of production in farms. This will promote environmental quality, water use efficiency, clean water while promoting climate change adaptation. One way of ensuring that smallholder farmers adopt urban farming and water quality management practices is by strengthening support from agricultural extension agents. Davis and Terblanche (2016) also support the involvement of extension officers in the implementation of sustainable farming practices stating that extension officers can equip smallholder farmers with skills to successfully contribute to the food value chain.

According to Atreya et al (2010), transforming the farmer’s perspectives towards the environment and the farming system through education and empowerment will improve ecosystem health. Therefore, it is essential to establish information systems through training, extension agents and research in orde76yr to transfer new knowledge and technologies to support the decision-making of farmers, water managers and policymakers. Khwidzhili and

Worth (2017) emphasized that extension officers need to understand their roles and responsibilities of disseminating information and technology in order to effectively enhance the farmers knowledge and skills. However, poor extension services are a common problem as attested by Davis and Terblanche (2016) in their study.

2.7 CHALLENGES ASSOCIATED WITH URBAN FARMING AND WATER QUALITY MANAGEMENT

Fraser *et al.* (2006) highlighted that the existing environmental management frameworks that address environmental issues associated with agricultural activities are often met with various institutional challenges. The establishment of a cluster of laws dealing with different aspects of resource use, pollution, and land-use planning as well as nature conservation as a result of an unclear definition of environmental management constrain the implementation of environmental management frameworks (Barrow, 2005; Fraser, 2006; Oelofse and Scott, 2012). Managing agricultural practices requires the consideration of a variety of factors including access to land and water, type of farming taking place, crops grown, agro-inputs used, the size and context in which the farm is operated at, farmer's knowledge and skills, and the cost-effectiveness of the proposed practice amongst many (Fraser *et al.*, 2006). This means that implementing management regulations will have to involve various stakeholders with different interests thus running the risk of fragmentation.

Furthermore, it will also lead to various departments' ineffective implementation of environmental frameworks, often accompanied by a scarcity of skills in the environmental sector, lack of accountability, and public participation (Barrow, 2005). However, assigning roles and responsibility to all the stakeholders involved will prevent ineffective implementation of environmental frameworks by various departments and will ensure accountability and participation by the stakeholders. This suggests that in order to address the environmental and institutional challenges that affect the farmers adoption of environmental management practices, a collaborative and participatory approach that can equip stakeholders with knowledge and skills needs to be employed.

Additionally, other hindrances that challenge the effective adoption of environmental management regulations in urban farming include the lack of capacity, expertise and limited understanding of sustainable farming practices by smallholder farmers. Clark and Tilman (2014) state that the existing and persistent environmental implications of urban farming are largely influenced by poor knowledge and skills in adopting sustainable farming practices. Smallholder farmers lack access to information services such as extension officers that can guide farmers in adopting appropriate farming practices. Countries in the Sub-Saharan Africa region including South Africa have poor extension support (Khwidzhili and Worth, 2017). A study conducted by Ajayi (2000), based on the awareness of negative impacts of agro- chemicals in developing countries, found that only 2% of the farmers were aware of the potential negative effects of farming inputs such as pesticides on the environment. The study indicates that the environmental risks associated with farming activities, especially the intensive application of toxic agro-chemicals, are not effectively communicated within farming systems in developing countries.

The FAO (2017) further state that in developing countries the limited knowledge and awareness among farmers on the proper production methods and the appropriate application of hazardous chemicals exacerbated by weak institutional frameworks hold significant challenges towards practicing sustainable food production. While Bisaga *et al.* (2019) state that the impact of urban farming activities on the environment is often disregarded and relevant regulations to mitigate them have not been well documented. This is not surprising as agricultural research and development and policy in South Africa has been mainly focused on increasing crop yields to feed the growing and urbanizing population (Pretorius and de Villiers, 2000; Vetter, 2013). Ultimately, this has contributed to the poor knowledge, skills and capacity in sustainable farming among farming professionals such as smallholder farmers and extension officers in developing countries.

Several regions across the African continent have established relevant policies and institutional frameworks in relation to sustainable agriculture, however, effectively utilizing them to offer sustainable solutions remains a challenge. The lack of an effective institutional framework that integrates health, environmental, social and economic aspects has shaped the lack of policy and programming development that encourages and guides sustainable urban farming for urban farmers (de Zeeuw and Dubbeling, 2009; Marshall *et al.*, 2017). Consequently, smallholder farmers often lack formal and/or informal training in farming, access to information services, advanced technological devices, access to micro-finance institutions and extension support which play a vital role in the farmers' ability to adopt urban farming and water quality management practices. Hlahla and Hill (2018) found that the local communities located on the outskirts of urban Pietermaritzburg had low adaptive capacity due to socio-economic issues including low livelihood options and income, poor service delivery and food insecurity. Presley (2014) attested to this stating that economic factors such as cost of adopting, labor demand are significant determinants of adoption. Therefore, it is expected that most of the smallholder farmers who lack these resources will likely employ misguided and inappropriate methods of production that will enhance environmental impacts of farming and exacerbate environmental constraints on crop production.

Although agriculture is affected by water insecurity, the practice itself is the largest water user and contributes to the accumulation and discharge of toxic waste into water sources. Despite the existing documents highlighting the impact of agricultural activities on water quality in urban areas, little efforts have been made to enforce water quality management initiatives within communities. Anderson et al (2016) state that unsustainable urban farming management practices leading to poor water quality can often be linked to a range of institutional factors and governance failures. The lack of policy and programming support provided to urban farming played a huge factor in this study because the farmers were lacking in knowledge and awareness of proper sustainable urban farming methods that promote water use efficiency and maintaining water quality standards. The lack of community-based water quality management initiatives is alarming given the rising concern of poor water quality in many parts of South Africa.

Odiyo and Makungo (2012) state that local municipalities lack the technical capacity and adequate finances which hinder effective implementation and monitoring of water quality management structures. According to Hodgson and Manus (2006), water quality frameworks were initially formulated to ensure the immediate provision of safe drinking water and sanitation to the previously disadvantaged population. In a sense this has allowed for the weak formulation and implementation of effective water quality management structures. Thus, it is no surprise that many regions in South Africa are faced with poor water quality due to poor governance, the lack of resources, skills and capacity to effectively control and monitor water quality. However, the authors further emphasize that the management of water pollution can be complex due to conflicting interests as multiple levels of government and livelihoods are affected. This comes into question as pollution control measures are set by a higher authority which is challenging to manage in areas with multiple municipalities involved due to conflicting interests. Consequently, numerous programs are undertaken by different levels of government and environmental management agencies, leading to the fragmentation of environmental responsibilities.

Despite the environmental risks of urban farming and the factors that influence the farmers' role, the demand for more food and the socio-economic benefits it provides for households and the country at large will not allow for it to be disqualified. The government is most likely to provide more incentives and subsidies particularly to smallholder farmers promoting highinput farming as its primary development tool to ensure food demands of the growing population are met. Chandini *et al.* (2019) recommend that people must first realize and understand the environmental implications of farming activities such as the application of chemical fertilizers and take initiatives for reducing their use.

2.8 Theoretical Grounding

According to (Martin, 1988; Tzilivakis, 1999), environmental management for agriculture is a viable strategy that guides farmers in addressing the negative impacts of agriculture on the environment for socio-economic and environmental resilience which is a significant element for sustainable agriculture. Sustainable farming focuses on natural resource management for socio-economic and environmental resilience to enhance agricultural productivity, thus improving food and nutrition security (Yusuf, 2002; Blignaut et al., 2014). Theoretically, this study hypothesizes that the adoption of environmental management practices associated with urban farming and water quality will reduce the impact of farming on the environment and improve food security. Studies have argued that even small-scale, low-input farming systems with reduced transport and food waste are contributing to environmental degradation that in turn affect the production and productivity of food, threatening food security (Reynolds et al., 2015; Tharrey et al., 2020; Dorr et al., 2021). Food security is affected by environmental constraints such as poor soil and water quality, pest outbreaks and climate change impacts that are exacerbated by the negative environmental impacts of farming practices (Blignaut et al., 2014). Poor smallholder farmers lacking in financial resources have limited response mechanisms, are the most vulnerable to environmental constraints and thus food and nutrition insecurity (Hlahla and Hil, 2018). Therefore, farmers need to be financially secure while pursuing environmental protection (Tzilivakis, 1999).

2.9 Conceptual framework

Figure 1 demonstrates the link between farming, the environment and food security. Moreover, it shows the role of the adoption of environmental management practices associated with farming and water as well as climate change adaptation strategies in reducing environmental impacts of farming and environmental constraints on crop production. Adopting environmental management practices in farming not only reduces the negative impacts of farming on the environment but promote sustainable farming, thus improve food and nutrition security. According to (Welch and Marc-Aurele, 2001; Prokopy et al., 2014; Sapbamrer and Thammachai, 2021) the adoption of environmental management practices in farming is dependent on the farmers access to lucrative markets, financial resources, information services, agricultural technology and stakeholder involvement. In this study, the focus is to outline the urban farming and water quality management practices, water use efficiency and climate change adaptation strategies adopted by the smallholder farmers in the communities. Sustainable farming practices that integrate the interests of the poor smallholder farmers in the case of conventional and cost-effective are significant to improve household food and nutrition security (Yusuf, 2002).

In South Africa poor smallholder farmers are vulnerable to the impact of environmental constraints including climate change on crop production due to poor response mechanisms (Hlahla and Hill, 2018). Although smallholder urban farming is considered a viable strategy for climate change mitigation, the respondents are more socially and economically motivated to engage in farming and less inclined to the concern of the environment. In other words, despite the environmental constraints on crop production, the poor smallholder farmers' priority is to produce extra food for their households, to fight of poverty, unemployment, food prices and not to address environmental issues such as climate change. This is likely to influence the farmers knowledge and awareness of farming-environment interactions and linkages to food security, thus the adoption of environmental management practices. This coming from several authors (Story and Forsyth, 2008; Hyland *et al.*, 2015; Sulewski and Golas, 2019) stating that the farmers are more willing to protect the environment if they are aware of the environmental problems associated with farming activities.

However, there are initiatives including the DUZI-Umngeni Conservation Trust (DUCT), in partnership with other organizations, civil society and local government, that are already providing communities that are dependent on water sources in the Msunduzi and uMngeni local municipalities with ecological goods and services to raise awareness on the significance of water quality. The rules and regulations established and implemented by the DUCT play a significant role in water quality management and to reduce the impact of anthropogenic activities on water quality. However, smallholder farmers are unlikely to be aware and knowledgeable of these rules and regulations, thus for such initiatives to be progressive, environmental management practices need to incorporate traditional methods of farming that the farmers will understand. This will promote sustainable farming, enhance agricultural productivity and improve food security.

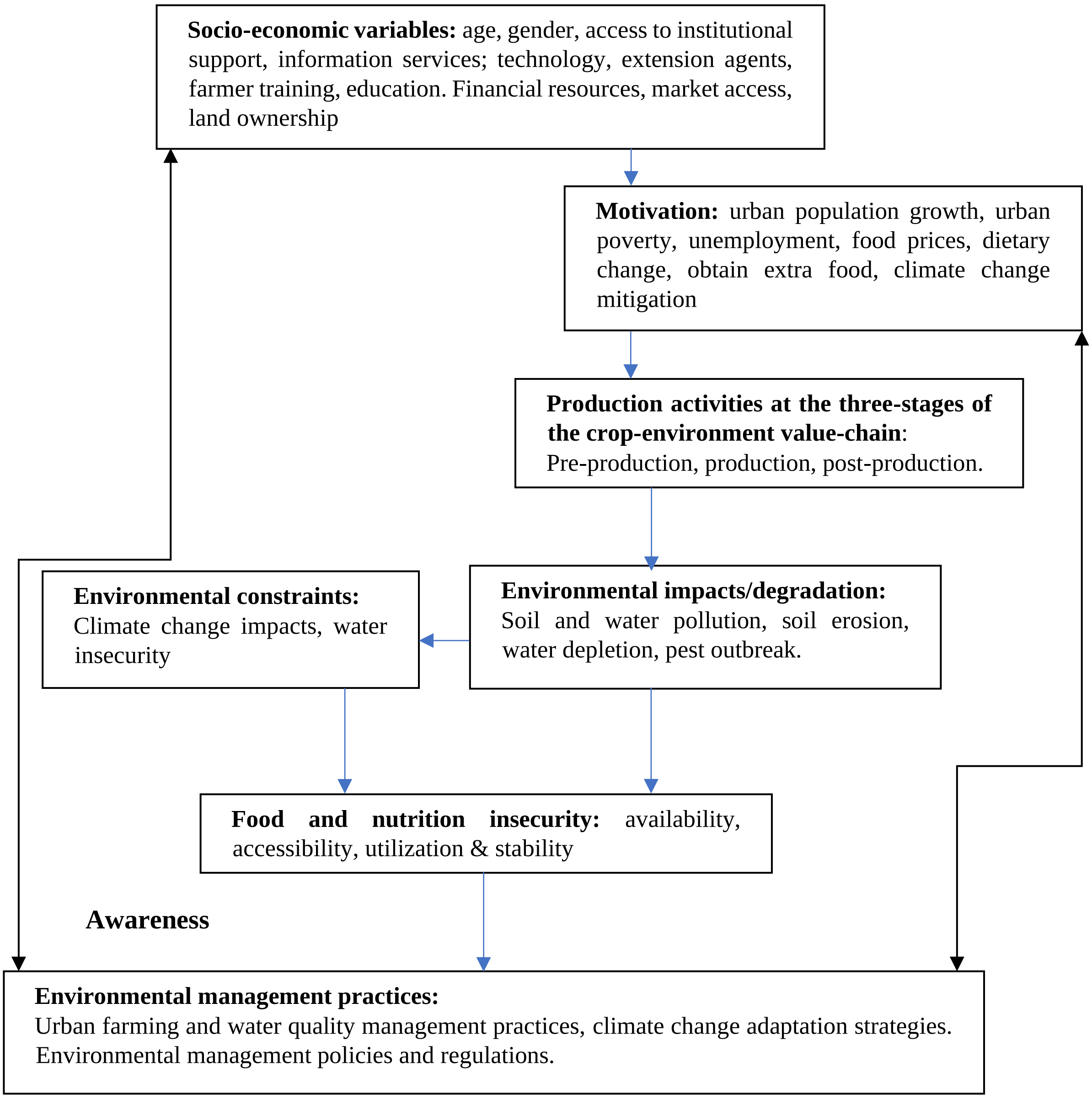

Figure 1: The link between farming, the environment and food security

2.10 CONCLUSION

This chapter focuses on the challenges of urban farming, environmental impacts of farming and implications on food security. Environmental management practices associated with urban farming and water quality as well as policies that support sustainable farming are also discussed. Moreover, challenges associated with the adoption of urban farming and water quality management are included in the literature. Environmental management associated with urban farming and water quality is significant for socio-economic and environmental resilience, thus the improvement of food and nutrition security. Smallholder farming is a viable strategy to address urban poverty, unemployment, high food prices and climate change mitigation. However, environmental impacts and constraints such as poor soil and water quality and climate change impacts affect crop production, threatening food security. Smallholder farmer's adoption of urban farming and water quality management practices is essential for socioeconomic and environmental resilience.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This section covers the overall methodology that was used to conduct the study and analyze data. In each, draft manuscript the specific methodology is detailed. It outlines a description of the sampled farmers as well as the background information of the common socio-economic and environmental issues faced. It also outlines information about the climate conditions, water quality conditions and agricultural activities in the Sobantu, Sweetwaters and Mpophomeni communities. This section also covers information about the research design, sampling method, and data collection tools and data analysis. The aim of this study was to investigate the environmental management of urban farming and water quality along with implications for food security in the communities of Sobantu, Sweetwaters and Mpophomeni, in the KwaZuluNatal province. The communities of Sobantu, Sweetwaters and Mpophomeni were chosen because there are urban and semi-urban, consisting of smallholder farmers who produce and sell a variety of leafy greens, vegetables, roots and tubers, cereals as well as tomato. The study explored the following research objectives:

1. Exploring the challenges of urban farming
2. Exploring the implications of urban farming on the environment and water quality: implications for food security
3. Identifying the environmental management practices adopted by the urban farmers
4. Determining the challenges around the state of the environmental management framework associated with urban farming and water quality: towards an environmental management framework associated for food and nutrition security

3.2 STUDY AREA AND DESCRIPTION OF SAMPLED FARMERS

The research study was conducted in the communities of urban Sobantu, semi-urban Sweetwaters and semi-urban Mpophomeni, located on the outskirts of urban Pietermaritzburg KwaZulu-Natal. Sobantu is identified as an urban community situated in the Msunduzi local municipality, while Sweetwaters and Mpophomeni are considered as semi-urban and situated in the Msunduzi and uMngeni local municipality, respectively (Integrated Development Plan, 2020/2021). Sweetwaters is governed by traditional authorities such as Chiefs and Izinduna as it is under the Ingonyama Trust (IDP, 2018/2019). Urban Pietermaritzburg has high rates of migration due to pull factors such as employment opportunities, with the majority being offered in the informal sector (IDP, 2020/2021). Consequently, urban, and semi-urban communities located on the outskirts of urban Pietermaritzburg including Sobantu, Sweetwaters and Mpophomeni are faced with increasing formal and informal settlements. The commonly shared socio-economic and environmental issues in the communities of Sobantu, Sweetwaters and Mpophomeni include high rates of poverty, unemployment between 15–34-year-olds, lack of capital and access to micro-finance institutions, poor institutional support, limited land space, water security and poor soil quality issues.

Figure 2: A map showing the location of the Msunduzi and uMngeni local municipality were urban Sobantu, semi-urban Sweetwaters and semi-urban Mpophomeni are located, respectively.

3.2.1 Climate conditions

The climate and weather conditions in urban Pietermaritzburg and its surrounding areas are strongly influenced by topography, experiencing cooler temperatures and rainfall. The average annual temperature varies between 16.3^{0}C and 17.9^{0}C with more rainfalls in the summer accompanied by dry winters and an average rainfall that varies between 748mm and 1017mm per annum (IDP, 2019/2020). The recent occurrence of climate change events of heavy rainfall resulting to floods and hailstorms in urban Pietermaritzburg have had negative effects on crop production, therefore challenging the sustainability of urban food systems and the socio-economic development of the communities. Considering the recent occurrences of heavy rainfall in the province of KwaZulu-Natal, the Sobantu community being situated on a floodplain was highly susceptible to flooding (Ramburran, 2014). The KwaZulu-Natal province has long since been experiencing extreme weather events which include heavy rainfall resulting to floods. In the years 1987 and 1989, the province of KwaZulu-Natal faced one of the worst floods which killed an estimated 388 people, with 68 000 more homeless and hailstorms which destroyed fruits and vegetables that were considered major cash crops (uMgungundlovu District Municipality, 2013).

3.2.2 Agricultural activities

According to the Integrated Development Plan (2020/2021), areas under urban Pietermaritzburg consist of diverse soil types that vary with the topography and rainfall patterns resulting in high agricultural potential despite large portions of land developed for other uses, including housing. The Sobantu community in particular is located on a floodplain in the lower region of the Baynespruit River, which is an advantage for agricultural activities (Ramburran, 2014). Identified agricultural activities in Sobantu, Sweetwaters and Mpophomeni include livestock production, which is not popular, and crop production of mostly various leafy greens, vegetables, roots and tubers, cereals as well as tomato. The most prominent crops produced included Cabbage, Spinach and Maize. The main motivation for farming was to obtain extra food and generate income from surplus produce in order to improve household food and nutrition security. Common environmental issues constraining urban farming include limited land space to diversify food crops, water security issues, and pollution caused by effluent discharge from nearby commercial premises.

3.2.3 Water security issues

There are two rivers viz; Baynespruit and Msunduzi River that run through Sobantu. The community is susceptible to flooding during the rainy season as it is located on a floodplain situated in the lower region of the Baynespruit River (Ramburran, 2014). The farmers are reliant on both rivers for household use and irrigation for small-scale urban farming (Ramburran, 2014). According to the IDP (2020/2021), although water quality varies between catchments, the impact is evident in the decrease in water quality along the urbanized parts of the Msunduzi municipality. Several studies (Neysmith and Dent, 2010; Ramburran, 2014) revealed that the poor water quality was a case of illegal waste discharge from industrial institutions, poor sewage infrastructure, and illegal dumping of waste from the residents who reside near the river.

Furthermore, the Sobantu community and both of the rivers are surrounded by several animal feeds premises and the New England Rd landfill site, which has been considered an environmental and health concern over the past years (Ramburran, 2014). Farmers in Sweetwaters and Mpophomeni were reliant on private tap water supplied by the local municipality to water their crops, thus assumed that the water was suitable for household and agricultural use. However, they reported constant water cuts administered by the local municipality and high-water tariffs, of which hindered the farmers' access to water.

3.3 RESEARCH DESIGN AND METHODOLOGY

The purpose of this study was to investigate the environmental management of urban farming and water quality in urban and semi-urban communities of Sobantu, Sweetwaters and Mpophomeni which are located on the outskirts of urban Pietermaritzburg. A mixed method research approach was used to collect data. This approach combines the collection and analysis of qualitative and quantitative data (Creswell, 2013). A qualitative research method was explorative in nature as the researcher fully engaged with the participants and allowed for open-ended, face-to-face interviews to gain in-depth and detailed information about their views on the subject matter without limitations (Creswell, 2013; Sutton and Austin, 2015). A quantitative method was used to collect numerical and statistical data, such as the participants' demographics (Creswell, 2013). Combining both methods is useful when comparing the data for in-depth understanding (Creswell, 2013). It is also useful as it aims to avoid the bias nature of only using a qualitative approach due to the personal interpretations made by the researcher. The researcher was therefore able to provide valid and reliable data on the research study.

3.4 SAMPLING TECHNIQUE AND SAMPLE SIZE

The non-probability sampling approach was employed in this study. This approach entails that there was no guarantee that every individual in the communities had a chance of being included in the sample. This approach was used because it allowed the researcher to purposively select a smaller group representing the views and opinions of the majority of the people residing in the communities of Sobantu, Sweetwaters and Mpophomeni. The purposive sampling technique was also used to deliberately choose participants that fit the selection criteria of the study to ensure efficiency (Creswell and Poth, 2017). The study used a purposive sampling technique to select 78 urban farmers who were active in production, experiencing environmental management challenges and willing to engage with the researcher. The farmers were interviewed in their local language which is isiZulu, using both open and close ended questions to share their knowledge, perceptions and beliefs about the environmental management of urban farming and water quality.

3.5 DATA COLLECTION TOOLS

Primary data was collected directly from the participants using survey questionnaires, focus group discussions, transit walks, field observations and photography. Secondary data will be obtained by reviewing relevant literature on the environmental management of urban farming and water quality in South Africa.

