POTENTIAL REUSE OF GREYWATER TO IMPROVE HOUSEHOLD FOOD SECURITY: A CASE STUDY OF TWO VILLAGES IN FETAKGOMO LOCAL MUNICIPALITY.

BY

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DECLARATION

This dissertation represents original work by the author and has not been submitted in any other form to any other University. All sources of literature have been duly acknowledged through citation and a list of references. This dissertation is submitted in fulfilment of the requirements for the Master of Science degree in Geography, the School of Agricultural and Environmental Sciences in the Faculty of Science and Agriculture, at the University of Limpopo, Polokwane, South Africa.

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Radingoana, MP (Ms) Date:

DEDICATION

This work is lovingly dedicated to my daughters Retang and Retlotlilwe Radingoana.

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ABSTRACT

Great interests in the geographical dimensions of poverty, food security, natural resources such as land and water, and livelihoods have been motivated by global efforts of reducing poverty and food insecurity, as part of the millennium development agenda. The achievement of household food security is a major concern facing the world at large, including South Africa due to the lack of land and water resources availability and accessibility. The study aimed at evaluating the potential reuse of greywater to improve household food security in two villages of Fetakgomo Local Municipality. The objectives of the study were to establish background characteristics, determine household food accessibility and availability, assess the reuse of greywater in relation to home gardening activities, ascertain the perceptions on greywater reuse and lastly to determine the household food security status of the households.

The study adapted a mixed research approach and a 4% sample size was used. Ninety five and seventy eight households were randomly selected for Ga-Seroka and Ga-Nkwana villages, respectively. Data was collected using a structured questionnaire and the results were analysed using Statistical Package for the Social Sciences (SPSS) version-23 software. General Household Survey (GHS) in combination with Household Food Insecurity Access Scale (HFIAS) were used to assess household food security status of the two villages.

The key results revealed that background characteristics of importance on greywater reuse include household size, educational level and employment status even though they varied in these two areas. Accessibility and availability of food was found to be more of a challenge in Ga-Seroka village than in Ga-Nkwana village. Respondents from Ga-Seroka village reused their greywater more as they drained it directly into their gardens. According to the HFIAS classification measure, 85% and 73% of households were categorised as least food insecure, 15% and 26% as medium food insecure and 0% and 1% as severely food insecure in Ga-Nkwana and Ga-Seroka villages respectively. Ga-Seroka village respondents preferred to reuse their greywater more often as compared to respondents in Ga-Nkwana village and were not reluctant to use it in their gardens. In conclusion, reuse of greywater has a potential to improve household food security. There is a need for the government to subsidize the

households with incentives such as quality seeds and fertilizers in order to enhance their productivity and thus improving their household food security.

Keywords: Food security, availability, accessibility, land, water, Fetakgomo Local Municipality, greywater reuse.

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LIST OF ACRONYMS

AFSUN:	African Food Security Urban Network
AISP:	Agricultural Input Support Programme
AO:	Agricultural Authority
CoG:	Co-operative Governance
CS:	Coping Strategy
DPLG:	Department of Provincial and Local Government
DWS:	Department of Water and Sanitation
DWQ:	Drinking Water Quality
EcoSan:	Ecological Sanitation
EIA:	Environmental Impact Assessment
FAO:	Food and Agricultural Organisation
FANTA:	Food and Nutrition Technical Assistance Project
FBS:	Free Basic Services
FLM:	Fetakgomo Local Municipality
FPI:	Food Price Index
FIVIMS:	Food Insecurity and Vulnerability Information and Mapping Systems
GDP:	Gross Domestic Product
GHS:	General Household Survey
GSDM:	Greater Sekhukhune District Municipality
HDDS:	Household Dietary Diversity Score
HFIAS:	Household Food Insecurity Access Scale
HFIAP:	Household Food Insecurity Access Prevalence

HSRC:	Human Sciences Research Council
IES:	Income and Expenditure Survey
IFSS:	Integrated Food Security Survey
LHWP:	Lesotho Highlands Water Project
MAHFP:	Months of Adequate Household Food Provisioning
MDGs:	Millennium Development Goals
NBR:	National Building Regulations
NFCS:	National Food Consumption Survey
NWA:	National Water Act
NWRS:	National Water Resource Strategy
RVFCW:	Recycled Vertical Flow Constructed Wetland
SANS:	South African National Standards
SAR:	Sodium Adsorption Ratio
SASAS:	South African Social Attitudes Survey
SAWQG:	South African Water Quality Guidelines
SFWS:	Strategic Framework for Water Services
SPSS:	Statistical Package for the Social Sciences
StatsSA:	Statistics South Africa
WFP:	World Food Programme
WFS:	World Food Summit
WMA:	Water Management Areas
WSA:	Water Service Authority
WSP:	Water Service Providers

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CHAPTER ONE

INTRODUCTION

1.0 Introduction of the chapter

This Chapter deals with the background, problem statement, motivation or rationale, scientific contribution and ethical consideration. The study aim and objectives, limitations of the study and operational definitions are also covered in this chapter.

1.1 Background

The global efforts at reducing poverty and food insecurity, as part of the millennium development agenda, have motivated great interests in the geographical dimensions of poverty, food security, natural resources such as land and water, and livelihoods (Szonyi et al., 2010; World Bank, 2007). Land and water resources availability and accessibility are central to the challenges of improving food security and reducing poverty across the world (FAO, 2011). Limited supplies of freshwater are a concern worldwide and especially in South Africa where annual rainfall is well below the world average. Precipitation is unevenly distributed and available water sources are under the added impediments of pollution from agricultural, industrial, mining and municipal etc. activities and over-exploitation. Provision of safe drinking water to communities in mountainous, peri-urban and remote rural areas is a real concern. The long-term needs of South African citizens as far as access to water is concerned, have already been spelt out in key government structures, with the targets for the provision of basic water and sanitation set out in the Strategic Framework for Water Services (SFWS) (DWAF, 2003) as well as in the Millennium Development Goals (MDGs) (UNICEF, 2007). Missing from the policy however, are the goals for managing future scarcity caused by climatic change and demographic shifts, as well as the handling of wastewater.

In South Africa, water is a human right, thus government introduced several measures to ensure that everyone has access to at least the basic level of services at no cost. The Water Services Act 108 of 1997 entitles everyone to a basic water supply and basic sanitation, and every water service institution must take reasonable measures to realise these rights. In terms of this Act, the district (or authorised local municipality) is the Water Service Authority (WSA) within its area of jurisdiction. Section 5 of the Act

further states that if the water services provided by a water services institution are unable to meet the requirements of all its existing consumers, it must give preference to the provision of basic water supply and basic sanitation to them (Van Der Linde & Ferries, 2010). The WSA and Water Services Providers (WSP) are entrusted by the Department of Water and Sanitation (DWS) with the task of ensuring that everyone in the country, including poor households who cannot pay for water services, have access to at least a basic level of service (defined as 25 litres per person per day) at no cost. Despite all the above processes put in place, most rural areas in South Africa are still experiencing the challenges of accessing water services because they cannot afford to pay for municipal services. Tissington et al. (2008) highlights that this problem is due to the fact that some municipalities in South Africa provide Free Basic Services (FBS), mainly the free basic water and free basic sanitation in an ad hoc manner and these in most cases do not comply with national standards.

Rural households use water for multiple purposes (domestic uses such as washing, cleaning, cooking, bathing etc. and productive uses such as making bricks, building houses and irrigation). The pattern of access and uses of domestic water is influenced by socio-economic characteristics of households such as livelihood activities, family size, gender, age of household head, income etc. The implications of lack of clean water and access to adequate sanitation are widespread. Young children die from dehydration and malnutrition, results of suffering from diarrheal illnesses that could be prevented by clean water and good hygiene (Metwally et al., 2006). Diseases such as cholera are spread rampantly during the wet season. Women and young girls, who are the major role-players in accessing and carrying water, are prevented from doing income-generating work or attending school, as most of their day is often spent walking miles for their daily water needs. They are also at an increased risk for violence since they travel such great distances from their villages daily, and are even at risk when they must go to the edge of the village to find a private place to relieve themselves (Lewis, 2016). Lack of FBS, especially water in rural households in relation to agriculture, will increase the vulnerability of the rural poor to poverty and food insecurity. Without water to produce food to consume at home and to sell as a way of generating income, households who view subsistence farming as their main source of food will be negatively affected.

Lack of access to water in the future will be determined by the detailed pattern of change in climatic, demographic, and other processes such as land use change and technical development (Rockström et al., 2009). The ongoing population growth and the expected rising incomes will have implications in terms of rising food demands, not only to feed the growing population but also to meet changing food preferences (Lundqvist et al., 2007). Since food production on either rain-fed land or irrigated land is inevitably coupled to consumptive water use, these changes will also have implications for the local water resources.

1.1.1 Food security

Recent decades have seen global food production increasing in line with and sometimes ahead of demand. Increasing demand for food is an outcome both of larger populations and higher per capita consumption among communities with growing incomes (Vermeulen et al., 2012). To meet this higher demand, food production is obviously of major importance. Food security for households that rely on subsistence agriculture is strongly dependent on local food availability. Furthermore, for the majority who exchange cash, other commodities or labour for food, the access component is of critical importance, especially in relation to dietary diversity and nutrition (Vermeulen et al., 2012).

Food production, especially by small-scale farmers and landless labourers is dependent on rainfed agriculture which is particularly vulnerable due to high seasonal variability in rainfall (Vermeulen et al., 2012). Rainfall is predicted to rise in the tropics and higher latitudes, but decrease in the already dry semi-arid to arid mid-latitudes and in the interior of large continents. Water-scarce areas of the world will generally become drier and hotter. Both rainfall and temperatures are predicted to become more variable, with a consequent higher incidence of droughts and floods, sometimes in the same place. This situation will negatively impact food production both by commercial and small-scale farmers. Climate change will significantly impact agriculture by increasing water demand, limiting crop productivity and by reducing water availability in areas where irrigation is most needed or has comparative advantage. Climate change predictions for South Africa point to a change in the variability of rainfall, with rainfall expected to be more infrequent but also more intense.

1.1.2 Freshwater availability and accessibility

The total volume of water on earth is about 1 400 million km^3 of which only 2.5% is freshwater. Most freshwater occurs in the form of permanent ice or snow, locked up in Antarctica and Greenland, freshwater lakes, wetlands or in deep groundwater aquifers (NEPAD, 2006). The principal sources of freshwater for human use are lakes, rivers and relatively shallow groundwater basins. The usable portion of these sources is only about less than 1% of all freshwater and only 0.01% of all water on earth (UNEP, 2002).

Freshwater resources are unevenly distributed, with much of the water located far from human populations. Many of the world's largest river basins run through thinly populated regions. Nine countries are the world giants in terms of internal water resources, accounting for 60% of the world's natural freshwater namely: Brazil, Russian Federation, Canada, Indonesia, China mainland, Colombia, United States of America, Peru and India. At the other extreme, the water poor countries are usually the smallest (notably islands) and arid ones such as Israel, Jordan, Libyan Arab Jamahiriya, Mauritania, Cape Verde, Djibouti, United Arab Emerites, Qatar, Malta, Gaza strip, Bahrain and Kuwait. Thirty-three countries depend on other countries for over 50% of their renewable water resources (FAO, 2003).

The availability and accessibility of freshwater for socio-economic development is well recognized globally, but with increasing population and industrialization and their demands for water for various uses, water scarcity is looming in many countries of the world. This is particularly the case in Africa where most people live in rural areas and are still heavily dependent on agriculture for their livelihoods (Pietersen & Beekman, 2000). Water is a crucial resource with great implications for African development. The freshwater situation in Africa, however, is not encouraging. Of the estimated 800 million people who live on the African continent, more than 300 million people live in water-scarce environments (NEPAD, 2006). Lack of water hampers development through constraining food production, health and industrial development.

Closely associated with the overall availability of water resources is the problem of water pollution and human diseases. Increases in pollution of surface and groundwater resources not only pose a threat to public and environmental health but also contribute to the high costs of water treatment, thus further limiting the availability of water for use (Pimentel et al., 2004). In addition to threatening the human food supply, water shortages severely reduce biodiversity in both aquatic and terrestrial ecosystems (Pimentel et al., 2004). Humans obtain the great majority of their nutrients from crops and livestock, and these nutrient sources require water, land, and energy for production (Pimentel et al., 2004). Other major factors that limit water availability include rainfall, temperature, evaporation rates, soil quality, vegetation type, and water runoff.

Africa is relatively arid, despite its average annual rainfall of 640 mm per year, its high temperatures and winds foster rapid evaporation (Pimentel et al., 2004). Africa is the second driest continent in the world after Australia. Fourteen African countries are already experiencing water stress and an additional 11 countries will join them by the year 2025, affecting approximately 50% of Africa's projected population (Vorosmarty et al., 2000). Many African nations are also among the countries most vulnerable to climate change (Vorosmarty et al., 2000; Hulme et al., 2001). Trends show a tendency toward greater extremes: arid or semiarid areas in northern, western, eastern, and parts of southern Africa are becoming increasingly drier, and the wetter tropical areas are witnessing intensified precipitation and flooding (Hulme et al., 2001). Continentally, less than four percent of Africa’s renewable water resources are withdrawn for agriculture, domestic supply and sanitation as well as industry.

South Africa is among the 14 African water scarce countries. The country is marked with spatial and temporal variability in the rainfall it receives (Earle, 2005). Total overall average annual rainfall for South Africa is 454 mm, compared with an overall world average of 860 mm. In most of the country the rainfall occurs during summer. It is unpredictable and unreliable and is largely influenced by moist air moving in from the Indian Ocean in the east and south east. The wettest regions are the eastern provinces like Mpumalanga, Orange Free State, Gauteng and Kwa-Zulu Natal with an average annual rainfall of up to 900 mm. The average annual rainfall in the central area of the country is around 400 mm, decreasing westward to less than 200 mm, leaving the

western and north western regions of the country with semi-desert and desert type of climates. An exception to the overall rainfall pattern of South Africa's climate is the south-western part of the Western Cape Province. The area is characterised by a typical Mediterranean climate with the rainfall occurring during the winter period, coming in from the Atlantic Ocean. The average annual rainfall for this area is 515 mm. Total rainfall is greatest in the east of the country and gradually decreases westward. Most parts of the country do not have high rainfall and droughts are an ever-present threat in all provinces. The natural variability in rainfall coupled with the high rates of potential evapotranspiration has placed the gathering, storage and reticulation of water high on the planning agenda from colonial times until the present (Turton et al., 2004).

South Africa's inland water resources are rivers, dams, wetlands, and subsurface aquifers. These water sources together with natural processes, (such as rainfall and evaporation) and anthropogenic influences (such as human-originated abstraction and discharges), form the hydrological cycle that controls the quality and quantity of the country's inland waters. South Africa has both perennial and seasonal rivers. Four of South Africa's main rivers are shared with other countries. These are the Limpopo, Inkomati, Pongola (Maputo) and Orange (Senqu) Rivers, which together drain about 60% of the country's land area and contribute about 40% of its total surface runoff. South Africa is also poorly endowed with groundwater as it is mainly underlain by hard rock formations which, although rich in minerals, do not contain any major groundwater aquifers which could be utilized on a material scale (Earle & Kgomotso, 2005).

Climate change is a key concern within South Africa. Mean annual temperatures have increased by at least 1.5 times of the observed global average of 0.65◦C over the past five decades and extreme rainfall events have increased in frequency (Ziervogel et al., 2014). Climate change poses a significant threat to South Africa's water resources, food security, health, infrastructure, as well as its ecosystem services and biodiversity. Serious impacts of global warming could include loss of biodiversity and increases in deforestation, desertification, and soil erosion. The continued loss of forests and other vegetation and the accumulation of carbon dioxide, methane gas, and nitrous oxide in the atmosphere are projected to lead to global climate change. Over time, such changes may alter precipitation and temperature patterns throughout the world (IPCC, 2002). These major changes are likely to reduce water availability for humans and

other living organisms, including the water needed for crop and forest production (Root et al., 2003). Considering South Africa's high levels of poverty and inequality, these impacts pose critical challenges for national development (Ziervogel et al., 2014).

Limpopo Province is one of the water scarce provinces in South Africa. The province receives summer rainfall and the winters are mild and mostly frost-free throughout the province (Mmbengeni & Makoka, 2002). The province receives an annual average rainfall of 691 mm. Most of the rainfall occurs between November and March with an average ranging between 80 mm and 130 mm (Mmbengeni & Makoka, 2002). Greater Sekhukhune District municipality (GSDM) is one of the five districts in Limpopo Province. GSDM has a very moderate climate, with a relatively normal rainfall and rocky land. According to Mpandeli (2014), the average annual rainfall of GSDM is less than 600mm. GSDM has both perennial and seasonal rives. Due to variability in rainfall and at times lack of rainfall during the rain seasons, some of these seasonal rivers dry up. Fetakgomo Local Municipality (FLM) falls within the GSDM (Figure 1) and has rainfall patterns that are highly variable. The local municipality is in the summer Rainfall Zone (SRZ) of the country and receives more than 80% of its rainfall between November and March. The average annual rainfall of FLM is 51 mm (FLM, 2014).

In Fetakgomo Local Municipality, some of the communities spend about a month without running tap water. These communities are forced to spend money buying water. Most of the people in these households are unemployed and depend solely on either child or old age grants. Those who cannot afford to pay for water resort to water from the wells, fountains or rivers for their domestic water needs and irrigation of their household gardens. The residents also have to share water from rivers with their livestock.

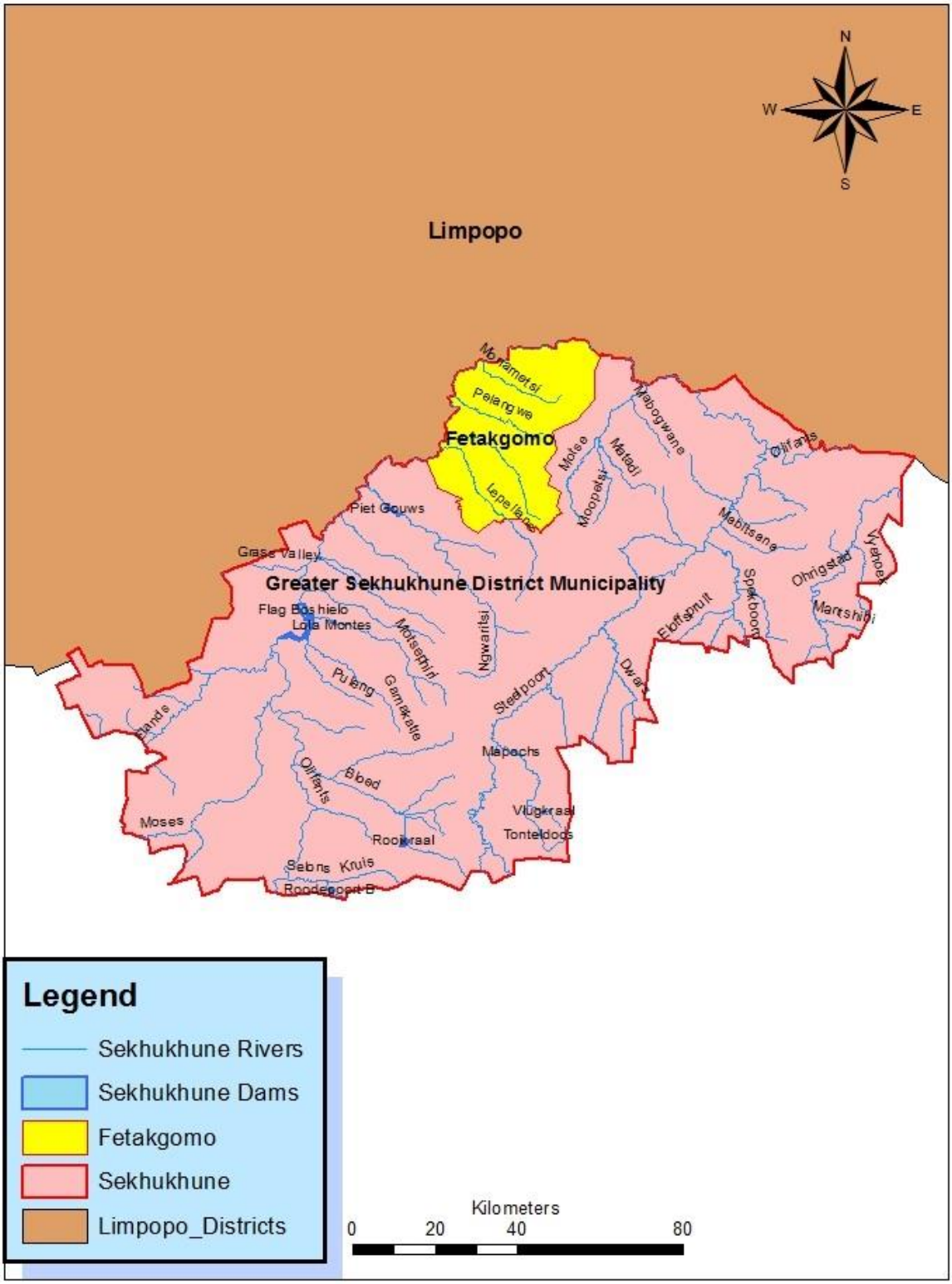

Figure 1: Fetakgomo Local Municipality water sources in context of Greater Sekhukhune District Municipality (Author)

1.1.3 Uses of freshwater in agriculture

Water is the most important source of life which no organism can survive without. Agriculture which is the backbone of human survival cannot succeed without the availability of water (Stern, 1989). Provision of clean water to the community can reduce the outbreak of water related diseases such as cholera since people will refrain from using water drawn from the streams and contaminated rivers (Masibambane, 2006). Water from different resources is withdrawn both for use in agricultural sector and industrial sector as well as for consumption in diverse human activities such as cooking, drinking, cleaning, health and sanitation.

Freshwater requirements in agriculture cover a wide range of consumptive and non-consumptive water uses. Consumptive water use refers to water that is unavailable for reuse in the basin from which it was extracted due to evaporation, incorporation into plant biomass, transfer to another basin, seepage to a saline sink, or contamination. These are sometimes referred to as irrecoverable losses (Pacific institute, 2014). Irrigation is a consumptive use of water because water is extracted from a source and the water is largely consumed by plants. Plants require water for photosynthesis, growth, and reproduction. The water used by plants cannot be recovered, because some water becomes a part of the chemical makeup of the plant and the remainder is released into the atmosphere. The processes of carbon dioxide fixation and temperature control require plants to transpire enormous amounts of water. It is therefore crucial that consumptive uses of water be performed in the most efficient manner possible to minimise water loss. Non-consumptive water use refers to water that is available for reuse within the basin from which it was extracted, for example through return flows. This water, also referred to as recoverable losses, usually has elevated levels of salts and other pollutants (Pacific institute, 2014).

Freshwater use for agriculture represents the dominant water use in the form of abstractions of flowing water for irrigation and as rainwater and soil moisture in croplands and forests (Appelgren, 2004). Irrigation uses about 70% of total globally abstracted water volumes while total agricultural use represents about 92% of total uses of flowing water and rainwater. Agriculture produces the necessary food for the world's populations under both rainfed and irrigated conditions (Appelgren & Klohn, 2001). In a wider perspective, agriculture is not only the main consumer of water but also a critical factor shaping important terrestrial and freshwater biomes that form part

of necessary life-supporting eco-system services. Agriculture has also become a critical cause and a source of water pollution that has also upset the nutrition cycle in the watercourses and soil-water systems and rendered the water unsuitable or less valuable for other water uses (Appelgren, 2004).

1.1.4 Ways to supplement water for food production

Faced by increasing demands for freshwater supplies to sustain their rising populations, many African countries are embarking on large engineering projects such as building dams, water diversion, extraction of fossil groundwater, rainwater harvesting and greywater reuse to secure their needs. Reuse of greywater offers one means of relieving pressure on freshwater supplies. It is possible that greywater could make some contribution to water conservation and to easing the pressure on sources of potable water by replacing this water in various uses, e.g. flushing toilets, irrigation of gardens, lawns, shrubs and trees, and dust control. The use of greywater in agriculture fits in well with the concepts of Ecological Sanitation (EcoSan) which seek to prevent pollution and disease by managing human urine and faeces as a resource rather than waste, with recovery and recycling of the nutrients (Winblad et al., 2004). It is established practice in a significant minority of households, especially in low income settlements where water is difficult to obtain and families are under financial pressure to minimise use of all resources (Rodda et al., 2010). Use of greywater specifically for irrigation is practised to a lesser extent than for other household uses, but does occur in middle and higher income suburbs in times of drought, and in low income areas to supplement water supplies for food production. Active promotion of greywater use for irrigation in gardens and small-scale agriculture has the potential not only to maximise use of limited water supplies, but also to improve food security in low income settlements (Rodda et al., 2010).

Water harvesting refers to methods used to collect water from sources where the water is occurring in large quantities. Water can also be collected at locations where it is unusable, unless some intervention is practiced to gather the water to locations where it can provide benefits. Rainwater harvesting as a water conservation method, provides a considerable water resource, not only in humid regions but also in semi-arid and arid regions. Large volumes of water flow from roofs. In many regions roof water, has not been collected because traditional roofing materials did not permit easy collection, and storage of collected water was difficult and expensive. However, in

recent years the ready availability of some form of roof sheeting and innovative ideas for water storage have made roof water a serious water resource consideration (Pereira et al., 2002).

In many regions of the world, rural populations continue to use some traditional methods for rainwater collection for their households and for animals. However, there is a need to pay better attention to these systems and support those populations to improve their primitive systems, to make them more efficient and safe with respect to human health. In such rural areas, it is very likely that the villagers are willing to adopt some kind of innovation. Existing systems usually have the potential to be improved and to continue in use for a long time, constituting a valuable alternative to more sophisticated systems, which are generally more difficult to implement and maintain (Pereira et al., 2002). In undulating to flat terrain where runoff collects into large numbers of very small stream channels, the available water resource may be quite large, but its diversity makes it difficult to use. Under these circumstances, it is often possible to capture part or all the flow in a small channel and divert it to another channel. Diversion channels which run almost parallel to the contours can be used to carry this diverted flow to a different location. If diverted flows from a few of these channels can be gathered, there might be enough water to fill an excavated hole or small dam which is deep enough to prevent loss of all the water by evaporation (Pereira et al., 2002).

1.2 Problem statement

Food security becomes apparent when all people, always, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996; FAO, 2009). The term “food security” is used to describe food availability, accessibility and use at many levels, including the global, national, local, household, and intra household levels (USAID, 2013). Establishing food security, particularly household food security, is widely acknowledged as an important milestone in advancing the living standards of the rural poor (Abdu-Raheem & Worth, 2011).

Food insecurity emerges when consistent access to adequate food is limited by lack of money and other resources at times during the year. It affects almost everyone in the world and the rural communities are the ones to feel its major effects. One way of

minimising food insecurity is through subsistence agriculture, which depends on limited natural resources (HLPE, 2013). Availability of natural resources for crop production such as land and water still restrict some rural communities when coming to subsistence agriculture practice. The ever-increasing population through births, urbanisation and immigration puts pressure on land and water resources and the demand for freshwater increases as competition for water between people, farming sector, industries and urban uses increase. Water scarcity is one of the contributors of food insecurity especially in rural areas where subsistence agriculture is still practised. Greywater reuse is one of the water conservation methods which could be used as a substitute for freshwater especially for home gardening purposes.