3.5.1 Survey Questionnaire

The research study administered a questionnaire consisting of open-ended and close-ended questions to obtain data on the research topic, such as the urban farmer demographic characteristics. Open-ended questions allowed the participants to provide in-depth information based on their perspectives and experiences on the research objectives. Close-ended questions enabled the participants to choose and rank from the options provided in the questionnaire.

3.5.2 Focus Group Discussion

A focus group discussion is an in-depth data collection method that brings together a purposively selected group of people to discuss the subject matter (Kabir, 2016). Focus group discussions consist of short questions that enable the researcher to obtain in-depth qualitative information and understanding of the research topic (Nyumba *et al.*, 2018). A focus group discussion comprising of 27 urban farmers, both women and man, was conducted in Sobantu to establish external environment factors namely *political, economic, social, technological, environmental and legal,* that challenged urban farming in the community. Further, challenges that hinder the farmers adoption of environmental management practices associated with urban farming and water quality were discussed. In the communities of Sweetwaters and Mpophomeni, a focus guide was used during face-to-face interviews with each of the farmers. The limitation to have focus group discussions in Sweetwaters and Mpophomeni was due to the fact that many of the farmers had other commitments and thus less people were available during the day to gather in groups. Table 1 below gives an illustration overview of the different concepts of each theme that was used to guide the discussions and interviews with the farmers.

THEMES	CONCEPTS
POLITICAL	Political disputes, constraints by existing policies, institutional support
ECONOMIC	Access to financial resources; microfinance institutions, farm profit generated
SOCIAL	Unemployment, aging, farm responsibilities for women, health care support, crime
TECHNOLOGICAL	Access to innovative agricultural technology, radio, TV, internet cellphone
ENVIRONMENT	Environmental constraints e.g., climate change impacts, air, soil and water pollution, climate suitability for UF.
LEGAL	Factors affecting adoption of adaptation strategies. Discrimination law, consumer law, employment law, health and safety law

Table 1: PESTEL model guide used to generate responses about the challenges of urban farming in the communities and the factors affecting adoption of adaptation strategies.

3.5.3 Field Observations

Field observations are another method of collecting qualitative data about people's behavioral patterns, the surroundings of the study setting and the subject at hand (Driscoll, 2011; Kawulich, 2012). This research method was used to identify and observe physical indicators of pollution of the Msunduzi River and the on-farm activities the farmers were engaging in. This was essential as it not only helped the researcher observe the environmental management practices adopted but to analyze the state of the agricultural land for physical indications of environmental degradation that may have been caused by the observed on-farm activities. It is an important data collection tool as it triangulates data, which means that through the observations, the researcher was able to verify findings derived from another methods of collecting data (Kawulich, 2012).

3.5.4 Photography

This method of collecting data involves taking photographs of the study setting and then using the photographs as actual data (Glaw *et al.*, 2017). In this study, a cellphone camera was used to capture photographs of the farm plots along with the type of crops cultivated and farming inputs used. Moreover, a photograph of the Msunduzi River was captured to highlight the physical pollution indicators that affected the water source while various urban farming and sustainable water use practices adopted by the farmers were also photographed. It is an effective tool as it does not entirely rely on what the participants say but allows the photographs to reveal in-depth and detailed information that cannot be conveyed through words. Furthermore, it helps the researcher enhance the richness of data by discovering additional layers of meaning, adding validity and depth, thus creating knowledge (Glaw *et al.*, 2017).

3.6 DATA ANALYSIS

The Statistical Package for Social Sciences (IBM SPSS version 27) was used in this analysis to generate descriptive statistics. Quantitative data from the questionnaire survey was coded and analyzed on SPSS using descriptive statistics while qualitative data obtained from focus group discussions, observations, and photography was analyzed and interpreted through a thematic analysis. A thematic analysis is a method of identifying, analyzing, and reporting patterns or themes of meaning in the collected data (Braun and Clarke, 2006 in Glaw *et al.*, 2017). The views, perceptions and experiences of the urban farmers were converted into a form of explanation or interpretation.

3.6.1 Principal Component Analysis

The study employed the Principal Component Analysis (PCA) method to generate urban farming and water quality indices.-The PCA is a popular multivariate analysis technique that is used to reduce the dimensionality of variables in a sense that information contained with a larger set of variables is reduced into a new smaller set of variables called principal components (PCs) with minimum loss of information (Jolliffe, 2002; Mellios & Payet, 2006; Miranda & Bontempi, 2008). The PCs which are computed by PCA are obtained as linear combinations of the original variables (Abdi & Williams, 2010). Studies further state that reducing the data set not only allows for the extraction of key information but helps to better understand and interpret the structure of the data (Jolliffe, 2002; Mellios & Payet, 2006; Abdi & Williams, 2010).

In order to obtain a set of variables of determinants of urban farming and water quality management practices for this study, a PCA was used. This technique allowed for the reduction of the original set of independent variables, $Xi, for\ i = 1, \ldots, n$, by removing redundant variables and extracting factors with the highest explanatory power. Factors noted w, are a linear combination of p original values, for $p = 1, \ldots, n$,: $w = \sum_{i=1}^{p} \beta i Xi$.

The Keiser-Meyey-Okin (KMO) measure of sampling adequacy and Bartlett's sphericity test were conducted to test the suitability of the data on water quality management practices (Dziuban & Shirkey, 1974). The value of the KMO test was 0.724, suggesting that the adequacy of input variables for the PCA was excellent, which is greater than 70%, while the test of the null hypothesis that the correlation matrix was an identity matrix reported a p-value < 0.000, which is less than 1%, thus suggesting that there was a relationship between the variables. PCA was therefore a suitable method for extracting environmental management practices. The retained principal components (PCs) representing the different dimensions of the water quality management practices employed by the farmers in the study area are presented in chapter 5. The PC contributed 54% to the variation in the data. In estimating the effect of water quality management practices on urban farming, the first loading with highest eigen value was used as a regressor in the logistic regression model as shown in chapter 5.

3.6.2 Logit regression model

A binary logit regression model was then used to determine the factors that influence the farmers' adoption of urban farming and water quality management practices. The logit model describes the relationship between a binary dependent variable and a set of binary or continuous independent variables (Ozdemir, 2011). The use of the logit regression model in this study is justifiable as it is not only a widely used technique but is easier to compute (Mellios & Payet, 2009; Dziwornu, 2013). Several studies have used this model to analyze the factors that influence the adoption of sustainable agricultural practices (Jayasinghe-Mudalige & Weersink, 2004; D'Emden et al., 2008; Zeng et al. 2018; Myeni et al., 2019; Serebrennikov et al., 2020).

The study assumes two possible outcomes "adopting urban farming and water quality management practices" or "not adopting urban farming and water quality management practices". A binary equation is set up, which defines Y=1 for a situation where a farmer is adopting urban farming and water quality management practices or Y=0 for a situation where a farmer is not adopting urban farming and water quality management practices.

The linear equation : $E(Yi) = \beta_1 X_1 + \beta_2 X_2 = \cdots BnXn$ (1)

However, in this case, the dependent variable (Yi) is not binary, thus the above linear equation is not appropriate for use and in order for the outcome of the dependent variable to take a binary value, a special function called the logistic function must be used $f(E(\text{Yi})$. This special function can be written as:

$$f(E(Yi)) = \boldsymbol{\alpha} + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta n X n \qquad (2)$$

Where the outcome Yi takes the value of 1 with the probability pi and the value of 0 with probability 1 -pi. Therefore, the standard equation for the logistic regression model can be written as:

$$Li = \frac{Pi}{1 - Pi} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta n X n + \varepsilon i \qquad (3)$$

Where *pi* is the probability of a farmer adopting urban farming and water quality management practices and *1-pi* is the probability of a farmer not adopting urban farming and water quality management practices. The β's are the vectors of binary regression coefficients, $\varepsilon i \cong (N\ 0, \sigma 2)$ is the error term, which is homoscedastic and normally distributed such as zero mean and constant variance, and X's are the independent variables used in the logit model.

Table 3.6.2: Independent variables used in the logit regression model

Variables	**Description**	**Expected sign**
Age	Age of respondent	+
Gender	Gender of the respondent	+
Education	Level of education of the respondent	+
Land ownership	Who owns the land cultivated on?	+
Access to extension support	Do extension officers provide agricultural services?	+
Access to credit	Does the respondent have access to micro-finance institutions?	+
Access to markets	Does the respondent have access to markets to sell produce?	+/-
Access to water	Does the respondent have access to water all year round? Does the respondent have access to transportation to distribute agricultural produce?	+/-
Access to transportation	Are there markets available for the respondents to sell agricultural produce?	+/-
Market availability	Does the respondent have knowledge about environmental management practices?	+/-
Awareness of environmental management practices	Has the respondent received training on soil management?	+
Training on soil management		+

3.7 ETHICAL CONSIDERATION

Ethical clearance was granted by the University of KwaZulu-Natal (UKZN), Humanities and Social Sciences Research Ethics Committee. In this section the researcher covered the following four main aspects: (1) confidentiality and (2) informed consent, as each farmer was asked for permission to participate in the study and to take pictures of their crops and agricultural inputs when it was necessary. The (3) anonymity of the farmers were maintained throughout the research and lastly the researcher ensured that (4) any fabrication or falsifying of data was prevented and ensured the promotion of the pursuit of knowledge and truth. The findings and recommendations of the study will be reported back to the communities once the study has been completed.

Table 2: A summary of objectives, data collection tools, the type of data collected and methods of analysis (Analytical framework) – Full details proved above.

Objectives	Data to be collected	Data collection techniques and tools	Data analysis
1. To explore the challenges of urban farming	PESTEL MODEL: Political, economic, social, technological, environmental and legal challenges faced by urban farmers in the three communities.	Focus Group discussion, Questionnaire, field observation	Thematic analysis, Descriptive and statistical analysis
2. To explore the implications of urban farming on the environment and water: implications for food security	Description of the production system. Description and characterization of water resources and irrigation systems. Awareness of environmental impacts and constraints. Crop losses and impact on profit.	Questionnaire, Field observations.	Thematic analysis, Descriptive and Statistical analysis.
3. To identify the environmental management practices adopted by the urban farmers.	Environmental compliance measures (e.g., EIA, polluter pays principle). Pest management practices, soil conservation practices, waste control, water use efficiency, water pollution prevention measures, Climate adaptation strategies.	Questionnaire, Field observations, Photography.	Thematic analysis, Descriptive and Statistical analysis, Principal component analysis, Logit regression analysis
4. Challenges around the state of the environmental management framework: towards an environmental management framework associated for food and nutrition security.	Governance issues e.g., institutional support, access to monitoring systems, institutional support, awareness of environmental management policies	Questionnaire, Focus Group Discussions.	Thematic analysis, Descriptive and Statistical analysis.

Image 1: Workshop where a focus group discussion was conducted with the farmers in urban Sobantu.

Image 2: Workshop where a focus group discussion was conducted with the farmers in urban Sobantu

CHAPTER FOUR

Implications of urban farming on the environment and water in urban Pietermaritzburg: a case study of Sobantu, Sweetwaters and Mpophomeni in KwaZulu-Natal

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Abstract

The environmental impacts of urban farming have been overlooked compared to rural farming as the practice has been alluded to its contribution towards climate change mitigation due to its reduced use of transportation, reduced produce waste during distribution and its contribution to flood water mitigation, water infiltration and urban greening. However, it has been argued that urban farming (UF), in its small scale comprises of various production systems and practices that can lead to poor soil conditions, water pollution and the extension of climate change impacts. The farmers' awareness of the environmental implications of urban farming, environmental challenges experienced and the implications on food security is significant for the adoption of environmental management practices. This will ensure the reduction of the negative impacts of smallholder UF. This study was conducted in the urban and peri-urban parts of the KwaZulu-Natal-uMgungundlovu district municipality namely urban Sobantu, peri-urban Sweetwaters and peri-urban Mpophomeni which comprise of diverse smallholder urban farmers. A purposive sampling technique was used to sample 78 urban and peri-urban farmers. The study employed a mixed methodology approach that consisted of Focus Group Discussions (FGD's), Field Observations and a Survey Questionnaire with open and close ended questions to collect qualitative and quantitative data. This study used a means-based evaluation of the environmental implications of urban farming on the environment and the quality of the water used for irrigation. The results revealed that the majority of the farmers were faced with environmental problems including poor soil conditions, water quality and access problems and climate change impacts, of which had an impact on crop yield and farm profit. Furthermore, results show that 69.2% of farmers were aware of the environmental implications of urban farming. However, it was found that due to socio-economic factors, farmers identified urban farming mainly as a source of income and a strategy to obtain extra food and less for the benefit of the environment. Therefore, environmental education, farmer training through extension

services could play a significant role in raising environmental awareness to reduce the negative impacts of urban farming on the environment and water.

Key words: urban farming, climate change, environmental implications, environmental awareness

4.1 INTRODUCTION AND BACKGROUND OF THE STUDY

The global increase in population has led to the mass rural-urban migration as people search for more greener pastures in the form of better livelihood opportunities and more improved service delivery in urban areas (Bisaga *et al.*, 2019). According to Orsini *et al.* (2013), 55% of the world population is projected to live in urban areas by the year 2030. A report by O' Neil (2021) on urbanization in South Africa state that over 67.35% of the total population in South Africa lived in urban areas and cities in the year 2020, a 0.49% increase from 2019. The report further state that about 46 inhabitants were now sharing less space per square kilometer (O'Neil, 2021), an indication of the depleting available land space. Additionally, the urbanization process has been accompanied by high unemployment levels, expansion of informal settlements with poor conditions, pollution, urban poverty, pressure on the already scarce water resources and food insecurity (Orsini *et al.* 2013; Bisaga *et al.*, 2019; O'Neil, 2021). Considering these socio-economic issues, it is unlikely that poor urban households are able to afford the average costs of the household food basket of R4,401.02 in January 2022 (Pietermaritzburg Economic Jusrtice and Dignity Group, 2022). Therefore, the government has made several attempts to address this by encouraging self-sufficiency in food production, a strategy that will offer various benefits to the ailing elements of the urban environment.

Urban areas with an influx of urban dwellers with growing demands of more food and infrastructure is likely to result in the exploitation of the already scarce and polluted natural resources, thus extending climate change impacts and challenging sustainability. Additionally, urban development has led to the loss of soil and vegetation of which has resulted to more impermeable surfaces with reduced water infiltration capacity, thus resulting to excessive storm water runoff (Heather, 2012). Therefore, to address the existing socio-economic and environmental issues in urban areas, UF has been placed at the government's mandate. UF, if done well, has the potential to improve food and nutrition security for the growing urban population while offering environmental benefits including flood water mitigation, water filtration and greening of the urban environment.

However, if not done well, UF can cause environmental impacts such as soil degradation, water pollution and the extension of climate change impacts. According to Trigo *et al.* (2021), agriculture has the highest water usage capacity and contributes to environmental pollution including the contamination of the quality of the water used for irrigation. South Africa is currently experiencing a rapid deterioration of the quality of water resources in several parts of the country, especially in urban areas (Department of Water Affairs, 2001; Muller, 2002; Griffin *et al.*, 2014, Cullis *et al.*, 2019). Odiyo and Makungo (2012) highlighted the major causes of the persistent poor water quality which include effluent discharges from commercial premises, sewage and solid waste from residential premises, runoff from urban areas and toxic agricultural waste. The authors further suggested that the runoff from urban areas and toxic agricultural waste containing fertilizers and pesticides have the largest source of nutrients that result in the eutrophication of water bodies.

Several authors (Van der Warf and Petit, 2002; Reynolds et al., 2015; Clark and Tilman 2017; Ritchie and Roser, 2020; Trigo et al., 2021; Feitosa et al., 2021) further stated that environmental implications are sourced back to production systems and the numerous practices farmers engage in. Climate change is a global issue with adverse impacts on people's lives, animals and the natural resources on earth (Van der Warf and Petit, 2002; FAO, 2018). The variability in rainfall patterns often result in excessive rainfall leading to floods accompanied by outbreaks of pests and diseases along with soil erosion, thus the reduction of arable land for agricultural production. High weather temperatures have also resulted to drought occurrences of which have completely reduced the capacity of farmers situated in dry and arid regions to sustain their production systems. A report by Wreford *et al.* (2010) under the Organization for Economic Co-operation and Development state that as the global community continues to assess the impacts and causes of climate change, it is already apparent that the impacts on agriculture has been the most severe on the poor and vulnerable. Harvey *et al.* (2014) state that the smallholder farmers in developing countries are the most vulnerable to climate change impacts. This is mainly due to existing institutional challenges including the lack of extension support as well as the lack of knowledge and skills, information, and financial resources that hinder their ability to understand, perceive and adapt to climate change strategies to gain resilience.

Existing environmental issues of soil degradation, water pollution and climate change impacts have economic consequences for farmers and consumers dependent on farming as a livelihood strategy and a means to meet food and nutrition security needs. In light of this, it is important that more awareness is raised on mitigating the anthropogenic activities that contribute to the changing climate conditions. The aim of this study was to evaluate the implications of urban farming on the environment and the quality of the water used for irrigation in the urban and periurban smallholder farming communities of Sobantu, Sweetwaters and Mpophomeni, located on the outskirts of urban Pietermaritzburg KwaZulu-Natal.

4.2 MATERIALS AND METHODS

4.2.1 Study area and description of sampled farmers

The research study was conducted in three communities namely urban Sobantu, semi-urban Sweetwaters and semi-urban Mpophomeni located on the outskirts of urban Pietermaritzburg in the province of KwaZulu-Natal. The communities were chosen as they are classified as urban and semi-urban with a rapid growth in population and urbanization accompanied by a low socio-economic status including high rates of unemployment and poverty (Baiyegunhi and Makwangudze, 2013; Dhilwayo, 2018; Hlahla and Hill, 2018; IDP, 2020/2021). Moreover, the communities have high agricultural potential due to robust soils and favorable climate conditions, hence the majority of the households are involved in subsistence and smallholder farming. The farmers were mostly involved in producing crops such as cabbage, beetroot, spinach, potatoes, maize, traditional pumpkin, onions. Cabbage and spinach were the most frequently cultivated crops as they are staple food crops amongst the communities. The farmers were also considered as market participants as they sold produce through informal and formal markets such as community members, fresh produce markets, schools, health facilities and street vendors. The major challenges affecting the growth of farming in the communities include climate change impacts, water insecurity, pest outbreaks, lack of capital, extension services and institutional support.

4.2.2 Sampling technique and sample size

The non-probability sampling approach was employed in this study. This approach was used because it allowed the researcher to purposively select a smaller group representing the views and opinions of the majority of the people residing in the communities of Sobantu, Sweetwaters and Mpophomeni. A purposive sampling technique was used in this study to select 78 urban farmers who were residing in the communities. Additionally, in this study the researcher included farmers who active in production, experiencing environmental management challenges and willing to engage with the researcher.

4.2.3 Data collection and Analysis

The data collected using survey questionnaire was coded and captured on the Statistical Package for Social Sciences (IBM SPSS version 27) for analysis. Descriptive statistical analysis in the form of frequencies was generated and used to summarize the coded quantitative data from the survey questionnaire. The frequency results were also used to support the presented qualitative data. The qualitative data from focus group discussions and field observations were analyzed using thematic analysis. Further analysis was done using the PESTEL analysis model and it identified external environment factors that challenged urban farming in the communities.

4.3 RESULTS AND DISCUSSION

The following section presents the results and discussion of the urban farming challenges and the environmental implications of urban farming and the impact of food security. Literature from several authors (local, national and international) was used to support the means-based findings of the environmental implications of urban farming on the environment and water quality.

4.3.1 Demographic Characteristics

Demographic information is significant in research as it helps the researcher to understand its influence on the decisions and actions that farmers take (Makhura, 2001; Siulemba and Moodley, 2014). In this regard, the researcher explored various demographic variables including gender, age, level of formal education, years of experience and formal training in farming presented in table 1.

Table 3: Gender, age and formal education levels of the farmers

Demographic variable	Category	Frequency (n=78)	Percentage (%)
Gender	1. Female	52	66.7
	2. Male	26	33.3
Age	1. >20	1	1.3
	2. 21-30	0	0
	3. 31-40	9	11.5
	4. 41-50	12	15.4
	5. 51-60	20	25.6
	6. <61	36	46.2
Level of Formal Education	1. No formal education	9	11.5
	2. Primary	27	34.6
	3. Secondary	16	20.5
	4. Finished both primary and secondary	23	29.5
	5. Vocational training	2	2.6
	6. Other	1	1.3
Years of experience in farming	1. <5	17	21.8
	2. 6-10	17	21.8
	3. 11-15	15	19.2
	4. 16-20	14	17.9
	5. 21-25	9	11.5
	6. 26-30	3	3.8
	7. >31	3	3.8
Formal training in farming	1. Yes	20	25.6
	0. No	58	74.4
Monthly source of income	1. Farming only	12	15.4
	2. Remittances	1	1.3
	3. Old age pension only	8	10.3
	4. Casual income	9	11.5
	5. Social grants	6	7.7
	6. Farming and old age pension	32	41.0
	7. Salary	10	12.8
Main livelihood strategy	1. Farming	37	47.4
	2. Employed/ job	10	12.8
	3. Casual labor	9	11.5
Access to credit	1. Yes	10	12.8
	0. No	68	87.2
Access to markets	1. Yes	56	71.8%
	0. No	22	28.2%

The results on Table 3 show that the majority of the farmers interviewed (66.7%) were female and 33.3% were male. According to Thamaga-Chitja and Morojele (2014), 80% of active smallholder farmers in SSA are female mainly because of their role in preparing food for their households. The results further show that the majority of the farmers are over the age of 61 years (46.2%) while only 1.3% fall under the youth category. These findings confirm the existing trend that highlights the elderly as being more interested and involved in farming compared to the youth as this group is discouraged by the lack of economic gains in crop production (Cele, 2016). Farmers stated that they are unable to attract the youth to engage in smallholder urban farming as they are discouraged by the lack of financial gains in smallholder urban farming. One farmer expressed that he has not gained enough profit to attract the youth and perhaps is the reason why they prefer to study for non-farming related degrees in the university. The older farmers had expressed their concerns about the disappearance of indigenous knowledge systems from society as they are unable to attract the youth to participate in farming. This also means that the older farmers are less likely to adopt new technology that would enhance their capacity to perceive the implications of urban farming on the environment and the quality of the water used for irrigation. Thus, climate change mitigation strategies that may contribute to sustained yields for market access will be important.

A total of 11.5% of farmers have no formal education, 33.3% have primary level of formal education, 23.1% secondary, and 28.2% have completed both primary and secondary formal education, while 3.8% have received vocational training. Farmers who have primary level of formal education were largely concentrated in grade 3. Although these results contradict the common trend that highlights illiteracy amongst smallholder farmers in South Africa, it can be explained by the fact that these farmers are in an urban area and thus education levels are generally higher. Nevertheless, there is still a large number of smallholder farmers who are unable to access higher education institutions or suitable vocational and practical education. The table further displays the results of the number of years the farmers have been farming. The number of years of experience were categorized and thus farmers were able to select the category they range in. The largest concentration of farmers was found within two categories viz less than five (21.8%) and 6-10 years (21.8%) of farming experience followed by 19.2% of farmers ranging from 11-15 years of experience, 17.9% with 16-20 years, 11.5% with 21-25, 3.8% (26-30 years) and 3.8% with more than 31 years of experience in farming. These results suggest that the majority of the farmers have long experiences in farming and therefore have observed the changes in the environment and acquired extensive knowledge and skills gained through lived experiences.

Additionally, a total of 25.6% of farmers specified that they have been formally trained in farming, while 74.4% farmers stated that they have no formal training in farming. This suggests that there are low-capacity building programs in the communities. Farmers in Sobantu revealed that in the year 2020, the local Department of Agriculture had implemented a training program that aimed to attract the youth in farming. However, the farmers had stated that due to the global Coronavirus outbreak, the training program was postponed. The farmers' participation in training programs plays a vital role in accessing relevant information that would enhance the capacity to understand and apply the acquired knowledge and skills in their own farm activities as well as sharing that information with other farmers. The farmers who have received training in farming play a vital role in the farmers ability to access relevant information that would enhance their knowledge and capacity to be perceive, understand and be conscious of their existing relationship with the environment and the implications of urban farming on the environment and quality of the water used for irrigation.

As demonstrated in Table 3, a total of 15.4% of farmers stated that their main source of income came from farming only, 1.3% from remittances, 10.3% of the farmers received pension grants, 11.5% were receiving casual income, 7.7% social grants, while the majority of the farmers in the case of 41% stated that both farming and pension grants were a main source of income. Only 12.8% farmers were receiving a salary. The 41% result of those who receive pension grant is expected since the majority of the active farmers in South Africa are over the age of 60 years and qualify to receive the government pension grant that amounts to R1 890 per month. Additionally, farmers specified that they cultivate crops either for subsistence and/or to generate an extra income. However, farmers expressed that the pension money and the generated profit from the farm produce, of which is an estimated average of R300-R400 per planting season is not sufficient to sustain their households and livelihoods. A total of 47.4% of the respondents stated that farming is their main livelihood strategy, 12.8% had salary paying jobs, while only 11.5% considered causal labor as the main livelihood strategy.

A total of 12.8% of farmers stated they had access to micro-finance institutions for credit, while 87.2% had no access to credit. The results show a high dependency of urban farming by the vulnerable urban dwellers as it offers job creation and sets to achieve the farmers food and nutrition security. Therefore, any vulnerability to environmental shocks and risks such as soil erosion, water quality and access problems, and climate change impacts will have adverse effect on their livelihoods and the food and nutrition security status of their households. This will be exacerbated by the urban food basket that has amounted to R977.57 as of June 2021 (National Agricultural Marketing Council, 2021). A means-based evaluation was employed to determine the implications of urban farming on the environment and the quality of the water used for irrigation.

Lastly, table 3 shows that a total of 71.8% farmers had access to various markets and these markets were community members (59%), fresh produce markets (7.7%), healthcare facilities (2.6%) and Schools (1.3%). While 28.2% said they do not have access to markets. Nine (9) of the farmers from each category stated that they also travelled to the Pietermaritzburg central business district where they sold their produce to street hawkers while others managed to sell to informal traders if they had produced and harvested enough yield. Approximately 61.5% of the farmers who were selling their crops stated that they did not generate enough income to sustain their livelihoods. However, these markets do not provide sufficient profit to sustain the farmers' livelihoods and households. Responses obtained from focus group discussions and qualitative responses from questionnaires revealed that the lack of access to lucrative markets and information services on how to access them were a major hindrance.

4.3.2 Description and characterization of the farmers' production systems

Survey questionnaires and focus group discussion questions were administered towards 78 urban farmers involved in urban food production, consumption and marketing of various leafy greens, vegetables, roots and tubers, cereals as well as tomato. From the onset, it was clear that 18 food crops were produced (Table 4 below.) and either traded or consumed for subsistence and sometimes both. The farmers' motivation for farming was to obtain extra food for their households and to generate an extra income. Table 4 shows that the most frequently cultivated crops were spinach (74.4%), cabbage (62.8%), Maize (36%), traditional pumpkin (29.5%), potatoes (28.2%), beetroot (26.9%), and onions (20.5%). Moreover, the three (3) most prominent food crops (*****) that were being cultivated by the majority of the urban farmers were identified to be Spinach (74.4%), Cabbage (62.8%) and Maize (36%). The prominent production of maize was surprising as it is generally cultivated in rural farming. Cabbage and Spinach were found to be cultivated a number of times throughout the year and on the same period of time which is an indication that these crops are staple food crops in the farmer's households and amongst their communities. This also suggests that any urban farming and environmental shocks or risks will not only affect the farmers profit and the farmers' ability to be self-sufficient in food production but will limit the communities' access to fresh and affordable produce.

The majority of the farmers estimated an average amount of R300-R400 of profit made from selling fresh produce to community members per planting season, of which is not sufficient enough to sustain their household needs and livelihoods. Farmers stated that they do not have sufficient access to land space to increase and diversify crop yield, of which would enable them to supply formal markets to obtain more profit, which was later confirmed during a FGD (Table 5 below). Whereas other farmers stated that some of their produce was utilized for household consumption and sometimes gifted to neighbors. These factors limited the farmers from gaining more profit. Additionally, the missing prices were attributed to the farmers' reluctance to disclose the exact profit they make per season, fearing that their profit gains would be disclosed to other farmers. Key institutional issues constraining the production and productivity of urban farming were found to be the lack of proper guidance from extension officers, access to financial resources and micro-finance institutions, agricultural inputs such as tractor, truck and seedlings, information about market access and high transportation costs. While environmental issues experienced by the farmers were found to be water quality and access problems, poor soil quality and climate change impacts including heavy rainfall leading to floods, hailstorms and high weather temperatures as well as the persistent occurrence of pests.

Table 4: Provides the results of the crops grown, price range and frequency of farmers

Crops grown	Price range	Frequency (n=78)	Percentage (%)
Sweet potatoes	No price, mostly used for household consumption	6	7.6
Amadumbe	R30 a bowl	6	7.6
Carrot	R10 per bunch	13	16.6
Lettuce	No price provided	13	16.6
Butternut	No price provided	6	7.6
Green pepper	No price provided	8	10.2
Tomatoes	No price provided	4	5.1
Brinjal/egg plant	No price provided	2	2.5
Green beans	No price provided	4	5.1
Chillies	R5	6	7.6
Kale	R10 a bunch	10	12.8
Imifino	No price, mostly for household consumption and gifting	2	2.5
Spinach	R10 per bunch	58	74.4*
Cabbage	R10-R15 per head	49	62.8*
Maize	R12-R15 per cob	28	36*
Potatoes	R10 per bowl	22	28.2
Traditional pumpkin	No price, mostly for subsistence/household consumption	23	29.5
Beetroot	No price, mostly for subsistence/household consumption	21	26.9
Onions	No price, mostly for subsistence/household consumption	16	20.5

4.3.3 Challenges faced by urban farmers

A focus group discussion (*table 5 below)* was conducted in Sobantu, while a focus discussion guide was used during interviews with farmers in Sweetwaters and Mpophomeni. The aim of the focus group discussion was to identify external environmental factors that challenge urban farming. The data analyzed indicated that all of the three communities have common political, economic, social, technological, environmental and legal issues that challenge the growth and performance of urban farming. The urban smallholder farmers interviewed show limited knowledge and awareness in regard to policies including water authorization policies by farmers using the Msunduzi River in Sobantu. This was attributed to the fact that the river runs through the Sobantu community, thus farmers believe that they hold automatic rights to it. While the farmers admitted to the assumption that there may be existing political issues and laws that may be affecting urban farming, however, they were unable to mention as they did not know of any. Furthermore, the farmers faced common economic issues including the lack of access to micro-finance institutions to access credit, low sources of income exacerbated by low farm input generated. Farmers in Sobantu stated that low farm inputs were attributed to the fact that market agents usually deduct a high percentage of market commissions that initially agreed on. This evoked feelings of discouragement from the farmers as they felt that they are being underpaid for their own produce.

In terms of social factors, urban farming in the study areas have been affected by COVID-19 of which affected farm operations and put a stop on a crop production training program that was implemented in Sobantu. Common social issues experienced by the farmers included theft of which affected farm profit. Furthermore, the lack of youth participation in the three study areas raised concerns from the farmers in regard to disappearing indigenous knowledge. The lack of youth participation also means that the older generation are unable to access new technology to assist farmers be in sync with the changing times. Farmers had no knowledge about the *Hello Choice* website designed for smallholder farmers to trade their produce. The study revealed that the majority of the farmers did not have access to cellphones with internet, of which hindered the farmers from accessing markets through technology. This placed emphasis on the need for the youth to participate in urban farming in order to ensure its sustainability.

The study found that urban farming in the areas is challenges by various environmental issues including the persistent occurrence of pests, high weather temperatures, heavy rainfall and hailstorms. Sobantu was particularly challenged by poor water quality conditions, of which most of the farmers had stopped using due to food safety concerns. While legal issues in Sobantu were based on the lack of certificates such as the South African Goods Products required by formal markets to ensure food safety and quality standards are met. This has created a barrier in terms of the farmers accessing lucrative markets as they do not have this certificate. The lack of transportation, access to tractors and seedlings, the lack of information sharing and unity amongst the urban farmers were some of the identified challenges in urban farming.

Table 5: A focus group discussion about the challenges that farmers experience in urban farming, generated using the PESTEL model

Themes	Concepts	Responses
Political	Political disputes, policy constraints	The overall findings imply that the famers are not aware of the environmental laws and policies that prohibit the illegal dumping of waste. Farmers expressed the lack of institutional support to gain market access, and agricultural inputs such as tractors and seeds. Extension support is poor. Training programs in Sobantu administered by the local government were postponed due the COVID-19 outbreak.
Economic	Access to micro-finance institutions Profit generated enough?	Farmers do not have access to credit as they are over the age of 61 years and have no steady salary. They do not generate enough income from selling due to limited land space. "I do not sell my produce because I do not have enough land, my family eats what I grow" Some of the farmers resorted to sometimes gifting their neighbors with produce instead of selling, thus were not generating profit. Farmers are unable to employ labor due to the lack of profit they are making.
Socio-cultural	Social issues affecting UF e.g. unemployment? Aging, disease outbreaks	Yes. COVID-19 slowed production and training programs in Sobantu were postponed. Farmers expressed that the lack of youth participation influences their lack of investment to new technology and thus lack information. The farmers are unemployed and have low income, thus are more socially and economically motivated and less inclined to the concern of the environment. "the youth can se themselves that we are struggling so they choose to go to university and find jobs in town"
Technological	Access to technology e.g., cell phone	Farmers mainly have access to television and cellphone without internet. Farmers with cellphone with internet access did not know how to use popular search engines such as *"Google"* to access information about market access
Environmental	Water quality issues. Soil problems. Water access.	Commonly experienced environmental stressors were identified to be heavy rainfall, high weather temperatures and hailstorms. Persistent occurrence of pests. Water access- "I use the municipal tap water and sometimes there are water cuts" *"sometimes there are water cuts in this area*. Farmers using rainwater- *"we are faced with a challenge during winter as there is not much rainfall"*. while others expressed high-water tariffs being a major limiting factor. Farmers in Sobantu stated that the Msunduzi river showed visible signs of contamination although they are still awaiting water quality results from scientific assessments that were conducted on the river by the local municipality and academics.

		Yes. The water is contaminated by the animal feeds factory that spills oil. Farmers are socially and economically motivated to farm and less inclined to the concern of the environment.
Legal	Are there any discrimination, consumer, employment and health and safety law?	"We do not have the certificates that the markets want from us and our produce is sold at low prices"

4.3.4 PRODUCTION ACTIVITIES: CROP AND ENVIRONMENT INTERACTIONS

A means-based evaluation was used to provide insight on the crop and environment interactions. This assisted the researcher to evaluate the impact of urban farming on the environment and quality of the water used for irrigation in the three study sites collectively. The three stages of the crop value chain (pre-production, production, post-production), an approach adopted by Gomez *et al.* (2011) was adopted in this study.

4.3.4.1 Pre-production

Farmers were asked about the soil preparation activities (Table 6 below) they employed before the cultivation of crops, and a total of 62.8% of the farmers removed weeds, 3.8% turned the soil, 1.3% applied chemicals on the soil, 30.8% removed weeds and turned the soil, while only 1.3% stated that they removed weeds, turned the soil, and applied chemicals. Four of the farmers selected more than one option, stating that they also applied chemicals on the soil. The results indicate that majority of the farmers are removing weeds and turning the soil in preparation of planting of which can have adverse impacts on the soil structure and quality. According to Reynolds et al. (2015) clearing the land in preparation of planting exposes the soil to degradation including soil loss due to erosion, compaction and thus reduces the soil capacity to retain water.

Table 6: Provides the results of the soil preparation techniques before planting

Soil preparation activities	Frequency (n=78)	Percentage (%)
1. **Remove weeds**	49	62.8
2. **Turn the soil**	3	3.8
3. **Apply chemicals on the soil**	1	1.3
4. **Remove weeds and turn the soil**	24	30.8
5. **Remove weeds, turned the soil and applied chemicals**	1	1.3

4.3.4.2 Production

The results on table 7 below reveal that the majority of the farmers plant produce either once (22.8%) or twice (41.8%) per annum, and on the period of zero cultivation, the land is left bare. One farmer during a FGD in Sobantu revealed that they have not cultivated any food crops this year while others have set a calendar to produce specific crops on specific dates in order to supply for a targeted market. This is an indication that some of the farmers have adopted a monoculture cropping system of which is known to cause vast environmental and agricultural impacts including soil loss and compaction as topsoil is lost through wind and water erosion. Consequently, the reduced water and nutrient holding capacity of the soil will result in the poor capacity for crop growth. The farmers who usually planted once or twice were found to have mainly planted spinach. This can be attributed to the fact that spinach is not only a cash crop but is also a staple food crop in the communities. Additionally, the majority of the farmers are planting on less than one (1) hectare of land, thus crop intensification and diversification is limited.

Table 7: Provides the results of the number of times farmers plant crop (per annum)

Number of times farmers plant	Frequency (n=78)	Percentage (%)
1. Once	18	23.1
2. Twice	32	41
3. Three times	11	14.1
4. All year round	17	21.8

The 16.5% of the conventional farmers that use synthetic chemicals indicated that that they do not follow the specified guidelines of chemical application, with some mentioning that they measure the amount to be applied or sprayed with their naked eyes and according to what they perceive is the right amount. This indicates that the farmers are not practicing the correct methods of agricultural chemical application and may run the risk of applying more than the recommended amount of which can be potentially harmful towards the environment in the long term. A study conducted by Ajayi (2000) found that only 2% of the farmers were aware of the potential negative impacts of farm inputs such as pesticides on the environment. The author further indicated that the environmental risks due to intensive application of toxic agricultural chemicals are not effectively communicated within farming systems in developing countries. This trend was further confirmed in this research study as the majority of the farmers (69.6%) lack the support and guidance of extension officers. This was confirmed in the study when the farmers revealed that they lacked information and guidance on the type of agricultural chemicals to use to control pests and insects as they had previously tested various agrochemicals of which proved to be ineffective.

Table 8: Access to water, type of water source used to irrigate crops and the irrigation systems used to abstract water

Water source	Category	Frequency (n=78)	Percentage (%)
Access to water all year round	1. Yes	72	92
	0. No	6	8
Type of main water source	1. Communal tap	4	5
	2. Private tap	60	77
	3. River	5	6
	4. Rainwater	3	4
	5. Borehole	4	5
	6. Other	2	3
Water abstractions	**1.** Buckets **(Manual irrigation)**	20	25.6
	2. Pipes	24	30.8
	3. Watering cans **(Manual irrigation)**	31	39.7
	4. Not applicable	3	3.8

Although Feola *et al.* (2020) claimed that urban agriculture is a resource-efficient practice. Several authors (McDougal *et al.*, 2019; Tharrey *et al.*, 2020) argued and demonstrated that urban agriculture can have a high resource usage capacity with larger climate change impacts especially when compared to rural agriculture. Table 8 above shows that a total of 92% of farmers had access to water all year round while 8% did not. The type of water sources included communal taps (5%), private taps (77%), river source (6%), rainwater (4%) and borehole (5%). Two farmers (3%) stated they make use of other sources of water which include a groundwater pipe and ground/spring water. Therefore, a total of 96% of farmers irrigated their land while 4% relied on rain fed urban farming. Implements farmers used to abstract water for irrigation were buckets (25.6%), pipes (30.8%), watering cans (39.7%), while only one farmer had used the drip irrigation method. Therefore, manual (65.5%), drip (1.3%) and localized (30.8%) irrigation methods were applied to irrigate crops.

Common challenges that hinder the remaining 7.7% of the farmers from accessing water all year round were found to be the frequent water cuts by the municipality as a quest to address water security issues in these areas. This has raised concerns about the severity of water scarcity issues in urban South Africa and therefore the focus has shifted towards monitoring water consumption patterns of intensive water users such as farmers. Majority of the farmers indicated that they irrigate their crops only when the weather temperatures are excessively high. Although it may seem that the farmers are not over-using water, further inquiry through open ended questions revealed that the farmers were not exactly keeping track of their water consumption levels nor measuring the amount they were using for each crop. However, the farmers were able to identify that the crops with the highest water usage capacity included Cabbage and Spinach. This was not surprising as Cabbage and Spinach are both naturally water demanding crops and are also staple food crops in the communities and thus were planted many times throughout the year. Considering the existing water availability and access problems in the communities, it is imperative that the farmers are conscious of their water consumption levels.

Several studies have reported that both the Msunduzi and Baynespruit rivers which are a vital source of water for the farming community in Sobantu are heavily polluted. Several studies (Neysmith and Dent, 2010; Ramburran, 2014) revealed that the poor water quality of the Msunduzi and Baynespruit Rivers was a case of illegal waste discharge from industrial institutions, a poor sewage infrastructure and illegal dumping of waste from the members of the community who reside in proximity to the river. Farmers in Sobantu alluded to the fact that the Msunduzi River they use to irrigate their crops was polluted by the sewage system from uphill as the river is located on the lower side of the topography. Findings from field observations (Image 3 below) revealed that the Msunduzi River that the farmers were using to irrigate crops had impaired water clarity and was murky brown in color, with litter surrounding the source. Moreover, the Msunduzi River is also surrounded by factories including three animal feeds factories and the New England Rd landfill site which has been considered an environmental and health concern over the past years. One farmer in a FGD revealed that the suspected cause of the poor water quality of the Msunduzi River was an oil spoilage from the three animal feeds factories located in proximity to the river and community.

Image 3: Msunduzi River source: researcher generated

4.3.4.3 Post-production

In Table 9 below, farmers state that after harvest is complete 2.6% of farmers burn the crop residues, the majority of the farmers in the case of 51.3% made green compost with the crop residues, while 46.2% of farmers discarded the crop residues on the side of the farm plots. Farmers were also asked on the type of packaging for distribution and only 17.9% used recycled plastic bags, while a total of 82.1% of farmers did not have any packaging. Since the majority of the consumers are community members and neighbors, they are encouraged to bring their own packaging materials when purchasing produce on-farm. The type of transport used included 2.3% small vehicle, 4.8% used public transport, 6.4% used a pick-up truck, while the majority of farmers in the case of 85.9% did not have transport of which was expected as the farmers main market is the community they live in. Therefore, transportation for the distribution of produce is not required. In terms of farm waste disposal, a total of 29.1% of farmers stated that the municipal waste truck consistently collected waste every week, while the majority of farmers in the case of 48.1% said they discarded the finished waste products on the side of the farm, 7.6% discarded waste products off-farm (illegally), while 2.5% burned the waste. The remaining 12.7% of the farmers had various ways of disposing waste products including making compost, as well as recycling and re-using plastics.

These results indicate that the majority of the farmers contribute less to the impact on the environment due to the low emission of greenhouse gases and food spoilage as the distribution of produce is conducted on-farm, thus no transport is required. Furthermore, the majority of the farmers use manual labor and hand planting during production and thus heavy machinery is not utilized. Additionally, the majority of the smallholder farmers make compost out of crop residues and encourage plastic recycling and reuse of which are essential for soil fertility and pollution control, respectively. This was expected since the farmers are small-scale with limited use of agricultural inputs and thus expected to cause minimum impact on the environment. Several authors (Grard *et al.* 2018; Orsini, 2020) in Dorr *et al.* (2021) argued that urban agriculture is a form of sustainable farming that uses resources efficiently and can contribute to climate change mitigation due to reduced transport and food waste. The farmers discarded farm products on-farm which can be attributed to the farmers lack of storage facilities and the lack of knowledge about the environmental laws that prohibit pollution and the illegal dumping of waste. However, the farmers make up with the avoided organic waste and greenhouse gas emissions.

Table 9: Provides the post-production activities farmers engage in

Variables	Frequency (n=78)	Percentage (%)
What do you do with crops residues?		
1. Burn them	2	2.6
2. Make compost	40	51.3
3. Discard them	36	46.2
Type of packaging		
1. Plastic bags	14	17.9
2. Crates	0	0
3. Cardboard	0	0
4. Knitted bags	0	0
5. Do not have packaging	64	82.1
Type of transportation		
1. Small vehicle	3	3.8
2. Public transport	3	4.8
3. Bakkie	5	6.4
4. Truck	0	0
5. Do not have transport	67	85.9
Waste disposal		
1. Municipal waste truck	23	29.1
2. Discard on-farm	38	48.1
3. Discard off-farm	6	7.6
4. Burn the waste	2	2.5
5. Other	10	12.7

4.3.5 FARMERS' AWARENESS OF THE IMPLICATIONS OF URBAN FARMING ON THE ENVIRONMENT

Table 10 below shows that the majority of the farmers in the case of 70.5% stated that they were aware of the environmental impacts of urban farming, while 29.5% were not. The researcher further asked farmers of their perceived causes of poor soil quality and the majority in the case of 69.2% stated that chemical fertilizers were the cause, while 2.6% agree on municipal sewage/waste, 2.6% on industrial chemicals, 12.8% on natural causes. A total of 11.5% of farmers were not sure and 1.3% stated other causes included human activities. In addition, a total of 48.7% of farmers responded positively to farm chemicals as a cause of poor water quality.

These results indicate that the majority of the farmers were not only aware that urban farming can cause harm towards the environment, but they were also able to perceive the use of agricultural chemicals as the cause of poor soil quality. This is expected since the majority of the farmers are farming organically. However, only perceiving the impact of chemicals and not on human activities suggests that the farmers do not realize their role in causing negative impacts on the environment. If the farmers are aware of the environmental impacts of UF on the environment as well as its adverse effects on the household food and nutrition security and farm profit, they will likely be more willing to adopt environmental management practices to reduce the negative impacts. Several authors (Story and Forsyth, 2008; Hyland *et al*., 2015) in Sulewski and Goals (2019) also stated that if the farmers are aware of the environmental problems caused by agricultural activities, they will be more willing to protect the natural environment.