1.3 Rationale or motivation

Food insecurity had and continues to be a major development problem across the globe, undermining people's health, productivity and often their very survival (Smith & Subandoro, 2007). Efforts to overcome the development challenges posed by food insecurity necessarily begin with accurate measurement of food security using various methods such as National Food Consumption Survey (NFCS), General Household Survey (GHS), Food Insecurity and Vulnerability Information and Mapping System (FIVIMS), Income and Expenditure Survey (IES), South African Social Attitudes Survey (SASAS) (Labadarios et al., 2009) and Coping strategies (CS) (Mjonono et al., 2009). The key indicators for these methods are food availability, accessibility, utilisation and stability at the household level (Labadarios et al., 2009).

South Africa is largely deemed a food secure nation producing enough staple foods or having the capacity to import food, if needed, to meet the basic nutritional requirements of its population (FAO, 2008). Hart et al. (2009) supported the argument that South Africa seems to be food secure at national level, but the same cannot be said about households in rural areas. This is so because there are more people in the average rural households than households in urban areas and most of these households receive small incomes or depend solely on social grants or even supplement their diet with subsistence agriculture produce.

Important natural resources needed for crop production are freshwater and arable land that steadily supplies nutrients and the organic substrate for plant growth (Gensch, 2008). Around 70% of the globally used freshwater resources support agricultural

irrigation purposes (Brown, 2006). Today's agriculture sector faces a complex series of challenges to produce food of better quality while using less freshwater per unit of output and to apply clean technologies that ensure environmental sustainability (FAO, 2010). Freshwater is also one of the major factors that limit the application potential of the gardens for general use such as watering flowers, vegetables and trees to improve household food security (Brown, 2006). According to Adewumi et al. (2009) many communities in South Africa struggle to access reliable and adequate quantities of potable water for diverse water requirements such as drinking, bathing, washing, cleaning, watering trees, flowers and vegetables.

Anthropogenic changes to the environment such as land degradation and urbanisation are occurring at an unprecedented rate, and will likely grow as humans continue to use natural resources in an unsustainable manner and human population continues to explode. The human activities and climate change have interacted synergistically to impact the relationship between social and ecological systems from the late twentieth century (Steffen et al., 2005). Water scarcity is a major problem and its causes are many and interrelated (Abrams, 2009). Scarcity arises when demand grows beyond available supply, whether supply is limited by uncoordinated planning and inadequate hydraulic infrastructure or by the physical availability of water itself. Demographic growth, economic development, urbanisation and pollution are putting unprecedented pressure on renewable water resources, especially in semi-arid and arid regions (FAO, 2012). Water is a critical factor in food production and important for subsistence production especially in rural areas where it could be considered non-negotiable. The acute freshwater challenge facing humankind over the coming 50 years can be met only if action to improve water use in agriculture is taken by saving freshwater through methods such as greywater reuse and practicing sustainability (FAO, 2012). Greywater reuse could be applied as a supplement for freshwater especially for household garden purposes so that low income families can substitute the food they buy by those grown in the household gardens.

1.3.1 Aim

The aim of this study is to evaluate the potential reuse of greywater to improve household food security in communities of Fetakgomo Local Municipality in Limpopo Province, South Africa.

1.3.2 Objectives

The objectives of the study are to:

i. Establish the background characteristics related to the livelihood status of the selected communities in Fetakgomo Local Municipality.
ii. Determine household food availability and accessibility within the selected communities.
iii. Assess the reuse of greywater in relation to home gardening activities to improve household food security within the selected communities.
iv. Ascertain the perceptions on the reuse of greywater for home gardening within the selected communities.
v. Determine the household food security status within the selected communities.

1.4 Scientific contribution

The study falls under the Human-Environment Interactions theory that deals with adaptations of humans on the environment through sustainable development strategies such as water conservation and how they change the environment. Since water is already a scarce resource, the results from the study will be useful to the local municipality of Fetakgomo in policy and decision making especially when coming to food security related matters. The study will also be used to encourage communities to reuse their greywater as a way of alleviating freshwater shortages and thus improving food security. The results will also add to existing knowledge on greywater reuse and it will also help other people academically as the published results will be referred to.

1.5 Ethical consideration

Permission for conducting this research was obtained from the University of Limpopo's Turfloop Research Ethics Committee (TREC) and Fetakgomo Local Municipality as well as headmen of the villages concerned. The researcher took into consideration the confidentiality of respondents by preventing anyone outside of the project from connecting individuals with their responses. Respect for respondents was shown in such a way that, the researcher acknowledged the respondents' individuality, their dignity and their right to make their own decisions regarding matters that affected them, was honest with them, answered their questions and considered their wellbeing at all times. The researcher also took into account the anonymity of respondents in

such a way that, no identifying information such as name, address, email address, contact numbers etc. was collected and the project did not link individual responses with participant's identities. No harm was posed to the respondents and they participated in the research voluntarily. A consent form was used to effect the ethical consideration.

1.6 Limitations of the study

The limitations of the study included:

- Estimation of the amount of crops yield produced by respondents (actual research inquiry) barrier: the respondents provided their crop yields in bunches, small buckets and bags. In order to convert these into kilograms, the researcher had to measure one unit from each to convert the yield into kilograms.
- Transport to and from the field for the researcher and assistant data collectors: the researcher used a family bakkie to collect all the assistant data collectors to and from the surveyed villages, as public transport took long and taxis could not leave without being full.
- Language barrier: some of the questions had to be translated into the interviewees' native language as most of the interviewees were elderly and did not understand English that well.
- Time frame: due to time constraints, data was also collected during the weekend and the researcher and assistant data collectors encountered situations where household heads were attending ceremonies and did not have time to answer the questionnaire and they had to revisit the same household the following day.

1.7 Operational definitions

- **Food insecurity**- Consistent access to adequate food is limited by a lack of money and other resources at times during the year (USDA, 2006)
- **Food security**- A situation whereby all people, always, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life (FAO, 2009).

- **Freshwater-** Freshwater is the naturally occurring water on the earth's surface containing less than 1 000 mg per litre of dissolved solids, most often salts (USGS, 2016).
- **Greywater-** Greywater is spelled and defined differently in different parts of the world. Also, commonly spelled graywater, greywater, or graywater, it refers to untreated household wastewater that has not come into contact with sewage (or "black water") (WHO-ROEM, 2006).
- **Headman-** A person who compose a traditional council and serve the chief in an advisory capacity (Boonzaaier, 2012).
- **Household-** A household comprises either one person living alone or a group of people, who may or may not be related, living (or staying temporarily) at the same address, with common housekeeping, who either share at least one meal a day or share common living accommodation (Thomas, 1999).
- **IDP-** A plan which all municipalities use as a tool to ensure that planning is conducted in a transparent and democratic manner (RSA, 2000).
- **Livelihood-** Ensemble or opportunity set of capabilities, assets, and activities that are required to make a living (Ellis et al., 2003).
- **Local municipality-** A Municipality that shares a municipal executive and legislative authority in its area with a district municipality within those areas under which it falls (Republic of South Africa, 1998) Sec. 35.
- **Water scarcity-** The relative shortage of water in a water supply system that may lead to restrictions on consumption (Kharraz et al., 2012).
- **Ward councillor-** A member of a municipal ward council (RSA, 2000).
- **General Household Survey (GHS)-** An annual survey conducted by the StatsSA and is designed to measure various aspects of the living circumstances of South African households (StatsSA, 2015).

1.8 Summary

The chapter focused mainly on freshwater availability and accessibility, uses of freshwater for agriculture and greywater reuse as one of the conservation methods that could be used to supplement freshwater for agriculture. The chapter also looked at the problem statement, motivation of the study and how the study will be of benefit scientifically as well as the ethical consideration and limitations of the study. The next chapter will focus on the literature review.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Improvements in health over the past century have been underpinned by positive advances in the management of vital resources such as water and land. Water supply, both in quantity and quality, and food security and safety are intertwined (Kirby et al., 2003). Freshwater resources, especially high quality freshwater resources, are becoming increasingly scarce. The driving factors include population growth, urbanisation, economic growth and global climate change (Kirby et al., 2003). The availability of freshwater resources adequate in both quantity and quality is vital to food security and production. It contributes in initial production and in processing (Kirby et al., 2003). Primary production of food requires abundant amounts of water. More than two thirds of all freshwater abstraction world-wide goes towards food production, although freshwater resources are depleted in many areas of the world (Kirby et al., 2003).

This chapter focuses on literature review about food security, methods of measuring food security, use of natural resources for agriculture, water scarcity, and greywater reuse as a coping strategy to improve agricultural production as well as South African legislations that govern the reuse of greywater.

2.2 Food security

Food security was defined at the 1974 World Food Summit (WFS) as: availability always of adequate world food supplies of basic foodstuff to sustain a steady expansion of food consumption and to offset fluctuations in production and prices (UN, 1975). In 1983, FAO expanded the concept to include securing access by vulnerable people to available supplies, implying that attention should be balanced between the demand and supply side of the food security equation, ensuring that all people always have both physical and economic access to the basic food that they need (FAO, 1983). The 1996 World Food Summit adopted a still more complex definition which states that: food security, at the individual, household, national, regional and global levels is achieved when all people, always, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active

and healthy life (FAO, 1996). The State of Food Insecurity (2001) then defined food security as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002).The Declaration of the World Summit on Food Security, published in 2009, defines food security as the condition in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life (FAO, 2009). The definitions of food security have "all people at all times, having physical, social and economic access to food" as their common key words which define food security and also focuses on accessibility, availability, utilization and stability of food.

According to FAO (2009), food security consists of four dimensions: (i) food availability, (ii) economic and physical access to food, (iii) food utilization, and (iv) stability (vulnerability and shocks). FAO's definition of food security encompasses production, consumption, access, and utilization of food. Among the above four dimensions, food utilization is the only dimension that focuses on nutrition, hence, nutritional security is a component of food security. If any of the dimensions is weakened, then food insecurity will occur.

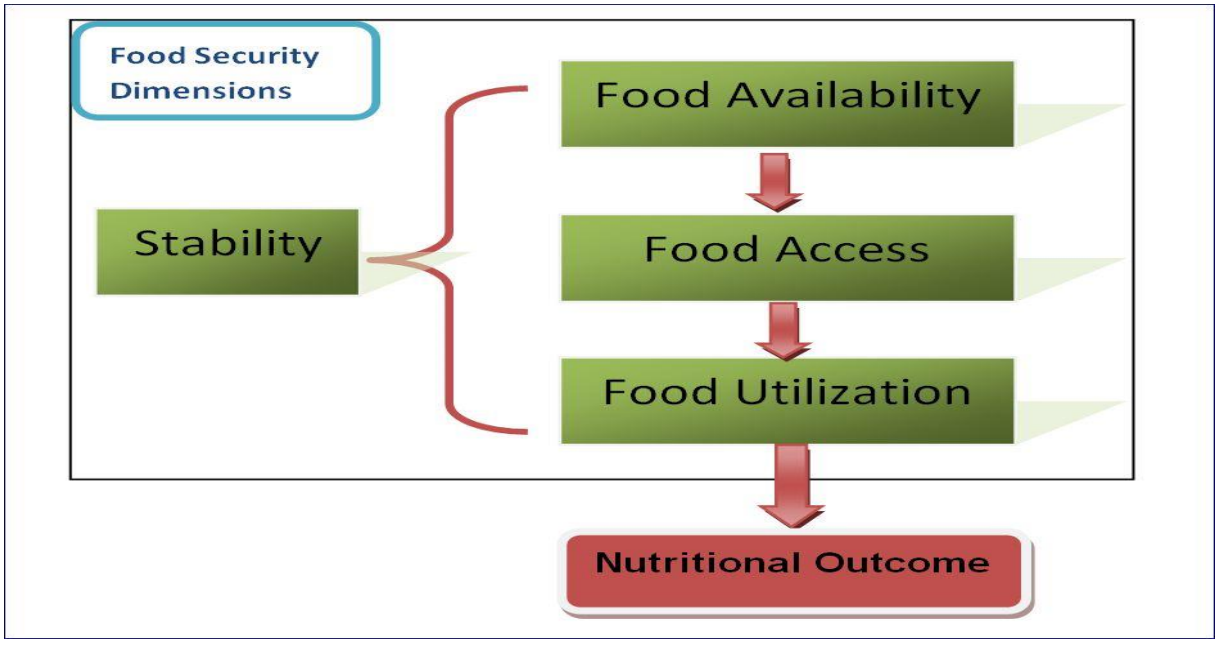

Figure 2. Dimensions of food security (Bajagai, 2013).

The Integrated Food Security Strategy (IFSS) of South Africa (2002) defines food security as the physical, social and economic access by all households at all times to adequate, safe and nutritious food and clean water to meet their dietary and food preferences for a healthy and productive life. Spatial or time aspect of food security definition relates to the fact that a country might be food secure at the national level, but still have local pockets of food insecurity, at various periods of the agricultural cycle (IFSS, 2002) and at different levels. Although the South African food situation is characterised by a state of sufficiency, factors with the potential to compromise the stability of food such as drought, climate change and population growth need urgent attention (DAFF, 2013)

Anderson (1990) sees it fit to distinguish between food security at national and household level. This distinction is crucial since the approaches to assess food security in those levels are not the same (DAFF, 2011). South Africa is food secure at the national level and produces the main staple foods and exports surplus food (Koch, 2011). The country can also import what is required to meet its food needs (IRIN, 2008). National food security indicators reveal that South Africa has been meeting the food needs of its population from domestic sources for the past 20 years (IRIN, 2008). Indicators in 2002 suggested that South Africa met the needs for the main staple, maize, by over 100%. It also met the requirements of wheat, which is the second most important food product, by up to 95% (Koch, 2011).

Despite the success of South Africa's food security at national level, the same cannot be said about household food security. Food security of the urban and rural poor is under threat (Koch, 2011). The urban poor are the worst affected when they do not have access to food, unlike the rural poor, whom at least have access to land to grow food and support their families. Section 27 (1) of the constitution of South Africa states that: every citizen of the country has the right to have access to sufficient food and water. In 1994, the government identified food security as a top priority and has increased spending on social programmes. Feeding schemes at schools, child support grants, free health services for children up to 6 years and for pregnant and lactating women, pension funds, provincial public works programmes and community food gardens initiatives were all introduced as safety nets to improve household food security (DAFF, 2002). Food safety nets do not really make a huge difference in some communities or households as they are not always in place to assist people who are

unable to meet their food needs or to mitigate the impact of natural and human disasters (DAFF, 2013).

Factors influencing household food security include: access to land; livestock ownership; food gardens availability; safe, accessible water supply; stable climatic conditions; access to food shops and income to buy food (Steyn et al., 1999). Food insecurity was non-existent among the African population. However, with the arrival of apartheid in 1948, all this changed. African farming declined through loss of land for agriculture and skills (DAFF, 2002). In rural areas, there was little access to education, health and social services and thus, poverty increased (DAFF, 2002). This was exacerbated by the creation of the Bantu homelands in 1951. Inequalities in access to land, other resources and urbanisation policies have led to household food insecurity in South Africa particularly in rural areas (Vorster et al., 1996).

Recent food security discourse stresses the need for multiple policy, economic and social actions addressing consumer demand, access, supply and nutrition (Grafton et al., 2015). Despite the collective effort to combat famine through continuous progress in production since 1990, reducing undernourishment and, more importantly, improving healthy nutrition remains challenging (FAO, 2012). Increasing population, modernized diet, and climate change will continue to pressure global food systems from agricultural production to nutrition consumption for the next decades (Godfray et al., 2010). Within the global food production and distribution system, poverty reduction strategies have renewed the focus on the role of smallholder agriculture, and identified the importance of upstream and downstream linkages such as other farming activities that are taking place closer to or further from their manufacturing or extraction place than the product in question, as well as non-farm activities (Hazell et al., 2007).

The current food security challenge in the context of South Africa consists of two dimensions: the first tries to maintain and increase South Africa's ability to meet its national food requirements. The second dimension seeks to eliminate inequalities and poverty amongst households that is made apparent by inadequate and unstable food production, lack of purchasing power, poor nutritional status and weak institutional support networks and disaster management systems. Achievement of food security in any country is typically an insurance against hunger and malnutrition, both of which hinder economic development of a country (Davies, 2009). In order to fully understand

food security status of households, better understanding of the poverty status of those households may be necessary in developing solutions for communities (Grobler, 2016).

2.2.1 Food availability

Food availability is the effective or continuous supply of food at both national and household level (DAFF, 2002). Food availability is enhanced by improvements in agriculture and the harvesting of forest products (FAO, IFAD & WFP, 2013). However, availability of food on its own does not ensure food security as food surpluses can exist alongside hunger and malnutrition (Chitiga-Mabugu et al., 2013). Research indicates that food availability may not be the only condition for food security, especially if households lack the financial or productivity resources necessary to acquire food (Adato & Basset, 2012; Miller et at., 2011; Migotto et al., 2006). As much as food availability remains a necessary condition for households and national food security, so remains the affordable access to the available food (FAO, 2015).

Global food availability can be satisfied while hundreds of millions of poor households still remain food insecure (FAO, 2015). The leading cause of household food insecurity is the lack of sufficient income to purchase food in local markets. This is more prominent during seasons and years when food is scarce and expensive (Harris & Orr, 2014; Nawrotzki et al., 2014; Barrett, 2010). As long as the global average production of food per person continues to increase, this pattern will also increase (Jayne et al., 2010).

Although food production has been increasing faster than the rate of population growth for many years, in all regions except sub-Saharan Africa (Jayne et al., 2010), Southern Africa is still undergoing food crisis of greater scale and novelty. The present Southern African food crisis confounds many expectations and food shortages are an ongoing problem. Long-term projections suggest that regional food per capita is likely to diminish into the future (Rosegrant et al., 2010). Farmers and pastoralists have developed some sophisticated coping strategies that are characterised by considerable resilience to climate change related weather extremes, shocks and risks and also accumulated skills including knowledge of wild foods and kinship networks (Davies, 1996). Only when the coping strategies fail, are African societies faced with

entitlement failure which is the inability to command sufficient food to prevent starvation, and outright starvation (Sen, 1981).

The main challenges undermining South Africa's ability to achieve food security is the fact that South African agriculture is made up of a dualistic or bi-modal production structure consisting mainly of few commercial farmers producing for local and export markets while subsistence farmers predominantly produce for household consumption only (Backeberg & Sanewe, 2010). Furthermore, poor land distribution, inadequate and unstable household food production, lack of purchasing power, weak support networks and disaster management systems, poor nutritional status and inadequate safety nets (IFSS, 2002) have contributed to the food security situation in South Africa.

Threats to food availability during the next 10 years include climate change, extreme weather, conflict, diseases, resource constraints such as land and water, and environmental degradation (ICA, 2015). Droughts and famines have afflicted large parts of Africa throughout history and food crisis have had a characteristic demographic and socio-economic profile (de Waal & Whiteside, 2003). A cycle of drought is taking place, in which region wide failures can be expected almost once in every decade (de Waal & Whiteside, 2003).

South Africa relies mainly on the overall performance of the agricultural sector, but also dependent on the country's ability to import, store, process and distribute food (DAFF, 2013). A high proportion of the population in South Africa lives in poverty (Leatt, 2006) and food prices are of great importance when determining whether poor people afford to eat a healthy diet or not (Temple et al., 2011). South African food situation has been and is still characterised by an overall state of sufficiency for the nation, as measured in terms of supply and demand indicators (DAFF, 2013). Although the South African food situation is characterised by a state of sufficiency, factors with the potential to compromise the stability of food such as variability in rainfall, population growth and climate change need urgent attention (DAFF, 2013). As population growth, can be a major stressor for food availability in the long-term, family planning is considered as an important social development (Headey, 2012).

2.2.2 Food accessibility

Food accessibility is the availability of sufficient resources to obtain appropriate foods for a nutritious diet at all times. This relates to promoting sustainable farming practises

such as crop rotation; planting cover crops and soil enrichment; enabling the rural poor access to land for agricultural production to supplement their diet with produced crops and employment of vulnerable rural poor in farms for income generation to enhance their power to purchase food. Promoting agriculture by small scale farmers and subsistence farming and implementing social protection measures for the poor and vulnerable will also improve their diet and encourage the production of nutritious and healthy food (Chitiga-Mabugu et al., 2013).

Access to food has both physical and economic dimensions. The economic dimension of food access pertains to the affordability of food at the household level. Even in areas with adequate infrastructure, households must earn the income required to purchase food in local markets. Many poor households are food insecure because they lack the money to purchase food (FAO, 2015). Food security at national and household levels can be notably impaired by price spikes. These spikes occur in response to regional crop shortages, and the resulting advertisement by producers and consumers in exporting countries (Briones, 2011). The disruption in food trade, caused by the advertisement of commodities for domestic consumption, can elevate a regional crop shortage into a global food crisis, with substantial welfare losses in food importing countries (FAO, 2015). Furthermore, economic dimension may be aggravated by import of production inputs. South Africa imports many of its production inputs, especially fuels and fertilizers and the price of these affects the cost of food (Pangaribiwo et al., 2013).

Lack of knowledge by most of the rural poor regarding sustainable farming practices, unavailability of land for farming, lack of support for small scale farmers and unavailability of social protection measures for poor and vulnerable communities also affects food production. A decline in agrarian activities, including subsistence agriculture, and growing urbanisation have meant that the South African economy has shifted from a net producer of food to a wage economy with net consumers of purchased food. This means that household cash income deficits are a major cause of inadequate access to food, as opposed to a lack of small-scale agriculture. Less than a quarter of households in South Africa are involved in agricultural activities, as a hobby or otherwise. Of that quarter, eighty-four percent (84%) of households engaged in agriculture do so to produce extra food for themselves (General Household Survey, 2011).

Physical food accessibility dimension embraces Sen's core thesis that food availability does not guarantee that everyone is free from hunger (Sen, 1981). Even though the undernourished population in South Africa has increased by 9% despite the 12% increase of global food production since 1990 (Barrett, 2010), this indicates that people were food insecure at a time of abundance (Webb, 2010). At the individual and household level, access to health care centres, social protection, safety net and transfer programs are all important interventions in the context of food and nutrition safety, and particularly access to food issues in the times of crisis (Pangaribiwo et al., 2013).

2.2.3 Food utilization

Food utilization is the appropriate use of food based on knowledge of basic nutrition and care, as well as adequate water and sanitation (Chitiga-Mabugu et al., 2013). Food utilization can also be described as a measure of a population's ability to obtain sufficient nutritional intake and nutritional absorption during a given time period (Pangaribiwo et al., 2013). Food utilization reflects the importance of good health, as both an input to achieving food security and as an indicator of successful outcomes (FAO, 2015). Providing safe water and sanitation to all residents in lower income countries are important objectives, and success in expanding services more broadly to urban and rural residents will improve food and nutritional security (Misselhorn et al., 2012). Improvements in health and sanitation are essential, and so is strengthening children's access to adequate nutrition to enhance food security.

Diversity of diets is essential to the achievement of food and nutrition security. These diverse diets tend to be richer in macro- and micro-nutrients, resulting in high dietary diversity (DAFF, 2013). Poor diet diversification is often associated with micro-nutrient deficiency and is a strong predictor of child stunting and maternal nutritional status (Ruel et al., 2010). Diet variety and anthropometric outcomes can be used to assess the intake and absorption of micronutrients by population (Pangaribiwo et al., 2013). It is essential for people to make best use of available food resources for their nutritional wellbeing and the food must be prepared and consumed in such a way that it ensures maximum nutrition (DAFF, 2013). The neglect of indigenous foods also exacerbates micronutrients deficiencies. The promotion of indigenous crops such as bambara ground nuts, amadumbe and cowpeas is integral to ensuring that household are consuming more diverse diets (DAFF, 2013).

2.2.4 Food stability

Food stability is the stability of the above three dimensions: availability, accessibility and utilizations at all times without risks. Food stability also recognises that food and nutrition security status may change. It also emphasizes the importance of having mechanisms in place to assure the availability, accessibility and utilization which might change with risk (Pangaribiwo et al., 2013). Stability involves risk and uncertainty at the global, national and household levels (FAO, 2015). Globally, over time, the output of major food crops can vary with changes in rainfall patterns, and because of floods, droughts, or pest infestations in key production areas. Such events can impact national food security, which depends on international trade, currency exchange rates and political considerations (FAO, 2015).

Other risks at global and national level might include riots that are sometimes sparked by food shortages or sudden price increases among food products and wars between countries over food and water. At the household level, poor hygiene behaviour, inequitable intra-household food allocation and household member's morbidity reduce micronutrient benefits and impair the stability of the availability, accessibility and utilization dimensions of food and nutrition security for households (Pangaribiwo et al., 2013). Rural households and smallholder farmers are particularly vulnerable to unexpected changes in market conditions. This is so because they are unable to pay higher prices for food when there is a regional scarcity, or are unable to change production options quickly in response to market changes (FAO, 2015). Safety nets and social protection belongs in principal to both stability and access indicators. Food stability dimension has cross-cutting drivers and safety nets such as social grants, government parcels and school feeding schemes programs for the most vulnerable groups; they are still considered as the main barrier for stability. For some groups (elderly and disabled), without social security networks, access to food will always depend on the existence of some kind of transfer/welfare programs (Pangaribiwo et al., 2013).

2.3 Methods of measuring food security

Food security matters immensely as it is a topic of keen interest to policy makers, practitioners, and academics around the world in large part because the consequences of food insecurity can affect almost every facet of society (Jones et al., 2013). Food security is measured because it is critical for targeting food and economic

aid; supporting early famine warning and global monitoring systems; evaluating nutrition, health, and development programs; and informing government policy across many sectors. Measuring food security is complicated by the multiple approaches and tools that are used for assessing food security (Jones et al., 2013).

The South African government committed itself to halve poverty between 2004 and 2014. One of the critical components in meeting that objective is household food security. The link between poverty, incomes and household food security is, however, not at all clear. While some households are poor they might experience food security by means of own food production. Hart et al. (2009) indicates that food security is a broad concept and the meaning and the measurement is not obvious as it may seem. Food security is multidimensional in nature. Accurate measurement and policy targeting, therefore remains a challenge.

According to Anderson (1990) there is sometimes confusion between national food security and household food security. Access to food at household level depends on how food markets and the distribution systems function rather than on total agricultural food production. South Africa lacks a national survey which assesses all dimensions of food insecurity although it uses several instruments to measure household food security. The national instruments used in South Africa to measure the dimensions of food and nutrition security include: National Food Consumption Survey, General Household Survey, Food Security and Vulnerability Information and Mapping System, Income and Expenditure survey as well as South African Social Attitudes Survey.