Table 10: Shows the results of the farmers' awareness to the environmental impact of urban farming

Variables	Frequency (n=78)	Percentage (%)
Are you aware of the environmental impacts of UF?		
1. Yes	55	70.5
0. No	23	29.5
Perceived causes of poor soil quality		
1. Chemical fertilizers	54	69.2
2. Municipal sewage	2	2.6
3. Industrial waste	2	2.6
4. Natural causes	10	12.8
5. Not sure	9	11.5
6. Other	1	1.3
Farm chemicals cause poor water quality		
1. Strongly agree	38	48.7
2. Agree	10	12.8
3. Somewhat agree	18	23.1
4. Somewhat disagree	6	7.7
5. Disagree	6	7.7
6. Strongly disagree	0	0

4.3.5.1 Noticeable changes on soil conditions over the years

Farmers were then asked to state whether they are any noticeable changes on soil conditions since the early years of production. On table 11 below, a total of 12.8% of farmers had noticed that the soil had become compacted, while 6.4% had indicated that there has been more soil loss due to erosion. The majority of the farmers (59%) responded by saying that there had been no changes on soil that they know of, 10.3% declared they were not sure, while the remaining farmers in the case of 11.5% stated that they had noticed other changes on soil conditions over the years including the change in soil texture and more persistent pests.

Table 11: Shows the results of the noticeable changes on soil over the years

Noticeable (visible) changes on soil over the Years	Frequency (n=78)	Percentage (%)
1. Soil is compacted/hardened	10	12.8 6.4
2. Soil erosion	5	59
3. None that I know of	46	10.3
4. Not sure	8	

5. Other	9	11.5

4.3.5.2 Rate of crops produced in the last 5 years

Farmers in figure 3 below indicated that 33.3% of the farmers had yielded more produce in the last 5 years, a total of 26.9% said they had yielded less produce, while the majority of farmers in the case of 39.7% stated that they had yielded more or less produce in the last 5 years.

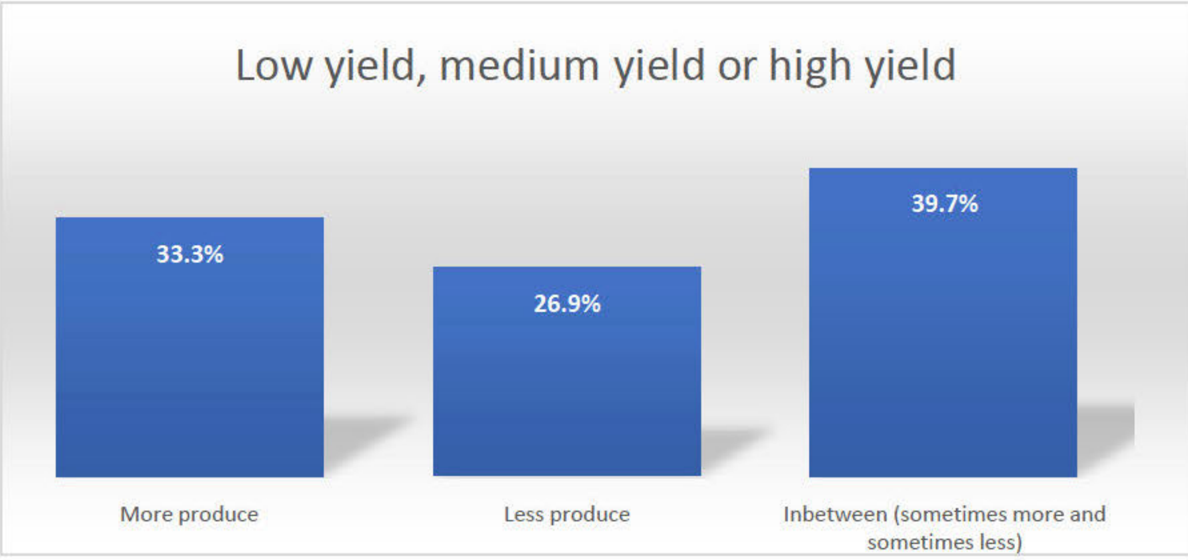

Figure 3: Shows results of whether the farmers have low, medium or in-between yield in the last five years

Despite the positive responses of the farmers' perceived current conditions of the soil over the years, it is clear that there is a variation in the accumulated crop yield. Many of the farmers yielded less and in-between produce in the last five years, an indication that the farmers at some point experience crop losses. The farmers stated that on the times when less produce is yielded, it is mainly due to the crops being eaten by pests and climate change impacts including heavy rainfall, high temperatures and hailstorms. As the majority of the farmers are not sure of the soil conditions, there is a significant need for the local government to assess and monitor the soil quality in the study areas as the farmers are not equipped and skilled for it. However, the farmers can actively participate by adopting environmentally friendly practices of farming to reduce the impacts of farming on the soil.

4.3.6 URBAN FARMING AND ENVIRONMENTAL RISK TO FOOD AND NUTRITION SECURITY

Farming is an essential livelihood strategy for the farmers in Sobantu, Sweetwaters and Mpophomeni, thus any urban farming and environmental risks will have an impact on the farmer's household food and nutrition security. Table 12 below shows that a total of 82.1% of the farmers stated that they experienced agricultural crop loss, while only 17.9% indicated that they did not. In figure 4 below, farmers stated that the causes of crop loss included not having enough water to sustain growth in the case of 15.4% of farmers. A total of 12.6% of farmers stated that the water is polluted, 6.4% said the soil quality is poor, 10.3% had crop loss due to compacted soil. Many of the farmers in the case of 28.2% stated that the crops were eaten by pests, 17.9% indicated that natural causes including flooding, hailstorms and high weather temperatures were the cause of crop loss. Crop losses often impact the farmers profit and thus farmers were asked whether the income they generated after the loss of crops is enough to sustain their households, 61.5% said no, while 11.5% said yes.

Table 12: Presents results of the farmer's experienced crop loss and whether income generated is enough

Variable	Frequency (n=78)	Percentage (%)
Have you experienced crop loss?		
1. Yes.	64	82.1
0. No	14	17.9
Is the income generated enough?		
1. Yes	9	11.5
0. No	48	61.5
2. Not applicable	21	26.9

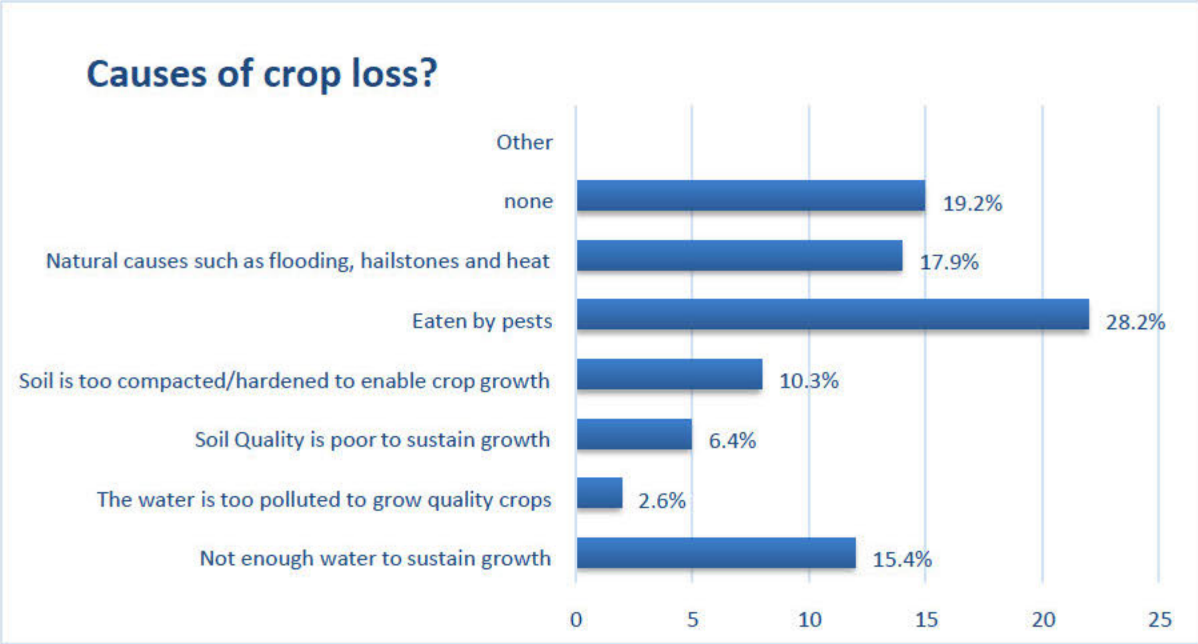

Figure 4: Provides the causes of the farmer's crop loss

This could be attributed to the fact that the majority of the farmers not only receive low income per month but have limited livelihood options due to age as they can only depend on farming. The largest concentration of farmers is under the category that is over the ages of 61 years and had indicated that the old age pension grant (R1 890) they receive per month is their main source of income (41%), with farming as an additional source of income to sustain both their livelihoods and households. The profit farmers usually made from selling produce ranges from R300-R400 per planting season, of which the farmers had stated that it was not sufficient to sustain their livelihoods and households. The other respondents who stated that they had casual labor (11.5%) made an average of R50-R150 in one day as recycling collectors, daycare nanny, selling food products and other goods (street vendor), while the respondents who received social grant (child support) received an average of R460 per month depending on the number of children in the household receiving this particular grant. The remaining respondents who had stable jobs (12.8%) received an average R4500-R16000 per month.

The National minimum wage is R3643 per month and the food poverty line is R624 per month since the 29th of September 2021 (Pietermaritzburg Economic Justice and Dignity, 2022; Statistics South Africa, 2021). Additionally, the cost for household food basket for Pietermaritzburg is R4 253.07 since the beginning of January 2022, while the urban food basket is R977.57 as of June 2021 (PMBEJD, 2022; National Agricultural Marketing Council, 2021). This means that the average farm profit and the majority of the farmer's sources of monthly income, excluding the farmers with stable jobs, is not enough in terms of the food poverty line, household and urban food basket. Overall, the results indicate that considering the farmers low income and the lack of livelihood options, farmers who experience crop losses as a result of urban farming and environmental risks are therefore vulnerable to food and nutrition insecurity. Additionally, the lack of knowledge about the adaptive strategies to address the climate change impacts exacerbates the impact on the farmers livelihoods and food security.

A focus group discussion (Table 5 above) was conducted in Sobantu, while a focus discussion guide was used during interviews with farmers in Sweetwaters and Mpophomeni. The aim of the focus group discussion was to identify external environment factors that challenge urban farming. Key findings show that farmers are affected by environmental issues including poor soil and water quality, persistent occurrence of pests, heavy rainfall, hailstorms and high weather temperatures. There is a lack of knowledge, expertise and capacity due to the lack of information services including farmer training, extension support and information sharing amongst the farmers. This hinders the farmer’s ability to adopt effective environmental management practices. Additionally, farmers indicated that because they do not know the severity of the soil and water quality conditions, they do not know of the appropriate environmental management practices to implement. Further discussions revealed that there is a lack of economic incentives including access and availability of lucrative markets, credit and farm profit to motivate the farmers to adopt effective environmental management practices so that they can meet market standards. The farmers stated that they are often required to provide the South African Good Agricultural Practices certificate to ensure food safety and quality standards set by the markets are met. Some of the farmers stated that if they had access to markets and in possession of the SA-GAP certificate, they would ensure that they yielded good quality produce. Therefore, urban farming and water quality management practices would be adopted.

Farmer attitudes towards the environment also play a significant role in adopting environmental management practices. The majority of the farmers are mostly interested in receiving incentives that are not environmentally friendly from the government, which include access to transportation, lucrative markets, tractors and seeds. Although the farmers are farming organically, these revelations indicate that farmers are more socially and economically motivated to engage in farming and less inclined with the concern of the environment. Farmers were further asked whether they were aware of the environmental benefits of urban farming which included flood water mitigation, water infiltration and urban greening. A total of 21.8% of farmers stated that they are aware of these environmental benefits, while the majority in the case of 78.2% said that they were not aware.

The fact that the farmers were planting diverse crops in an urban and peri-urban setting automatically benefited the environment in terms of water infiltration, flood water mitigation and urban greening. However, farmers only identified urban farming as a strategy to obtain extra food and generate an income. These findings suggest that there is a lack of environmental awareness amongst the farmers. According to Sulweski and Golas (2021), the key to farmers implementing effective environmental management practices is the farmers environmental awareness.

4.4. CONCLUSION & RECOMMENDATIONS

The study investigated the implications of urban farming on the environment and water quality in the communities of urban Sobantu, peri-urban Sweetwaters and peri-urban Mpophomeni located on the outskirts of urban Pietermaritzburg in the province of KwaZulu-Natal. The results from the focus group discussions and observations revealed that the urban farmers were not only challenged by environmental problems but were also faced with political, economic, social, technological, and legal constraints. These challenges were found to be the lack of institutional support and poor guidance from extension officers, lack of credit as the majority of the farmers are old age pension grant recipients, insufficient farm profits due to poor marketing skills and the farmers lack of capital and access to large hectares of land to increase yields to meet the supply demands of formal markets. Environmental challenges were found to be poor soil conditions, water quality issues, and crops were further stressed by pests, heavy rainfall, high weather temperatures and hailstorms. Whereas the majority of the farmers were over the age of 61 years with limited access and know-how to advanced technology to access markets.

CHAPTER FIVE

Urban farming and water quality management practices: towards an environmental management framework associated for food and nutrition security

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Abstract

The adoption of urban farming and water quality management practices can reduce environmental impacts. The provision of environmental services including flood water mitigation, water filtration and urban greening. This will further contribute to soil productivity, water use efficiency and the maintenance of water quality standards for irrigation while sustaining livelihoods and improving urban food and nutrition security. However, the lack of knowledge, skills and capacity influenced by the lack of institutional support and a governance framework in urban farming has made it difficult to facilitate the adoption of environmental management practices. This study aimed to identify the urban farming and water quality management practices adopted by the farmers in the farming communities of Sobantu, Sweetwaters and Mpophomeni, KwaZulu-Natal. An environmental management framework was designed to address the farmers' challenges on understanding environmental management of urban farming and water found in this study. The study employed a mixed methodology viz Survey Questionnaire with open and close ended questions, Focus Group Discussion (FGD's), and Field Observations. A purposive sampling technique was used to sample 78 urban and peri-urban farmers. The study found that the farmers' adoption of urban farming and water quality management practices were challenged by socio-economic and institutional factors such as education levels, farmer training, access to markets, access to credit and extension support. A logit regression was used to examine the factors that influence the adoption of urban farming management practices. The logit regression analysis revealed that market availability ($p=0.003$), training on soil management ($p=0.0011$) and access to credit ($p=0.097$) are all statistically significant factors in the adoption of urban farming practices. An environmental management framework was provided to address the challenges found in the study.

Policymakers should take into consideration these findings and the local government must provide educational and training programs to increase the farmers knowledge, capacity and skills to adopt urban farming and water quality management practices.
Key words: urban farming, sustainability, environmental management, socio-economic factors

5.1 INTRODUCTION AND BACKGROUND OF THE STUDY

The global population is projected to reach 9 billion by 2050, and it is expected that food demands will increase enormously (Food and Agriculture Organization, 2012). This rapid growth in population will exacerbate the existing socio-economic challenges including high unemployment and poverty levels which have given rise to rural-urban migration as people migrate to cities for better livelihood opportunities (Bisaga *et al.*, 2019). Orsini *et al*. (2013) indicated that 55% of the world population is projected to live in urban areas and is expected to increase to 60% and 70% in 2030 and 2050, respectively. As part of the second Sustainable Development Goal, to end hunger, achieve food and nutrition security and promote sustainable agriculture, a 70% increase in food production is therefore required before 2050 (Alexandratos and Bruinsma, 2012; Montemrro and Diacono, 2016; Hunter *et al.*, 2017).

Urban cities and towns will bear most of the brunt in terms of the use and competition for the already scarce and limited natural resource, especially as more food demands and changing diets increase. Covid 19 lockdowns have exacerbated food access and availability, which is more challenging for most communities including the urban poor (High Level Panel of Experts on Food Security and Nutrition (HLPE), 2020; Boza-Kiss *et al.*, 2021). Several authors (Orsini, 2020, Tharrey *et al.* 2020), further state that urban farming, although small-scale with reduced transportation and food waste during distribution can be an environmentally destructive practice causing climate change impacts more than its counterpart viz rural farming. Despite this, urban farming is still considered a viable strategy to alleviate the socio-economic and environmental issues that are driven by the urbanization process. However, it has also been highly emphasized that the intensification of food production must be met with sustainable farming practices. The Department of Environmental Affairs and Development Planning and Department of Agriculture of the Western Cape government (DEA, DP & DA, 2018) indicated that natural resources must be utilized, conserved and protected effectively to sustain the farmers' well-being and livelihoods.

As more countries globally begin to feel the impact of climate change with smallholder farmers especially in developing countries the most affected, there has been a call for the implementation of adaptation strategies to reduce the negative environmental impacts while gaining resilience. However, smallholder farmers are often unable to adopt proper environmental management practices due to the lack of institutional support, lack of governance framework, and access to finances, education and farmer training. It is therefore imperative that cost-effective and easily accessible environmental management practices including climate-smart practices are introduced and effectively implemented. This is important as more households may turn to own food production given the impact of C19 lockdown and various impact on incomes and disrupted food systems. The study aims to identify urban farming and water quality management practices adopted by the urban farmers and to determine the challenges around the state of the environmental management framework associated with urban farming and water quality.

5.2 MATERIALS AND METHODS

5.2.1 STUDY AREA

The study was conducted in three communities located on the outskirts of urban Pietermaritzburg, in the province of KwaZulu-Natal. These communities included urban Sobantu, peri-urban Sweetwaters, both situated in the Msunduzi municipality and peri-urban Mpophomeni, which is located in the uMngeni municipality on the boundary of the central business district (CBD) of urban Pietermaritzburg (Integrated Development Plan, 2020/2021). These communities were chosen due to high rates of migration, unemployment, socioeconomic vulnerabilities, and high agricultural potential. The climate and weather conditions in urban Pietermaritzburg and surrounding areas are strongly influenced by topography with cooler temperatures and rainfall. In the past and recent years, the KwaZulu-Natal province has faced extreme weather events including heavy rainfall and floods causing significant damage to society and environment, threatening food security and livelihoods (uMgungundlovu District Municipality, 2013; Ndlovu et al., 2019). The farmers commonly produced crops such as spinach, cabbage, maize, traditional pumpkin, potatoes, beetroot, onions, sweet potatoes, *amadumbe,* carrot, lettuce, butternut, green pepper, tomatoes, brinjal, green beans, chilies, kale and *imifino*. The main motivation for farming was to obtain extra food and generate income from surplus produce in order to improve household food and nutrition security. Many of the farmers were selling the produce they cultivated, hence can be considered to be market participants. The farmers mostly had access to informal and formal markets such as community members, schools, clinics and fresh produce markets. However, it was noted that access to formal and lucrative markets was a challenge due to high market standards the sampled farmers are unable to meet.

5.3 SAMPLING TECHNIQUE AND SAMPLE SIZE

A representative sample, a smaller group representing the views and opinions of the majority of people in the communities of urban Sobantu, semi-urban Sweetwaters and semi-urban Mpophomeni was purposively selected. A purposive sampling technique was employed to interview 78 urban farmers who were willing to participate in the study, were active in production and experiencing environmental management challenges.

5.4 DATA COLLECTION AND ANALYSIS

The study employed a mixed methodology approach which combined the collection and analysis of qualitative and quantitative data. The Statistical Package for Social Sciences (IBM SPSS version 27) was used in this analysis to generate descriptive statistics. Data collected from survey questionnaire were coded and descriptive statistics in the form of frequencies was generated. The frequency results were also used to support the presented qualitative data while information from focus group discussions, photography and observations was analyzed and interpreted through thematic analysis. Further analysis was conducted using the principal component analysis and the logit regression model.

5.5 RESULTS AND DISCUSSION

5.5.1 Farm characterization

A commonly shared characteristic amongst urban farmers was the farm sizes. Urban farmers lack sufficient land space and that hinders the diversification of food crops. Table 13 shows that 98.7% of the farmers are farming on less than 1 hectare of land, while only 1 farmer was cultivating on more than 1 hectare of land. These results attest to the findings by several authors stating that smallholder farmers usually have small farms. Furthermore, 83.3% of the farmers own the land they are cultivating in, 12.8% are owned by the municipality, 12.6% are family owned and only one farmer was renting the land. Cele (2016) found that the farmers who did not own the land they were cultivating on were discouraged from adopting land use management practices.

Table 13: Results of the characteristics of farms based on land ownership, size of farm, land use form

Farm characterization	Category	Frequency (n=78)	Percentage (%)
Farm size	1. <1 ha 2. 1 – 2 ha	77 1	98.7 1.3
Land ownership	1. Family owned 2. Municipality 3. Own 4. 4. Rented land	2 12.8 65 1	2.6 12.8 83.3 1.3

5.6 URBAN FARMING AND WATER QUALITY MANAGEMENT PRACTICES

Environmental management practices in agricultural production are significant as they aim to prevent farmers from breaking environmental laws and facilitating sustainable agricultural production. This will not only effectively protect the natural state of the environment and its elements, but it will also enhance the biological and economic productivity of crops while avoiding adverse environmental impacts both on and off the farm such as soil degradation, water contamination and the extension of climate change impacts. However, environmental management practices are knowledge intensive and sometimes require the farmers' understanding and investment in advanced technology and innovation. The main aim of the research was to identify environmental management practices adopted by urban farmers in the uMgungundlovu district.

Field observations and Focus Group Discussions and Questionnaire surveys with open and close ended questions were administered towards 78 farmers who were involved in urban food production, consumption and marketing of various leafy greens, vegetables, roots and tubers, cereals as well as tomato. The respondents were asked various open and close ended questions on the different environmental management practices that they were adopting to ensure that their urban farming activities were causing minimum if not zero impacts on the environment and the quality of the water used for irrigation. From the onset, it was clear that the farmers were employing various practices to prevent soil infertility, soil loss and water contamination on water resources that are in proximity to the farms while promoting water use efficiency.

5.6.1 Urban farming management practices

The results displayed on figure 5 below shows that the majority of the farmers (82%) have employed organic methods of farming while 18% have adopted conventional methods of farming. When sixty-four (64) of the organic farmers were asked why they had opted for this particular farming system, only forty-four percent (44%) of the organic farmers agreed that they were protecting the natural state of the environment and its elements. The rest of the farmers (56%) stated that farming organically was cost-effective and thus convenient as it was cheaper compared to conventional farming. This was expected as the majority of the smallholder farmers lack the finances and access to micro-finance institutions to afford the purchase of farm inputs including agricultural chemicals and accessing heavy machinery. Furthermore, the limited land space and lack of access to lucrative markets have played a contributing factor in the farmers' adoption of the organic farming system as they do not need large amounts of farm inputs to diversify and improve crop yield to meet market standards.

Figure 5: Results of the type of farming the farmers are engaging in

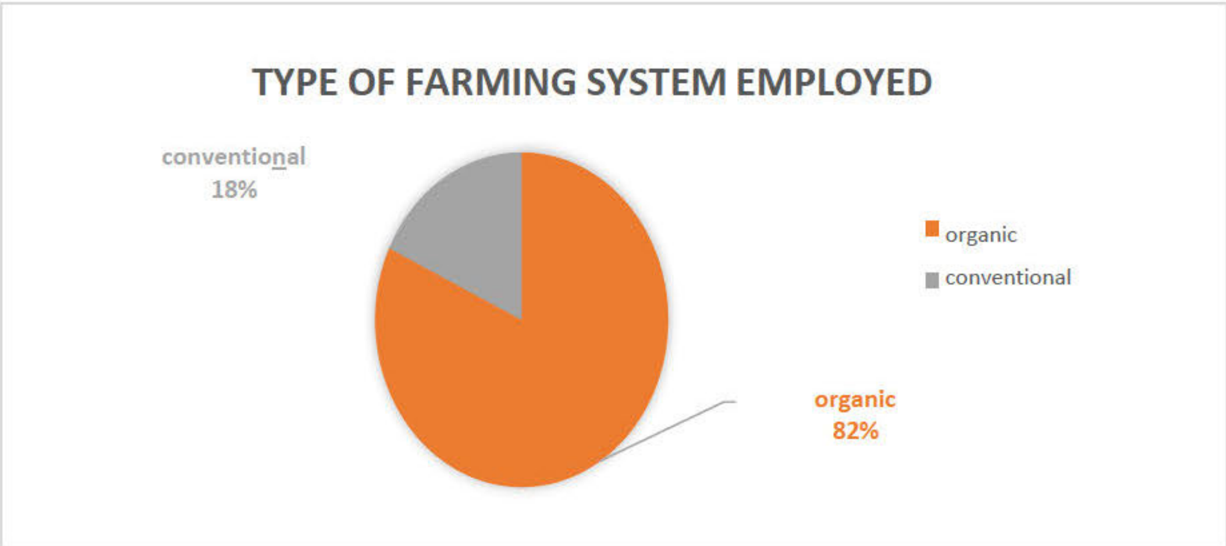
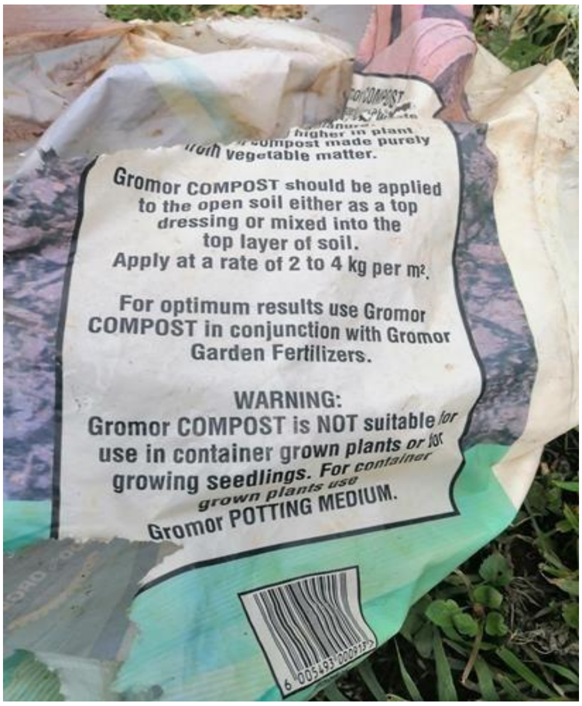


Table 14: Practices that the farmers were engaging in to protect the soil against soil infertility

Practices to protect the soil against soil infertility	Frequency (n=78)	Percentage (%)
1. Apply compost	55	70.5
2. Crop rotation	12	15.4
3. Cover crops	2	2.6
4. None	2	2.6
5. Other Composting, apply chicken manure, cow manure, cover beds, intercropping, mulching, plant traditional crops, add lime.	7	9

Table 14 shows the various management practices the farmers employed to protect the elements of the environment viz the soil against soil infertility. The majority of the farmers (70.5%) stated that they made compost comprising of a mixture of various organic matter including grass, crop residues and food waste of which was then applied directly on the soil before cultivating. This was done to protect and restore any possible loss of quality in the soil. According to (Martinez-Blanco *et al.*, 2013) compost comprises of various agronomic and environmental benefits such as strengthening soil biological properties and improves soil moisture content, thus contributing towards ensuring crop nutritional quality. The Table further shows that 15.4% of the farmers employed the crop rotation method. Another soil protection management practice was cover crops, of which was defined as crops that were cultivated between the main focus of crops to improve soil quality.

Farmers (2.5%) employing this particular method had mostly planted traditional food crops with the lowest water usage capacity and require less water and synthetic chemicals such as Maize, *Amadumbe and* traditional pumpkin. Other practices included applying cow and chicken manure, employing the intercropping technique, and adding lime by 8.9% of the farmers. However, the researcher noted that the farmers who were making use of lime did not have enough information about its functions and effects on the soil stating that they had heard about it through word of mount from other farmers. Bayu (2004) states that animal manure provides essential organic matter and nutrients that restores soil fertility and improves crop production. Francis *et al.* (1990) cited in Bayu (2004) that applying animal manure on the soil is an ancient practice that is employed in many farms within the African continent. Given that this is a common practice amongst the respondents is an indication that the conventional methods of production are still widely adopted in many smallholder farms.



Images 4 and 5: Store bought compost made from stable waste including horse manure

Image 6 and 7: Cabbages planted in rows with grass applied in-between to retain water and prevent soil erosion.

Table 15: Soil erosion control practices

Note: some farmers gave two (2) responses which were also included in the "other" option.

Soil erosion control	Frequency (n=78)	Percentage (%)
1. Planting all year round	2	2.6
2. Crop rotation	10	12.8
3. Mulching applying grass between crops	10	12.8
4. ALL the above	3	3.8
5. Build windbreaks	1	1.3
6. Avoid excessive tillage	7	9.0
7. None	29	37.2
8. Other	16	20.5

Table 15 shows that two respondents (2.6%) stated that they cultivate the land all year round to ensure that the soil is always covered and protected against water and wind erosion. Another practice adopted by the respondents (12.8%) include crop rotation, a practice widely known and adopted. However, the results of this particular practice were surprising as more than half of the farmers had initially revealed that one of the cropping methods, they employed on the farm was crop rotation. The results further indicate that the farmers have mostly adopted practices of cropping systems that protect the soil against water and/or wind erosion. This gives an indication that some of the farmers, which were found to be 47% do not recognize crop rotation as a soil erosion control practice, a possible effect of the limited access to information sources including extension agents, training and technology devices.

Mulching was employed by 12.8% of the respondents stating that they covered the soil with grass which assisted in retaining water in the soil especially during heavy rainfall, reducing surface runoff and thus preventing soil erosion through water. Additionally, 3.8% of the farmers had employed all three (all year cultivation, crop rotation and mulching) to prevent soil erosion through water. Only one farmer (1.3%) had planted various fruit trees including a peach, lemon, plum, and fig and pomegranate tree alongside other food crops. The respondent who had received training in various farming practices stated that the function of these was to act as windbreaks against the loss of soil when strong winds occur. Another essential soil erosion management practice was voiding excessive tillage in the case of 9% of the farmers.

According to Bhat *et al.* (2019) maintaining the cultivation of crops all year round, crop rotation, intercropping, applying grass and mulching, building windbreaks and avoiding excessive tillage are effective strategies of preventing soil erosion from wind and water. Despite these results, 37.2% of the farmers had no knowledge about management practices that prevented soil erosion, while 20.5% mentioned other soil erosion management practices including the adoption of the intercropping method, covering the soil with crop residues as well as cultivating cover crops alongside the main crop. These findings indicate poor agricultural extension engagement. Poor extension services is a common problem as attested by Davis and Terblanche (2016) in their study.


Image 7: intercropping: cabbages and spinach planted in proximity

The overall quantitative results in Table 14 and 15 as well as information attained through open-ended interview questions made it clear that although the farmers were adopting management practices that protected the soil against infertility and erosion on their farm plots, they were simply employing the traditional methods of farming they had been taught about while growing up and not necessarily environmental management practices that they had knowledge of. Cele (2016) was provided with similar results, stating that the respondents were employing sustainable practices of farming but do not define them as such as they were simply doing what their parents used to do. This further answers the question of whether the farmers are able to identify, perceive and understand the various environmental management concepts in agriculture.

One of the questions, that were initially included in the questionnaire that was first administered to the farmers in Sobantu, was to find out whether the farmers knew of any environmental management concepts and regulations such as Environmental Impact Assessment, Polluter Pays Principle and Participation Principle. Preliminary results had indicated that the farmers were not only not aware of such environmental management concepts but were also not aware of the environmental laws enshrined in the constitution that serves to protect the environment. At this point, it was only when the researcher had broken down these concepts that the farmers were then able to respond. In light of this, it was then significant for the researcher to understand and take into consideration that due to the demographic characteristics such as farmers age, formal education levels, lack of access to information services, it was less likely that they would be aware of such knowledge intensive concepts.

Additionally, the lack of tertiary education and formal training in farming were constraints that hindered the farmers' ability to perceive and understand such concepts. The farmers in Sweetwaters also had not understood the environmental management concepts. While interestingly in Mpophomeni, one farmer mentioned that besides having been formally trained in farm management practices, the farmer had also been involved in various sustainable urban farming projects prior the COVID 19 outbreak. One of the major production challenges many of the farmers were faced with included the persistent occurrence of pests that were reducing crop quality and yield, therefore affecting farm profit. The farmers were then asked to identify pest management practices they were adopting.

Table 16: Results of the various pest management practices adopted by urban farmers

Pest management practices	Frequency (n=78)	Percentage (%)
1. Apply chemicals	33	42.3
2. Plant repellent/indigenous plants	1	1.3
3. None	39	49.4
4. Other	5	6.3

Questions on how farmers manage the persistent occurrence of pests (Table 17) revealed that the majority of the farmers (42.3%) applied a synthetic chemical known as *"Blue Death"*. Only one farmer (1.3%) stated that they had cultivated a plant repellent alongside their main crops. The majority of the respondents had revealed that despite engaging in several pest management practices, none of their methods were effective which has led to 49.4% of the farmers no longer adopting pest management practices. The results indicate that there is a lack of knowledge and adoption of pest management practices by the respondents.

5.6.1.1 Factors that challenge the adoption of urban farming management practices

Farmers in a FGD (Table 17 below) revealed that the lack of supportive factors including poor contact and communication with extension agents, poor information sharing amongst other farming neighbors as well as the lack of access to resources such as finances and technology were challenges that affected their adoption of urban farming and water quality management practices.

Table 17: Focus Group Discussion on the factors that challenge the adoption of urban farming

Themes	Concepts	Responses
Urban farming management practices	Motivation for farming. Hindrances to adopting urban farming management practices	Farmers are socially and economically motivated to farm and less inclined to the concern of the environment. Although farmers were employing urban farming management practices, they did not identify these practices as such but had stated that there were practices they had engaged in while growing up. There is a poor contact and communication with extension agents, poor information sharing amongst other farming neighbors as well as the lack of access to resources such as finances 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*
management practices	Hindrances to adopting water quality management practices.	*are water cuts in this area"*, while others expressed high-water tariffs being a major limiting factor. Farmers stopped using the Msunduzi River due to pollution. There was little knowledge about the water quality management practices. The perception is that the local government should be managing the quality of the river source in Sobantu as farmers not equipped to carry out such practices.

5.6.2 Water use efficiency and water quality management practices

Table 18 below reveals that a total of 92% of farmers had access to water all year round while 8% did not. The type of water sources included communal taps (5%), private taps (77%), river source (6%), rainwater (4%) and borehole (5%). Two farmers (3%) stated they make use of other sources of water which include a groundwater pipe and ground/spring water. Therefore, a total of 96% of farmers irrigated their land while 4% relied on rain fed urban farming. Implements farmers used to abstract water for irrigation were buckets (25.6%), pipes (30.8%), watering cans (39.7%), while only one farmer had used the drip irrigation method. Therefore, manual (65.5%), drip (1.3%) and localized (30.8%) irrigation methods were applied to irrigate crops. The results indicate that farmers are mainly dependent on manual labor as well as buckets and watering cans to distribute water across the farm plot. This is expected since the majority of farmers are constrained by the lack of financial resources exacerbated by insufficient farming profit made to afford the purchase of advanced and costly irrigation methods such as drip and sprinkler. Additionally, the small land sizes most farmers are cultivating on, and low crop diversification was a determinant in the type of irrigation methods applied

Table 18: Access to water, type of water source used to irrigate crops and the irrigation systems used to abstract water (n=78)

Water source	Category	Frequency	Percentage (%)
Access to water all year round	1. Yes 0. No	72 6	92 8
Type of main water source	1. Communal tap 2. Private tap 3.River 4.Rainwater 5.Borehole 6.Other	4 60 5 3 4 2	5 77 6 4 5 3
Water abstractions	1.Buckets (Manual irrigation) 2. Pipes 3. Watering cans (Manual irrigation) 4. Not applicable	20 24 31 3	25.6 30.8 39.7 3.8

Although the majority of the farmers had access to water all year round, 8% of the farmers who had no access to water all year round revealed in a FDG (Table 18 above): 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 high-water tariffs being a major limiting factor. Farmers who were dependent on the river source in Sobantu were forced to cease the use of the source due to visible contamination, therefore limiting their access to water.

Table 19: Results of the management practices farmers have adopted to save water

Variables	**Category**	**Frequency (n=78)**	**Percentage (%)**
Frequency of irrigation?	1. Daily (twice) 2. Every other day 3. Only whenweather temperatures arehigh 4. other	15 19 40 4	19.2 24.4 51.3 5.1
Sustainable water use source	1. Rainwater harvesting 2. Mulching 3. Wastewater 4. No employed practices	60 4 4 10	76.9 5.1 5.1 12.8
Crop selection is based on less water consumption.	1. Strongly agree 2. Agree 3. Somewhat agree 4. Somewhat disagree 5. Disagree Strongly disagree	27 5 25 5 6 10	34.6 6.4 32.1 6.4 7.7 12.8

Table 19 shows the results of the management practices farmers have adopted to avoid the over-use of water, therefore ensuring that more water is saved. Approximately 19.2% of farmers stated that crops are irrigated twice per day, 24.4% irrigated crops every other day, 51.3% irrigated crops only when the weather temperatures are high and the remaining 5.1% were cultivating crops that do not need irrigation. Given the limiting factors including the constant water cuts and high-water tariffs, poor smallholder farmers need cost-effective but reliable water sources. Therefore, farmers were asked to state sustainable water sources they have adopted to limit intensive irrigation. Approximately 77% alternatively use harvested rainwater, stored in Jojo Tanks and other large water containers, 5% alternatively adopt the mulching technique which involves covering the soil surface around the crops with organic matter (respondents mainly use grass) to prevent water loss and 5% use wastewater. The remaining 13% were not adopting any sustainable water sources.

Image 8 and 9: rainwater harvesting for sustainable water use

To shed light on whether farmers are aware that water needs to be saved during crop production, the researcher asked farmers whether crop selection is based on less water consumption requirements. A total of 35% of farmers strongly agreed, 6% agree, 32% somewhat agree, 6% somewhat disagreed, 8% disagreed and 13% strongly disagreed. The results indicate that majority of farmers are conscious about saving water, preventing exploitation and depletion. This points out that although majority of farmers have reliable sources of water, there are other existing limiting factors such as the uncertainty on the quality of the river source in Sobantu as well as water cuts and high-water tariffs administered in all the research sites. This automatically made farmers conserve water unknowingly to the benefit of the environment. Bernstein (1997) attested to this stating that water charges and tariffs are economic instruments that provide incentive to regulate behavior of water users and polluters in support of water use and pollution control. However, the study found that the farmers are not saving water to address the water security issues the country is facing but because of the influence from the local government and the farmers socio-economic constraints.

Table 20: Results of the various water quality management practices adopted by farmers

Water quality management variables	Category	Frequency (n=78)	Percentage (%)
Does the government monitor the quality of the water used for irrigation?	1. Yes	2	2.6
	0. No	76	97.4
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

In table 20, 2.6% of the farmers stated that the local government does monitor the quality of the water used for irrigation while the rest (97.4%) said that they did not. Some farmers in Sobantu had mentioned that there had been students and people from the municipality who would come to take water samples but had the tendency of not providing feedback to the community. Concerning 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 using 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 Msunduzi River, however they were forced to stop using the water source due to visible signs of contamination as well as results from several authors declaring the Msunduzi River unsuitable to use (Neysmith and Dent, 2010; Ramburran, 2014). Focus group discussions had previously revealed that there was also the perception that protecting the river source against pollution should be the local municipality's responsibility as the river was being contaminated due to factories located in proximity. Additionally, the farmers alluded to the fact that the local government is better resource equipped and skilled to test, monitor and protect the river from pollution.

It is clear that although the illegal dumping of waste is a major contributor to the pollution of the Msunduzi River, the farmers however, are not aware of their role in society and in protecting the environment, a right enshrined in the constitution. Furthermore, although the farmers in Sobantu stated that the local government does not monitor the water quality from the Msunduzi and Baynespruit Rivers that run through their community. It was found that the Duzi-Umngeni Conservation Trust (DUCT) does take water samples on the Sobantu- Baynespruit River to identify spillage from factories surrounding the community with reports published on the internet (DUCT, 2021). In addition, there are strict regulations from the local municipality that restricts the illegal dumping of waste into rivers and residents are also not allowed to build in proximity to riverbeds. However, it should be noted that the results on Table 25 above indicate that majority of the farmers are not aware of this information and can be attributed to the lack of access to information services such as extension services and technological resources. Therefore, despite the implemented policies, the surroundings of the Msunduzi River were observed to be dirty and littered (*Image 10*).

Image 10: showing the Msunduzi River with litter

5.6.3 Climate-smart farming practices

The key to the farmers' capacity to adapt to climate change is knowledge and awareness of what climate change entails, its causes and the impact it has on the environment and the farmers' livelihoods. This will be dependent on the farmers' access to information services such as extension officers, sources of technology and interactions with other neighbouring farmers.

5.6.3.1 Farmers awareness to climate change

Table 21 below shows that 43.6% of farmers are aware of climate change, while 56% are not aware of the changing climate. The researcher had asked the 43.6% of farmers who said they were aware of climate change to describe exactly what climate change is to them and the responses were largely concentrated on heat, heavy rainfall and floods stating that it is *"when there is too much rain"*. Additionally, information services available and accessible to the farmers include television (37.2%), cell-phone with internet (2.6%), and radio (3.8%). These sources of technology warned and made them aware of the changing climate conditions, while the remaining 44% were not aware of the changing climate. Approximately, 100% of farmers indicated that they did not have access to extension officers and thus were not provided with information regarding climate change.

Table 21: Results of the farmers' awareness to climate change and farmers' access to information services

Awareness to climate Change	Category	Frequency (n=78)	Percentage (%)
Are you aware of climate change?	1. Yes 0. No	34 44	43.6 56.4
<u>Information services</u> **Climate change warning systems?**	1. Television 2. Cell phone (internet) 3. Radio 4. Not aware	29 2 3 44	37.2 2.6 3.8 56.4
Extension officers	1. Yes 0. No	0 78	0 100

5.6.3.2 Perceived causes of climate change

Figure 6 below provides the results of the farmers' perceived causes of climate change. The results show that 62.8% of the farmers are not sure of the causes of climate change, 14.1% state that it is farming, industrial and human activities that cause climate change, 1.3% indicated that it is farming activities only, 3.8% believe that it is industrial activities that release chemicals, while only 17.9% indicated that climate change is caused by human activities.

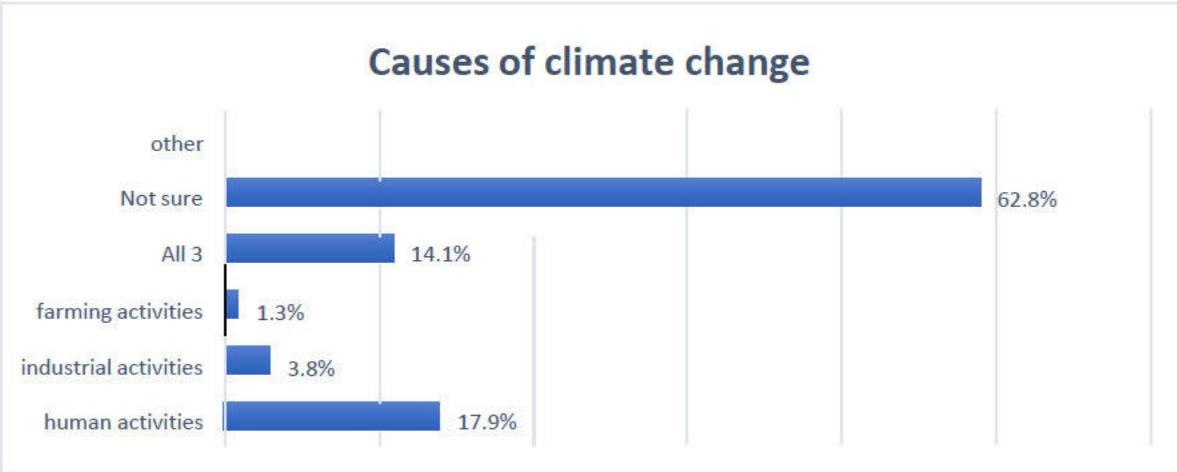


Figure 6: shows the causes of climate change farmers perceived

The results in table 21 and figure 6 together reveal that although the majority of the farmers are not aware of climate change, there is a low distinction to the farmers that are aware. However, the percentage of farmers who do not know the causes of climate change surpass the percentage of the farmers who are aware of climate change. This suggests that the majority of the farmers are not aware of the causes of climate change and thus they are unknowing to the contributory role farming activities play in the cause and/or extension of climate change. This will influence the farmers adoption of climate change adaptation strategies. According to several authors (Story and Forsyth, 2008; Hyland *et al*., 2015; Sulewski and Goals, 2019) farmers' awareness to environmental issues caused by farming activities will influence the farmers' willingness to protect the environment and its elements. The lack of in-depth knowledge about the causes of climate change was expected due to the fact that all three (3) farming communities lack access to information services including technological devices with poor extension officers, farmer training programs, and poor communication with neighbouring farmers.

5.6.3.3 Farmers exposure to climate change impacts

Farmers were asked to indicate climate change impacts that have affected crops on Table 22 below. A total of 1.3% of farmers indicated that they have only been affected by heavy rainfall that has led to flooding and 9% of farmers stated they have been affected by excessive heat/high weather temperatures. The largest concentration of farmers in the case of 74.4% have been affected both by heavy rainfall and high weather temperatures. Amongst the 74.4% of the farmers, some had also indicated that hailstorms had affected their crops. A total of 3.8% of farmers had stated that the other climate change impact that had affected them were hailstorms only. The remaining 11.5% of farmers indicated that they had not been affected by the changing climate conditions.