2.3.1 National Food Consumption Survey (NFCS)

National Food Consumption Survey is a method used to determine the nutrient intakes and anthropometric status of children as well as factors that influence their dietary intake. The survey was conducted twice, in 1999 and 2005. The focus of the survey was households with children between the ages of 1 and 9 years. The survey assessed food procurement, anthropometric indicators (measurements of the size and proportion of the human body) such as stunting, underweight etc. and food inventories of households. The sample population for this study was drawn from the national census sampling framework. According to Hendricks (2005), the instrument assessed nutritional status based on:

- Socio-demographic household factors related to the environment in which the child lived.
- A 24-hour recall of food consumption for the child.
- A qualitative food frequency questionnaire for the past six months.
- An inventory of food procurement and household food stocks.
- A hunger scale questionnaire providing information on actual hunger experienced (or not) by the child.

At national level, stunting was by far the most common disorder affecting almost one in five children, and those children living in urban areas were least affected. The most severely affected were those children living in informal urban areas as compared to those children living in formal urban areas. For South African children, their intakes on most of the measured variables were below two-thirds of the recommended dietary allowances. One in two households experienced hunger, one in four households were at risk of hunger and only one in four households appeared food secure (Hendricks, 2005).

By virtue of its economic growth, South Africa is considered to be one of the countries in sub-Saharan Africa that is undergoing rapid demographic and nutritional transition (Bourne et al., 2001). Several studies have documented the dietary and lifestyle changes that have been part of this transition (Steyn et al., 2000a; Steyn et al., 2000b). These changes include opting for foods that are healthy such as protein, fruits and vegetables instead of unhealthy foods which have high concentration of fats or sugars. Change in lifestyle may include incorporating gym or exercise in daily routines of people who hardly exercise. Such changes have also, in more recent times, been associated with an increase in overweight and obesity in the adult population and an increasing incidence of non-communicable diseases, such as stroke, coronary heart disease, and diabetes mellitus (Fourie & Steyn, 1995). Overweight and obesity have also become common nutritional disorders among children in high- and low-income countries (Yanavski & Yanavski, 2003). South Africa has a complex burden of diseases, which differ not only between different age and gender groups but also between ethnic groups and between urban and rural dwellers (StatsSA, 2000; Labadarios et al., 2011).

2.3.2 General Household Survey (GHS)

General Household Survey is a large national study which asks general questions and which focuses on hunger over time. Between 2002 and 2008, the GHS asked households to indicate whether or not and how often adults and children went hungry because there was not enough food in the household. The question was discontinued in 2009 but reinstated in the 2010 questionnaire. Since 2009, the GHS questionnaire included a set of questions based on the Household Food Insecurity Access Scale (HFIAS) to determine households' access to food. These questions aim to measure household food access by asking households about modifications they made in their diet or eating patterns during the previous month because of limited sources to obtain food (Stats SA, 2012).

The reported levels of hunger in 2008 were very close to those for 2006 and slightly up from the 2007 levels. However, it has remained low at 2.4% for adults and 2.5% for children. In 2002, 6.8% of households said their children and adults suffered from hunger. During all the survey years, female-headed households were more likely than male-headed households to have either hungry adults or children in their households (StatsSA, 2008; Labadarios et al., 2011).

2.3.3 Food Insecurity and Vulnerability Information and Mapping System (FIVIMS)

Food Insecurity and Vulnerability Information and Mapping System is a global system or network of systems that assembles, analyses and disseminates information about people who are food insecure or vulnerable to food insecurity. A regional study conducted in 2005 in selected areas (Mpumalanga and Limpopo) measured hunger in households. Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS), was used to cover 597 households in Sekhukhune. Although this survey was not national in scope, it was included because it measured hunger in some rural South African provinces (Mpumalanga and Limpopo). The results showed that the people in the selected areas were food insecure and lack of rainfall affected their ability to produce crops. The communities also resorted to the coping strategies where adults would skip meals so that children can eat. The results also indicated that a large majority of households were food-insecure and that energy deficit and micronutrient deficiencies were common, resulting in a high prevalence of stunting (Labadarios et al., 2011).

2.3.4 Income and Expenditure Survey (IES)

Income and Expenditure Survey explores the extent of poor households' expenditure on food. The IES provides information on the food spending and home food production patterns. This national survey collects household information on income levels and sources and expenditure patterns. In the 2005/6 survey the diary method was used for the first time together with the recall method. Households were requested to record in a diary provided all the acquisitions of that household over a period of 4 weeks.

The data collection methodology used for the IES 2010/2011, namely a combination of diary and recall methods, was first used in the IES 2005/2006. However, in an effort to improve diary reporting, the diary-keeping period was reduced from one month to two weeks. After extensive testing, the reduced diary-keeping showed an increase in the number of items reported in the weekly diary and had a noticeable impact on reducing respondent fatigue. Despite the reduction to two weeks, the survey was still designed to ensure diary data for every day across the whole 12-month data collection period (StatsSA, 2012).

The results of the IES 2010/2011 showed that the total annual households' consumption expenditure between September 2010 and August 2011 was estimated at R1.25 trillion. The average South African household spent approximately R95 183 with the main components of that expenditure coming from housing, transport, food and miscellaneous goods and services. Following the trend established by previous IESs, housing, water, electricity, gas and other fuels has remained the largest contributor to household consumption expenditure across households.

Expenditure on food, beverages and tobacco accounted for R173 75 billion of the total consumption expenditure for the entire South African households. Households headed by females allocated a higher proportion of their household budget on food, beverage and tobacco as compared to their male counterparts. Females spent R323 175 million of their consumption expenditure on food, beverages and tobacco as compared to males who spent R211 975 million (Labadarios et al., 2011).

2.3.5 South African Social Attitudes Survey (SASAS)

South African Social Attitudes Survey is a nationally representative, repeated cross-sectional survey that has been conducted annually by the Human Sciences Research Council (HSRC) since 2003. The survey series charts explain the interaction between

the country's changing institutions, their political and economic structures, and the attitudes, beliefs and behaviour patterns of its diverse populations. Each round of SASAS has been designed to yield a representative sample of between 3500-7000 individuals aged 16 and older, regardless of nationality or citizenship, in households which are geographically spread across the country's nine provinces. The 2005 survey found out that dissatisfaction with service delivery is present both among impoverished South African families who lack services as well as those who have access to higher levels of service. Crucial differences in terms of incomes and levels of service delivery were identified between the two groupings. Interestingly, respondents with lower incomes and levels of service (absolutely deprived) exhibit high levels of dissatisfaction with service delivery but have correspondingly low levels of distrust in local government (Labadarios et al., 2011).

2.3.6 Measurements of food security used in other countries

In Lesotho, the survey instrument used by Laduka et al. (2015), was the standard African Food Security Urban Network (AFSUN) which is an urban food security baseline survey developed collaboratively by the project partners. AFSUN is an organisation founded in 2008 to generate knowledge on the dimensions of food insecurity among Africa's urban poor, to propose practical solutions on how to feed Africa's hungry cities, and to build the capacity of African researchers, policy-makers, and civil society organizations to develop solutions to the urgent but complex problems of urban food insecurity on the continent. The survey collects basic demographic information on the household and its members, housing type, livelihoods, income-generating activity, food sources and levels of household food insecurity. AFSUN uses four international cross-cultural scales developed by the Food and Nutrition Technical Assistance Project (FANTA) to assess levels of food insecurity. Most of the surveyed households in Maseru (80%) had between 1 and 5 members with an average household size of 4 members. Four main types of households were identified, based on the sex and primary relationship of the household head: female- and male-centred households, nuclear households of immediate blood relatives and extended households of immediate and distant relatives and non-relatives. Twenty-eight percent (28%) of the adult population in the surveyed Maseru households were employed full-time and twenty-one percent (21%) were in part-time or casual employment. As many as half of the adults were unemployed, around ten percent (10%) of employed

household members were away working in South Africa. The results indicated that Maseru is food insecure with a limited diet.

In Zimbabwe, the food security measurement tools used by Tawodzera et al. (2012) are the four measures of food security by AFSUN which have been developed, tested and refined by the Food and Nutrition Technical Assistance (FANTA) project over a number of years (Swindale & Bilinsky, 2006). These included (a) the Household Food Insecurity Access Scale (HFIAS); (b) the Household Food Insecurity Access Prevalence Indicator (HFIAP); (c) the Household Dietary Diversity Score (HDDS); and (d) the Months of Adequate Household Food Provisioning (MAHFP) measure.

The HFIAS measures the degree of food insecurity during the month prior to the survey (Coates et al., 2007). An HFIAS score is calculated for each household based on answers to nine "frequency-of-occurrence" questions. The minimum score is 0 and the maximum is 27. The higher the score, the more food insecurity the household experienced. The individual questions also provide insights into the nature of food insecurity experienced. The individual questions were used to find out if the household members had to worry about not having enough food, were unable to eat preferred food, ate few kinds of food, ate food they did not want to eat, ate smaller portions, ate fewer meals, had no food of any kind in the household, went to sleep hungry or went the whole day and night without eating. HFIAS shows that surveyed households in Harare were amongst the most food insecure in the region.

The Household Food Insecurity Access Prevalence (HFIAP) indicator uses the responses to the HFIAS questions to group households into four levels of household food insecurity: food secure, mildly food insecure, moderately food insecure and severely food insecure (Coates et al., 2007). The surveyed households in Harare scored worse on the HFIAP indicator than those in any other city. In general, in every city except Johannesburg and Blantyre, less than 20% of households fell into the food secure category. Only 2% of the Harare households were food secure, the lowest proportion of all eleven cities.

Household Dietary Diversity Scale (HDDS): Dietary diversity refers to how many food groups are consumed within the household in the previous 24 hours (Swindale & Bilinsky, 2006). The maximum number, based on the FAO classification of food groups

for Africa, is 12. An increase in the average number of different food groups consumed provides a quantifiable measure of improved household food access. According to the HDDS most families ate cereals or foods made from grains, vegetables, sugar and foods mixed with oil, butter, or fat. Less than twenty percent (20%) of households consumed fruit, meat or poultry, eggs or dairy.

Months of Adequate Household Food Provisioning (MAHFP): The MAHFP indicator captures changes in the household's ability to ensure that food is available above a minimum level the year round (Bilinsky & Swindale, 2007). Households are asked to identify in which months (during the past 12 months) they did not have access to sufficient food to meet their household needs. MAHFP indicator shows that about 92% of the households in the survey had experienced some months of inadequate food provisioning during the year preceding the survey. The months of greatest inadequacy were from June to October. During these months, more than 50% of households experienced food shortages.

2.4 Uses of natural resources for agriculture

The world in which man lives contains several resources that make it possible for man to exist on the planet earth and reproduce after his own kind, and produce goods and services to meet his needs. Man, did not create these resources, they were found here on earth existing "in nature". These resources include the geophysical resources of water, soil and its productive qualities, intermediate and long-term carbon stocks, biodiversity of the managed landscapes, and the stability and resilience of the ecosystem of which agriculture is a part (CGIAR, 2003). Water can also be used in industries for fabricating, processing, washing, diluting, cooling, or transporting a product within a manufacturing industry. Agricultural production relies on a set of basic inputs (labour, land, water, seeds, fertilizers, chemicals, animal power, machinery, etc.). The productivity of any one of these inputs varies with the availability of one or more of the other inputs. In terms of the natural resources needed, food production requires mainly water and arable land that steadily supplies nutrients and the organic substrate for plant growth (FAO, 2008).

Land and water are often distributed unevenly around the world and many soils have been depleted or damaged by inappropriate agricultural practices (Gensch, 2008). The

vulnerability of rural people remains considerable owing to a combination of highly variable and erratic precipitation, poor development of hydraulic infrastructure management and markets, non-conducive land and water governance, and a lack of access to water for domestic and productive uses (Faurès & Santini, 2008).

2.4.1 Land

Population and income growth cause increase in the demand for land to produce agricultural products. World production has been growing steadily ahead of population, causing a rising tendency in agricultural and food output per capita. Such growth has been achieved with very little addition of extra land. Land use for agriculture peaked around 1990 and has been stagnant or declining since. Extra land contributed just about 5% of agricultural output growth from 1961 to 2011, and almost nothing in the latest decades (Maletta, 2014).

Land issues relate to access or tenure arrangements for formal and informal settlements, urban agricultural production and locating sites of informal-sector activity. Most poor rural people in the developing world depend on agriculture for their livelihoods in one way or another and most of them are smallholder farmers. In this regard, it has been estimated that about 86% of rural people depend on agriculture as a major source of their livelihoods (World Bank, 2007). In broad terms, it has widely been argued that unequal land access is a bottleneck to poverty reduction and economic growth. In that sense, it is implied that when people gain equitable and secure access to land, economic growth performance tends to be higher and more broadly distributed among the society. Relative to other regions such as Latin America, equality of land distribution is limited in most sub-Saharan African countries (Cotula et al., 2004).

Land scarcity for agricultural purposes can be caused by factors like population pressures, social inequality, and environmental issues. It is also possible for a market to create the perception that available land is scarce when this is not actually the case, which can contribute to the inflation of a real estate bubble. Changes in how people use land can also add to land scarcity. Suburban dwellers might expect a larger, more remote lot, for example, which eats into formerly unused land. Farming techniques can shift over time, adding to land scarcity by requiring more land for agricultural activities. Population pressures are also of concern because the growing numbers of people

need more land to live on and support farming to feed them. Populations can also migrate, which can contribute to land scarcity. Refugees may be driven off traditional lands, for example, requiring relocation, but there may be nowhere for them to settle as a group. This can create tensions that have more to do with the distribution of land than the actual amount of land available. People with limited income and assets may not be able to afford land, especially in a rising economy leading to social inequality even though the land might be available it will still remain inaccessible to many, creating a sensation of land scarcity (Pepeteka, 2013). This will then result in wealthier individuals holding a disproportionate amount of available land, which makes it hard to buy into real estate for people with limited resources. In many regions, land is protected for farming and environment and this can contribute to land scarcity by locking up supplies of potentially usable land although there may be social benefits to this, such as ensuring that countries can produce enough food, or preserving natural heritage (Pepeteka, 2013).

Throughout sub-Saharan Africa, land is a fundamental resource viewed not only as an economic asset, but an essential element in the formation of individual and group identity, constituting the cultural, political and social fabric of rural people (IFAD, 2008). While secure access to productive land is critical for the livelihoods of millions of poor people living in rural areas, current trends and patterns suggest that access to land in many African countries particularly among poor rural households has been in decline attributed to growing demographic pressure, worsening land degradation, and land alienations (Jayne et al., 2010). Southern African countries still experience inequitable land distribution patterns due to the historical legacy of racially-based policies of colonial rule in the region (Jayne et al., 2006). By 2012 post-apartheid land reform had transferred 7.95 million hectares into black ownership (Nkwinti 2012), which is equivalent, at best, to 7.5% of formerly white-owned land.

Jayne et al. (2006) pointed out that increasingly limited and unequal land access has been among the principal challenges facing smallholders in sub-Saharan African countries and also supports the argument that the distribution of available land is highly unequal. One important point is that highly skewed inequalities in the distribution of land is not only limited between minority white commercial farmers and majority black smallholders, as in the case of South Africa, Zimbabwe and few other countries, but major disparities in land distribution has also been witnessed within the smallholder

sector itself. In South Africa, more than 90% of the land was forcibly taken from its indigenous people, reducing the bulk of these people to permanent and migrant workers. Those who remained in the rural areas of the former homelands were gradually forced to rely on non-agricultural activities primarily in the form of remittances from migrant workers and later state pensions of various sorts. Land shortage in the rural areas of the former Bantustans and the growing population in these areas in particular, made crop production especially difficult to embark upon (Ntsebeza, 2010).

According to South Africa's Natives Land Act no 27 of 1913, Africans were restricted to buying, leasing and selling land only in the demarcated areas which were referred to as 'reserves' while whites were prohibited from owning land in those areas. The demarcated areas amounted only 7.3% of the whole of South Africa while the area set aside for the White minority was almost ten times larger than that of the African majority. Land available to Africans was later increased by 5% through the Native Administration Act no 38 of 1927, the Bantu Trust and the Land Act no 18 of 1936, which provided for the conversion of the reserves into Homelands. The process of dispossession culminated in the Apartheid era accompanied by the forced removal of numerous black communities (African, Coloured and Indian). Thus, millions of people were evacuated from their ancestral lands often with deliberate cruelty and without compensation. The current highly skewed and racially-unequal pattern of land ownership is evidence of the territorial segregation brought about by the 1913 Native Land Act. With the abolition of Apartheid in 1994, South Africa began the process of redressing past injustices through land reform and a broad-based programme of economic empowerment of the black population in the agricultural sector (Pepeteka, 2013).

South Africa has one of the most unequal distributions of income in the world, with income and quality of life being strongly correlated with race, location and gender (May, 2000). Since 1994, South Africa has embarked on a multi-faceted programme of land reform, designed to redress the racial imbalance in land holding and secure the land rights of historically disadvantaged people (Lahiff et al., 2004). In terms of overall achievements, land reform in South Africa has consistently fallen far behind the targets set by the state, and behind popular expectations. In 1994 virtually all commercial farmland in the country was controlled by the white minority and the incoming ANC government set a target for the entire land reform programme

(redistribution, tenure reform and restitution) of redistributing 30% of white-owned agricultural land within a five-year period (Williams, 1996; African National Congress 1994). By July 2006, a total of 3.4 million hectares had been transferred through the various branches of the land reform programme, benefiting an estimated 1.2 million people (although many of these are members of large community-based restitution claims and have no direct access to the land in question) (Lahiff et al., 2004). Land redistribution, however, has moved slowly. By 2010, only 7.4 million hectares of farmland had been transferred under this programme, representing 29.6% of the 2014 target (Provincial budgets and expenditure review, 2010/11- 2016/17).

Agricultural production in South Africa can be divided broadly into two categories: well-developed commercial farming and smaller-scale farming largely on communal land and predominantly in the former homeland areas. Commercial agriculture remains important to the South African economy. In 2007, primary agriculture contributed just fewer than 3% of South Africa's Gross Domestic Product (GDP) (NDA, 2008). The average size of a commercial farm is about 2 500 ha. At the other end of the scale, 1.3 million small-scale farmers use about 14 million ha with an average farm size of just over 11 ha (Koch, 2011). The different nature of commercial and small-scale farming in terms of irrigation, crop type and use of the produce has implications for food security. This is based on the fact that for each type of farming there is a different relationship between water and food production. The deregulation of agricultural markets and services and the withdrawal of state support to commercial farmers after 1994 resulted in an increase in large-scale intensive farming in high production areas and a shift from maize production to livestock production in marginal areas (Goga & Pegram, 2014). Provinces that have historically had large homeland areas, like the Eastern Cape, KwaZulu-Natal and Limpopo, have a higher proportion of households practicing agriculture. This is due to the larger proportion of rural populations and a favorable climate for small-scale agriculture to supplement dietary requirements.

2.4.2 Water

Water is one of the basic resources, but it is often in short supply. Population and economic growth increases the demand for water. Global demand for water has tripled since the 1950s, but the supply of freshwater has been declining (Gleick, 2003). Half a billion people live in water-scarce countries, and by 2025 that number will grow to

three billion due to an increase in population. The agricultural sector is the largest consumer of water. Around 70% of the globally used water resources are used for agricultural irrigation purposes (Brown, 2006). In Africa and Asia, an estimated 85-90% of all freshwater used is for agriculture (Shiklomanov, 1999). Although agriculture is the main water consumer, it cannot be compromised due to its role in domestic food security and export supplies (Chiuta et al., 2002).

Industrial uses account for about 20% of global freshwater withdrawals. Of this, 57-69% is used for hydropower and nuclear power generation, 30-40% for industrial processes, and 0.5-3% for thermal power generation (Shiklomanov, 1999). Domestic water use is related to the quantity of water available to populations in cities and towns. Analysis indicates that people in developed countries on average consume about 10 times more water daily than those in developing countries. It is estimated that the average person in developed countries uses 500 l-800 l per day (300 m^3 per year), compared to 60 l-150 l per day (20 m^3 per year) in developing countries (UNESCO, 2000).

In sub-Saharan Africa, more than 60% of the households live in rural areas and rainfed agriculture is their main or only source of livelihood (Faurès & Santini, 2008). Rainfed cereal crops, roots and tubers are the main sources of food and income, but have limited nutritional content and low market value and, thus, have low poverty and malnutrition reduction potential (Burney et al., 2013). Due to lack of access to water, agricultural production is often interrupted during the dry season when many farmers must rely on food stocks accumulated during the rainy season and/or on food purchases (Domenech, 2015).

Rural livelihoods in developing countries often comprise of more than one activity to provide food, cash and other goods, satisfying a range of human needs (Chambers & Conway, 1992). Rural livelihoods in sub-Saharan Africa are highly dependent on natural resources and water may be one of the largest constraints to expanding and diversifying livelihood activities. However, water supply programmes typically focus on providing water to meet basic or domestic needs, such as drinking, cooking, washing, and bathing, and fail to incorporate household-based productive use (Faures & Santini, 2008). Access to water is also of central concern, not only for clean potable water for domestic purposes, but also for use in irrigating gardens, and for other

entrepreneurial livelihood activities (Gordon et al., 2000). Access to safe potable water for domestic use and for use in informal-sector activities associated with food processing is obviously crucial. Water is also important to the livelihoods of the urban poor as a waste product used for irrigating agricultural plots and in aquaculture (Binns & Lynch, 1998). A livelihood is described as the capabilities, assets and activities required for a means of living (Chambers & Conway, 1992). A sustainable livelihood can cope with, and recover from, shocks and stresses and can maintain or enhance its assets and/or capabilities and provide the same opportunities to the following generation (Knowles & Wareing, 1996). Population and income growth will increase the demand for irrigation water to meet food production requirements, household and industrial demand.

With respect to the water availability internationally, South Africa ranks very low in terms of water availability per capita. According to The World Factbook, South Africa ranks 93rd in terms of long-term average water availability for the country in cubic kilometres of precipitation, recharged ground water, and surface inflows from surrounding countries. In South Africa, water services are a critical component to the development of communities. A large part of the country is dry and dependent on the capacity of local government to provide piped water to households (Basson, 1997). The rainfall of South Africa is one of great variability. South Africa receives low rainfall of about 450 mm annually by an international standard which is about 60% of the world's average of 860 mm. All but the south-western and southern regions of South Africa rely on summer rainfall, which normally falls between October and March. Rainfall is heaviest in the east and decreases westward (SAWS, 2016).

The effects of variable rainfall patterns and different climatic regimes are compounded by high evaporation rates across the country. The physical scarcity of resources in South Africa means that there are significant trade-offs between food, energy and water. Water is the most significant resource constraint, since South Africa is a water-scarce country that experiences huge variations in temporal and spatial distribution of rainfall. At the same time, there is limited water for irrigation and the electricity-generation sector is largely coal-fired and thus water-intensive (Goga & Pegram, 2014). Access to safe drinking water and sanitation is fundamental for the enjoyment of other rights such as the rights to education, health, safety and an environment that is not harmful to human health or wellbeing (SAHRC, 2014). Lack of access to water

and sanitation not only hinders access to other rights, but increases the vulnerability of certain groups of people such as people with disabilities, women and girls especially during their monthly periods.

According to the key results from the 2011 Statistics South Africa (StatsSA, 2011) Census, 46.3% of households in South Africa have access to piped water. Just over 85% have access to water that is of a Rural Development Programme (RDP) acceptable level. This level of access, however, is not reflected across all provinces in the country. In the Eastern Cape, 31.1% of households do not have access to water of an RDP-acceptable level while the same is true for 27.2% of households in Limpopo. Most of the communities in Limpopo, although they have access to indoor home taps and communal taps, the water is not available daily. Access to water for productive purposes is highly skewed, with 95% of water used in agriculture being in the hands of white commercial farmers (Goga & Pegram, 2014).

Agriculture has to compete increasingly for water resources with domestic demand, industry, tourism, commerce and infrastructural institutions. The provision of water for small productive activities, such as home gardens, fruit trees and small off-season vegetable plots, helps in addressing land and labour bottlenecks, of female-headed households in multi-local livelihood systems (Faurès & Santini, 2008). Water problems related to water-use management are typically studied at the farm-level, the river-catchment-level or the country-level. Rural and agricultural water use can be analysed in terms of three main components: access, control, and management. Access describes the degree to which a household can obtain water from rainfall (in rainfed conditions), surface water sources, groundwater, surface or subsurface return flows from agriculture, or wastewater from urban or peri-urban areas. Control describes how well a household can move water from a source to the location at which the water is applied. Elements within the control component might include farmer-operated canals and ditches, small pipelines, and sharing arrangements with other farmers. Management describes farm-level decisions and practices regarding the application of water for crop and livestock needs. Agricultural activity has always included adaptation to several diverse stresses and opportunities-elements that continue influencing developments in the agri-food sector. Climate and weather conditions are a good example of factors that require on-going adaptation (Wall & Smit, 2005).

Although water-scarce areas do not represent a large share of the world's population in absolute terms, semi-arid areas and dry sub-humid climates such as savannahs and steppe ecosystems are hosts to many malnourishment hotspots in which rainfed agriculture is the primary source of food, and where water scarcity limits crop growth (Molden, 2007). While rainfed agriculture relies on soil moisture generated from rainfall, irrigated agriculture focuses on withdrawals of water from surface and groundwater sources. Surface water and groundwater are both important sources not only for human use but also for ecological systems. While in some countries groundwater resources still are abundant and readily available for development, in others depletion due to over-drafting, water-logging, salinization as well as pollution cause severe problems (Calzadilla et al., 2010). Similarly, overexploitation of surface water resources in some regions is damaging aquatic ecosystems by reducing water flows to rivers, lakes and wetlands. Since world-wide use of surface water has remained constant or increased at a slower rate, the increase in global water use in recent years has been based on groundwater (Villholth & Giordano, 2007).

2.5 Water scarcity

Water scarcity refers to the relative shortage of water in a water supply system that may lead to restrictions on consumption (Kharraz et al., 2012). Abrams (2009), while re-iterating the relative nature of water scarcity, also defined it as a concept describing the relationship between demand for water and its availability. He stressed the fact that the demands vary considerably between different countries and regions depending on the sectoral usage of water, and highlighted the fact that it also varies according to local climatic conditions. The cause of water scarcity in each area varies. In other areas, the causes may be natural, while in other areas they may be human made. Scarcity is the extent to which demand exceeds the available resources and can be caused either by drought and floods or by human actions such as population growth, water misuse and inequitable access to water (Kharraz et al., 2012). Water scarcity is already a critical concern in parts of the world (Fedoroff et al., 2010) and by acknowledging that scarcity is the result of multiple causes and therefore, requires different responses, three main dimensions of water scarcity should be considered:

- Scarcity in availability of water of acceptable quality with respect to aggregated demand, in the simple case of physical water shortage;

- Scarcity due to the lack of adequate infrastructure, irrespective of the level of water resources, because of financial, technical or other constraints; and
- Scarcity in access to water services, because of the failure of institutions (including legal rights) in place to ensure reliable, secure and equitable supply of water to users. This dimension brings together the organizational and accountability dimensions proposed by the World Bank (2007).