The results indicate that heavy rainfall and high weather temperatures were of high concern. Sobantu is particularly vulnerable to flooding during the rainy season as it is located on a floodplain situated in the lower region of the Baynespruit and Msunduzi Rivers that run through the community. This suggests that heavy rainfall would raise water levels in the rivers resulting to flooding and thus farmers in proximity to the river source would be severely affected. Therefore, it is imperative that farmers are aware of what climate change is, are able to perceive the effect climate change impacts have on crops and the effect on livelihoods and food security. This knowledge and awareness will encourage the farmers to adapt against the phenomenon.

Table 22: Results of the frequency of the farmers' whose crops have been affected by climate change impacts

Variable	**Frequency (n=78)**	**Percentage (%)**
Which climate change impacts has affected crops?		
1. Heavy rainfall/flooding only	1	1.3
2. High weather temperature only	7	9
3. Heavy rainfall/flooding and high weather temperatures	58	74.4
4. Other (Hailstorms)	3	3.8
5. None	9	11.5

5.6.3.4 Climate change adaptation strategies adopted by farmers

Table 23 below shows that 61 (78.2%) of the farmers alternate to harvesting rainwater to ensure the availability of water during the dry season and out of the 61 farmers, 6.5% had stated they also make use of wastewater. A total of 10.3% of farmers stated that they make use of wastewater only, 1.3% specified saying that they make use of a piped underground water source belonging to the municipality as the other alternative, while 10.3% had no other alternative to adapt to climate change impact. Rainwater harvesting is a cost-effective and essential method of collecting and storing water in Jojo tanks and other large containers during the rainy season to be used during the dry season. However, it is noted that the variability in rainfall patterns will require the use of other alternatives. However, farmers are reluctant to utilize wastewater as they deem it as dirty.

Table 23: Results of the various strategies farmers engage in to adapt from climate change impacts

Alternative water source during dry season (periods of high weather temperatures)	Frequency (n=78)	Percentage (%)
1. Rainwater harvesting	61	78.2
2. Wastewater	8	10.3
3. Other	1	1.3
4. No alternative	8	10.1

Figure 7 below shows that the majority of the farmers (67.9%) strongly agree that their decision on the type of crops to plant is relatively based on the area's seasonality changes, 5.1% agreed and 6.4% somewhat agreed while 2.6% somewhat disagreed, 2.6% disagreed and 15.4% strongly disagreed. This suggests that the majority of the farmers are aware of the changing climate conditions because they know when to plant certain crops and are harvesting water in preparation of the dry season.

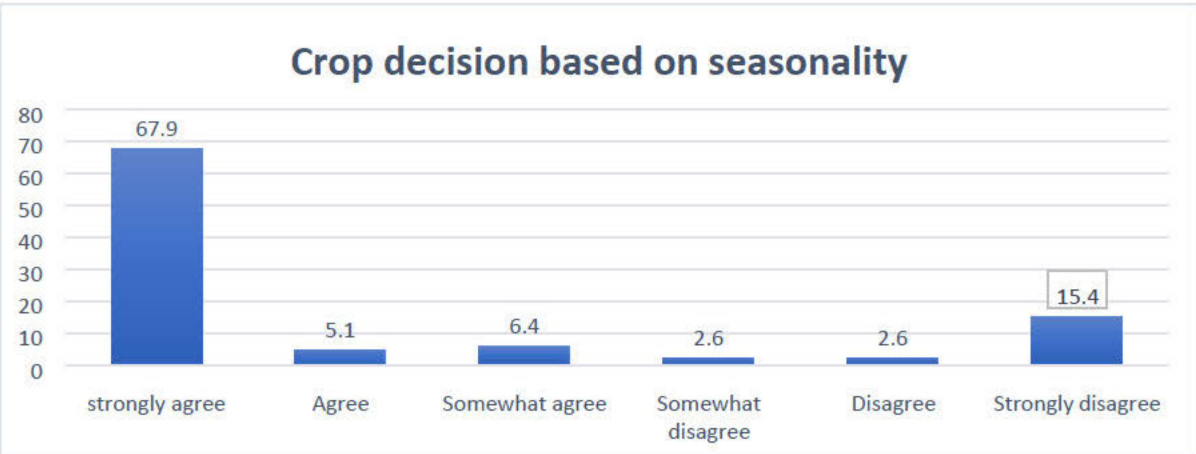


Figure 7: Farmers decision on the type of crop to plant based is on seasonality

In addition, figure 8 below shows that the majority of the farmers (34.6%) strongly agree that their decision on the type of crops to plant is relatively based on the less water consumption the crops will require, 6.1% agreed and 32.1% somewhat agreed, while 6.4% somewhat disagreed, 7.7% disagreed and 12.8% strongly disagreed. However, it was noted that this decision was influenced by the administered water cuts and to avoid high-water tariffs. The decision was less as a means to adapt against climate change impact such as drought and high weather temperatures. This indicates a lack of knowledge and expertise about climate change adaptation strategies amongst the farmers. Therefore, there is a great need for the government to implement educational and training programs with strengthened extension support to help farmers gain resilience against climate change impacts that threaten the farmers' livelihoods and food and nutrition security.

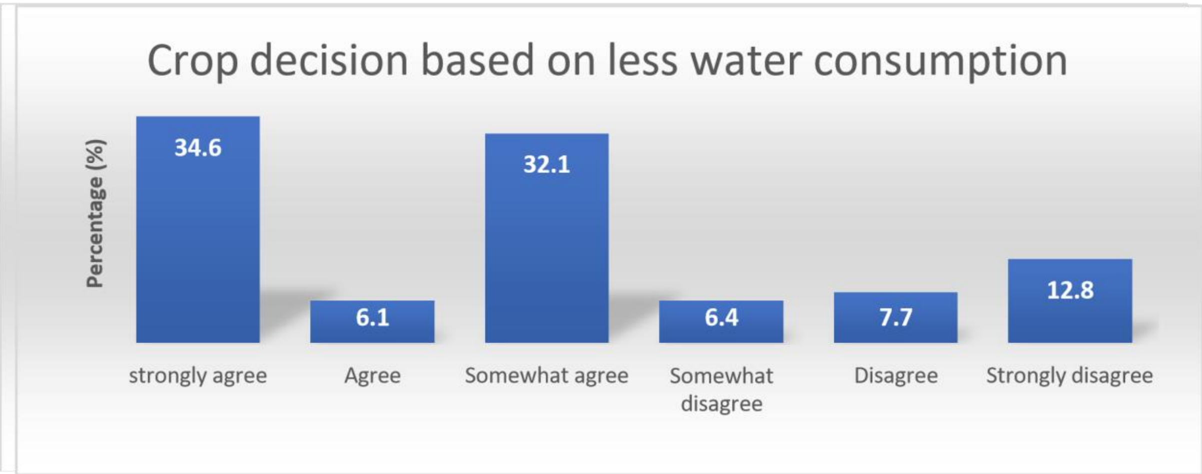


Figure 8: Farmers' decision on the type of crop to plant is based on less water consumption requirement

However, these climate change adaptation strategies are not "perfect" enough to help farmers gain resilience against climate change impacts. Additionally, despite the fact that some of the adopted urban farming and water quality management practices were also climate change adaptation strategies, the farmers had not identified these practices as measures that could mitigate climate change impacts. The fact that the farmers were planting diverse crops in an urban and peri-urban setting automatically benefited the environment in terms of water infiltration, flood water mitigation and urban greening. However, farmers only identified urban farming as a strategy to obtain extra food and generate an income. This suggests that there is a lack of knowledge and understanding about climate smart farming practices. This could be attributed to the lack of financial resources, extension support, farmer training, and other government interventions promoting climate smart strategies of which are still not well disseminated amongst smallholder farmers.

5.7 FACTORS INFLUENCING FARMER'S ADOPTION OF URBAN FARMING AND WATER QUALITY MANAGEMENT PRACTICES

The result of principal component analysis (PCA) used to compute the dimension of water quality management practices is presented in Table 24. To test the suitability of the data on water quality management practices for climate change for the PCA, both the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (Dziuban & Shirkey, 1974) were used.

Table 24: Dimensions of water quality management practices by PCA

Variable	Training on environmental Practices	Sustainability	Awareness of environmental
Sustainabl~s	-0.148	**0.561**	-0.075
ControlSoi~n	-0.221	**0.403**	0.054
DisposeFar~e	0.162	**0.396**	0.231
ControlPests	-0.189	0.224	**0.317**
WaterPolut~n	0.170	0.135	-0.482
SoilProtec~s	0.276	**0.374**	0.243
AwareoFNeg~F	**0.330**	0.262	-0.153
TrainingOn~e	**0.482**	-0.051	0.269
TrainingOn~t	**0.495**	-0.032	0.278
ChemicalAp~s	**0.384**	-0.164	-0.213
AwareOfEnv~s	-0.170	-0.244	**0.572**
Eigenvalue	2.979	1.557	**1.448**
% of Variance	54%		
KMO Test	0.714		
Barllet's test (P-value)	**0.0000*** **		

The value of the KMO test was 0.724, suggesting that the adequacy of input variables for the PCA was excellent, which is greater than 70%, while the test of the null hypothesis that the correlation matrix was an identity matrix reported a p-value < 0.000, which is less than 1%, thus suggesting that there was a relationship between the variables. PCA was therefore a suitable method for extracting environmental management practices. Table 24 shows the retained principal components (PCs) representing the different dimensions of the water quality management practices employed by the farmers in the study area. The PC contributed 54% to the variation in the data. In estimating the effect of water quality management practices on urban farming, the first loading with highest eigen value was used as a regressor in the logistic regression model as shown in Table 25.

Table 25: Effect of water quality–management practices on urban farming by Logit regression model

Urban farming practices	Coef.	St.Err.	p-value	dy/dx	std. error	P-value
MarketAvailability	0.934	0.315	0.003***	0.095	0.025	0.000***
TrainingOnSoilMana~t	7.161	2.830	0.011**	0.728	0.251	0.004**
AccessToCredit	1.846	1.112	0.097*	0.188	0.107	0.078*
Accesstoextension	-0.922	1.008	0.361	-0.094	0.101	0.353
AccessToMarkets	-2.483	0.929	0.008***	-0.253	0.076	0.001***
Gender	-1.467	0.977	0.133	-0.149	0.095	0.115
Age	-0.738	0.526	0.161	-0.075	0.052	0.147
Education	-0.678	0.565	0.230	-0.069	0.057	0.223
AccessToWater	-2.256	1.637	0.168	-0.229	0.160	0.151
LandOwnership	0.883	0.752	0.240	0.090	0.075	0.230
Environmental mgt practice	-1.231	0.637	0.053*	-0.125	0.060	0.038*
Income generating activities	-1.013	0.856	0.236	-0.103	0.085	0.224
Transportation	-0.961	0.455	0.035*	-0.098	0.042	0.021*
Constant	9.094	4.401	0.039*			
Pseudo r-squared	0.512					
Chi-square	53.175					
Akaike crit. (AIC)	78.765					
Bayesian crit. (BIC)	111.759					
Prob > chi2	0.000***					
Mean VIF	2.01					

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

The aim of this research was to determine the urban farming and water quality management practices adopted by the farmers, of which a logit regression was used to analyze factors influencing the farmers adoption of urban farming management practices. The qualitative data obtained from focus group discussions, field observations and photography were analyzed thematically, while quantitative data obtained from survey questionnaires was analyzed using descriptive statistics.

The explanatory variables used for the logit model were tested for multicollinearity using the variance inflation factor (VIF). As seen in Table 26, the mean VIF is 2.01. A VIF below 10 indicates the absence of multicollinearity. These variables are market availability (p=0.003), training on soil management (p=0.011), access to credit (p=0.097) which are all positively significant, while access to markets (p=0.008), environmental management practice (p=0.053) and transportation (p=0.035) are all negatively significant. Variables including access to extension services, gender, age, education, access to water, land ownership, income generating activities were statistically insignificant, of which means that these variables do not influence the farmers adoption of urban farming management practices.

Table 25 further shows that the p value for training on soil management practices ($p=0.011$) is less than 5% ($p<0.05$). This indicates that the farmers' training on soil management practices is statistically significant in influencing the farmers adoption of urban farming management practices. The likelihood of the farmers' adoption of urban farming management practices is based on a magnitude of 7.161. These results could be attributed to the farmers consciousness to their on-farm soil conditions and access to information services and acquired knowledge through formal and informal training that may have enhanced the farmers know-how and capacity to apply the information in their own farms. Therefore, if the farmers had access to information services including farmer training, there would be a likelihood of influencing the adoption of urban farming management practices. Sapbamrer and Thammachai (2021) found similar results stating that training promotes the adoption of sustainable practices of farming.

The coefficient of access to credit was found to be statistically significant in influencing the farmers' adoption of urban farming management practices in the case of $p=0.097$ of which is less than 10% ($p<0.1$). Considering that the majority of the farmers in this study revealed that they had no access to credit, the implications of these results could be attributed to the farmers being forced to farm organically since organic farming is considered cheaper and easier to manage by the farmers. Studies conducted by several authors (Welch and Marc-Aurele, 2001; Prokopy et al, 2014) found a positive association between farmers access to credit and the adoption of farm management practices. The study conducted by Welch and Marc-Aurele (2001), further revealed that poor farmers who are mostly dependent on farming as a main livelihood strategy can be encouraged by financial incentives to adopt farm management practices.

Table 25 further shows that the farmers access to markets ($p=0.008$) is negatively significant, which means that access to markets negatively influence the farmers adoption of urban farming management practices. Although the study revealed that the majority of the farmers have access to markets, however on an entrepreneurial point of view, those markets were not lucrative enough to provide incentives and motivate the farmers to meet the food safety standards set by formal markets. A study conducted by Yusuf (2004) opined that markets that did not integrate the interests of the poor smallholder farmers often result to environmental degradation.

Therefore, if the farmers had access to lucrative markets, it would yield positive significance in influencing the farmers adoption of urban farming practices.

The findings further show that the awareness of environmental management practices (p=0.053) has a negative effect on the adoption of urban farming management practices. This means that the farmers awareness of environmental management practices negatively influenced the adoption of urban farming practices. This could be attributed the fact that the majority of the farmers were not aware of environmental management regulations, while they also did not identify their conventional ways of farming as environmental management practices. This could also be because of the farmers lack of access to information services including extension services, cellphone with internet and formal farmer training to enhance the farmers ability to apply management practices. Therefore, there is a less likelihood of the farmers adopting urban farming management practices. Sulewski and Goals (2019) found that while the farmers lacked the knowledge about the environmental compliance measures.

Transportation (p=0.035) has a negative significance in influencing the farmers adoption of urban farming management practices. This means that transportation has a negative influence in the farmers adoption of urban farming management practices. The implications of the results could be attributed to the fact that the majority of the farmers do not have access to transport, and they also sell their fresh produce at farm gate with their community members as consumers. Therefore, transportation is not required. According to Myeni *et al*. (2019) ownership of farm equipment such as trucks to transport produce had no significant effect on the adoption of urban farming management practices.

5.8 ENVIRONMENTAL MANAGEMENT FRAMEWORK ASSOCIATED FOR FOOD AND NUTRITION SECURITY

The first ten (10) questionnaires that were administered to 10 farmers in Sobantu revealed that the farmers did not understand the various environmental management principles and regulations enshrined in the National Environmental Management Act (NEMA) such as Environmental Impact Assessments, Polluter Pays principle and public participation. Additionally, the farmers were not able to perceive their responsibility to protect the environment through regulative measures as per the Constitution of South Africa. The socio-economic characteristics of the farmers such as age, level of formal education, farmer training, sources of income, access to credit, farm size, access to extension officers and technology played contributing factors towards the farmers’ ability to access knowledge intensive information such as that of environmental management. However, although the previous results indicate that the farmers have adopted various urban farming and water quality management practices as well as climate change adaptation strategies, it was apparent that the farmers did not identify them as such but were merely adopting the cost-effective and easier ways to manage conventional (traditional) methods of farming that they had accumulated since they were young. Cele (2016) was provided with similar results, stating that the respondents were employing sustainable practices of farming but were not defining them as such, as they were simply doing what their parents used to do. This indicates a knowledge gap amongst smallholder farmers about knowledge intensive policies and regulations that bide farmers by law to adopt urban farming and water quality management practices. Therefore, there is a significant need for the integration of indigenous knowledge in environmental management frameworks implemented through policies and programs that promote sustainable farming practices.

5.8.1 Institutional support/services, programs and policies

Table 26 below shows that a total of 100% farmers in all three study sites indicated that although they acknowledge the existence of the extension officers in their area, some even going as far as mentioning their names, little to zero assistance has been provided. Farmers further expressed that extension officers tend to come into their communities only to make promises that would not be fulfilled. The Department of Agriculture in South Africa assigns extension officers to farming communities around the country to provide valuable sources of information as well as to train and equip farmers in crop and livestock production, however, there are reports of poor extension services throughout the country. Consequently, the lack of another information service tool set to enhance farmer knowledge and technical know-how about the adoption of environmental management practices is a major setback. This means that institutional interventions are not sustainable.

Table 26: Challenges in the environment management framework

Challenges (EMF)	Category	Frequency (n=...)	Percentage (%)
Access to extension services/support?	1. Yes 0. No	0 78	0 100
Does the government monitor the soil and water quality?			
Sobantu (n=27)	1. Yes 0. No	1 26	3.7 96.3
Sweetwaters (n=12)	1. Yes 0. No	0 12	0 100
Mphophomeni (n=39)	1. Yes 0. No	1 38	2.6 97.4

Since the smallholder farmers cannot monitor the soil and water themselves due to the lack of expertise, information and finances, the responsibility falls in the hands of the extension officers to link the farmers with experts who would lend their expertise for the benefit of the natural resources and the farmers. However, due to the little interest being given to urban farmers, it is expected that there would be little to zero government assistance such as monitoring soil and water. Table 26 further shows that in Sobantu, 3.7% said the government had monitored the soil and water quality, while the majority in the case of 96.3% said no. One farmer further stated that there have been academics and people from the Department of Agriculture who had taken water and soil samples, respectively. However, with no feedback given back to the community. They are farming on soil there are not sure of in terms of quality and are irrigating crops with water from the river they are not entirely sure of in terms of quality. In Sweetwaters, a total of 100% of farmers stated that the government had not monitored the quality of the soil and water. Mpophomeni had 2.6% of farmers stating that the government had monitored the soil, while the majority in the case of 97.4% said no. This suggests that there is very little involvement and support of urban farming by the government.

However, the Sobantu farming community was found to have received assistance from government stakeholders including a representative from Agri-SETA who had been involved in assisting the farmers with seedlings, accessing tractors and trucks for transportation. Additionally, assisting farmers in accessing markets such as health facilities and school feeding schemes in order to become active participants in the local economy and contribute to the improvement of food security. However, it was clear that the focus of these government programs was solely based on providing farmers with incentives to increase crop production and market access with no emphasis on environmental education and awareness. Additionally, farmers in Sobantu who are dependent on the river source to irrigate crops stated that for as far as they are aware, there are no implemented water policies that restrict the use of the river either for domestic or farm purposes.

Based on the challenges on understanding environmental management of urban farming and water found in this study, it is clear that an environmental management framework for smallholder urban production on how to address these challenges is needed. The aim of this framework is to provide a rationale for policy makers to use to develop policies to increase farmers' awareness and knowledge of the environment and improve farmers' adoption of environmental management practices. This framework illustrated in Figure 9 below outlines the importance of collective action to ensure accountability and the effective implementation of strategies to address the challenges.

The framework outlines the socio-economic challenges that hinder the farmer's understanding of environmental management. These challenges include farmers age, formal educational levels, farmer training, sources of income, access to credit, farm profit, access to markets, access to technology, lack of environmental and climate change awareness. External challenges are institutions and policies that play a role in the provision of basic services to the farmers. The lack of institutional support and poor agricultural services through extension agents are common challenges that prohibit the adequate transfer of knowledge for the farmer learning process. Possible solutions focus on equipping farmers with knowledge and skills to adopt environmental management practices. While emphasis is also placed towards equipping extension officers with knowledge and skills to facilitate sustainable crop production activities in all three communities. This suggests collective action and support from various stakeholders including emerging smallholder farmers, skilled farmers, extension officers, government, non-governmental organizations and the private sector. Khwidzhili and Worth (2017) state that policies should not be formulated for farmers but should encourage collaborative action including the involvement of many stakeholders to ensure an effective implementation of sustainable farming practices.

This will ensure that farmers have enhanced environmental knowledge and awareness. Therefore, enhanced management skills and adaptation capacity amongst farmers for better urban farming, environmental and financial and market decision making. Lastly, when the farmers are better equipped, skilled and supported to adopt revised and effective integrated environmental management practices, they will gain resilience against urban farming and environmental risks. Thus, environmental, socio-economic development and political stability which will enable sustainable food systems, improved household food and nutrition security.

FIGURE 9: **ENVIRONMENTAL MANAGEMENT FRAMEWORK ASSOCIATED FOR FOOD AND NUTRITION SECURITY**

Challenges:

Internal factors (farmer)

Age, formal educational levels, farmer training, sources of income, access to credit, farm profit, access to markets, access to technology, lack of environmental and climate change awareness.

External environment (policies and institutions)

Impractical environmental and compliance regulations, impractical market standards, unsustainable government incentives, lack of institutional and extension support, lack of farmer-farmer communication, unemployment, youth participation.

Possible solutions:

- Environmental education and farmer training
- Development and implementation of practical compliance regulations with theintegration of indigenous knowledge
- Facilitate access to micro-finance institutions
- Facilitate market education
- Facilitate, train and equip extension officers
- Attract youth involvement through jobcreation in farming
- Training and equipping farmers withtechnical skills
- Facilitate and implement inclusivemarket access policies

Who is responsible?

- Government, extension services, otherskilled farmers
- Policymakers, government, extensionservices, farmers
- Government, NGOs/private sector, farmers
- Government, formal markets, farmers
- Government
- Government, other skilled farmers, privatesectors, academic research, media, youth
- Government, NGOs/private sector, farmers
- Government, formal markets, farmers
- Government, extension services, farmers

Intended outcome: Adoption of EMPs for food and nutrition security

- **Internal factors:** increased environmental knowledge and awareness, adaptation, technical and market skills and capacity amongst farmers for better urban farming, environmental and financial and market decision making.
- **External factors:** strengthened and developed inclusive policies, increased institutional involvement andcollective action amongst all affected stakeholders and actors including farmers, government, skilled extension officers, NGOs, private sector
- Farmers better equipped, skilled and supported to adopt revise effective integrated environmental management practices. Gained resilience against urban farming and environmental risks
- Environmental, socio-economic development & political stability = sustainable food system = Food and nutrition security

5.9 CONCLUSION AND RECOMMENDATIONS

The objective of this study was to identify the urban farming and water quality management practices that were adopted by the urban farmers. An environmental management framework associated for food and nutrition security was designed to address the challenges that hinder farmers understanding and adoption of environmental management practices. Many of the farmers were found to have adopted environmental management practices associated with urban farming, although they did not identify them as such due to the lack of knowledge with regard to environmental management concepts. Moreover, the study found that the majority of the farmers did not adopt water quality management practices of which was attributed to the fact that many of the farmers were mostly dependent on tap water to irrigate crops and the perception that it is the local go. However, water use efficiency practices were adopted by the farmers, of which was influenced by the high-water tariffs they wanted to avoid. The lack of knowledge and environmental awareness exacerbated by the lack of access to extension support, credit, market availability and formal farmer training which had an influence on the farmers' adoption of urban farming management practices. Therefore, it is recommended that policymakers include the smallholder's challenges when developing policies associated with urban farming and water quality management. Further, government and policymakers should place more emphasis towards raising environmental awareness amongst smallholder farmers through education and training. And lastly, investing in new technology and innovation is the key to growing urban farming and thus attracting youth participation should be promoted.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Overview

This chapter presents the main conclusions and recommendations of the study. The aim of this study was to investigate the environmental management of urban farming and water quality in the communities of urban Sobantu, peri-urban Sweetwaters and peri-urban Mpophomeni, located on the outskirts of urban Pietermaritzburg in the KwaZulu-Natal province. The communities of Sobantu, Sweetwaters and Mpophomeni were chosen because there are urban and semi-urban, consisting of smallholder farmers who produce and sell a variety of leafy greens, vegetables, roots and tubers, cereals as well as tomato. The study explored the following research objectives:

- Exploring the challenges of urban farming
- Exploring the implications of urban farming on the environment and water quality: implications for food security
- Identifying the environmental management practices adopted by the urban farmers
- Determining the challenges around the state of the environmental management framework associated with urban farming and water quality: towards an environmental management framework associated for food and nutrition security

6.2. Conclusions

The results of the study revealed that the farmers in the communities of Sobantu, Swetwaters and Mpophomeni are highly dependent on urban farming as a main livelihood strategy of which was used mainly to obtain extra food and to generate an income for the household. The majority of the farmers were female with many over the age of 61 years, suggesting that the active farmers involved in farming in the three communities are the older generation who are female, with their formal education levels largely concentrated at the primary and secondary levels. **In terms of objective 1 and 2 which were aimed at exploring challenges of urban farming, implications of urban farming on the environment and water quality, as well as the implications on food security.** It was found that urban farming in the communities was challenged by the lack of institutional support and extension services, farmers lack of access to markets, low financial capacity and credit access with insufficient profit generated from the produce sales and water access issues. Further, the study found that urban farming was challenged by climate change impacts which were perceived as heavy rainfall leading to floods, high weather temperatures and hailstorms. Compacted soils and soil erosion were evaluated environmental impacts on the three farming communities, with water quality issues in the river source used by farmers in Sobantu. Many of the farmers were aware of the environmental implications of urban farming but the use and application of chemical fertilizers were the only perceived causes, of which contradicted the farmers claim of awareness in that regard. The study also found that the farmers attributed produce loss to heavy rainfall, high weather temperatures and hailstorms, thus profit loss and enhance food insecurity.

Objective 3 and 4 with the aim of identifying urban farming and water quality management practices: towards an environmental management framework for food and nutrition security, the study found that although many of the farmers had adopted urban farming management practices to avoid environmental degradation, many of them were challenged by socio-economic and institutional factors such as lacked knowledge, farmer training, access to markets, access to credit and extension support. The logit regression analysis revealed that market availability, training on soil management and access to credit all significantly influenced the farmer's adoption of urban farming practices. Many of the farmers in Sobantu stopped using the river source due to visible signs of pollution, of which the study found attributed to the farmers lack of knowledge and capacity to adopt water quality management practices. Whereas farmers were not aware of the causes of climate change and thus the poor adaptation strategies. The lack of effective urban farming, water quality management and climate change adaptation strategies were attributed to the lack of governance, institutional support, access to information services through training, access to technology, extension services and the financial capacity. To address the governance, institutional, farmers' socio-economic, and environmental challenges identified throughout the study, an environmental management framework was designed.

6.3. Policy recommendations

In conclusion, the study indicates that the majority of the smallholder urban farmers in Sobantu, Sweetwaters and Mpophomeni are highly dependent on smallholder urban farming as a main source of income and livelihood strategy. Consequently, any urban farming and environmental risks can affect the farmers household food security and thus it is imperative that urban farmers gain resilience by adopting urban farming and water quality management practices. However, although the farmers have adopted environmental management practices, the study found that the farmers had the tendency of adopting cost-effective and easier to manage practices. The severity of the current urban farming and environmental risks require that the farmers adopt effective environmental management practices to gain resilience. Therefore, it is imperative that the local government provides educational and training programs to enhance farmers knowledge, capacity and skills to raise environmental awareness and to adopt urban farming and water quality management practices. Agricultural incentives should not only focus on intensifying food production to improve household food and nutrition security but should also ensure that the incentives integrate environmental aspects to ensure no harm is caused towards the environment and its elements. In light of this, policymakers should use the challenges found in this study to focus on establishing environmental management practices that are suitable in terms of its simplicity and cost-effectiveness for the poor smallholder urban farmers.

Additionally, there is a low count of youth participation in the study areas, hence it is vital that the government assist the older farmers attract the youth in participating in urban food production. This will improve the adoption of new technology and innovation.

REFERENCES

Abdi, H. and Williams, L.J., 2010. Principal component analysis. Wiley interdisciplinary reviews: computational statistics, 2(4), pp.433-459.

Ajayi, O.F. and Akinbobola, T.O., 2020. Links among bioeconomy, food security, and Sustainable Development Goals in Nigeria. *Zero hunger. Encyclopedia of the UN Sustainable Development Goals. Cham: Springer. doi*, *10*, pp.978-3.

Ajayi, O.O., 2000. *Pesticide use practices, productivity and farmers' health* (No. 3). Special Issue Publication Series.

Alexandratos, N. and Bruinsma, J., 2012. World agriculture towards 2030/2050: the 2012 revision.

Anderson, J.A., Gipmans, M., Hurst, S., Layton, R., Nehra, N., Pickett, J., Shah, D.M., Souza,

Andersson, K., Dickin, S. and Rosemarin, A., 2016. Towards "sustainable" sanitation: Challenges and opportunities in urban areas. *Sustainability*, *8*(12), p.1289.

Appiah, D.O., Asante, F. and Nketia, B.A., 2017. Perceived agricultural land use decisions in a peri-urban district, Ghana. *Journal of Agricultural and Crop Research*, *5*(1), pp.1-10.

Archer, D.W., Dawson, J., Kreuter, U.P., Hendrickson, M. and Halloran, J.M., 2008. Social and political influences on agricultural systems. *Renewable Agriculture and Food Systems, 23*(4), pp.272-284.

Aryal, J.P., Sapkota, T.B., Khurana, R., Khatri-Chhetri, A., Rahut, D.B. and Jat, M.L., 2020. Climate change and agriculture in South Asia: Adaptation options in smallholder production systems. Environment, Development and Sustainability, 22(6), pp.5045-5075.

Aryal, R., Vigneswaran, S., Kandasamy, J. and Naidu, R., 2010. Urban stormwater quality and treatment. *Korean Journal of Chemical Engineering,* 27(5), pp. 1343-1359.

Atreya, K., Kumar Sitaula, B., Overgaard, H., Man Bajracharya, R. and Sharma, S., 2012. Knowledge, attitude and practices of pesticide use and acetylcholinesterase depression among farm workers in Nepal. *International journal of environmental health research*, *22*(5), pp.401-415.

Azam, M.S. and Banumathi, M.J.I.J., 2015. The role of demographic factors in adopting organic farming: A logistic model approach. *Int. J. Adv. Res*, *3*, pp.713-720.

Bachev, H. and Terziev, D., 2017. Environmental sustainability of agricultural farms in Bulgaria. *Journal of Environmental Management & Tourism*, *8*(5 (21)), pp.968-994.

Bachev, H., 2014. Environmental management in agriculture. *Икономическа мисъл*, (1), pp.56-79.

Bachev, H., 2014. Environmental Management in Agriculture–Case of Bulgaria.

Bachev, H., 2014. Environmental management in agriculture-mechanisms, forms and efficiency.

Bachev, H., 2016. A framework for assessing sustainability of farming enterprises. *Journal of Applied Economic Sciences (JAES)*, *11*(39), pp.24-26.

Barrow, C. and Barrow, C.J., 2005. *Environmental management and development* (Vol. 5). Psychology Press.

Barrow, C., 2006. *Environmental management for sustainable development*. Routledge.

Bisaga, I., Parikh, P. and Loggia, C., 2019. Challenges and opportunities for sustainable urban farming in South African low-income settlements: A case study in Durban. *Sustainability*, *11*(20), p.5660.

Bobylev, A.V., Bubin, M.N. and Rasskazova, N.S., 2016. The geoecological modelling of small water reservoirs and river catchment areas as a procedure in urban development. *Procedia Engineering*, *150*, pp.2067-2072.

Bobylev, N., 2016. Transitions to a high-density urban underground space. *Procedia Engineering*, *165*, pp.184-192.

Braun, V. and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), pp.77-101.

Brinkley, C., 2012. Evaluating the benefits of peri-urban agriculture. *Journal of Planning Literature*, 27(3), pp. 259-269

Calicioglu, O., Flammini, A., Bracco, S., Bellù, L. and Sims, R., 2019. The future challenges of food and agriculture: An integrated analysis of trends and solutions. Sustainability, 11(1), p.222.

Campbell, B.M., Beare, D.J., Bennett, E.M., Hall-Spencer, J.M., Ingram, J.S., Jaramillo, F., Ortiz, R., Ramankutty, N., Sayer, J.A. and Shindell, D., 2017. Agriculture production as a major driver of the Earth system exceeding planetary boundaries. *Ecology and Society*, *22*(4).

Caputo, S., Schoen, V., Specht, K., Grard, B., Blythe, C., Cohen, N., Fox-Kämper, R., Hawes, J., Newell, J. and Poniży, L., 2021. Applying the food-energy-water nexus approach to urban agriculture: From FEW to FEWP (Food-Energy-Water-People). *Urban Forestry & Urban Greening*, *58*, p.126934.

Cele, P.D., 2016. *Sustainable agricultural practices in smallholder farming systems: a case study of smallholder farmers in the Ugu District, KwaZulu-Natal, South Africa* (Doctoral dissertation).

Chandrasekaran, B., Annadurai, K. and Somasundaram, E., 2010. *A textbook of agronomy*. New Age International Limited.

Clark, M. and Tilman, D., 2017. Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters*, *12*(6), p.064016.

Collier, P., Conway, G. and Venables, T., 2008. Climate change and Africa. Oxford Review of Economic Policy, 24(2), pp.337-353

Conceição, P., Levine, S., Lipton, M. and Warren-Rodríguez, A., 2016. Toward a food secure future: Ensuring food security for sustainable human development in Sub-Saharan Africa. *Food Policy*, *60*, pp.1-9.

Creswell, J. W. 2013. Research design: Qualitative, quantitative, and mixed methods approaches, Sage publications.

Creswell, J.W. and Poth, C.N., 2017. *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Creswell, J.W., 2013. Steps in conducting a scholarly mixed methods study.

Cullis, J.D., Horn, A., Rossouw, N., Fisher-Jeffes, L., Kunneke, M.M. and Hoffman, W., 2019. Urbanisation, climate change and its impact on water quality and economic risks in a water scarce and rapidly urbanising catchment: case study of the Berg River Catchment. *H2Open Journal*, *2*(1), pp.146-167.

D'Emden, F.H., Llewellyn, R.S. and Burton, M.P., 2008. Factors influencing adoption of conservation tillage in Australian cropping regions. Australian Journal of Agricultural and Resource Economics, 52(2), pp.169-182.

Dalvie, M.A., Sosan, M.B., Africa, A., Cairncross, E. and London, L., 2014. Environmental monitoring of pesticide residues from farms at a neighbouring primary and pre-school in the Western Cape in South Africa. *Science of the total environment*, *466*, pp.1078-1084.

Darkoh, M.B.K., 2009. An overview of environmental issues in Southern Africa. *African Journal of Ecology*, *47*, pp.93-98.

Davids, R., Rouget, M., Boon, R. and Roberts, D., 2016. Identifying ecosystem service hotspots for environmental management in Durban, South Africa. *Bothalia-African Biodiversity & Conservation*, *46*(2), pp.1-18.

De Villiers, S. 2007 The deteriorating nutrient status of the Berg River, South Africa. Water SA 33, 659–664

de Vries, F.P., 2003. *Integrated land and water management for food and environmental security* (Vol. 1). IWMI.

Denison, J.A. and Wotshela, L., 2012. An overview of indigenous, indigenised and contemporary water harvesting and conservation practices in South Africa. Irrigation and Drainage, 61, pp.7-23.

Department of Environmental Affairs, Development Planning and Department of Agriculture (2018). Sandveld Environmental Management Framework. Provincial Government of the Western Cape, Cape Town.

Dorr, E., Goldstein, B.P., Horvath, A., Aubry, C. and Gabrielle, B., 2021. Environmental impacts and resource use of urban agriculture: a systematic review and meta– analysis. *Environmental Research Letters*.

Drescher, A.W., 2003. What is urban agriculture? In *FoodAfrica, Internet Forum. UK: Natural Resource Institute*.

Driscoll, D.L., 2011. Introduction to primary research: Observations. *Surveys, and Interviews*.

Dziuban, C.D. and Shirkey, E.C., 1974. When is a correlation matrix appropriate for factor analysis? Some decision rules. *Psychological bulletin*, *81*(6), p.358.

Dziwornu, R.K., 2013. Factors affecting mobile phone purchase in the greater Accra region of Ghana: a binary logit model approach. International Journal of Marketing Studies, 5(6), p.151.

ETHEKWINI Municipality. Durban Crowned the Greenest City in the World. Available online: http://www.durban.gov.za/Resource_Centre/Press_Releases/Pages/Durban-Crowned-the-GreenestCity-in-the-World.aspx (accessed on 25 November 2019).

Fadeyi, O.A., Ariyawardana, A. and Aziz, A.A., 2022. Factors influencing technology adoption among smallholder farmers: a systematic review in Africa.

FAO (Food and Agricultural Organization of the United Nation**s).** 2015. The state of food insecurity in the world: Meeting the 2015 international hunger targets: taking stock of uneven progress, pp.1-62. Rome, Italy. URL: http://www.fao.org/3/ai4646e.pdf (Accessed 2017, October 5)

FAO, I. and UNICEF, WFP, and WHO. 2017. 'The state of food security and nutrition in the world. Building resilience for peace and food security'. *Food and Agricultural Organization of the United Nations (FAO), Rome, Italy*.

FAO, I. and UNICEF. 2018. WFP and WHO 'The State of Food Security and Nutrition in the World 2018. *Building climate resilience for food security and nutrition'in The State of the World (Report, 2018)*.

FAO. Food and Agriculture Organization of the United Nations. AQUASTAT Report 2016. Country Profile—Mozambique. Available online: http://www.fao.org/3/i9805en/I9805EN.pdf (accessed on 26 November 2019).

Feola, G., Sahakian, M. and Binder, C.R., 2020. *Sustainability assessment of urban agriculture* (No. BOOK_CHAP, pp. 417-437). Cambridge University Press.

Feola, G., Suzunaga, J., Soler, J. and Wilson, A., 2020. Peri-urban agriculture as quiet sustainability: Challenging the urban development discourse in Sogamoso, Colombia. *Journal of Rural Studies*, *80*, pp.1-12.

Fetting, C., 2020. The European Green Deal. ESDN Report, December.

Food and Agriculture Organization of the United Nations (FAO). Climate Change, Water and Food Security; FAO Water Reports No. 36; FAO: Rome, Italy, 2011.

Fraser, E.D., Dougill, A.J., Mabee, W.E., Reed, M. and McAlpine, P., 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of environmental management*, *78*(2), pp.114-127.

Gao, H., Yan, C., Liu, Q., Ding, W., Chen, B. and Li, Z., 2019. Effects of plastic mulching and plastic residue on agricultural production: A meta-analysis. *Science of the Total Environment*, *651*, pp.484-492.

Giller, K.E., Andersson, J.A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O. and Vanlauwe, B., 2015. Beyond conservation agriculture. *Frontiers in plant science*, *6*, p.870.

Glaw, X., Inder, K., Kable, A. and Hazelton, M., 2017. Visual methodologies in qualitative research: Autophotography and photo elicitation applied to mental health research. *International Journal of Qualitative Methods*, *16*(1), p.1609406917748215.

Govender I. 2016 Monitoring and evaluating service delivery as a wicked problem in South Africa. Journal of Human Ecology 55, 21–34.

Grard, B.J.P., Chenu, C., Manouchehri, N., Houot, S., Frascaria-Lacoste, N. and Aubry, C., 2018. Rooftop farming on urban waste provides many ecosystem services. *Agronomy for sustainable development*, *38*(1), pp.1-12.

Griffin, N.J., Palmer, C.G. and Scherman, P.A., 2014. *Critical analysis of environmental water quality in South Africa: Historic and current trends* (No. 2184/1, p. 14). WRC report.

Hansen, J., Hellin, J., Rosenstock, T., Fisher, E., Cairns, J., Stirling, C., Lamanna, C., van Etten, J., Rose, A. and Campbell, B., 2019. Climate risk management and rural poverty reduction. Agricultural Systems, 172, pp.28-46.

Harvey, Celia A., Zo Lalaina Rakotobe, Nalini S. Rao, Radhika Dave, Hery Razafimahatratra, Rivo Hasinandrianina Rabarijohn, Haingo Rajaofara, and James L. MacKinnon. "Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar." Philosophical Transactions of the Royal Society B: Biological Sciences 369, no. 1639 (2014): 20130089.

Havas, K. and Salman, M., 2011. Food security: its components and challenges. *International Journal of Food Safety, Nutrition and Public Health*, *4*(1), pp.4-11.

Heather, K.L., 2012. The environmental benefits of urban agriculture on unused, impermeable and semi-pe

Heather, K.L., 2012. The environmental benefits of urban agriculture on unused, impermeable and semi-permeable spaces in major cities with a focus on Philadelphia, PA.

Hlahla, S. and Hill, T.R., 2018. Responses to climate variability in urban poor communities in Pietermaritzburg, KwaZulu-Natal, South Africa. *Sage Open*, *8*(3), p.2158244018800914.

Hodgson, K. and Manus, L., 2006. A drinking water quality framework for South Africa. *Water SA*, *32*(5).

Hoornweg, D. and Munro-Faure, P., 2008. Urban Agriculture for Sustainable Poverty Alleviation and Food Security (Position paper). *Final Draft*, p.83.

Hunter, M.C., Smith, R.G., Schipanski, M.E., Atwood, L.W. and Mortensen, D.A., 2017. Agriculture in 2050: recalibrating targets for sustainable intensification. *Bioscience*, *67*(4), pp.386-391.

Hyland, J.J., Henchion, M., McCarthy, M. and McCarthy, S.N., 2017. The role of meat in strategies to achieve a sustainable diet lower in greenhouse gas emissions: A review. *Meat science*, *132*, pp.189-195.

IDP. 2020/2021. uMsunduzi Local Municipality: Final IDP Review.

IPCC, 2014. Chapter 8 – Urban Areas. In: Climate Change 2014: Impacts, Adaptation, and

Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Field, C., Barros, V., Dokken, D., Mach, K., Mastrandrea, M., Bilir, T., Chatterjee, M., Ebi, K., Estrada, Y., Genova, R., Girma, Y., Kissel, E., Levy, A., MacCracken, S., Mastrandrea, P. & White, L., eds). Cambridge University Press, Cambridge, UK and New York, USA, p. 113.

Jayasinghe-Mudalige, U.K. and Weersink, A., 2004. Factors affecting the adoption of environmental management systems by crop and livestock farms in Canada. Sri Lankan Journal of Agricultural Economics, 6(1381-2016-115719), pp.25-36.

Jepthas, G. and Swanepoel, J.W., 2019. Implications of the environmental impact assessment regulations on the agricultural sector in the Overberg District in the Western Cape for emerging farmers. *South African Journal of Agricultural Extension*, *47*(2), pp.128-139.

Jolliffe, I.T., 2002. Principal component analysis for special types of data (pp. 338-372). Springer New York.

Kawulich, B., 2012. Collecting data through observation. *Doing social research: A global context*, pp.150-160.

Kehrig, R.F., 2002. *Agricultural practices and water quality in Saskatchewan: The social ecology of resource management* (Doctoral dissertation, University of Saskatchewan).

Khodapanah, L.W.N.A., Sulaiman, W.N.A. and Khodapanah, N., 2009. Groundwater quality assessment for different purposes in Eshtehard District, Tehran, Iran. *European journal of scientific research*, *36*(4), pp.543-553.

Khwidzhili, R. and Worth, S., 2017. The sustainable agricultural imperative: Implications for South African extension. In *Young Scientists Conference. Vienna, Austria*.

Khwidzhili, R.H. and Worth, S.H., 2017. Evaluation of policies promoting sustainable agriculture in South Africa. *South African Journal of Agricultural Extension*, *45*(2), pp.73-85.

Kotze, L.J., 2009. Environmental governance. *Environmental Compliance and Enforcement in South Africa: Legal Perspectives. South Africa: Juta.*

Kotze, L.J., 2009. Environmental governance. *Environmental Compliance and Enforcement in South Africa: Legal Perspectives. South Africa: Juta.*

Krishnan, S., Nandwani, D., Smith, G. and Kankarta, V., 2016. Sustainable urban agriculture: A growing solution to urban food deserts. In *Organic farming for sustainable agriculture* (pp. 325-340). Springer, Cham.

Loboguerrero, A.M., Campbell, B.M., Cooper, P.J., Hansen, J.W., Rosenstock, T. and Wollenberg, E., 2019. Food and earth systems: priorities for climate change adaptation and mitigation for agriculture and food systems. Sustainability, 11(5), p.1372.

Manus, L.A. and Hodgson, K., 2008, May. Drinking Water Quality in South Africa. In *Proceedings of the Water Institute of Southern Africa (WISA) Biennial Conference*.

Matovic, I.M., 2020. PESTEL Analysis of External Environment as a Success Factor of Startup Business. *ConScienS,* p.96.

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), pp.129-134.

Mcdougall, R., Rader, R. and Kristiansen, P., 2020. Urban agriculture could provide 15% of food supply to Sydney, Australia, under expanded land use scenarios. *Land Use Policy*, *94,* p.104554.

Menyuka, N.N., Sibanda, M. and Bob, U., 2020. Perceptions of the Challenges and Opportunities of Utilising Organic Waste through Urban Agriculture in the Durban South Basin. *International Journal of Environmental Research and Public Health*, *17*(4), p.1158.