There are growing public concerns that the footprints of food security on the environment are substantial (Khan & Hanjra, 2009). The severity of the water crisis has prompted the United Nations (UNDP, 2007) in concluding that it is water scarcity, not a lack of arable land, which will be the major constraint to increased food production over the next few decades. Water scarcity is fundamentally dynamic and varies in time because of natural hydrological variability, but more so as a function of prevailing economic policy, planning and management approaches and the capacity of societies to anticipate changing levels of supply or demand (FAO, 2012).

Causes of water scarcity vary in nature and require specific responses. In South Africa, like everywhere else in the world water is becoming a scarce resource and a crucial one, particularly because people and different economic activities such as industries, agriculture, power generation etc., all require water. Often moving water over long distances from dams or rivers to sustain industries and people living in towns and cities is no easy task, since such dams are not conveniently located (Stone, 2009). The Comprehensive Assessment of Water Management in Agriculture (CA, 2007) states that water scarcity is a critical constraint to agriculture in many parts of the world. Based on prior work by Seckler et al. (1998), it distinguishes two main types of water scarcity, namely physical scarcity and economic scarcity.

2.5.1 Types of water scarcity

Water scarcity can be grouped into two types, namely physical and economic scarcity.

- Physical water scarcity

Physical water scarcity occurs when there is not enough water to meet all demands, including environmental flows. Physical water scarcity can be divided into two main concepts: demand-driven scarcity (water stress) and population-driven scarcity (water shortage) (Falkenmark et al., 2007). Demand-driven scarcity can be measured by examining how much water is being withdrawn from rivers and aquifers, known as the

use-to-availability index. The water shortage is related to the number of people that have to share each unit of water resources, and can be measured by using the water crowding index, also known as the Falkenmark water stress index (Falkenmark et al., 2007). It should be noted that there are various categories of water demand, the main ones being water for industrial and municipal water supply, agricultural and environmental needs. The role of environmental water requirements in physical water scarcity calculations has only recently been assessed by Smakhtin et al. (2004). Indices aiming to combine physical and social water scarcities include the water poverty index (Sullivan et al., 2003) and the social water stress index (Ohlsson, 1998).

- Economic water scarcity

Economic water scarcity is a situation caused by lack of investment in water infrastructure or insufficient human capacity to satisfy the demand of water especially in areas where the population cannot afford to use an adequate source of water. Countries having adequate renewable resources with less than twenty-five percent (25%) of water from rivers withdrawn for human purposes, but needing to make significant improvements in existing water infrastructure to make such resources available for use, are considered “economically water scarce” (Seckler et al., 1998). An estimated 1.6 billion people around the world live in areas of economic water scarcity, with 780 million people living in areas with no basic water services (Paulson, 2015). Economic water scarcity is predominant throughout Africa, particularly in sub-Saharan Africa.

2.5.2 Causes of water scarcity

Water scarcity can be caused by numerous factors which include and are not limited to the following:

- Climate change

According to Zhang (2007), climate change is the cause of change in the distribution of the world’s water. This conclusion boils down to the fact that water availability is also dependant on climatic conditions. Scarcity of water for domestic use may further be linked to low flow periods during summer. High temperatures during summer periods call for more water for agricultural purposes (Middelkoop et al., 2001). Impacts of climate change will be both short term, resulting from more frequent and more

intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns. Climate change will increase water shortages due to change in precipitation patterns and intensity. It will also decrease natural water capacity from glaciers or melting of snow-caps and subsequently reduce long-term water availability. Climate change will focus melting of snow and precipitation into shorter time frames, making water releases more extreme and drought events more continuous, affecting the capacity and reliability of water supply infrastructures (Zhang, 2007).

Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels (FAO, 2008). Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock (FAO, 2008). Climate change affects everyone and everything in the world and the effects are greater among poor people in developing countries who are highly dependent on climate-sensitive natural resources yet have the least adaptive capacity to cope with climate impacts (FAO, 2015). Climate change will increase water demand for agriculture, primarily for irrigation, due to prolonged dry periods and severe drought as well as excessive rainfall. Fischer et al. (2007) estimated over 40% increase in irrigated land by 2080. Higher atmospheric temperatures increase water demand for hydration needs of billions of farm animals. Increased atmospheric and water temperatures increases the quantities of water needed for industrial cooling (Smith et al., 2006). Climate is the primary determinant of agricultural productivity. Given the fundamental role of agriculture in human welfare, concern has been expressed by federal agencies and others regarding the potential effects of climate change on agricultural productivity (Abrams et al., 1998).

Climate change will influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain. Crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like

droughts, floods, and wind storms (Abrams et al., 1998). Plausible climate change scenarios include higher temperatures, changes in precipitation, and higher atmospheric CO_2 concentrations. Although temperature increases can have both positive and negative effects on crop yields, in general, temperature increases have been found to reduce yields and quality of many crops, most importantly cereal and feed grains (Abrams et al., 1998).

- Drought

Drought can be defined as a prolonged period of abnormally low rainfall, leading to a shortage of water. Droughts are natural phenomena and can be classified as hazards or disasters. They can be called disasters because during drought, there is little or no precipitation resulting in the disruption of the water supply to the natural and agricultural ecosystems as well as human activities. They can also be regarded as hazards because they occur naturally and are unpredictable (Pereira, 2005). Drought is probably the most common form of disaster affecting rural communities, occurring with varying magnitude almost every year in some parts of South Africa. Droughts affect the rural poor in several ways including loss of subsistence crops and livestock, loss of agricultural jobs and food price inflation (May et al., 1998).

When a drought event begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can be rapidly depleted during extended dry periods (Pereira, 2005). A balance must be maintained between the water supplied and the surface run-off to replace it. South Africa is a semi-arid to arid country with a highly variable climate with highly constrained freshwater resources. These limited water resources are affected by weather extremes imposed by climate variability and change. Drought, which devastated parts of the country, is a recurrent characteristic feature of the country's highly variable climate and weather extremes (WRC, 2015).

In 2009 to 2011 the Southern Cape Region was devastated by a severe drought while the rest of the country generally received above normal rainfall. The severity of the Southern Cape drought was amplified by the interacting risk drivers that had progressively escalated the risk of a widespread water shortage (WRC, 2015). These drivers included climate variability, changing weather conditions and greatly increased

water consumption before the onset of meteorological drought conditions, both in agriculture and in rapidly growing coastal towns. Prior to the drought emergency in this region, the water resource development had not kept pace with rising demand, there was no rigorous water conservation and demand management, and there was a lack of systematic drought risk management planning (WRC, 2015).

- Surface runoff

Runoff has, according to Wallace (2000), been shown to be a major loss of water. When rainfall is high and infiltration rate is low because of steep slopes, runoff becomes high and a high quantity of water is lost. During heavy rainfalls, less water infiltrates the surface to form groundwater and be stored in aquifers because most of the surface runoff is lost to rivers, sea and oceans. This reduces the water table or underground water for irrigation and other uses. Uitto & Biswas (2000) theorized that, surface runoff is also a cause for drinkable water shortage. This is due to the fact that, flood carries different objects from the ground into the drinkable water sources. The rivers, fountains and dams that normally provide water to the households may be rendered undrinkable during heavy floods and also for some days or weeks after the flood. At times, a river which may be a sole source of clean water for the community may also become a source of flooding. This may lead to a situation whereby the community is left without water for household use (Uitto & Biswas, 2000). Similarly, Twort et al. (2000) agree that, the peak runoffs are difficult to estimate as a result of the damage occasioned by the debris and sediment brought down by the floods. These objects render the water unusable for some household activities including drinking.

- Earthquakes

Earthquakes may cause water shortage in that, they may destroy a variety of infrastructures including those of water supply. The water service may be destroyed for days, weeks, months or even for longer periods depending on the seriousness of the damage (Uitto & Biswas, 2000).

- Evapotranspiration

Evapotranspiration is a combination of the two processes, namely, evaporation and transpiration. The term evapotranspiration comes from combining the prefix “evapo” (for soil evaporation) with the word transpiration. Both soil evaporation and plant transpiration represent evaporative processes; the difference between the two rests in the path by which water moves from the soil to the atmosphere. Evapotranspiration is the key part of the hydrological cycle. Oceans, seas, lakes and rivers provide nearly 90 percent of the moisture in the atmosphere via evaporation with the remaining 10 percent being contributed by plant transpiration (USGS, 2016).

- Population growth

Population growth is a major contributor to water scarcity. Population growth increases both the demand for freshwater and the amount of wastes that are discharged into the environment, thus leading to more pollution of scarce water resources. Many nations are over pumping their water resources which concurrently could lead to the simultaneous depletion of surface and groundwater, and in turn, cause agriculture cutbacks. Thus, the world’s current water scarcity could soon lead to a devastating food scarcity (Brown, 2006). The most water stressed areas are typically those with few water resources, high population densities, and high population growth rates (UN-Water & FAO, 2007). Population growth limits the amount of water available per person, drives people into marginal regions which are already water stressed and also into cities.

At the household level, demand for water is determined by demographic factors, economic status and educational levels of people. Other demographic factors such as population distribution, age structure and increase in income level (UNPD & FAO, 1994) modify the pattern in demand and determine increases in household water demand.

- Economic growth

Demand of water for industrial use is increasing with rapid industrialization to meet the many needs of a growing population. Increase in income level and the changes in consumption pattern play a larger role (UNPD & FAO, 1994).

2.5.3 Impacts of water scarcity on agriculture

Water scarcity leads to enormous problems for the populations and societies. The available water is not sufficient for the production of food and for alleviating hunger and poverty in regions, where quite often the population growth is larger than the capability for sustainable use of the natural resources. The lack of water does not allow industrial, urban and tourism development to proceed without restrictions on water uses and allocation policies for other user sectors, particularly agriculture. Poverty associated with water scarcity generates migratory fluxes of populations within countries or to other countries (Pereira et al., 2002).

Agriculture, and in particular irrigated agriculture, is undergoing rapid changes and facing a lot of challenges such as growing competition for water and increased scarcity, climate change and increased water demand by energy sectors. Farmers across the world have to adapt to a world where trade and globalization have rapidly increased interconnection and interdependence between people's production and consumption patterns, and where technological progress has boosted agricultural productivity (FAO, 2012). Agriculture is both a cause and a victim of water scarcity. Inter-sectoral competitions for water is most obvious in the hinterlands of large urban centres, but water scarcity can arise in all catchments where the intensification of agriculture in headwater areas reduces water supply downstream (FAO, 2012).

The current high food prices have their origins in 2000, when global grain stocks began to decline steeply from over 110 days' worth of food to just over 60 days' worth in 2004. The per capita availability of food declined from 177 kg per person per year in 1991 to 152 kg per person per year (WHO & FAO, 2004). Extreme weather in 2006 caused cereal production to decline by 21%. Starting in 2006, food prices rose sharply. The Food Price Index (FPI) rose by 9% in 2006, by 24% in 2007 and by 51% in the 12 months leading to July 2008 (FAO, 2009). This trend has continued, with the price of wheat increasing by between 60-80% by September 2010 as a result of drought and fire in Russia and the Ukraine (HNA, 2011). For most of the last decade, food prices have been volatile and largely on the increase. In 2002, the World Food Programme (WFP) warned of a famine in sub-Saharan Africa and similar warnings have been issued since 2008. South Africa is not immune to rising food prices. It is part of an interconnected global system and participates in global trade. South Africans are thus

also feeling the effects of the global food crisis due to climate change related extreme weather events, causing variabilities in rainfall and water scarcity (Earl, 2011).

2.5.4 Ways to cope with water scarcity

Coping with water scarcity means to live in harmony with the environmental conditions set by limited available water resources. In the future, the natural resources needed to sustain the human population will exceed available resources at current consumption levels. There are various ways or measures for coping with water scarcity and the ones that will be discussed in this section are: surface water capture and storage, return flows, inter-catchment water transfer, desalination, household water usage control, as well as greywater reuse.

- ❖ Surface water capture and storage

Surface water capture and storage is the capturing and storing of stormwater runoff from impervious surfaces when it rains. This can be done through directing the runoff to open spaces and allowing the water to infiltrate into the ground to recharge groundwater supplies or by harvesting the runoff. Runoff can be harvested primarily from rooftops into drums and tanks for direct use in non-potable water applications. Surface water runoffs may be moderated by erecting structures to dam or divert rivers and store water in a natural lake or reservoirs. Though the overflow of water during rainy seasons may be captured into dams or reservoirs, these have to be balanced against the value of storing water from year to year as insurance against drought. This means that there should be budgets for taking care of these resources or for payment of personnel taking care of them (Machete, 2011).

South Africa depends mostly on rivers, dams and underground water for water supply. The country does not get a lot of rain, around 450 mm a year. South Africa is one of the driest countries in the world and to maximize water for drinking, growing food and for industries the government builds dams to store water. These dams make sure that communities don’t run out of water in times of drought. About half of South Africa’s annual rainfall is stored in dams and these dams can also prevent flooding when there is an overabundance of water. Reservoirs are usually found in areas of water scarcity or excess, or where there are agricultural or technological reasons to have a controlled water facility. Where water is scarce, for example, reservoirs are mainly used to

conserve available water for use during those periods in which it is most needed for irrigation or drinking water supply. When excess water may be the problem, then a reservoir can be used for flood control to prevent downstream areas from being inundated during periods of upstream rainfall or snow-melt (Thornton et al., 1996).

The Gariep Dam, in the Free State, has the largest storage capacity ever built in South Africa. Constructed in 1972, it stores water from the Orange River in a 100 km long dam with a surface area of 374 km^2. Dams are not always a good thing. If they are not planned properly they can have devastating effects on rivers and freshwater ecosystems. It is very important to choose dam sites that will have the least impact on the environment. Dams can change the hydrology of the river and disturb the seasonal fluctuations. Dams also change daily flows by releasing water as a reaction to demands for irrigation, energy and so on (South, 2005).

According to the National Environmental Management Act 107 of 1998, Environmental Impact Assessment (EIA) must be carried out before construction of a new dam or enlargement/repair of an existing dam and licence must be issued.

- ❖ Return flows

Return flow is surface and subsurface water that leaves the field following application of irrigation water or the treated effluent from wastewater treatment works that is released back into receiving water bodies such as rivers. Return flows in irrigation systems generally return to the irrigation centre after a period of about three to four weeks. Due to this, farmers usually need to pour bleach into the water to clean it of any organisms that have entered the stream. If this is not taken care of, diseases such as typhoid or cholera could enter the irrigation system and pose a risk of epidemic disease to surrounded towns and cities (Cram101, 2016).

In the interior of the country most of the water used in a non-consumptive manner is directly recycled for re-use, or is returned to the rivers after treatment, thereby becoming available for re-use (NWRS, 2004). In urban and industrial areas such as Pretoria and Johannesburg approximately 50% of the total water requirements becomes available as return flow and is re-used. Similar return flows are available in coastal cities such as Cape Town, and the Durban/Pietermaritzburg area, but only about 5 and 15% respectively is re-used in these cities (NWRS, 2004).

Several municipalities were tasked to conduct feasibility studies of water re-use options in all water-scarce areas. Such investigations were planned for eThekwini (treated effluent from eThekwini and KwaMashu), Nelson Mandela Bay, Rustenburg, Mangaung, Buffalo City, George-Mossel Bay, and Mbombela-Bushbuckridge over the next five years. Where the municipality lacks capacity to conduct such a study, the DWS promised to provide support (NWRS, 2013). The performance of existing wastewater treatment plants in terms of meeting discharge standards and reliability is critical to the successful integration of water re-use into Reconciliation Strategies and into water supply systems in South Africa. These facilities discharge treated wastewater into the water environment with consequences for the safety, economy and fitness for use of the water resources by downstream users (NWRS, 2013).

- Inter-catchment water transfer

Inter-catchment water transfer is the man-made water conveyance schemes which move water from one river basin where water is available in large quantities to another basin where water is less available. Water can also be transferred to basins where they could be utilized for human development. Inter-catchment water transfer is a reality in South Africa. Many cities, towns and villages are located far away from the river basins and they draw water through transfers from other areas (Machete, 2011). Long distance conveyance of water may be inevitable but, it is also expensive as it may involve many miles or kilometres from the city of origin. The cost of pumping involves very long pipelines and often entails conflicts with the city of origin (Machete, 2011).

To facilitate the management of water resources, the country was divided into 19 catchment-based Water Management Areas (WMA). Of the 19 WMA's only the Mzimvubu to Keiskamma water management area was not linked to another management area through inter-catchment transfers. The inter-linking of catchments gives effect to one of the main principles of the National Water Act (36 of 1998), which designates water as a national resource. Eleven of the 19 WMA's share international rivers (NWRS, 2004). In rethinking the management model, and based on viability assessments with respect to water resources management, available funding, capacity, skills and expertise in regulation and oversight, as well as to improve integrated water systems management, in NWRS (2013) the 19 WMAs were

consolidated into 9 as follows: Limpopo, Olifants, Inkomati-Usuthu, Pongola-Mzimkulu, Vaal, Orange, Mzimvubu-Tsitsikama, Breede-Gouritz and Berg-Olifants. The boundaries of these water management areas take into account catchment and aquifer boundaries, financial viability, stakeholder participation, and equity considerations and are, as a result, not aligned with provincial or local government boundaries (NWRS, 2013).

The transfer of water from the Upper Orange River to the Upper Vaal water management area via the Lesotho Highlands Water Project (LHWP) is reflected as being from the Upper Orange water management area. The transfer of 170 million cubic metres per area out of South Africa relates to water being delivered from the Crocodile West and Marico water management area to Gaborone in Botswana, the minimum flow released from the Inkomati water management area to Mozambique and abstractions from the Orange River Project by Namibia (NWRS, 2004). The bulk of the transfers are between water management areas, either by aqueducts or in the form of yield released along rivers (NWRS, 2004).

- Desalination

Desalination is any process that removes salts from water. It is being implemented on a small scale in South Africa. The industrial and mining sectors desalinate used water for reuse. Brackish groundwater desalination by reverse osmosis provides drinking water to small towns and communities along the west coast. Desalination of acid mine drainage has been pioneered in eMalahleni and is now under consideration for the Witwatersrand goldfields. Seawater desalination is being used to supplement municipal water supplies in towns along the southern and eastern Cape coastlines (Hedden & Cilliers, 2014).

- Households water usage control

Household water usage control is the individual methods put in place by households to save water or methods encouraged by the government for households to save water. There are many ways for saving water in the house, for example, people may use a bowl for cleaning vegetables instead of a running tap, washing machines may only be used when there is a full load; leaking taps should be fixed to curb the water loss and cars should be washed with a bucket instead of a hose pipe (Fabrizi, 2009). The grass or lawn should be allowed to grow a little longer during dry periods.

Households should know that there is no need to water well established shrubs and trees. Collecting rain water for watering gardens and using watering cans instead of a hosepipe is suggested (Fabrizi, 2009).

The municipal authority is empowered, at its discretion, under special circumstances, or in case of emergency, flood, drought, or water shortage, to: prohibit or restrict use of water during specified hours; on specified days, or for any specified purpose, impose a special tariff for water consumed in excess of a set amount, and a general surcharge in respect of consumption; order a consumer to install meters to measure and devices to restrict the flow of water; as well as to restrict the use of a water-consuming appliance, or the connection of such an appliance to the water supply and require a consumer to install a measuring device, or device restricting the flow of water, at the consumer's expense (Still et al., 2008).

Furthermore, Schedule 1 (Section 38) of Water and Sanitation bylaw prohibits watering of gardens, sports fields, parks or other grassed areas, between 10:00 and 16:00, without prior written authority and potable water may not be used to dampen building sand and other building material to prevent it from being blown away (Still et al., 2008).

- ❖ Greywater reuse

Greywater is usually defined as all wastewater produced in households, except toilet wastewater (black water). Typically, this includes water from bathroom sinks, baths, and showers and may also include water from laundry facilities and dishwashers (Queensl, 2003). Greywater can be used for flushing toilets, washing cars as well as irrigation and landscaping. When irrigating outdoors, it is applied only to flat areas where runoff is not likely. In arid areas where there is dry grass, greywater is ideal for irrigating firebreaks, because it contributes plant nutrients in the process. Greywater composition varies widely from household to household, depending on the personal habits of residents and the products used in the home, reflecting the lifestyle of the residents and the choice of household chemicals for laundry, bathing, etc. (Khalaphallah, 2012).

Greywater represents the largest potential source of water savings in domestic residences, accounting for as much as 50-80% of the total water uses (Boghos, 2004;

Flowers, 2004; Al-Jayyousi, 2003; Christova-Boal et al., 1996). In general, it contains high concentrations of easily degradable organic material, i.e. fat, oil and other organic substances, residues from soap, detergents, cleaning agents, etc. and generally low concentrations of pathogens (Ridderstolpe, 2004). Greywater in general has low content of any metals or organic pollutants, but depending on the type of building, it can increase with the addition of environmentally harmful substances (Ridderstolpe, 2004).

The potential beneficial role of water reuse is highlighted specifically in the most recent draft of the National Water Resource Strategy (2013). 'Water reuse' is defined as Technical Strategy #7 and the document goes on to describe actions such as targeted investments in the reuse of water and implementation of water reuse infrastructure in water scarce and urban areas (NWRS, 2013). In non-sewered areas of South Africa, the disposal of household wastewater arising from activities such as bathing, washing clothes and washing dishes (greywater) is commonly disposed off to the ground in the vicinity of the dwelling which can lead to the pooling of wastewater. This in turn could lead to unpleasant odours, pollution of groundwater and surface runoff, soil erosion, health hazards and mosquito breeding (Salukazana et al., 2004).

2.6 Greywater reuse as a coping strategy to improve agricultural production

In an era of dwindling water resources, the treatment and reuse of greywater is rapidly becoming a subject of great interest to researchers. Agricultural water needs represent the lion's share of global water use, and greywater reuse is an attractive alternative with good potential to supplement freshwater supplies (Finley, 2008). In a household context, greywater is the used water from baths, showers, hand basins, washing machines and kitchen sink. Greywater is named after its cloudy appearance and its status as being between potable water known as white water and sewage water (black water). Greywater is usually defined as all wastewater produced in households, except toilet wastewater (black water) (Dimitriadis, 2005). Typically, this includes water from bathroom sinks, baths, and showers and may also include water from laundry facilities and dishwashers (Queensl, 2003). Any water containing human faecal waste is considered blackwater. Nonetheless, greywater contains microorganisms but the microorganism loads are substantially lower as compared to microorganism loads found in blackwater (Dimitriadis, 2005).

The abstraction of water for irrigation in the agricultural sector amounts to 80% of the global water consumption, and it is the limiting factor in food production in many countries (Hanjra & Qureshi, 2010). Innovative approaches are therefore needed to attain both water and food security, particularly in Sub-Saharan Africa (Rodda et al., 2011; Hanjra & Qureshi, 2010; Finley et al., 2009). Innovative approaches to reduce pressure on water supplies include the reuse of greywater for irrigation (Pinto et al., 2010). Greywater is already used for irrigation of crops, more widely so in arid regions where its reuse reduces potable water use by up to 50% (Al-Hamaiedeh & Bino, 2010). One commonly applied individual initiative to reuse greywater is the recycling of greywater specifically for irrigation purposes (Travis et al., 2010). Greywater is a potentially reusable water resource for irrigation of household lawns and gardens (Al-Jayyousi, 2003) as diversion of laundry effluent. According to Jeppesen (1996), this is technically possible without treatment.

Greywater is applied directly to the soil, not through a sprinkler or any method that would allow contact with the above ground portion of the plants. Plants that thrive only in acid soil are not watered with greywater, which is alkaline. Greywater is used only on well-established plants, not seedlings or young plants. Greywater is dispersed over a large area, and it rotates with freshwater to avoid build-up of sodium salts (Florida DEP, 2006). In South Africa, parts of the country receive less than 500 mm annual rainfall required for rainfed cropping (Schulze, 1997). Greywater could therefore be used in these regions for irrigation of crops, especially for small-scale implementation such as household and community food gardens (Lubbe et al., 2016).

2.6.1 Case studies on greywater reuse for agricultural purposes

- Global

Godfrey et al. (2009) constructed a greywater treatment and reuse system in residential schools in Madhya Pradesh, India and treated greywater was used for toilet flushing and irrigating food crops. The internal costs consisted of construction of a greywater reuse system as well as the operation and maintenance costs. Faraqui & Al-Jayyousi (2002) study focused on greywater reuse in urban agriculture for poverty alleviation. The study allowed the poor in Tufileh, Jordan, to reuse untreated household greywater in home gardens and the project allowed the community to offset food purchases and generate income by selling surplus production, saving or earning

an average of 10% of its income. Al-Hamaiedeh & Bino (2010) treated greywater produced from a 4-barrel and confined trench treatment units were used for irrigation of olive trees and some vegetables in Jordan. The quality of treated and untreated greywater was studied to evaluate the performance of treatment units and the suitability of treated greywater for irrigation according to Jordanian standard. The results showed that salinity, sodium adsorption ratio (SAR) and organic content of soil increased as a function of time, therefore leaching of soil with fresh water was highly recommended.

Gross et al. (2008) developed an economically sound, low-tech and easily maintainable treatment system that would allow safe and sustainable use of greywater for landscape irrigation in small communities and households of Israel. The system is based on a combination of vertical flow constructed wetland with water recycling and trickling filter, and is termed recycled vertical flow constructed wetland (RVFCW). The RVFCW was efficient at removing virtually all of the suspended solids and biological oxygen demand, and about 80% of the chemical oxygen demand after 8 hours. Fecal coliforms dropped by three to four orders of magnitude from their initial concentration after 8 hours, but this was not always enough to meet current regulations for unlimited irrigation. The treated greywater had no significant negative impact on plants or soil during the study period. Misra et al. (2010) conducted a glasshouse experiment to examine variation in growth, water and nutrient use of tomato using tapwater, laundry greywater and solutions of low and high concentration of a detergent surfactant (LC and HC, respectively) as irrigation treatments in Australia. The results suggested that, laundry greywater has a potential of reuse as irrigation water to grow tomatoes. Pinto et al. (2010) conducted glasshouse experiments to examine the effects of greywater irrigation on the growth of silverbeet plants, their water use and changes in soil properties in Australia. Results showed that greywater irrigation had no significant effect on soil total Nitrogen and total Phosphorus after plant harvest, but there were significant effects on the values of soil pH and electrical conductivity. Furthermore, there were no significant effects of greywater irrigation on plant dry biomass, water use and number of leaves.

Bino et al. (2010) conducted a study on the greywater reuse for irrigation in southern Jordan between February 2004 and October 2007. Greywater was used to irrigate

vegetables that were not eaten raw, so that the cooking process can remove all toxins in the food. Roman et al., (2007) conducted a study in the capital city of Peru, Lima, where residents in this highly populated shanty town actively grow vegetables using untreated wastewater and greywater.