Middleton, J., Goldblatt, M., Jakoet, J. and Palmer, I., 2011. Environmental management and local government. *PDG Occasional paper*, (1), pp.1-31.

Miranda, A.A., Le Borgne, Y.A. and Bontempi, G., 2008. New routes from minimal approximation error to principal components. Neural Processing Letters, 27(3), pp.197-207

Moglia, M.r, 2014. Urban agriculture and related water supply: Explorations and discussion. *Habitat International*, *42,* pp.273-280.

Mohsin, T., Arhonditsis, G., Mirza, M. and Gough, W.A., 2019. Key Agri-Climatic and Socio-Economic Indicators for Cereal Production across the World. *International Journal of Environment, Agriculture and Biotechnology*, *4*(2).

Mongale, I.P. and Masipa, T.S., 2019. Human capital development, regulatory quality and economic growth Nexus: Ardl approach. African Journal of Development Studies, 9(1), pp.271-291.

Montemurro, F. and Diacono, M., 2016. Towards a better understanding of agronomic efficiency of nitrogen: assessment and improvement strategies. *Agronomy*, *6*(2), p.31.

Muller, M., 2002, March. Inter-basin water sharing to achieve water security—a South African perspective. In *Director-General, Department of Water Affairs and Forestry, Pretoria. Speech at the World Water Forum, The Hague. Available at: http://www. dwaf. gov. za/Communications/Departmental% 20Speeches/2002/hague% 20transfe r% 20final. doc*.

Mungai, L.M., Snapp, S., Messina, J.P., Chikowo, R., Smith, A., Anders, E., Richardson, R.B. and Li, G., 2016. Smallholder farms and the potential for sustainable intensification. *Frontiers in plant science*, *7*, p.1720.

Murungu, F.S., 2012. Conservation agriculture for smallholder farmers in the Eastern Cape Province of South Africa: recent developments and future prospects. *African Journal of Agricultural Research*, *7*(38), pp.5278-5284.

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), p.3003.

Nations, U., 2016. World population ageing 1950-2050. United Nations, Department of Economic and Social Affairs, Population Division.

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.

Notarnicola, B., Sala, S., Anton, A., McLaren, S.J., Saouter, E0.. and Sonesson, U., 2017. The role of life cycle assessment in supporting sustainable agri-food systems: A review of the challenges. *Journal of Cleaner Production*, *140*, pp.399-409.

O. Nyumba, T., Wilson, K., Derrick, .J. and Mukherjee, N., 2018. The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and evolution*, *9*(1), pp.20-32.

Odiyo, J.O. and Makungo, R., 2012. Water quality problems and managodusement in rural areas of Limpopo Province, South Africa. *WIT Transactions on Ecology and the Environment*, *164*, pp.135-146.

Odusola, A., Mugisha, F., Workie, Y. and Reeves, W., 2017. Income inequality and population growth in Africa. *Income Inequality Trends in Sub-Saharan Africa: Divergence, Determinants and Consequences (2017)*.

Oelofse, C. and Scott, D., 2002. Geography and environmental management in South Africa. *South African Geographical Journal*, *84*(1), pp.38-47.

Office for ECOSOC Support and Coordination United Nations. 2008. *Achieving sustainable development and promoting development cooperation*: *dialogues at the Economic and Social Council*. UN

Ogundipe, A.A., Ogunniyi, A., Ogundipe, O.M. and Asaleye, A.J., 2019. Agricultural productivity and inclusive growth in Africa: A Conceptual Framework. Abstracts & Proceedings of SOCIOINT.

Orsini, F., 2020. Innovation and sustainability in urban agriculture: the path forward. *Journal of Consumer Protection and Food Safety*, *15*(3), pp.203-204.

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), pp 695-720

Orsini, L., Vanoverbeke, J., Swillen, I., Mergeay, J. and De Meester, L., 2013. Drivers of population genetic differentiation in the wild: isolation by dispersal limitation, isolation by adaptation and isolation by colonization. *Molecular ecology*, *22*(24), pp.5983-5999.

Orton, J., 2010. *Urban agriculture-a community development project* (Doctoral dissertation, University of Pretoria).

Oshunsanya, S.O. and Adeniran, T.O., 2014. Water quality and crop contamination in peri-urban agriculture. *Agricultura Tropica et Subtropica*, *47*(3), pp.94-105.

Petersen, B. and Snapp, S., 2015. What is sustainable intensification? Views from experts. *Land use policy*, *46*, pp.1-10.

Pienaar, L.O.U.W. and Boonzaaier, J.O.H.A.N.N., 2018. Drought policy brief Western Cape Agriculturek. *Western Cape Department of Agriculture (WCDoA) and the Bureau for Food and Agricultural Policy (BFAP), Elsenburg*.

Prain, G. and Dubbeling, M., 2011. Urban Agriculture: A Sustainable Solution to Alleviating Urban Poverty, Addressing the Food Crisis, and Adapting to Climate Change. *Leusden, Netherlands: RAUF Foundation*.

Pretorius, E. and de Villiers, G.D.T. An integrated approach for the development of a cost-effective strategy for managing stormwater quality effects of a developing community in the south-eastern suburbs of Bloemfontein, South Africa, WISA 2000 Biennial Conference, Sun City, South Africa, 2000. http://www.ewisa.co.za/misc/WISAConf/ default2000.htm.

Prokopy, LS., Towery, D., Babin, N. Adoption of Agricultural Conservation Practices: Insights from Research and Practice. Purdue Extension; West Lafayette, IN, USA: 201

Ramburran, E. 2014. 1st draft to rehabilitate the Baynespruit River for increased water supply to improve the water quality, Msunduzi Municipality, Pietermaritzburg, South Africa.

Reimer, A., Thompson, A., Prokopy, L.S., Arbuckle, J.G., Genskow, K., Jackson-Smith, D., Lynne, G., McCann, L., Morton, L.W. and Nowak, P., 2014. People, place, behavior, and context: A research agenda for expanding our understanding of what motivates farmers' conservation behaviors. *Journal of Soil and Water Conservation*, *69*(2), pp.57A-61A.

Reimer, A., Thompson, A., Prokopy, L.S., Arbuckle, J.G., Genskow, K., Jackson-Smith, D., Lynne, G., McCann, L., Morton, L.W. and Nowak, P., 2014. People, place, behavior, and context: A research agenda for expanding our understanding of what motivates farmers' conservation behaviors. Journal of Soil and Water Conservation, 69(2), pp.57A-61A.

Reimer, A.P. and Prokopy, L.S., 2014. Farmer participation in US Farm Bill conservation programs. *Environmental management*, *53*(2), pp.318-332.

Ritchie, H. and Roser, M., 2018. Urbanization. *Our World in Data*.

Roberts, D. and O'Donoghue, S., 2013. Urban environmental challenges and climate change action in Durban, South Africa. *Environment and Urbanization*, *25*(2), pp.299-319.

Samat, N. and Elhadary, Y.A.E., 2012. Urban Development Pressure at the Peri-urban Areas:

Challenges to the Agriculture Sector. In *Proceedings of USM-AUT International Conference 2012 Sustainable Economic Development: Policies and Strategies* (Vol. 167, p. 179).

Sarker, A.H., Bornman, J.F. and Marinova, D., 2019. A framework for Integrating Agriculture in Urban Sustainability in Australia. *Urban Science,* 3(2), p.50.

Sarker, M.N.I., Wu, M., Alam, G.M. and Islam, M.S., 2019. Role of climate smart agriculture in promoting sustainable agriculture: a systematic literature review. *International Journal of Agricultural Resources, Governance and Ecology*, *15*(4), pp.323-337.

Schiefer, J., Lair, G.J. and Blum, W.E., 2015. Indicators for the definition of land quality as a basis for the sustainable intensification of agricultural production. *International Soil and Water Conservation Research*, *3*(1), pp.42-49.

Schroeder, K. and Smaldone, A. 2015. October. Food insecurity: A concept analysis. In *Nursing forum* (Vol. 50, No. 4, pp. 274-284).

Serebrennikov, D., Thorne, F., Kallas, Z. and McCarthy, S.N., 2020. Factors influencing adoption of sustainable farming practices in Europe: a systemic review of empirical literature. Sustainability, 12(22), p.9719.

Shabalala, A.N., Combrinck, L. and McCrindle, R., 2013. Effect of farming activities on seasonal variation of water quality of Bonsma Dam, KwaZulu-Natal. *South African Journal of Science*, *109*(7), pp.1-7.

Siborurema, E., 2019. *The contribution of urban agriculture to sustainable development: potential role in improving food security and reducing poverty* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Singh, V. and Dubey, A., 2012. Land use mapping using remote sensing & GIS techniques in Naina-Gorma Basin, part of Rewa district, MP, India. *International Journal of Emerging Technology and Advanced Engineering, 2*(1), pp. 151-156.

Siulemba, G.K. and Moodley, V., 2014. A gendered analysis of sustainable agricultural practices with changing climate in the Chankumba agricultural community, Zambia. *Agenda*, *28*(3), pp.135-146.

Springmann, M., Godfray, H.C.J., Rayner, M. and Scarborough, P., 2016. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proceedings of the National Academy of Sciences*, *113*(15), pp.4146-4151.

Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H.C.J., Gollin, D., Rayner, M., Ballon, P. and Scarborough, P., 2016. Global and regional health effects of future food production under climate change: a modelling study. *The Lancet*, *387*(10031), pp.1937-1946.

Statistics South Africa (SSA). 2019. Towards measuring the extent of food security in South Africa; an examination of hunger and food adequacy. Statistics South Africa; Pretoria, South Africa: 2019

Steenkamp, J., Cilliers, E.J., Cilliers, S.S. and Lategan, L., 2021. Food for Thought: Addressing Urban Food Security Risks through Urban Agriculture. *Sustainability*, *13*(3), p.1267.

Story, P.A. and Forsyth, D.R., 2008. Watershed conservation and preservation: Environmental engagement as helping behavior. *Journal of Environmental Psychology*, *28*(4), pp.305-317.

Sulewski, P. and Gołaś, M., 2019. Environmental awareness of farmers and farms' characteristics. *Zagadnienia Ekonomiki Rolnej/Problems of Agricultural Economics*, (4).

Sutton, J., & Austin, Z., 2015. Qualitative Research: Data Collection, Analysis, and Management. *The Canadian journal of hospital pharmacy*, *68*(3), 226–231.

T.L.P. and Tripathi, L., 2016. Emerging agricultural biotechnologies for sustainable agriculture and food security. *Journal of agricultural and food chemistry*, *64*(2), pp.383-393.

Thamaga-Chitja, J.M. and Morojele, P., 2014. The context of smallholder farming in South Africa: Towards a livelihood asset building framework. *Journal of Human Ecology*, *45*(2), pp.147-155.

Tharrey, M., Sachs, A., Perignon, M., Simon, C., Mejean, C., Litt, J. and Darmon, N., 2020. Improving lifestyles sustainability through community gardening: results and lessons learnt from the JArDinS quasi-experimental study. *BMC public health*, *20*(1), pp.1-13.

The Msunduzi Municipality, 2020/2021. The Msunduzi Integrated Development Plan.

Tilman D, Clark M (2014) Global diets link environmental sustainability and human health. Nature 515(7528):518–522.

Tzilivakis, J. and Lewis, K., 1999. Environmental Management for Agriculture (EMA) and Sustainable Agriculture. Perspectives of Modern Information and Communication Systems in Agriculture, Food Production and Environmental Control.

United Nations Department of Economic and Social Affairs (UN DESA), 2015. World Urbanization Prospects: The 2014 Revision. New York: UN DESA.

United Nations Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2012 Revision, Volume II, Demographic Profiles (ST/ESA/SER.A/345); United Nations: New York, NY, USA, 2013.

United Nations Environment Program (UNEP)., 2009. Water security and ecosystem services: The critical connection. *A contribution to the United Nations World Water Assessment Program*

Urbanization Prospects: The 2014 Revision. New York: UN DESA.

Van der Werf, H.M. and Petit, J., 2002. Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. Agriculture, Ecosystems & Environment, 93(1-3), pp.131-145.

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), pp.5-22.

Van Wyk, R.B. and Dlamini, C.S. 2018. The impact of food prices on the welfare of households in South Africa. *South African Journal of Economic and Management Sciences*, *21*(1), pp.1-9.

Vetter, S., 2013. Development and sustainable management of rangeland commons–aligning policy with the realities of South Africa's rural landscape. *African journal of range & forage*

Vilakazi, B.S., Zengeni, R. and Mafongoya, P., 2019. Indigenous strategies used by selected farming communities in KwaZulu Natal, South Africa, to manage soil, water, and climate extremes and to make weather predictions. *Land Degradation & Development*, *30*(16), pp.1999-2008.

Vilakazi, N., Nyirenda, K. and Vellemu, E., 2019. Unlocking Water Issues Towards Food Security in Africa. In *Food Security in Africa*. Intech Open.

Welch, E.W. and Marc-Aurele Jr, F.J., 2001. Determinants of farmer behavior: Adoption of and compliance with best management practices for nonpoint source pollution in the Skaneateles Lake watershed. *Lake and Reservoir Management*, *17*(3), pp.233-245.

Welch, E.W. and Marc-Aurele Jr, F.J., 2001. Determinants of farmer behavior: Adoption of and compliance with best management practices for nonpoint source pollution in the Skaneateles Lake watershed. Lake and Reservoir Management, 17(3), pp.233-245.

World Commission on Environment and Development and Brundtland, G.H., 1987. Presentation of the Report of World Commission on Environment and Development to African and International and Non-governmental Organizations… June 7, 1987, Nairobi, Kenya. World Commission on Environment and Development.

Wreford, A., Moran, D. and Adger, N., 2010. Climate change and agriculture. OECD publishing.

Zhang, X.Q., 2016. The trends, promises and challenges of urbanisation in the world. *Habitat international*, *54*, pp.241-252.

Zougmoré, R.B., Partey, S.T., Ouédraogo, M., Torquebiau, E. and Campbell, B.M., 2018. Facing climate variability in sub-Saharan Africa: analysis of climate-smart agriculture opportunities to manage climate-related risks. Cahiers Agricultures (TSI), 27(3), pp.1-9.

QUESTIONAIRE

African Centre for Food Security

School of Agricultural, Earth and Environmental Sciences,

College of Agriculture, Engineering, and Science

University of KwaZulu-Natal,

Pietermaritzburg

Date: ________________________ Questionnaire ID: ________________________

General instructions:

The information to be captured in this questionnaire is strictly confidential and will be used for research purposes by staff and students at the African Centre for Food Security, University of KwaZulu-Natal working on investigating the environmental management of urban farming and water quality. The study adds to the body of knowledge and policy by identifying urban farming and water quality management practices aimed at addressing poor water quality and the environmental implications of urban farming.

A. Socio-demographics characteristics of the respondent

1. Respondent's name: ____

2. Gender of respondent

1. Male	0. Female

3. Age of respondent .... years

4. Respondent's level of formal education

0.No formal education	1.primary	2.Secondary	3. Finished both primary and secondary	4. vocational training	5.Other

5. How many years did you spend in school? ....Years 6.
Do you have formal training in farming?

1. Yes	0. No

7. Sources of monthly income

1.Farming	2. Salary	3.Pension	4. Casual income	5.Social grants	6. Farming and pension	7. Other

8. What is the main livelihood strategy for the household?

1. Farming	2. Employed/Full time job	3. Causal labour	4. Other, please specify

B. To understand urban farming activities and environmental implications

1. Do you have access to agricultural land?

1. Yes	0. No

2. If yes, who owns it? **……………**

3. Farming experience? .... years

4. Size of farm? .... hectares

5. Type of farming

1. Organic farming **Why? …………………………**	2. Conventional farming **Why? …………………………**

6. What do you use the land for?

1. Crop farming	2. Livestock husbandry	3. Crop and livestock farming	4. Other, specify

7. Type of livestock?

1. Cattle	2. Goats	3. Chicken	4. Other, specify

8. Types of crops you produce.

Crop type	To sell, and how much?	To eat	Both
1. Sweet potatoes			
2. Amadumbe			
3. Cabbage			
4. Beetroot			
5. Carrot			
6. Lettuce			
7. Spinach			
8. Chickens			
9. Potatoes			
10. Butternut			
11. Onions			

12. Green Pepper			
13. Pumpkin			
14. Tomatoes			
15. Brinjol/egg plant			
16. Green beans			
17. Chillies			
18. Maize			

9. List the **crops** that **you grow** that **use the highest amount** of the following.

1. Water	
2. Land space	
3. Chemicals; fertilizers, pesticides	

10. Type of cropping method you have employed?

Cropping method	**Tick**
1. Monocropping	
2. Crop rotation	
3. Intercropping	
4. Crop rotation and intercropping	

11. What land preparation activities do you employ before planting?

1.Remove weeds	2. Turn the soil	3.Apply poison/chemicals on the soil	4. Remove weeds and turn soil	5.Other, specify

12. Farming technique employed

1.Hand planting	2. Machinery methods	3. Mixed methods

13. How many times do you plant a year?

1. Once	2. Twice	3. Three times	4. All year round

14. Type of soil

Type of soil	**Tick**
1. Clay	
2. Sandy soil	
3. Loam	

15. What do you think causes poor soil quality?

1.Chemical fertilizers	2. Municipal sewage	3.Industrial chemicals	4.Natural causes	5. Not sure	6. Other

16. Have you experienced produce loss?

1. Yes	0. No

17. **If yes**, what caused the produce loss?

Causes (Tick)
1. Not enough water to sustain crop growth
2. The water is too polluted to grow quality crops
3. The soil quality is poor to sustain crop growth
4. The soil is too compacted/hardened to enable crop growth
5. Eaten by pests/insects
6. Natural causes viz flooding, hailstones, hot temperature
7. Other, specify

18. After harvest what do you do with your crop residues?

1. Burn them	
2. Make compost	
3. Discard them	
4. Other, specify	

19. Do you have access to extension services?

1. Yes	0. No

20. Do you have access to markets to sell your produce?

1. Yes	0. No

21. **If yes,** who is your market?

1. Community members
2. Fresh produce market
3. Health facilities (hospitals, clinic)
4. School
5. Do not have a market
6. Other, specify ………………………

22. Type of transportation

1. Small vehicle
2. Public transport e.g., minibus taxi
3. Truck
4. Bakkie
5. Do not have transport

23. Do you make enough profit from selling the crops you produce?

1. Yes	0. No

24. Do you have access to credit?

1. Yes	0. No

25. What challenges do you experience during crop production?

1. Water problems
2. Soil problems
3. Pests and insects
4. Climate conditions
5. All the above mentioned
6. None
7. Other, specify ………………………

26. How would you rate the state/condition of your agricultural land?

1. Low	2. Average	3. Good

27. In the past 5 years, have you produced more or less crops? ……………..

28. What type of packaging do you have for your produce?

1. Plastic bags	2. Crates	3. Cardboard	4. Knitted bags	5. Don't have packaging

29. Which sources of technology do you have access to?

Source	**Tick**
1. TV	
2. Cellphone with internet	
3. Cellphone without internet	
4. Radio	
5. Other, specify	

C.Tounderstand water quality problems in the farmer's area l

1. Do you have access to water all year round?

1. Yes	0. No

2. Type of water source?

1. Communal taps	2. Private tap	3. River	4. Rainwater	5. Borehole	6. Tap and river	7. Other

3. Distance of water source from the farm? .... (in Km or Meter) 4. Do you think the water is suitable to use for irrigation?

1. Yes	0. No **why? ………………….**

5. What do you think are the causes of poor water quality in the area?

Causes	**1. Strongly disagree**	**2.Disagree**	**3.Somewhat disagree**	**4.Agree**	**5. Strongly Agree**
1. Human activities					
2. Natural processes					
3. Liquid waste from industrial premises					
4. Farm chemicals					

6. How many times do you water your crops?

1. Daily	2. Every other day	3. Only when hot	4. Once a week	Other, specify

7. What implements do you use to water your plants?

1. Buckets	2. Pipes	3. Watering cans	4. All the mentioned	5, Other, specify

8. What alternatives do you use during dry season?

1. Rainwater harvesting	2. Wastewater	3. Other, specify

9. Are you aware of climate change? 1. Yes **…….** 0. No **…….**

10. If yes what is climate change in your own understanding? **……………………………**

11. What do you think are the causes of climate change?

1. Human activities	2. Industrial activities	3.Farming activities	4. All the mentioned	5. Not sure	6. Other

12. Have you experienced crop loss due to the following?

Climate condition	1. Yes	0. No
1. Excessive rainfall		
2. Extreme hot temperatures		
3. Other, specify ……………….		

13. How are you made aware of climate change?

1. TV	2. Radio	3. Cellphone	4. Other

D. To identify urban farming and water quality management practices

A) Why do you think you should have urban farming and water quality management practices?

1. For long-term economic benefits
2. To maintain the beauty of nature
3. To ensure human health
4. To ensure crop quality
5. To prevent the loss of natural resources

B) Urban farming management practices

1. Do you practice urban farming? **Y/N**

2. Do you know the following benefits of urban farming on the environment?

Environmental benefits	1. Yes	0. No
1. Mitigates flood water		
2. Water infiltration		
3. Urban greening		

3. Which of the following do you think are negatively affected by farming activities?

1. Soil	2. Water	3.Crops & animals	4. Air	5. Landscape	6. Climate

4. Are you aware of any environmental management regulations or policies that farmers need to follow in order to prevent damage on soil and water used for irrigation? **Y/N**

5. Do you follow guidelines on how to apply synthetic chemicals/fertilizers? **Y/N** **6.** Is there any government or NGO intervention that monitors the quality of the soil? **Y/N**

7. What practices do you employ to protect the soil and maintain its quality?

1. Apply compost	2. Rotate crops	3. Cover beds	4. Mulching	5. Other, specify

8. Practices employed to control pests/insects?

1. Apply chemicals	2. Plant repellent /indigenous crops	3. None	4. Other, specify

9. Where do you dispose farm waste products?

1. Municipal waste truck	2. Dump on the side of farm	3. Dump elsewhere	4. Burn

10. How do you reduce soil loss/erosion?

1. Plant year-round	2. Rotate crops	3. Apply grass	4. All mentioned	5. Windbreaks	6. None	7. Other, specify

C) Water quality management practices

1. Any government or NGO intervention that monitors the quality of the water used? **Y/N**

2. If the farmer is using a **river/lake/borehole**, are there **policies** placed that allow you to use the water source? **Y/N**

3. Sustainable water use practice during dry season?

1. Rainwater harvesting	2. Mulching	3. Wastewater	4. Other, specify

4. Do you measure the amount of water used when watering the crops? **Y/N**

5. How do you prevent water pollution **if using river/borehole/well?**

1. Build protective zones around water source 2. Do not wash farm implements with chemicals in the river 3. Clean the area around the water source 4. None 5. Other, specify **…………………………….**

6. Do you keep records of farm operations**? Y/N**