- Africa

The study by Madungwe & Sakuringwa (2007) on greywater reuse which focused on strategy for water demand management in Harare, Zimbabwe demonstrated findings of other research done on benefits of greywater reuse for irrigation in some countries, applicable to African countries. The study concluded that the reuse of greywater, however raise concern over the potential health impacts of uncontrolled wastewater use on both the growers and consumers of their crops. Travis et al. (2010) conducted a controlled study on the effect of greywater irrigation on soil properties. The study then demonstrated that treated greywater can be effectively irrigated without detrimental effects on soil or plants growth. However, untreated greywater may significantly change soil properties that can impact the movement of water in soil and the transport of contaminants in the vadose zone. Kinobe et al. (2010) set up greywater tower gardens with tomatoes and onions at selected households. The vegetables did not have any negative impact as they were eaten cooked. A study by Kulabako et al. (2011) focused on creating an understanding of greywater characteristics and demonstrating a low cost reuse option involving application of small tower gardens for greywater treatment reuse in peri-urban settlements of Kawaala, Uganda. The planted vegetables were tomatoes, collard greens and “buga”. These vegetables thrived with the irrigation of greywater, however, they were attacked by pests necessitating pesticides application. The vegetables were not eaten raw.

In a peri-urban area of Harare, Zimbabwe, researchers found that greywater was being used for a variety of activities such as toilet flushing, washing of cars and irrigating vegetable gardens, where there was no need for superior water quality (Hoko & Nhapi, 2002).

- South Africa

Adewumi et al. (2010) conducted a study that focused on treated greywater reuse in South Africa. This study provided an overview of the South African water resources situation and wastewater generation in order to put the need for greywater reuse such

as irrigation into perspective. The study concluded that there is a significant potential for implementing wastewater reuse for large non-drinking applications (e.g. landscape irrigation and industrial processes) in arid areas of South Africa especially Western Cape Province. In a study by Rodda et al. (2011), an above-ground crop Swiss chard (*Betavulgaris var. cicla*) and a below-ground crop carrot, (*Daucus carota*) were irrigated in pots with mixed greywater sourced from households in an informal settlement using a simple form of sub-surface irrigation. The results showed that, the vegetables increased in growth. Carden et al. (2007) surveyed greywater generation and provision for greywater management in unsewered settlements across South Africa. The greywater guidelines for home gardens in Gauteng states that: lavender, rosemary, olives and pertunia are some of the plants that thrive well on greywater irrigation. Gold Fields gold mine in Driefontein, south west of Johannesburg, Gauteng Province, has used greywater for flushing communal toilets at one of the high density residences and for landscape irrigation (Ilemobade et al., 2009). Mzini (2013) planted vegetables and irrigated them with greywater, potable water and diluted greywater. Irrigation from diluted greywater showed a significant increase in yield, in the head mass and in appeal of cabbages. Onion yields were significantly higher when irrigated with greywater. Spinach also obtained significantly higher yields when irrigated with greywater. However, many leaves from this treatment were infested with leaf-spot disease. Beetroot yield and quality was not affected with greywater irrigation.

2.7 Acts/policies that govern reuse of greywater

The reuse of greywater for different purposes is a worthwhile consideration. As the amount of water available to South Africans shrinks in the face of its expanding population, reuse of greywater is fast becoming a necessity. Thus, the government through various policies/acts provide for reuse of greywater. These policies/ acts include: the Constitution of South Africa of 1996, The National Water Act 36 of 1998, the National Water Resource Strategy 2nd edition of 2013, the National Building Regulations and Building Standards Act 103 of 1977, National Policy on Water and Sanitation as well as the South African Model bylaws.

- The constitution of South Africa of 1996 is the core to all Acts, policies or legislations in South Africa and does not specifically address greywater. Section

27 subsection 1b of the constitution states that “everyone has the right to have access to sufficient food and water”.

- The National Water Act (NWA) of 1998 is the major piece of legislation addressing water resources conservation, management, use and disposal of water containing waste etc. in South Africa. The Act makes no specific reference to greywater, but refers to “disposal of waste or water containing waste”. This may be considered to apply also to greywater. In terms of the NWA, use of water containing waste for irrigation is considered a “controlled activity”. Although greywater is not mentioned among the types of wastewater considered, this is probably the closest existing legislation that provide guidance for quality of greywater intended for irrigation use.
- National Water Resource Strategy (NWRS) (2013), states that in view of the projected water shortages in future and the cost of rendering drinkable water, the recycling and reuse of greywater should be encouraged. NWRS (2013) allows the implementation of water reuse to take place at different scales or levels: at a local level involving a single facility such as a building or a factory, for a group or cluster of facilities, at a treatment facility level or at a river system level.
- The National Building Regulations (NBR) in terms of the National Building Regulations and Building Standards Act 103 of 1977, recognises only storm-water and sewage (domestic wastewater including toilet wastewater) as water leaving a property and provides regulations for how each is to be managed. Greywater is not defined separately and would be considered to fall under sewage. In terms of the NBR, there is therefore no provision for the storage and use of greywater on a property (Rodda et al., 2010).
- National Policy on Water and Sanitation defines minimum levels of sanitation and water supply to which all South Africans are entitled, but fails to address the disposal of greywater (DWAF, 1994; DWAF, 2003). Irrigation with wastewater is addressed under national health guidelines (Department of National Health and Population Development, 1978), although these do not make specific reference to greywater.

Existing legislation does not specifically exclude use of greywater for irrigation, but there are inconsistencies which arise from the absence of a clear definition of

greywater as a subset of domestic wastewater which differs in character and hazards from blackwater. This needs to be resolved to clarify the legal position of use of greywater for irrigation (Rodda et al., 2010).

- South African Model bylaws

The Model Water Services bylaws are recommendations intended to assist municipal authorities in the formulation of their own bylaws dealing with the supply of potable water and incidental matters. Much of the content of these Model bylaws has been incorporated by most of these municipalities. The Model bylaw provisions pertaining to the conservation of water and prevention of water wastage contain the following main provisions: municipal consent for the installation of new pipes and fittings; standards pertaining to the quality and installation of pipes and fittings; powers of municipal authority to prevent wasteful use of water or to impose restrictions of the use of water in the event of water shortage, drought or flood; prohibitions on the waste of water by consumers and requirement of an annual water audit required by water users who consume more than 3650 kl per annum and greywater reuse.

- South African Water Quality Guidelines for irrigation

With specific reference to the irrigation aspect of greywater use for small-scale irrigation, the South African Water Quality Guidelines (SAWQG) (DWAF, 1996) for irrigation use (Volume 4 of the SAWQG) may also be used as an indicator of acceptable water quality as it entails use of raw quality water for irrigation.

- Greywater reuse bylaws provided by municipalities of South Africa

The City of Cape Town's wastewater and industrial effluent bylaw aims to protect the environment, people, property, streets, rivers, vleis and lakes by regulation of the bylaw across industrial, commercial, institutional and residential sites. The City of Cape Town does this by ensuring that: wastewaters, with the exclusion of rainwater, are correctly discharged to the correct reticulation system, in other words the volumes of the wastewater discharged to the sewerage system do not result in surcharge of the sewerage system, overflow to the streets, rivers and vleis and so create unsafe, unhygienic conditions (The City of Cape Town effluent bylaw, 2010).

The Water Supply bylaws of the Durban Metropolitan Municipality (2008) states that, no person is permitted to use water obtained from a source other than the water supply system of the municipality, except with prior consent of the Authorised Officer (AO)

and in accordance with such conditions as it may impose for domestic, commercial and industrial purposes as well as filling of swimming pools.

Section 61 of the Moses Kotane Local Municipality (2008), Water and Sanitation bylaw states that, any device which entails the recycling or reuse of water shall not make use of water derived from any kitchen, clothes washing machines or from toilet discharges.

In Greater Sekhukhune District Municipality and Fetakgomo Local Municipality, there are no bylaws on greywater or wastewater reuse.

2.8 Summary

This chapter discussed in detail literature review about food security, methods of measuring food security, use of natural resources for agriculture, water scarcity, greywater reuse as a coping strategy to improve agricultural production as well as South African legislations that govern the reuse of greywater. The next chapter will describe the methodology of the study.

CHAPTER THREE

METHODOLOGY AND ANALYTICAL PROCEDURES

3.1 Introduction

This chapter presents the description of the study area and the research methodologies used in collecting, analysing and presenting the data in the study on "The potential reuse of greywater to improve household food security: a case study of two villages in Fetakgomo Local Municipality in Limpopo Province of South Africa".

3.2 Study area

Limpopo is the northernmost province of South Africa, having international borders with Botswana, Mozambique and Zimbabwe (StatsSA, 2003). It is divided into 5 district municipalities namely: Mopani, Vhembe, Capricorn, Waterberg and Sekhukhune. Sekhukhune District Municipality is further divided into 5 local municipalities namely: Elias Motsoaledi, Greater Tubatse, Ephraim Mogale, Makhuduthamaga and Fetakgomo (Sekhukhune IDP, 2014).

The name "Fetakgomo" stems from: Fetakgomo o sware motho, a movement that was formed to resist the apartheid regime. It originates from the Pedi idiom "Feta-kgomo o sware motho, mafeta-kgomo ke moriri o a hloga" which simply means People First (Fetakgomo IDP, 2015/16). The Department of Cooperative Governance and Traditional Affairs (COGTA) (2009) describes category B4 municipalities as those municipalities which are mainly rural, located in economically depressed areas, consequently having difficulties in attracting and retaining skilled managers/professionals and are struggling from a revenue generation perspective. Fetakgomo Local Municipality falls within this category (Fetakgomo IDP, 2015/16). The Municipality borders Makhuduthamaga in the south, Greater Tubatse in the east and Lepelle Nkumpi Local Municipalities on the west and north and covers an area of 1104 745 km^2 (110 475 ha), which represents 8.3% of the Sekhukhune District Municipality's total land area. The municipality is divided into 13 wards and 4 nodal points namely: Atok, Apel, Mphanama and Strydkraal (Fetakgomo IDP, 2015/16).

Fetakgomo Local Municipality is completely rural in nature, dominated by traditional land ownership with a population of 93 814 people that reside in 87 villages with a total of 22 851 households (StatsSA, 2011). The majority of these villages are small with

less than 1000 inhabitants in each. Like most rural municipalities in the country, Fetakgomo is characterised by a weak economic base, poor infrastructure, major service backlogs, dispersed human settlements and high poverty levels (Fetakgomo IDP, 2015/16). The municipality is geographically located at $24^{0}50'0"$ S and $29^{0}50'0"$ E. Fetakgomo Local Municipality receives most of its precipitation between October and March, with the highest average monthly rainfall during January (100.84 mm) and the lowest during July (2.89 mm) (Fetakgomo IDP, 2014/15). The study was conducted in two villages in the Fetakgomo Local Municipality which are Ga-Seroka village consisting of 2 381 households and Ga-Nkwana village consisting of 1 960 households (Fetakgomo IDP, 2015/16). The map below (Fig.3) presents the physical location of Ga-Seroka and Ga-Nkwana villages.

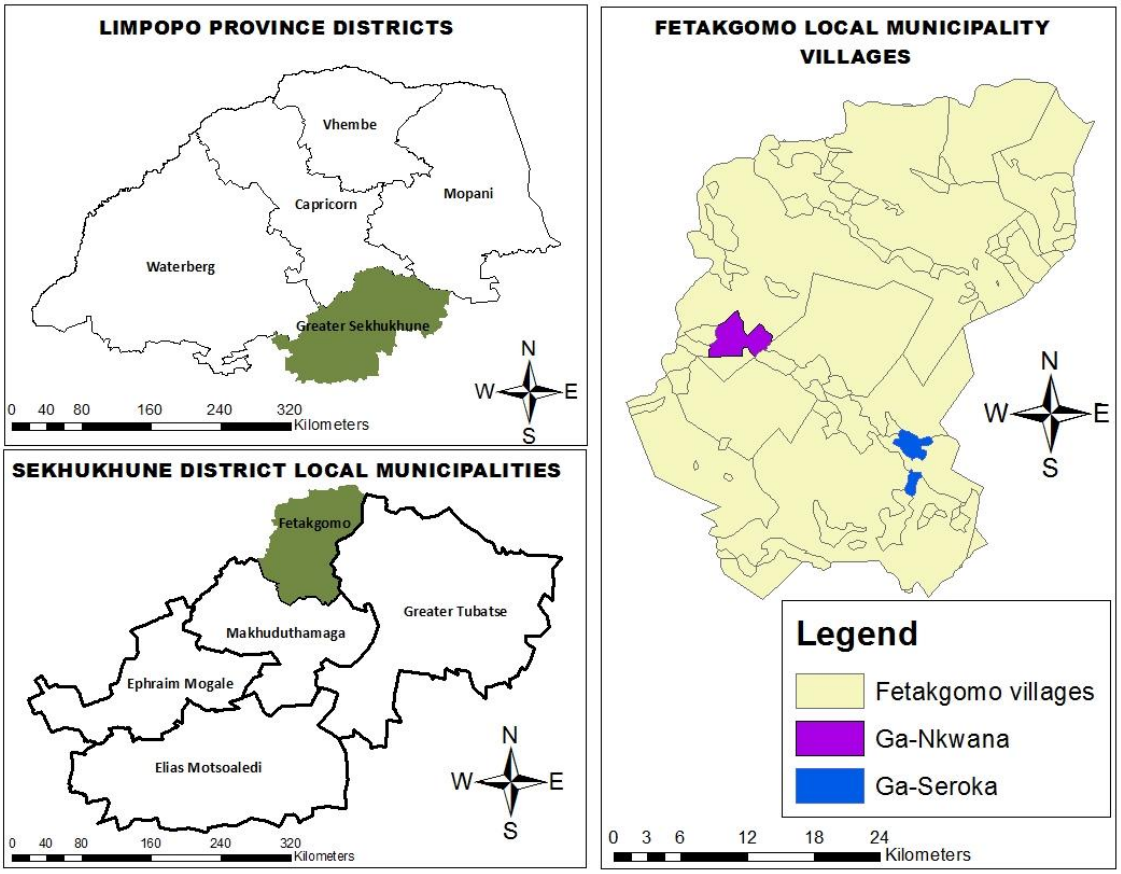

Figure 3: The maps showing study areas within Fetakgomo Local Municipality, the villages Ga-Nkwana and Ga-Seroka are shown in red and blue, respectively (Author).

3.3 Research design

The study adapted a mixed research approach because this approach helps to expand the scope or breadth of research to offset the weaknesses of either approach alone

(Rossman & Wilson, 1991). A mixed methods research design is a procedure for collecting, analysing, and “mixing” both quantitative and qualitative research methods in a single study to understand a research problem (Creswell, 2012). This research method was chosen due to it being grounded with the Human-Environment Interaction theory that deals with not only people’s perception about the environment but interrelationships of phenomena on the environment. This method also provided a comprehensive understanding of the research problem than either quantitative or qualitative approaches alone.

3.4 Sampling

3.4.1 Sampling frame

The sampling frame was the 87 villages of Fetakgomo Local Municipality, with a population of 93 814 people and a total of 22 851 households (StatsSA, 2011). From the 87 villages of Fetakgomo Local Municipality, two villages which are Ga-Nkwana village containing 1 960 households with a population of 7 429 and Ga-Seroka village with 2 381 households and a population of 6 956, were purposefully selected. The reason for this is that Ga-Seroka village is a rural settlement where there is no daily available running water and they still supplement their daily diet with subsistence agricultural produce. On the other hand, Ga-Nkwana village has been identified as a potential growth point with improved service delivery such as availability of clean running water, shopping complex, police station etc. Consequently, a comparison of the greywater reuse, and household food security status between these two settlements will be useful.

3.4.2 Sample size

A 4% sample was taken from each of the selected villages. For Ga-Seroka village with 2 381 households, a sample of 95 households was selected while 78 households were selected from Ga-Nkwana village with a total number of 1 960 households.

3.4.3 Sampling method

A systematic random sampling method was used to select the required households from these two villages. The k^{th} value is a sampling interval or the skip. In this case, the k^{th} value was obtained when the total number of households was divided by the sample size in each village. The k^{th} value in both villages was 25. The first household was randomly selected and thereafter every 25^{th} household was selected.

3.5 Data collection method

3.5.1 Secondary data

Secondary data and literary background on greywater reuse and household food security was obtained from both published and unpublished research reports, journal articles, the internet and books.

3.5.2 Primary data

Primary data was collected using questionnaires, key informant interviews and field observation.

3.5.2a Questionnaire

The data collected during the study was gathered using one questionnaire that has two types of questions. The questionnaire had close-ended and open-ended questions dealing with the background characteristics of the communities, their household food availability and accessibility, their reuse of greywater in relation to home gardening as well as their perceptions on greywater reuse for home gardening. A total of 173 questionnaires were self-administered in the chosen communities, with 95 in Ga-Seroka and 78 in Ga-Nkwana villages. The household heads or any elder member within the household was required to complete the questionnaire.

3.5.2b Key informants

Key informants who are familiar with the ways used by the communities to improve the household food security specifically through the reuse of greywater in Ga-Seroka and Ga-Nkwana villages, were interviewed. The key informants were Ga-Nkwana and Ga-Seroka villages royal council committee members as well as a representative from the Water Service Authority of Fetakgomo Local Municipality.

3.5.2c Field observation

Field observations were conducted where communities were visited and pictures of how they reuse their greywater for household gardening were taken by the researcher. This is an important method for identifying areas which reuse their greywater for gardening purposes and those which do not.

3.6 Pilot study

A duration of 4 days in each village was spent conducting a pilot study in Fetakgomo Local Municipality. The purpose of the pilot study was to help the researcher gain more

confidence before the actual data collection begins, to evaluate the quality of data to be collected and lastly to find out if the respondents will not find the questionnaire too long or not easy to understand. The outcomes of the pilot study assisted in validating the research instrument.

3.7 Data Analysis and presentation

Close-ended responses on background characteristics related to the livelihood status of the selected communities, the reuse of greywater in relation to home gardening activities to improve household food security, as well as food accessibility and availability were analysed using Statistical Package for the Social Sciences (SPSS) version 23 software to obtain the interrelationship of responses to different questions. SPSS is a package of programs for manipulating, analysing, and presenting data and is widely used in the social and behavioural sciences, although it is now popular in other fields as well. Descriptive statistics in the form of frequencies and means were computed to describe the characteristics of the collected data. The analysed data is presented in the form of tables and graphs.

Open-ended responses allow the respondent to answer a question in their own words, often provide richer and more valued information and are an important source of insight since they can generate information that was not anticipated. These responses on the communities' perceptions on the reuse of greywater were analysed by going through all the responses of the open-ended questions and manually coding similar or related responses in order to be able to generalise on the responses and to develop suggestions and recommendations to minimize the challenges of freshwater shortage faced by the communities. The reuse of greywater in relation to home gardening activities to improve household food security were identified through the photographs taken from the households that reuse greywater for gardening purposes within the selected communities. The analysed data is presented in the form of paragraphs and photographs.

3.7.1 Pearson's Chi-Square Test

Statistical Package for the Social Sciences software was used to perform a Chi-Square Test in order to assess if greywater had a potential to improve household food security in the two villages. This test is usually obtained using the following formula:

$$x^2 = \sum \frac{(O-E)}{E}$$ (Equation 1)

Where: X^2 is the Chi-Square

Σ is the 'sum of'

O is the frequencies observed

E is the frequencies expected.

For this study however, Chi-Square was used to test the association between question 48 (Have you ever reused greywater in your household) and question 55 (Do you think the reuse of greywater will increase the amount of food you produce) of the questionnaire.

3.8 General Household Survey (GHS) to measure household food security.

The General Household Survey is a large national study which asks general questions which focus on hunger over time (Stats SA, 2012). The GHS covers six major areas, namely education, health and social development, housing, household access to services and facilities, food security and agriculture (du Toit, 2011). The GHS discloses trends in the experience of hunger over time, sets the basis for understanding where hunger remains most challenging and provides some basis for directing future food security or poverty alleviation interventions, both in terms of kind and location of households. Furthermore, GHS was coupled with Household Food Insecurity Access Scale (HFIAS) to pinpoint household food security status (StatsSA, 2012).

3.8.1 Household Food Insecurity Access Scale (HFIAS)

The HFIAS score is defined by Coates et al. (2007) as a continuous measure of the degree of food insecurity (access) in the household in the past 30 days. GHS coupled with Household Food Insecurity Access Scale (HFIAS) (StatsSA, 2012) was adopted and used for this study.

In this study, it was based on the frequency-of-occurrence questions (question 36 of questionnaire instrument). The answers obtained from question 36 were divided into 3 categories namely: least, medium and severe. The scores for the three categories were "never and less than one", "once and twice", and "every day and 3 to 6 times", respectively. The HFIAS score (0-24) for each household in the two villages was

calculated by summing the frequency-of-occurrence in the past month for the food insecurity-related conditions (Q36a + Q36b + Q36c etc. of the questionnaire).

Where: Q is question 36 of the questionnaire

a is rely on less preferred and less expensive foods

b is borrowed food, or rely on help from friends and relatives

c is purchase food on credit etc.

The overall distribution of the three HFIAS categories and their scores were:

17 – 24: Severe food insecure households

12 – 16: Medium food insecure households

0 – 11: Least food insecure households.

The lower the score, the less food insecurity a household experienced (Coates et al, 2007). The HFIAS score for each household in each village was extended to calculate the average HFIAS score for all households per village. This was done according to Coates et al. (2007) formulae:

$$\text{Average HFIAS score in a village} = \frac{\text{Sum of HFIAS Scores}}{\text{Total number of households in sample}} \quad \text{(Equation 2)}$$

The total numbers for households were 78 and 95 in Ga-Nkwana and Ga-Seroka villages, respectively.

3.9 Summary

This chapter presented the research design and methodology that was followed to get responses from the field. The chapter also showed that a mixed research design was chosen in order to allow an in-depth probing of the respondents. The chapter explained, among others, the study area, sample size and sampling frame, data collection methods and data analysis and presentation. The next chapter will deal with the research findings and discussion.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

Chapter four provides some insight into the reuse of greywater as a potential method to improve household food security in rural areas. It presents results on background characteristics, household food availability and accessibility, reuse of greywater in relation to home gardening activities and the perceptions of households on the reuse of greywater for home gardening. The results are presented in the form of tables, graphs and photos.

4.2 Background characteristics

In the background characteristics section, the structured questionnaire probed the following information: gender, age, household head, marital status, educational level, employment status, occupation and monthly incomes of the respondents and the way it is spend.

4.2.1 Gender of respondents

Gender is defined by WHO (2016) as the socially constructed characteristics of women and men, such as norms, roles and relationships of and between groups of men and women. Figure 4 illustrates the composition of males and females in both Ga-Nkwana and Ga-Seroka villages who contributed to this study.

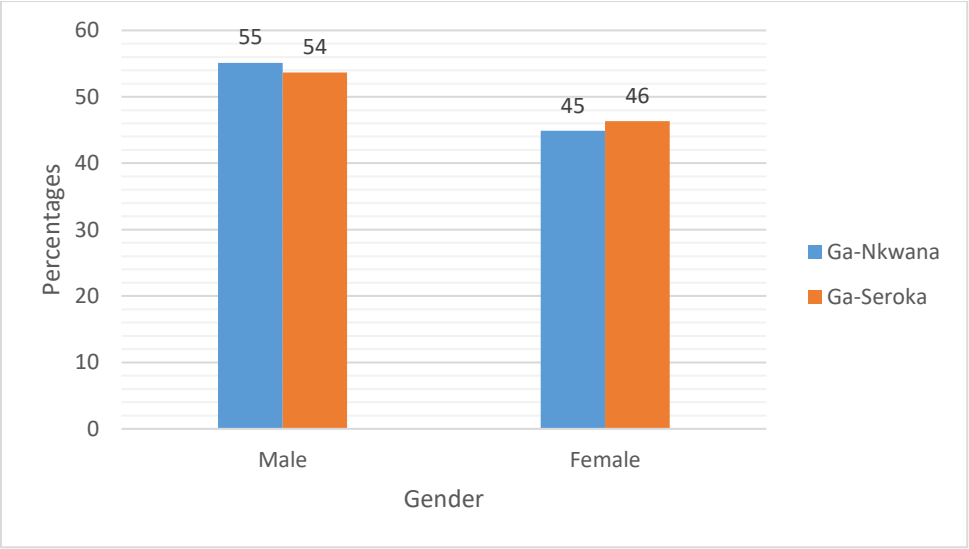

Figure 4: The gender of respondents

Out of 78 interviewed respondents in Ga-Nkwana village, 55% were males while females only made up 45%. In Ga-Seroka village, 54% of the respondents were males while females made up 46% of the total 95 interviewed households. The percentages of respondents regarding gender from both villages were almost similar, with Ga-Nkwana village being above Ga-Seroka village with just 1%. The general opinion is that the number of women exceeds the number of men. In contrast, the domination of males in the rural areas of South Africa is still common (Montshwe, 2006). In some areas in South Africa for example the Free State Province, males exceed women (65%) while females are 34% (StatsSA, 2011).

4.2.2 The ages of respondents

Age is the interval of time between the day, month and year of birth and the day, month and year of occurrence of the event expressed in the largest completed unit of solar time such as years for adults and children, and months, weeks, days, hours or minutes of life, as appropriate, for infants under one year of age (StatsSA, 2010). The results from the questionnaire show the age distribution of the respondents ranging from below 25 to above 45 years. The ages of respondents were grouped into four categories as indicated by Figure 5.

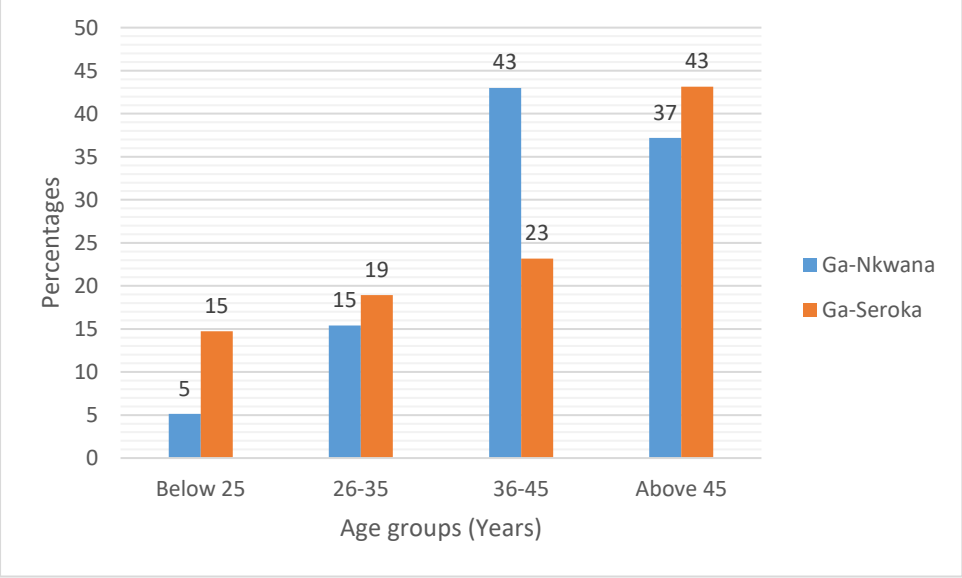

Figure 5. The age of respondents

In Ga-Nkwana village, most of the respondents (43%) were aged between 36 to 45 years followed by 37% of the respondents aged above 45 years. Fifteen percent (15%)

of the respondents were aged between 26 and 35 years while the group that was below 25 years represented only 5% of the respondents.

The distribution of respondents' age in Ga-Seroka village had the highest percentage (43%) in the above 45 years age group which was followed by 23% of respondents in the 36 and 45 years age group. The age group of 26 and 35 years was represented by 19% of the respondents while the age group below 25 years had 15% of the respondents. The reason Ga-Nkwana village ranked higher in the age group of 36 and 45 years is because at this stage the respondents are stable and active in their jobs, and therefore have moved to this village to be closer to services such as shopping complex, police station and private schools and also due to other developments that are taking place in the village. In Ga-Seroka village, the highest rank (43%) was in the age group that was above 45 years. The reasons for this might be due to the fact that, Ga-Seroka village lacks development as compared to Ga-Nkwana village. Ga-Seroka village also has a lot of families headed by elderly people while the young couples relocate to areas with better developments and facilities as they marry and leave their family homes. Furthermore, a reasonable number of the working group was at home when the data was collected. The results are almost similar to those of Bikombo (2014), which show that most of the respondents were in the age group of 35 to 50 years. The results do not agree with those of Ojo & Babayo (2013), which indicated that majority (53% and 84%) of the male and female respondents respectively fell within 20-49 years of age.

4.2.3. Household Head

Household head is defined as the main decision-maker, or the person who owns or rents the dwelling, or the person who is the main breadwinner (StatsSA, 2014). A household head can either be a male or female as long as they fit the definition of a household head above. Household surveys define a household head to ensure that households are not counted twice and to report the relationship with other members. Figure 6 illustrates the composition of household heads and non-household heads who contributed to this study. Most respondents in Ga-Nkwana village (60%) were household heads while 40% were not household heads. In Ga-Seroka village, 54% of the respondents were not heads of the interviewed households while 46% of the respondents were household heads.

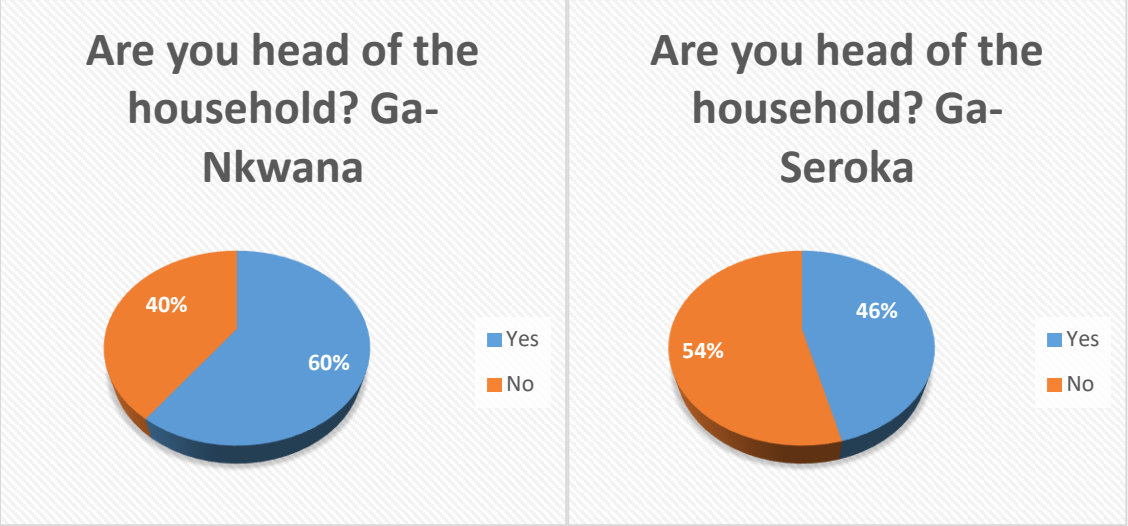

Figure 6: The household head

Table 1 below illustrates the gender of households in Ga-Nkwana and Ga-Seroka villages. Sixty eight percent (68%) of the respondents who were household heads in Ga-Nkwana village were males while 32% of the respondents who were household heads were females (Table 1). In Ga-Seroka village, 65% of the household heads were males with 35% of household heads being females (Table 1). This study shows a similar trend to a study by Ndobo (2013) in Kwakwatsi township which revealed that male headed households constituted a higher percentage (69.30%) as compared to female headed households which constituted 30.70% of the total sampled population.

Table 1: Gender of households

	Ga-Nkwana		Ga-Seroka	
	Male	**Female**	**Male**	**Female**
Yes	68%	32%	65%	35%

4.2.4 Relationship of respondents to household head

Relationship is the way in which people are related or connected to one another, either through blood, marriage, adoption or other circumstances (StatsSA, 2001). In Ga-Nkwana village, 60% of the respondents were household heads followed by 19% of the respondents who were spouses of the household heads. The responses from children made up 15% followed by 3% of responses from siblings of the household heads. Three percent (3%) of the responses were from other family members.

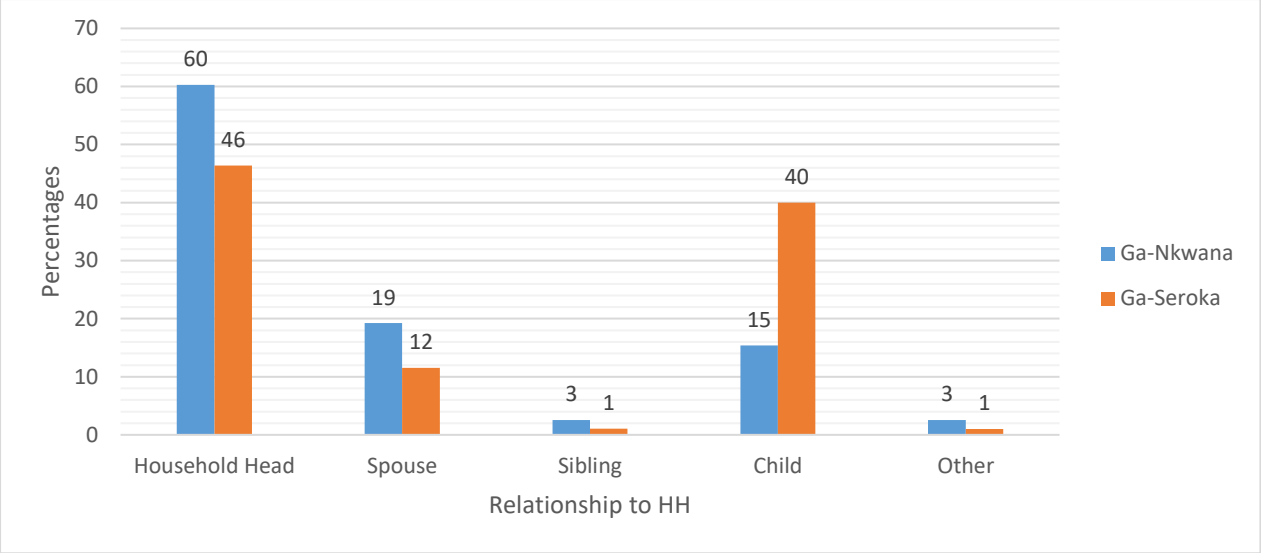

Figure 7: The relationship of respondents to household head

Forty six percent (46%) of the respondents in Ga-Seroka village were household heads followed by 40% of the responses coming from children of the household heads. The responses from spouses in Ga-Seroka village only made up 12% of the total interviewed households and the least responses of 1% each are from siblings of the household head and other members of their family. The reason behind this trend could be that in Ga-Seroka village there is a high percentage of households that are headed by single parents. Stats SA (2011) indicated that 56.20% of households in the black/African population were headed by males while 43.80% were headed by females and further indicated that, female-headed households among the black society was the highest when compared to other racial groups.

4.2.5 Marital status of respondents

Marital status is defined by StatsSA (2007) as a personal status of each individual in relation to the marriage laws or customs of a country. Figure 8 displays the marital status of the respondents. In Ga-Nkwana village, 62% of the respondents were married, while 21% of the respondents were single. Fifteen percent (15%) of the respondents were widowed and only 2% of the entire sample size was divorced. Some of the respondents from Ga-Nkwana village were newly wedded couples who left their maternal homes to start their own, while others moved to Ga-Nkwana village due to work being closer either for the household head or spouse. Ga-Seroka village respondents had a similar sequence when coming to their marital status, although, percentages are different. Forty six percent (46%) of the respondents in Ga-Seroka

village were married while 41% were single. Thirteen percent (13%) of the respondents were widowed while none of the respondents were divorced. There is a high percentage of married people in Ga-Nkwana village as compared to Ga-Seroka village because a lot of newly wedded couples from the surrounding villages move to Ga-Nkwana village due to availability of services such as a shopping complex, police station and medical centres.

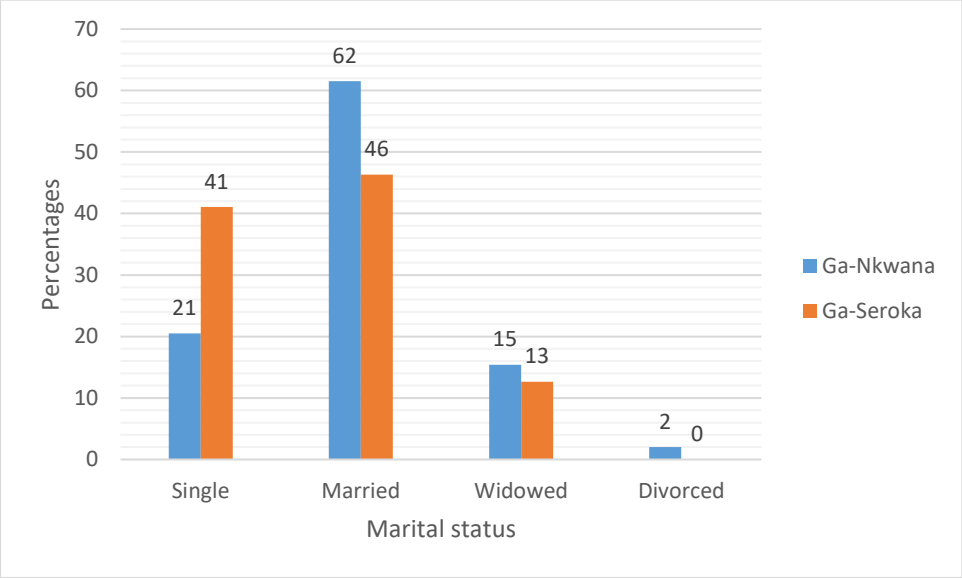

Figure 8: The marital status of respondents

The results concur with Zenda (2000), and the author reported that married couples have advantage because they have a partner to share responsibilities with. More so households with married people are able to share household activities such as agricultural production, harvesting of fruits, weeding, fetching of firewood and water, while divorcees, single and widowed people have to do all the household activities on their own as they do not have all the support except from their older children who are fit to assist with the household activities. Census Report South Africa (2011) also shows that, married people in South Africa are more as compared to divorced people. The study is supported by that of Adekunle (2013) which found that 70.4% of male and 65% of female respondents were married while 20% of male and 10% of female respondents were single and divorced respondents were made up of 8.0% of males and 5.2% of females. Finally, widowed respondents interviewed were 1.6% of male and 4.8% of female respectively.

4.2.6 The educational level of respondents

Statistics South Africa (2007) defined educational level as the highest grade completed at school or the highest post-school qualification obtained. In South Africa, the right to basic and higher education for all citizens is highlighted in Section 29 (1) of the Constitution. The Constitution acknowledges that the government is responsible for providing access to education (Calderhead, 2011). Education is viewed as an effective tool for enhancing social and economic development (Badat, 2009). According to Muchara (2010) the people who have a higher educational level are able to interpret information better. On the other hand, illiteracy is one of the factors that limit economic, social, physical, technical and educational development in less developed countries (Bester et al., 1999).

Fifty five percent (55%) of the respondents in Ga-Nkwana village were in tertiary education category or had some sort of the same qualification, while 26% of the respondents reached secondary level. The lowest percentage (4%) of the respondents only went up to primary school. Fifteen percent (15%) of the respondents did not go to school at all (Figure 9).

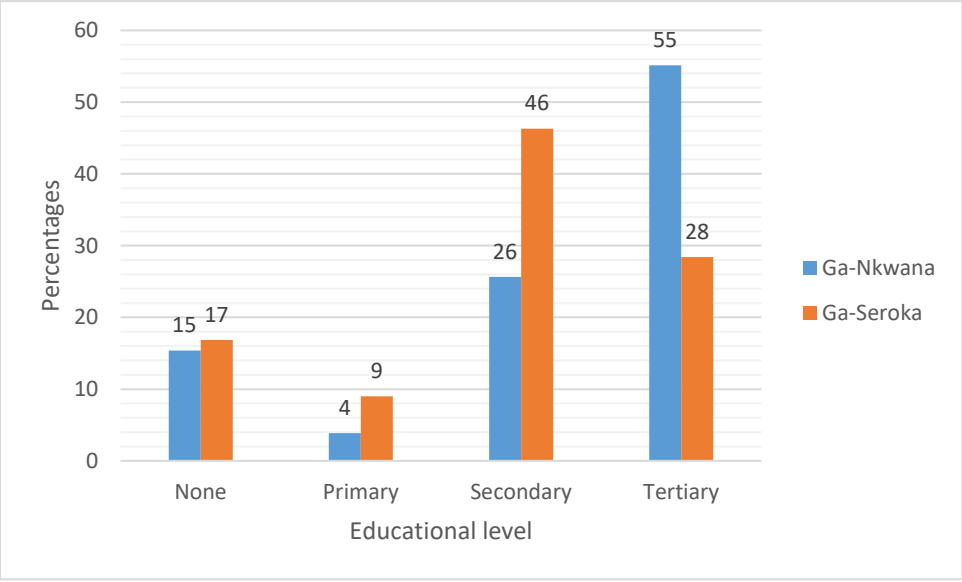

Figure 9: The educational level of respondents

The highest percentage (46%) of the respondents in Ga-Seroka village reached secondary level, while 28% attained tertiary level. Nine percent (9%) of the respondents only had primary school education. Seventeen percent (17%) of the total respondents did not have any formal education (Figure 9). The reason for the high

proportion of respondents in Ga-Seroka village having only secondary education is because some of the respondents had to drop out of school earlier in life in order to search for jobs to support their parents, also due to lack of motivation to study as well as having no hope of going to an institution of higher learning as the family cannot afford their fees. The other reason is because learners become parents at an early age and end up dropping out of school. Some learners become pregnant so that they can qualify for the child social grant as a way of helping financially at home. The problem of some of the respondents having never attended school is diminishing quite remarkably over the years as access to education is improving significantly in rural areas (Nkhori, 2004). This is because many of the existing household heads are elderly, but today's youths will have had considerably more basic education by the time they become household heads as the youths have better access to education nowadays.

In Ga-Nkwana village, more respondents had attained their tertiary qualification as compared to Ga-Seroka village, and the reason for this is because Ga-Nkwana village is well developed with a private school where students find encouragement to study further. Another reason is that most of the younger working group live there. Educational attainment outcomes continue to change with improved access to educational facilities and services. Among individuals aged 20 years and older, the percentage that attained Grade 12 as their highest level of education increased from 21.9% in 2002 to 27.7% in 2013 (StatsSA, 2014).

4.2.7 Employment status of respondents

Employment status refers to the status of an economically active person with respect to his or her employment, that is to say, the type of implicit or explicit contract of employment with other persons or organisations that the person has his or her job (OECD, 2003). Figure 10 shows the employment status of respondents. Fifty one percent (51%) of the respondents in Ga-Nkwana village were employed while the least percentage of the respondents (13%) was unemployed. Self-employed respondents accounted for 14% of the total respondents while pensioners accounted for 22%. The reason for the high percentage of the respondents in Ga-Nkwana village being employed is because they have a high percentage of respondents with tertiary qualifications which increases their chances of being employed. The occupations of the respondents who are employed included educators, health practitioners, hair

dressers, clerks, security officers, police officers, traffic officers, cashiers, mine workers and brick layers.

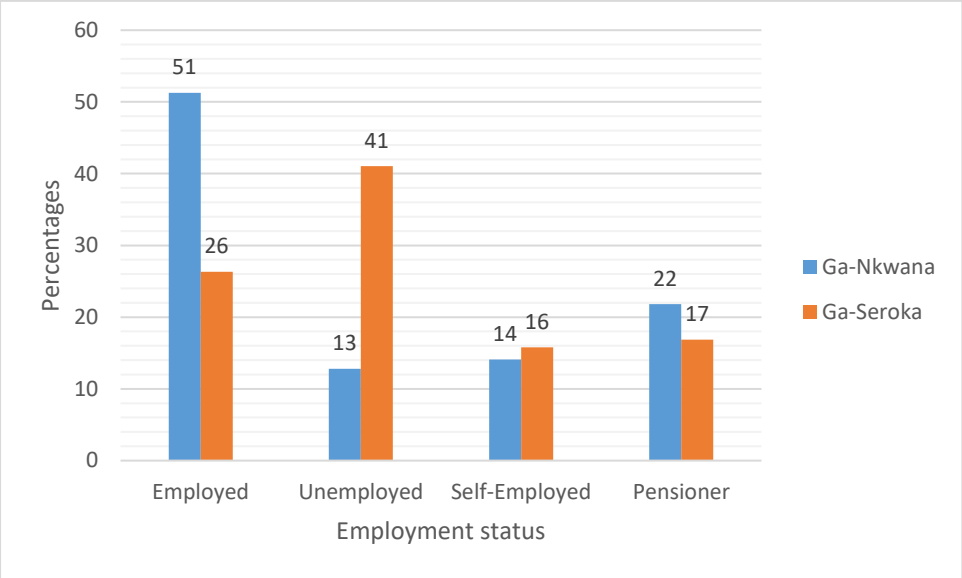

Figure 10: The employment status of respondents

The employment status for Ga-Seroka village respondents was different from that of Ga-Nkwana village, as the highest percentage of the respondents (41%) was unemployed, followed by 26% who were employed. Seventeen percent (17%) of the respondents were pensioners while 16% were self-employed (Figure 10). Most of the respondents only had a secondary qualification which does not really make them marketable as a tertiary level qualification would. Another reason is because they might not be looking for a job, while on the other hand they are afraid of relocating to another area in search of a job. Illiteracy is one of the factors that limit economic, social, physical, technical and educational development in less developed countries (Bester et al., 1999). Unemployment in South Africa is structural in nature and still remains a cause for concern (Tabarrok, 2010). Lack of employment is regarded as a serious economic problem as it generally leads to poverty, crime and loss of self-esteem for those who are discouraged and have not taken further steps to seek employment (Dwivedi, 2010).

The occupations of Ga-Seroka village respondents who were employed included educators, health practitioners, receptionists, clerks, social workers, mechanics, mine workers and brick layers. Although the type of occupations might be similar to those of Ga-Nkwana village, the difference might be the incomes and levels of jobs and

therefore the responsibilities assigned to them, hence making Ga-Nkwana village respondents more financially secure as compared to Ga-Seroka village respondents. Less educated individuals are less likely to find better paying jobs than individuals with higher levels of educational achievements (Kai, 2011). Two percent (2%) of bricklayers in Ga-Nkwana village were within the age group of 36 to 45 years while 1% of bricklayers in Ga-Seroka village were within the same age group. One percent (1%) of the respondents who were clerks in both villages were in the age group of 26 to 35 years whereas 2% of mine workers in Ga-Seroka village were within the age group that is above 45 years. In Ga-Nkwana village, only 1% of mine workers were within the age group that was above 45 years. Seven percent (7%) of the respondents who were educators in Ga-Seroka village were in the 36 to 45 years age group followed by 2% of the respondents falling in the age group that is above 45 years. One percent (1%) of the educators was in the age group that is below 25 years while another 1% was within the age group 26 to 35 years.

In Ga-Nkwana village, 9% of the respondents who were educators were within the age group 36 to 45 years while another 9% of the respondents were within the age group that is above 45 years, followed by 4% of respondents that were in the age group of 26 to 35 years. Health practitioners in Ga-Seroka village made up 1% which was part of the age group of 26 to 35 years, while in Ga-Nkwana village 6% of health practitioners were within the age group of 36 to 45 years. One percent (1%) of the respondents who were health practitioners was in the 26 to 35 years age group (Figure 10). In comparison to the national unemployment rate at 25%, for the first quarter of 2012 (StatsSA, 2012), the unemployment rate for Ga-Nkwana village is low (13%), while the unemployment rate of Ga-Seroka village is high (41%).

4.2.8 Monthly income of respondents

Monthly income is the total income of an individual or household in a month. Income of a person plays an important role in shaping the economic conditions of an individual or household which in turn is likely to have a bearing on the responses about a problem posed to them. Figure 11 demonstrates the level of monthly incomes of respondents in Rands. Thirty two percent (32%) of Ga-Nkwana village respondents earn above R15 000 followed by 28% who earn below R5 000. Twenty five percent (25%) of respondents earn between R5 001 to R10 000, while 15% earn between R10 001 to R15 000 (Figure 11). The reason for this might be because a lot of respondents in Ga-

Nkwana village have a tertiary qualification, which might have aided them in finding better jobs. Ga-Seroka village respondents represented the highest percentage (53%) earning below R5 000, followed by 22% of the respondents earning between R5 001 to R10 000. Seventeen percent (17%) of the respondents in Ga-Seroka village earn above R15 000 while only 8% earn between R10 001 to R15 000 (Figure 11). Most of the respondents in Ga-Seroka village did not reach tertiary level, which somehow minimised their chances of getting better paying jobs. Furthermore, the reason for the monthly income difference between the two villages even though they have the same type of employment might be because of their education qualification status.

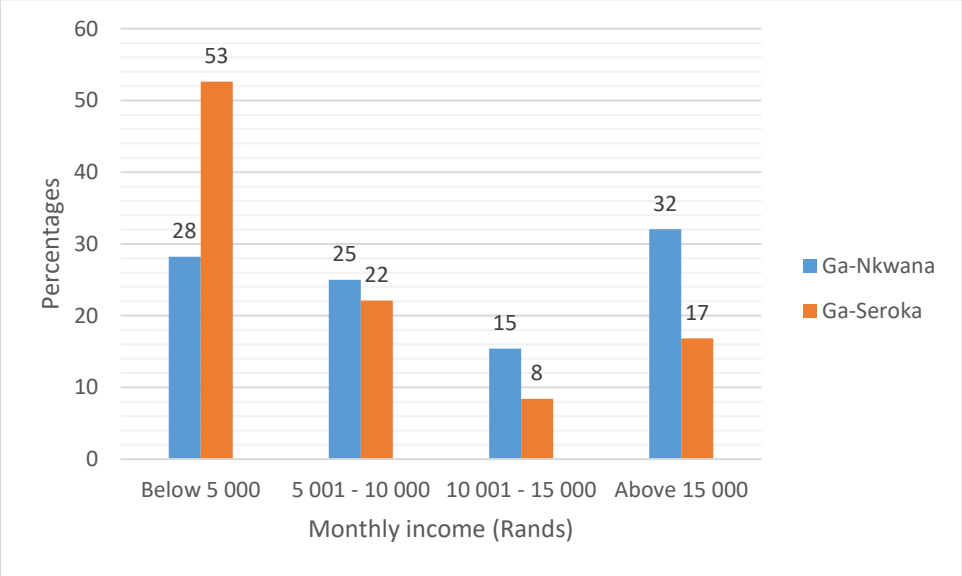

Figure 11: The monthly income status of respondents (Rands)

Ga-Nkwana village respondents might have an advantage of having a higher paying job than respondents in Ga-Seroka village even though they are working under the same profession. For example, they might be classified as educators while one is a Head of Department (HoD) or headmaster whereas the other one is just an educator. Many skilled sectors in South Africa are having difficulty in filling certain positions and unemployment is structural in nature, also contributing to long-term unemployment (DTI, 2004). The highest levels of unemployment and low incomes were formerly reserved for those with only a primary school education, whereas those who have attended high school and failed to attain their grade 12 are also at risk. Those with higher education levels from tertiary appear also to being subjected to the increasing unemployment over time (Leibbrandt et al., 2010).

4.2.9 Income expenditure

Income expenditure refers to all expenditures made by households from their own cash resources as well as all the counterpart of income in kind that households might have received, such as remuneration in kind and other transfers in kind (StatsSA, 2005).

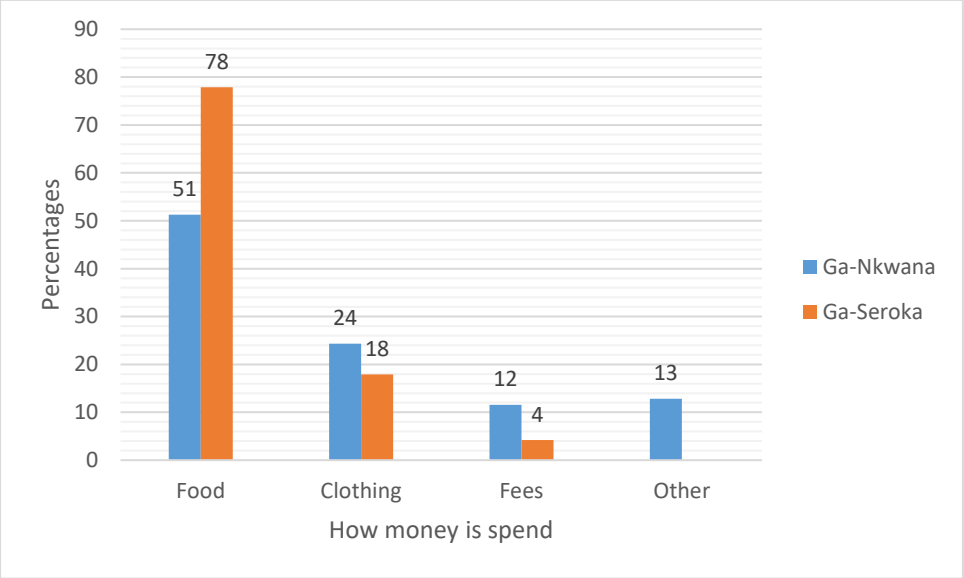

Figure 12: Monthly expenditure of respondents

Figure 12 shows that 51% of the respondents in Ga-Nkwana village spend their money on food followed by 24% of the respondents who spend their money on clothing. Twelve percent (12%) of the respondents stated that they spend their money on fees while 13% spend their money on other things such as contributions to societies/clubs, transport to work, electricity etc. The results for Ga-Seroka village almost have a similar trend as that of Ga-Nkwana village except that the percentages are different. The highest percentage of respondents (78%) spends their monthly income on food, followed by 18% of the respondents spending their monthly income on clothing. Four percent (4%) of the respondents stated that they spend their monthly income on fees (Figure 12). In the 2010/2011 IES survey, it was found that most South Africans spend their income on housing, water, electricity, gas and fuel. Black African households spent a far larger proportion on food and clothing than their Coloured, Indian and White counterparts (StatsSA, 2012).

4.3 Household food accessibility and availability

Food security is one of the important conditions that must be achieved for an individual to be nutritionally secure and to maintain good health. At the national level, food security was perceived mainly in terms of food available for consumption, as derived from food balance sheets, while at the household or individual level, the emphasis has shifted from simple "availability of food" to a more complex system of "food access" (FAO, 1997). Food is a critical determinant for health, because the quality and quantity of food that is consumed influences health (Ostry, 2010). Food is vital because it helps to improve wellness in terms of physical, mental and social health. Without food, people cannot carry out various activities and in turn this lowers productivity. An individual can attain food by producing, purchasing and obtaining it through food aid (Madiziakapita, 2008). Factors influencing availability and accessibility of food include: household size, employment status within households, sources of food, availability of land, accessibility of land and availability of production inputs. These factors are used to also determine whether they contribute to the days when respondents do not have enough food in the household (Ndobo, 2013).

4.3.1 Household size of respondents

Household size is measured by the number of members within a household (Feleke et al., 2005). Households with many members are expected to consume more food than small households (Jacobs, 2009). Figure 13 expresses the household size of respondents in Ga-Nkwana and Ga-Seroka villages. In Ga-Nkwana village, 41% of respondents mentioned that they live with 3 to 4 people in their household followed by 30% of the respondents who shared their household with 5 to 6 people. Fifteen percent (15%) of the respondents had more than 6 people living in their household, whereas only 14% of the respondents were living with 1 to 2 people in their household (Figure 13). The reason for the highest percentage reflecting on the 3 to 4 people is because Ga-Nkwana village has a lot of newly wedded couples who live only with their children. The other reason might be because when the children get married they leave their maternal homes to start their own. Thirty-seven percent (37%) of Ga-Seroka village respondents had 3 to 4 people living in their household followed by 36% of the respondents stating that 5 to 6 people were living in their household during the time of data collection. Eighteen percent (18%) of the respondents in Ga-Seroka village has

more than 6 people living in their household while only 9% of the respondents mentioned living with 1 to 2 people (Figure 13).

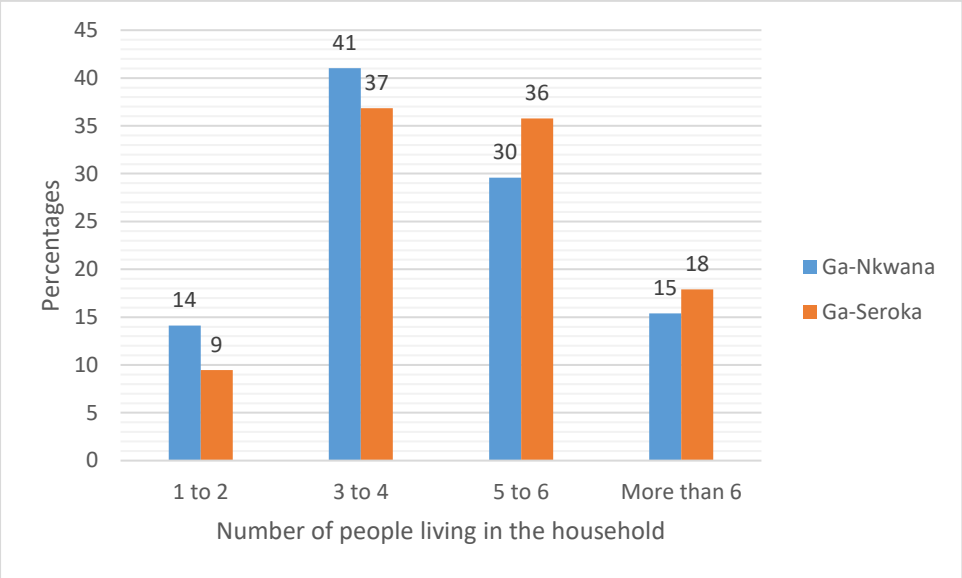

Figure 13: The household size of respondents

The reason for this might be the fact that Ga-Seroka village has a lot of respondents who did not further their studies up to tertiary level. This might have resulted in the respondents not getting jobs and staying with their parents and kids. A study conducted by Olayemi (2012) found that household size and food security are negatively correlated; this is because as household size increases food security decreases. Aidoo et al. (2013) observed that an increase in one additional member of a household generally reduces income per head, expenditure per head and per capita food consumption.

There is no huge percentage difference between groups 3 to 4 (37%) and 5 to 6 (36%) in Ga-Seroka village and the reason is because respondents mentioned having a household with a maximum of 4 people while other households had a maximum of 5 people. According to Babatunde et al. (2007), larger households may be more likely to be vulnerable to food insecurity. Badisa (2011) stated that household size can give an indication of the extent of the pressure that could be exerted on the household resources. Similarly, Ngwenya (2013) has outlined that a larger household size discourages the selling of farm produce because the household need to meet its demand before a decision to sell surplus produce for cash can be arrived at.

Households with many members are expected to consume more food than small households (Jacobs, 2009).

4.3.1a Employment status within the household

Employment status refers to the status of an economically active person with respect to the type of implicit or explicit contract of employment with other persons or organisations (OECD, 2003). Figure 14 shows the employment status of people in the household.

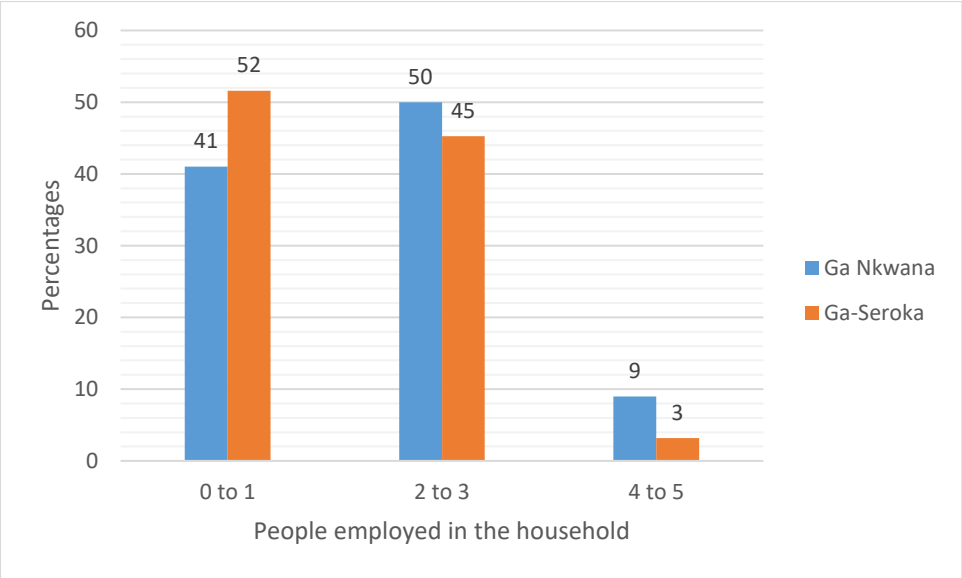

Figure 14: The number of people employed in the household

Fifty percent (50%) of respondents in Ga-Nkwana village had 2 to 3 people in their household who were employed followed by 41% of the respondents who had 0 to 1 people in their household who were employed. Only 9% of the respondents had 4 to 5 people in their household who were employed. The highest percentage (52%) of Ga-Seroka village respondents had 0 to 1 people in their household who were employed while 45% of these respondents had 2 to 3 household members employed. The least percent (3%) of respondents had 4 to 5 working members (Figure 14). The reason for these results might be because some of Ga-Nkwana village respondents furthered their studies until tertiary level which might have increased their chance of employability and thus earning an income. The higher the number of non-working individuals in the household, the higher the burden for working individuals in the provision of food, which in turn increases the likelihood of food insecurity (Amaza et al., 2009).

4.3.1b Family members working away from home

In Ga-Nkwana village, 71% of the respondents had family members who were working away from home while 29% of the respondents did not have family members working away from home (Figure 15).

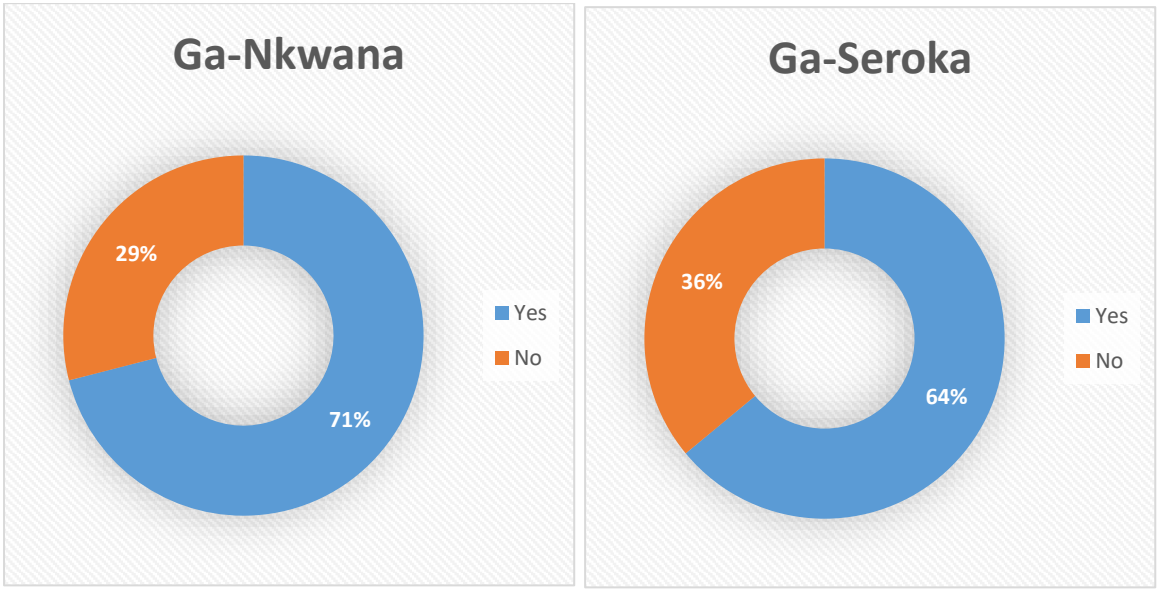

Figure 15: Family members working away from home

Sixty four percent (64%) of the respondents in Ga-Seroka village had family members working away from home while 36% of the respondents did not have family members who were employed away from home (Figure 15). Women are less likely to migrate than men, presumably due to traditional gender roles in household production, but however, higher levels of poverty on a community level have led to an increase in the probability of women migrating (van der Berg et al., 2003). Migrants seem to stem from households with adequate household resources to fund the migration process (Alderman et al., 2000). However, the attainment of the old age pension by a member of a household has led to the encouragement of individuals who have successfully completed high school to migrate in search for work (Ardington et al., 2013).

4.3.2 Are employed household members spending on food?

Access to food is primarily determined by income since the majority of the households in rural areas of South Africa do not practice agriculture and depend on purchasing food instead of production (Musemwa et al., 2013). In Ga-Nkwana village, 99% of the respondents had employed household members who contributed to buying food in the

household while 1% of the employed members did not contribute to buying food (Figure 16).

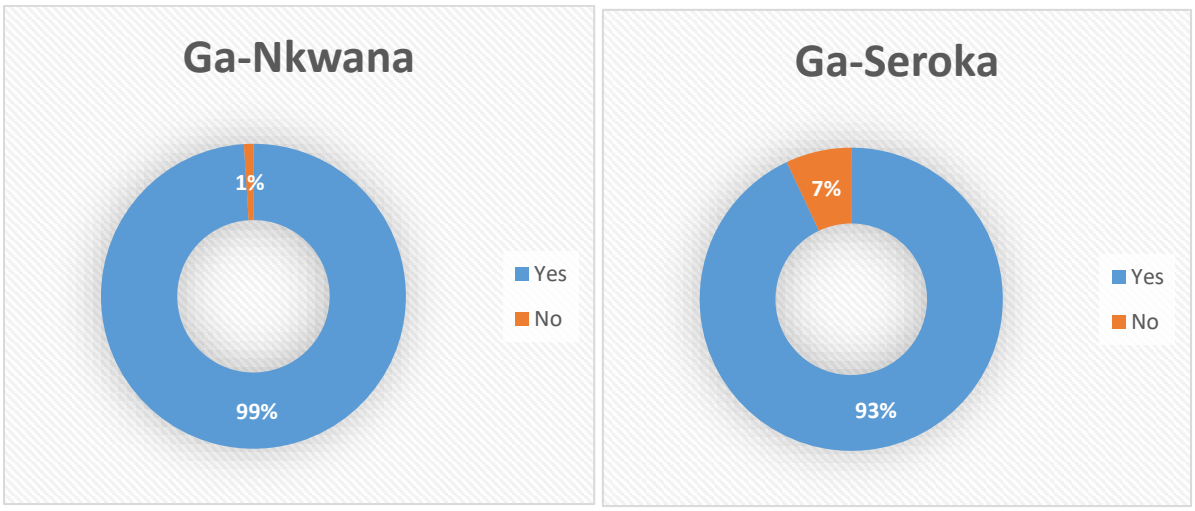

Figure 16: Contribution to buying food by employed household members

In Ga-Seroka village, 93% of the respondents had family members who were employed and contributed to buying food that was needed in the household while only 7% of the respondents had employed family members who did not contribute to buying food for the household (Figure 16). Many people who work away from home tend to bring food home when they are visiting, especially during holidays and days which they are allowed to take leave from work and rest. Some of these people also send remittances or money home every month end to help family members financially.

4.3.2a Are working household members bringing food when they come home?

In Ga-Nkwana village, 95% of the respondents whose family members worked away from home brought extra food when they returned home. Five percent (5%) of the respondents had working family members who did not bring extra food when they come home (Figure 17).

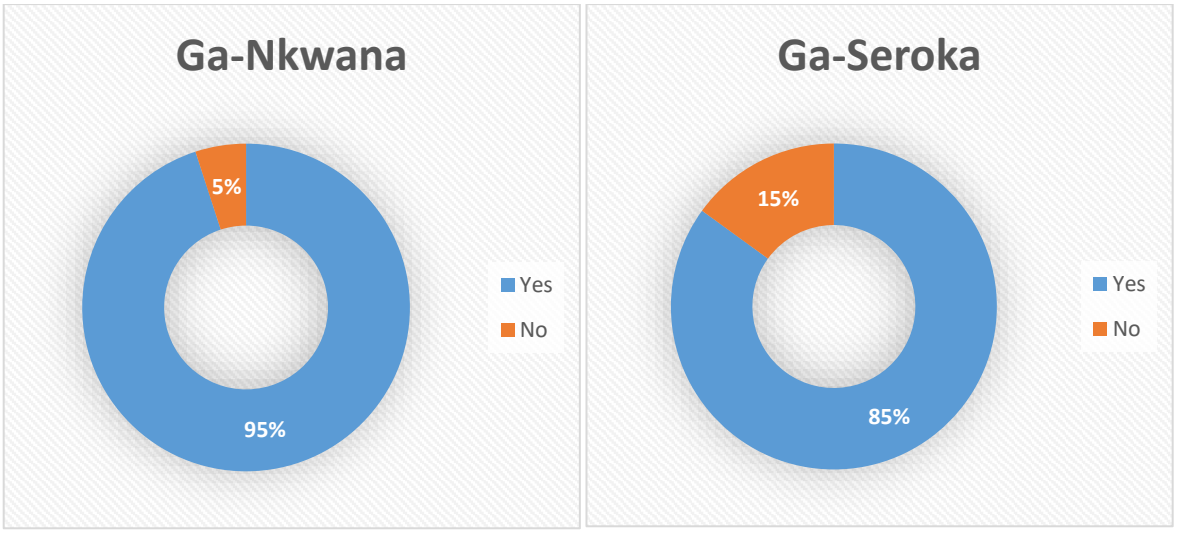

Figure 17: Family members bringing food when they come home.

In Ga-Seroka village, 85% of the respondents had family members working away who brought extra food when they came home while 15% of the respondents had family members who worked away from home but did not bring extra food when they return home (Figure 17).

4.3.3 Access to food by household

Access to food by households is the way in which households go about to obtain food in their households. Food accessibility is the availability of sufficient resources to obtain appropriate foods for a nutritious diet at all times. There are different strategies that households adopt for food acquisition in order to feed their household members and that is by buying, by own food production or by getting food assistance from other households or buying on credit etc. All (100%) of the respondents in Ga-Nkwana village bought most of their food from supermarkets or town and none of the respondents obtained food from subsistence agriculture, government parcels or other sources. The reason for these results might be because the respondents from Ga-Nkwana village are closer to a shopping complex and easily access the shops sometimes even without using any means of transport. According to the results by Musemwa et al. (2013), monthly household income significantly affected household access to food positively. Households that had more monthly income had more access to enough food. This is in line with reports by Alaimo et al. (2001) and Fraser et al. (2003).

Ninety-seven percent (97%) of the respondents in Ga-Seroka village bought their food from supermarkets, while 3% obtained food from subsistence agriculture. None of the respondents got their food from government parcels or other sources. The reason for these results might be because Ga-Seroka village is far from most shopping complexes and it requires respondents to have a mode of transport. Although there are availability of informal spaza shops, most of them are selling goods at a higher price compared to supermarkets found in town or shopping complexes. According to Musemwa et al. (2013), females are normally involved in many household activities and most of them in the rural areas are not employed hence they do not have any other source of income. This therefore limits their access to enough food as most of the households in South Africa depend on food purchases.

Average household size, educational status and households' income are some of the factors that have an influence on the accessibility of food by households. When a household is large, the demand for food will be high. Moreover, household size matters because food consumption increases with a rise in household members. Ankomah (2001) found that the size of a household also influences the amount spent on food. Household food expenditure peaks at a household size of 4 and decline with an increase in household size beyond 4. In addition, large households have the lowest incomes in society. These groups of households are therefore more vulnerable to food insecurity and malnutrition. The higher the number of unemployed individuals in a household, the higher the burden for employed individuals in the provision of food, which in turn increases the likelihood of food insecurity (Amaza et al., 2009). Ga-Seroka village with 41% of unemployed respondents (Figure 10) gives more burden to the employed household members in the provision of food. Access to food is primarily determined by income since the majority of the households in rural areas of South Africa do not practice agriculture and depend on purchasing food instead of production (Musemwa et al., 2013). In rural areas of South Africa where in most cases employment opportunities are minimal, the main sources of income for households are government grants, remittances and agriculture. Agriculture, especially livestock production, is the main economic activity that takes place due to high incidents of droughts and poor soils which make crop production impossible (Musemwa et al., 2013).

Low income households are more likely to suffer from food insecurity as compared to middle income and wealthier households (Jacob, 2009). Low income households are found to depend on social welfare transfer and food aid to access food. Most rural households are highly dependent on social grants and wage incomes in addition to own food production (Shange, 2015). This is also evidenced in the study of Amha (2006) where the researcher revealed that, agricultural production is not the only source of monetary income. May & Rogerson, (1995) suggest that in the urban areas of South Africa, urban agriculture is viewed as the major means of supplementing incomes. There have been instances where low income households end up in debt because of insufficient income to access food (Omonona et al., 2007). Ga-Nkwana village has a good chance of accessing food as compared to Ga-Seroka village because Ga-Nkwana village had the highest percentage (51%) of employed respondents (Figure 10) and 32% of the respondents earned above R15 000 (Figure 11). In a study by Musemwa et al. (2013), education positively affected access to food. The more an individual is educated the more the household is likely to access food and educated individuals are more likely to be absorbed in the labour market and would get better remunerations that would improve their access to food.

4.3.4 Land tenure

Land tenure is defined as the relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. It is guided by rules that define how land access is granted in terms of use, control and transfer. Furthermore, the rules provide for the responsibilities and restraints on the land use (FAO, 2002). The difference between land tenure and land ownership is that, land ownership deals with who can own land (states, communities or private institutions or individuals) while land tenure shows how this land can be accessed (permits, renting or buying). The difference between private and rented land is that, private land is bought by the owner either from the village's headman or the municipality in charge while in the case of rented land, the person renting pays money to the owner of the land.

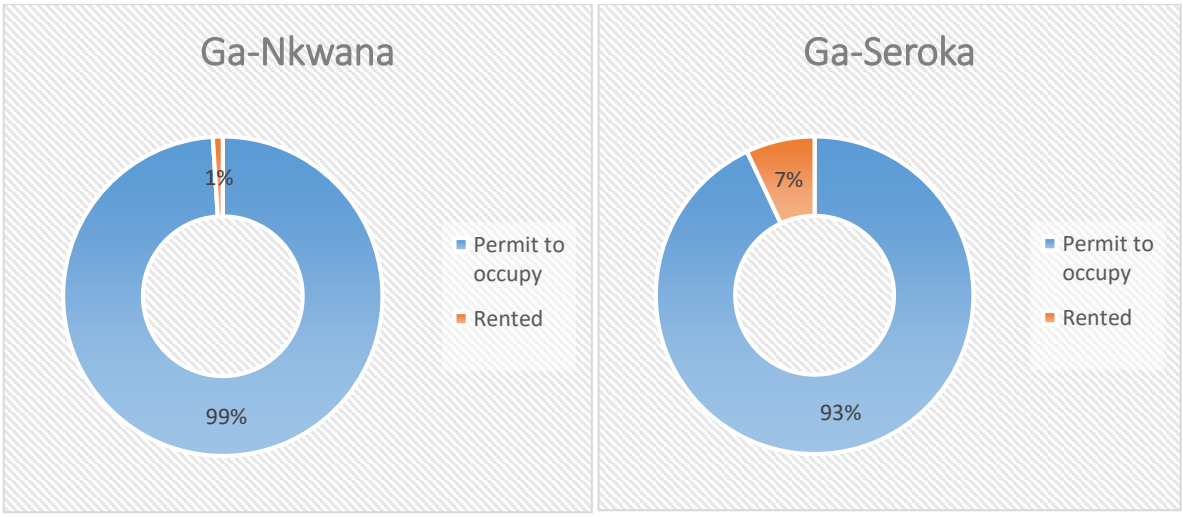

Figure 18: The tenure type of respondents

Agriculture plays a vital role of enhancing food security of households located in remote areas as it is the backbone of the economies of these areas. An important area of focus when addressing the problem of food insecurity in remote areas where employment opportunities are minimal is how to improve household's access to food production on land (Abdu-Raheem & Worth, 2011). Eighty-five percent (85%) of the respondents had ownership to land in both Ga-Nkwana and Ga-Seroka villages respectively, while only 15% in both villages did not own any land. Figure 18 shows the tenure type of respondents' land.

Ninety nine percent (99%) of the respondents in Ga-Nkwana village had permits to occupy their land, while 1% of respondents in Ga-Nkwana village rented the land they stay in (Figure 18). Ninety three percent (93%) of respondents in Ga-Seroka village had permits to occupy their land, while 7% of the respondents stay in rented land (Figure 18).

4.3.4a Land tenure by gender

In Ga-Nkwana village, 50% of the male respondents owned land as compared to 35% of females who owned land. Nine percent (9%) of the female respondents did not own land as compared to 6% of the males who did not own any land (Figure 19). In Ga-Seroka village, 48% of males owned land while 37% of the female respondents owned land. Ten percent (10%) of the females did not own land, while 5% of the male respondents did not own land (Figure 19).

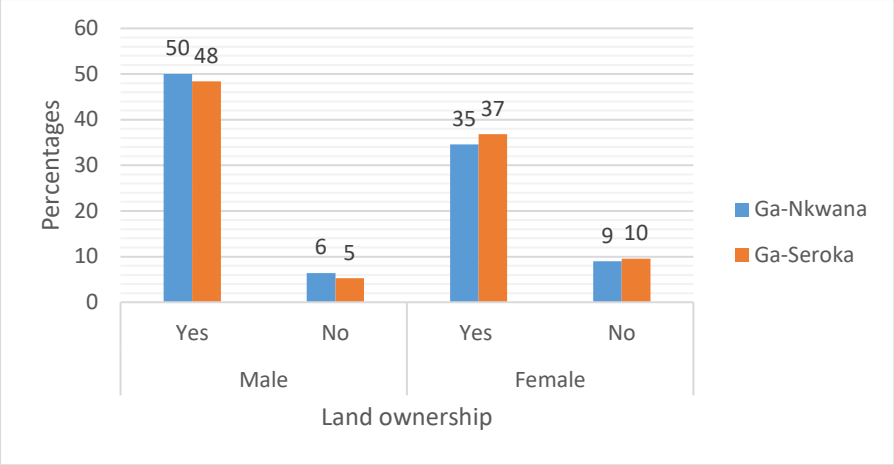

Figure 19: The ownership of land by gender

A high percentage (50%) of males in Ga-Nkwana village had land as compared to 48% of males in Ga-Seroka village whereas 37% of females in Ga-Seroka village owned land as compared to 35% of females in Ga-Nkwana village, having only a difference of 2% in each gender. The reason behind a high proportion of Ga-Seroka village females owning land might be because a lot of the female respondents in Ga-Seroka village are single parents and might have been given their land by their parents. On the other hand, a high percentage of Ga-Nkwana village males owned land, because there are newly wedded couples staying together and the land is bought through the headman of the village and not from the municipality which will instead give them title deeds. Sixty eight percent (68%) of the respondents from Ga-Nkwana village who were males were also household heads (Table 1). Males are the ones whom in most cases have better access to land as heads of households compared to females who only own land when the spouse has passed on. Despite the significant role women played in food production, they continue to have poor command over land ownership pattern in the study area. Women had to purchase land or receive land gifts from men to increase their ownership of land (Ojo & Babayo, 2013).

Women are assumed to be transient within the polity and therefore not strategic as grantees of rights to land which constitutes the core of a community's existence (Kameri-Mbote, 2009). According to Rahama (2009), even though it has been recognized that women play a major role in food supply to households, they do not have the opportunity to own land as men do.

Men control household land because community authorities who are predominantly male have allocated the land to male household heads and these lands are passed down to male heirs. For most women, access to land depends on their relation to male relatives. A husband, for instance, has an obligation to provide arable land to his wife to farm but decides which piece of land the woman can use and for how long (Lanstaria-Cornhiel, 1997). Results of a study by Ojo & Babayo (2013) showed that majority of the male respondents (74%) had farm sizes of 3.5 hectares and above while 73.7% of the female respondents had less than 3.0 hectares of land. This implies that the male respondents had more access to larger farm lands when compared to the female respondents. In many developing countries, according to Udry et al. (1995) land is predominantly owned by men and transferred inter-generationally to males.

4.3.5 Accessibility of land

Land accessibility is broadly defined as the processes by which people individually or collectively gain rights and opportunities to occupy and utilise land (primarily for productive purposes but also other economic and social purposes) on a temporary or permanent basis (FAO, 2006). Figure 20 shows access to land by respondents in the two villages of Ga-Nkwana and Ga-Seroka.

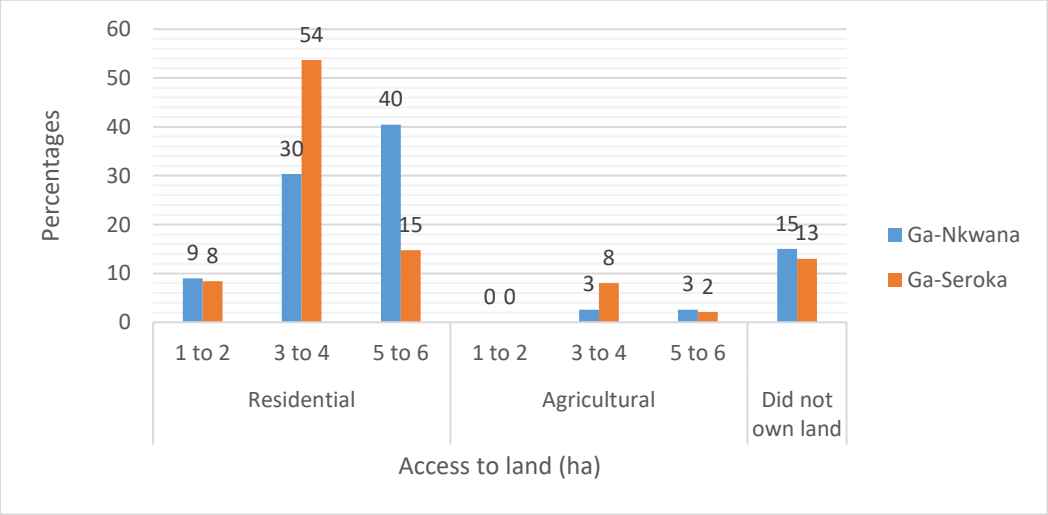

Figure 20: Access to land (ha)

Forty percent (40%) of the respondents in Ga-Nkwana village had 5 ha to 6 ha of residential land, followed by 30% of the respondents who had 3 ha to 4 ha of residential land. Nine percent (9%) of the respondents in Ga-Nkwana village owned 1 ha to 2 ha of residential land. Three percent of the respondents (3%) had access to 3 ha to 4 ha

and 5 ha to 6 ha of agricultural land, respectively. Fifteen percent (15%) of the respondents did not own land and this percentage was inclusive of siblings and children of the household head (Figure 20).

The highest percentage (54%) of the respondents in Ga-Seroka village had access to 3 ha to 4 ha of residential land, followed by 15% of the respondents who had access to 5 ha to 6 ha of residential land. Eight percent (8%) of the respondents had access of 1 ha to 2 ha of residential land, followed by 8% of the respondents who had 3 ha to 4 ha of agricultural land (Figure 20). The least percentage of respondents (2%) had access to 5 ha to 6 ha of agricultural land. Thirteen percent (13%) of the respondents did not own land and this included siblings and children of the household head. The reason for these results might be because some of Ga-Nkwana village respondents have purchased some of the new stands being sold by households who no longer need their agricultural land, while Ga-Seroka village respondents still occupy stands which were given to them by their Chiefs. In countries where agriculture is a main economic activity, access to land is a fundamental means whereby the poor can ensure household food supplies and generate income. Household farming remains the backbone of rural livelihoods in many parts of the developing world such as West Africa, and has been shown to be dynamic, responsive to change, and an important source of investment in agriculture (Toulmin & Guèye, 2003). Access to land is often considered a determinant of peoples' involvement in agriculture (Aliber et al., 2009). Lack of access to land has a limiting effect on capacity to provide food to the family. The situation is worsened when family size is large (Ojo & Babayo, 2013). In South Africa, small holder farmers have small farm holdings of about 0.5 ha to 4 ha producing food for household consumption and little for selling (Kalineza et al., 2008).

4.3.6 Availability of agricultural land

Seventy one percent (71%) of the respondents in Ga-Nkwana village had no agricultural land, while only 29% of the respondents had agricultural land. In Ga-Seroka village, 51% of the respondents had agricultural land while 49% did not have agricultural land (Figure 21). The reason for these results in Ga-Seroka and Ga-Nkwana villages might be because, in the olden days when Chiefs gave residential land to households, they also gave agricultural lands. A number of cases within the Mpumalanga and Limpopo Provinces demonstrate that traditional elites have been able to exploit the ambiguities surrounding land ownership while utilizing new

development opportunities to further expand their influence in rural areas (Forrest, 2001; Land Reform, 2001; Ramutsindela, 2001; Yende, 2001).

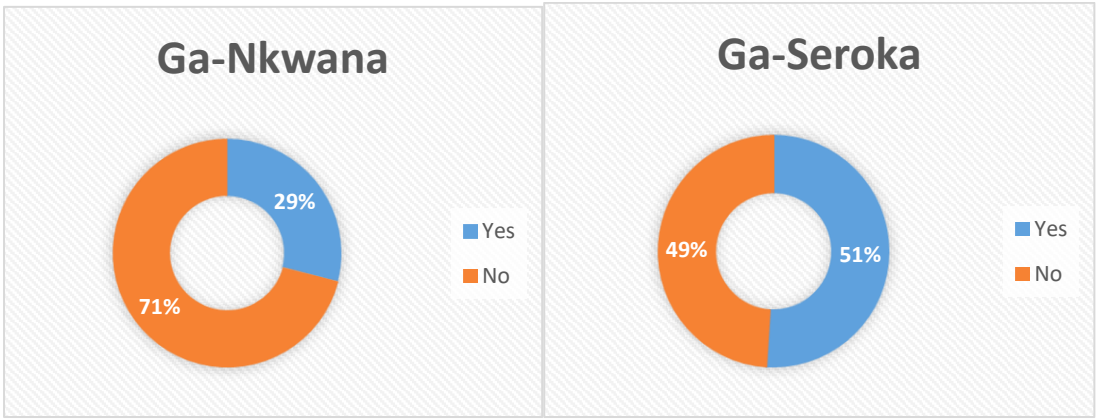

Figure 21: The availability of agricultural land

Ntsebeza (2000) suggests that the use of traditional authorities by colonial powers enabled them to exploit an ambiguity in the relationship between chieftaincies and their people, particularly in terms of the accountability and legitimacy of traditional systems. A series of rulings, including the Glen Grey Act of 1894 and the case of Hermansberg Mission Society v. Commissioner of Native Affairs and Darius Mogale of 1906, strengthened the power of traditional authorities at the local level. The Glen Grey Act was instrumental in shifting land ownership systems within the native areas from communal to individual tenure, while leaving the chief with control over unallocated land (King, 2004). Ntsebeza (2000) reported that, in the ruling, the court held that 'an African Chief, as trustee of the community's land, may alienate land with the consent of the chief's council and without the direct participation of the community. The other reason for Ga-Seroka village with a high percentage of respondents owning agricultural land might be because some of the respondents have been inheriting agricultural lands from their grandparents and parents. There is a high percentage (71%) of Ga-Nkwana village respondents who did not have access to agricultural land and the reason might be because most agricultural land in Ga-Nkwana village have been bought and converted into space for development and new residential stands.

4.3.7 Availability of crop production inputs

The resources that are used in crop production include inputs such as chemicals (e.g. pesticides, herbicides and fertilizers), water, equipment, seeds and agricultural land. Although a high percentage (51%) of the respondents in Ga-Seroka village had access

to agricultural land, other production inputs such as fertilizers, water, seeds and pesticides were not always available (Figure 22).

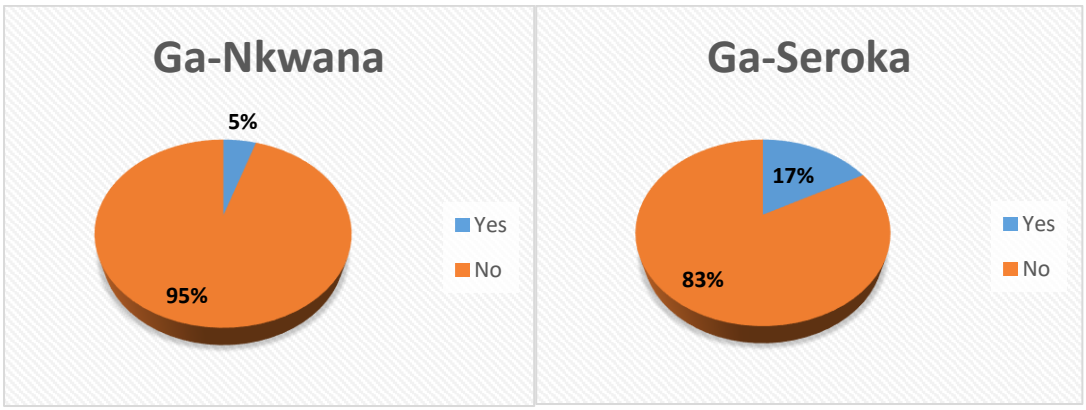

Figure 22: The availability of other crop production inputs

Ninety five percent (95%) of the respondents in Ga-Nkwana village did not have access to crop production inputs, while only 5% of the respondents had access to crop production inputs (Figure 22). Eighty three percent (83%) of the respondents in Ga-Seroka village had no access to production inputs, while only 17% of the respondents mentioned that they had access to crop production inputs. Some respondents in Ga-Seroka village mentioned borrowing, buying and accessing some of the production inputs from their tribal house. Lack of crop production inputs such as water, seeds and fertilizers hinder the production of enough food for a household. Lessons from elsewhere in Africa suggest input support that target smallholder farmers can boost production and food security (Baiphethi & Jacobs, 2009). In Malawi as Baiphethi & Jacobs (2009) show, the Agricultural Input Support Programme (AISP) has raised yields across a large number of stable foods produced by smallholder farmers.

4.3.8 Complementing food with household garden produce

Complementing food through subsistence farming or buying more is another way of making sure that a household does not run out of food. Fifty five percent (55%) of the respondents in Ga-Nkwana village complemented their food with household garden produce while 45% of the respondents did not supplement their food with household garden produce. Sixty six percent (66%) of the respondents in Ga-Seroka village enhanced their food with household garden produce, while only 34% of the respondents did not enhance their food with household garden produce. In Ga-Nkwana village 28% of the respondents complemented their food with household

garden tomatoes followed by 26% of the respondents who complemented their food with spinach grown in their household garden (Figure 23). Sixteen percent (16%) of the respondents in Ga-Nkwana village supplemented their food with cabbages from their home gardens followed by 14% of respondents who added on with maize. Nine percent (9%) of the respondents supplemented their food with other produce harvested from their garden while 7% of the respondents enhanced their food with beans (Figure 23).

In Ga-Seroka village, 24% of the respondents complemented their food with maize grown in their gardens, while 22% of the respondents complemented their food with beans. Nineteen percent (19%) of the respondents in Ga-Seroka village enhanced their food with spinach, while another 19% of the respondents indicated that they supplement their food with tomatoes (Figure 23). Eight percent (8%) of the respondents augmented their food with household grown cabbages followed by another 8% of the respondents who augmented their food with other produce grown in their household gardens (Figure 23).

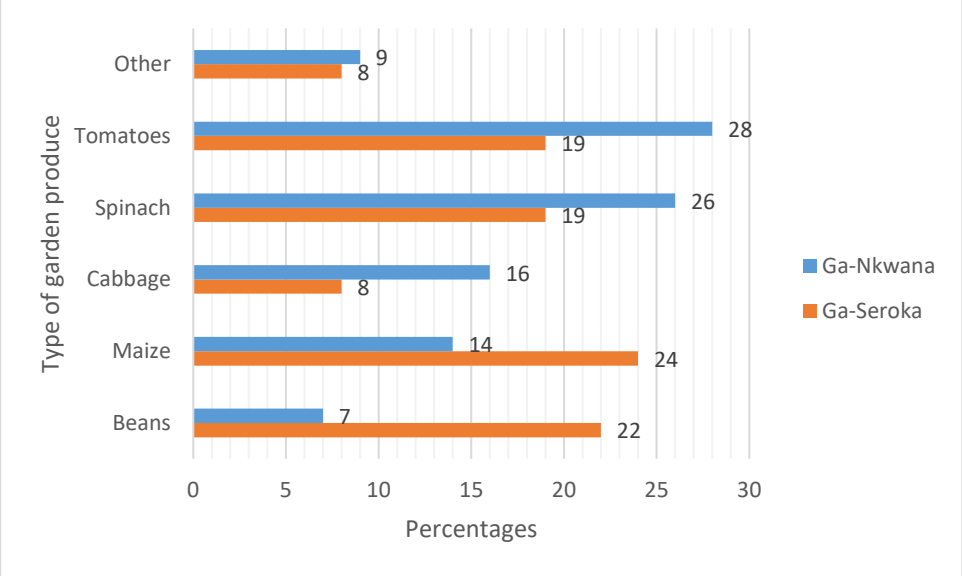

Figure 23: The type of garden produce used to supplemented food.

One of the characteristics of food insecurity in rural areas is lack of variety of food. There are about 4 million people who practice smallholder agriculture in rural and urban areas of South Africa (Baiphethi & Jacobs, 2009). Among those who practice farming, more than 600 000 households do so to produce the main source of food for their families. In addition, over a million households farm to supplement what they

purchase (Watkinson & Makgetla, 2002). Kamal Uddin Khan, (2002) states that in Bangladesh, homestead gardens are primarily the source of supplementary food for a family.

4.3.8a Quantity of garden produce per year

Most of the respondents in both villages supplemented their food with beans, maize, cabbages, spinach and tomatoes from their household gardens. Some of these garden produce were irrigated with greywater while others were irrigated with freshwater (Figures 24a, 24b, 24c, 24d and 24e).

Figure 24a: A home garden with bean plants irrigated by freshwater.

Figure 24b: A home garden with sweet potato plants irrigated with both freshwater and greywater from rinsing dishes.

Figure 24c: A home garden with cabbages irrigated with freshwater.

Figure 24d: A home garden with orange and mango trees irrigated with greywater from bathing and washing clothes and dishes.

Figure 24e. A home garden with sugarcane crop irrigated with greywater from bathing.

Figure 25 shows that 21% of the respondents in Ga-Nkwana village stated that they produced 500 kg to 650 kg of spinach followed by 19% of the respondents who produced 50 kg to 150 kg of tomatoes. Fourteen percent (14%) of the respondents in Ga-Nkwana village harvested 50 kg to 150 kg of maize followed by 12% of the respondents harvesting 500 kg to 650 kg of cabbages. Ten percent (10%) of the respondents in Ga-Nkwana village produced 200 kg to 300 kg of tomatoes, while another 10% produced 50 kg to 150 kg bags of other produce such as fruits, beetroots and onions. Seven percent (7%) of the respondents in Ga-Nkwana village harvested 50 kg to 300 kg of beans, followed by 5% of the respondents harvesting 350 kg to 450 kg of cabbages. Two percent (2%) of the respondents harvested 350 kg to 450 kg of spinach.

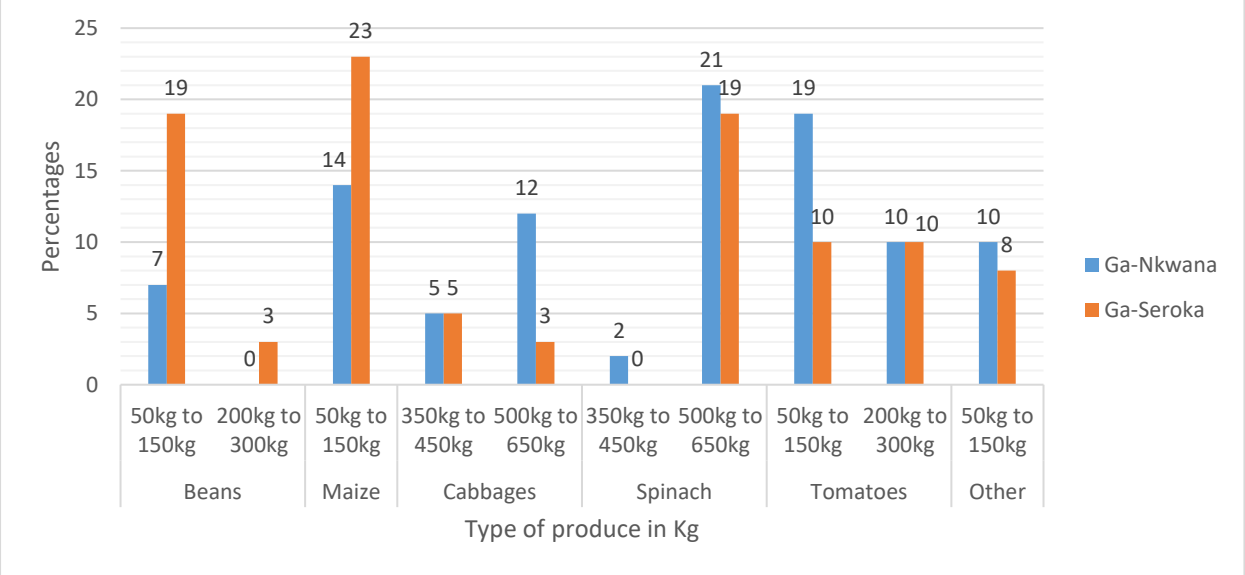

Figure 25: Amount of produce made per year

In Ga-Seroka village, 23% of the respondents produced 50 kg to 150 kg of maize followed by 19% of the respondents who produced 50 kg to 150 kg of beans. Nineteen percent (19%) of the respondents in Ga-Seroka harvested 500 kg to 650 kg of tomatoes, whereas 10% of the respondents produced 50 kg to 150 kg of tomatoes. Ten percent (10%) of the respondents in Ga-Seroka village harvested 200 kg to 300 kg of tomatoes while 8% of the respondents produced 50 kg to 150 kg of other produce such as sweet potatoes, beetroots, carrots and fruits. Five percent (5%) of the respondents in Ga-Seroka village produced 350 kg to 450 kg of cabbages while 3% of the respondents harvested 500 kg to 650 kg of cabbages. The last 3% of respondents in Ga-Nkwana produced 200 kg to 300 kg bags of beans (Figure 25).

According to Koyenikan (2007), households own home gardens since there are benefits attained such as increment of quality food production, improvement of household health and nutrition, generation of income and the use of available space of land.

4.3.9 Produce saved for time of need

Saved produce is the food that is produced either from subsistence or commercial farming and stored to eat during the time when food is not enough. Figure 26 presents the percentages of the respondents saving their produce for time of need during the year when food is not enough. In Ga-Nkwana village 67% of the respondents saved some of the produce to eat during a certain time of the year when food is not enough while 33% of the respondents in Ga-Nkwana village never saved their produce for times when there is no enough food (Figure 26).

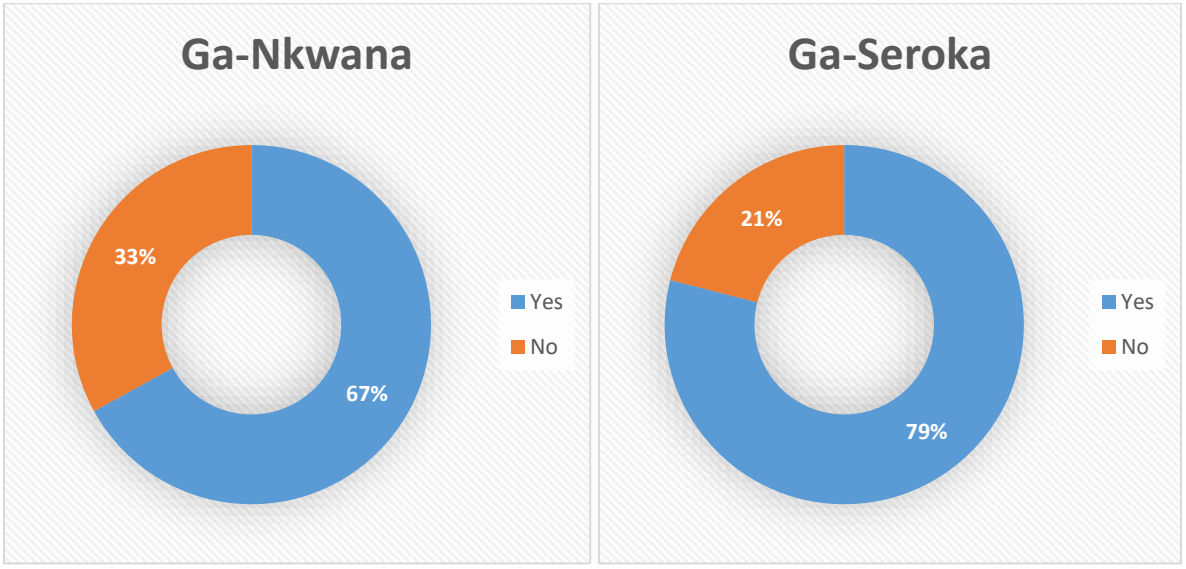

Figure 26: Produce saved to eat during the year when food is not enough

Seventy nine percent (79%) of the respondents in Ga-Seroka village saved their produce, while 21% of the respondents did not save their produce to consume during times when food is not enough (Figure 26).

4.3.10 Money spend on food

Spending money is when an individual uses up their money in return for something. The item can be in the form of food, clothes or even school fees. All the respondents (100%) in Ga-Nkwana village mentioned buying food from local supermarkets or town. Ninety eight percent (98%) of the respondents in Ga-Seroka village bought food from

supermarkets and town, while 2% of the respondents got their food from subsistence agriculture. Figure 27 demonstrates the amount of money spend on food monthly. Thirty three percent (33%) of the respondents in Ga-Nkwana village spent between R2 001 to R3 000 on food, while 27% of the respondents spent between R3 001 to R4 000 on food. Twenty one percent (21%) of the respondents used up between R1 001 to R2 000 on food while the lowest percent (19%) of the respondents spent between R1 to R1 000 on food every month (Figure 27). In Ga-Seroka village, the highest percentage (36%) of the respondents spent between R1 to R1 000 on food monthly, followed by 30% of the respondents who used up between R1 001 to R2 000. Twenty one percent (21%) of the respondents spent between R2 001 to R3 000, while 13% of the respondents spent between R3 001 to R4 000 on food every month. The reason for such a trend is that most of the respondents in Ga-Nkwana village earn more than some of the respondents in Ga-Seroka village (Figure 11), even though they might be employed in the same sector. Income, education, and occupation are interrelated.

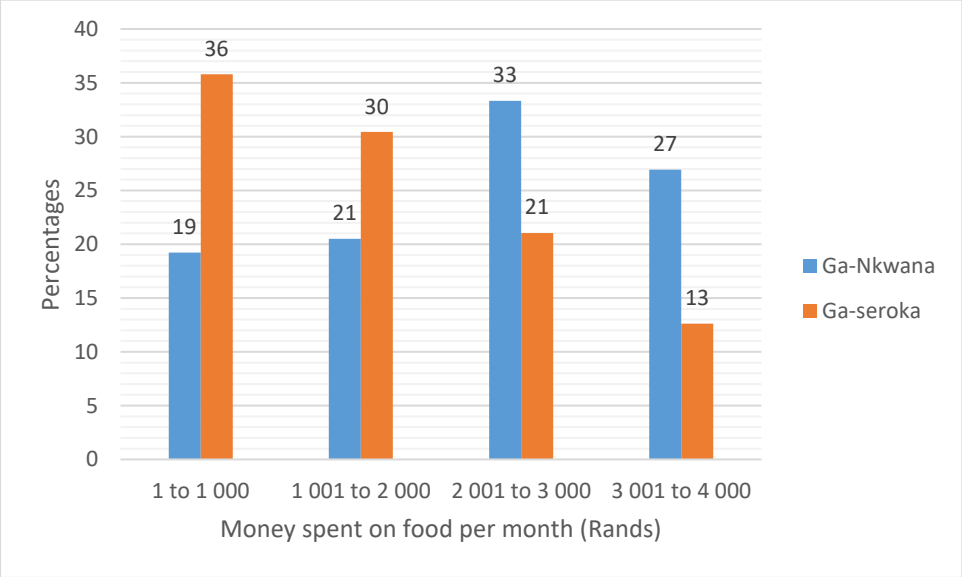

Figure 27: The money spent on food per month

Furthermore, Ga-Seroka village is dominated by pensioners and the youth who are not employed or did not even finish high school. From Aliber (2009), analysis of Income and Expenditure Survey of 2005/06, it shows that poor rural households spend a larger share of their total expenditure on food more than their urban counterparts, apart from the poorest deciles. According to Bonti-Ankomah (2001), most households in rural areas typically spend less on food than households in urban areas. Rudolph et al.

(2012) found a clear correlation between households' income and food security: households in low income class experienced high incidences of food insecurity as compared to households in high income class. A study by Olyuole et al. (2009) revealed that the proportion of the food secure households tends to increase with a rise in household income.

4.3.11 Lack of sufficient food

Rural households in most developing countries are food insecure and unable to meet their daily dietary food needs (Averbeke & Khosa, 2007). Reily et al. (1999) and Bonti-Ankomah (2001) emphasize that to achieve food security households should have sufficient availability and adequate access to physical food supplies through their own production, market or other sources, and those food supplies be appropriately utilized to meet the specific dietary needs of individuals. Food is regarded as the most important basis for human and economic development (Smith et al., 2006). It is one of the basic physical needs for human survival. Food is a critical determinant for health, because the quality and quantity of food that is consumed influences health (Ostry, 2010). In Ga-Nkwana village, 72% of the respondents did not run out of food at any time of the year while 28% of the respondents had days on which their food was not enough (Figure 28). Ga-Seroka village had 65% of the respondents who did not experience days of less food while 35% of the respondents had days when their food was not enough (Figure 28).

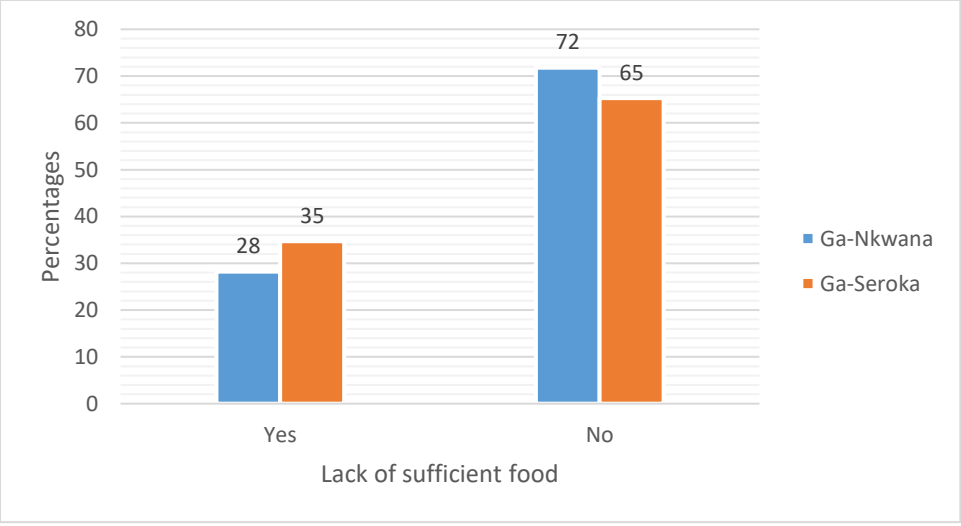

Figure 28: Lack of sufficient food

Hunger and malnutrition in South Africa stem from insufficient, unstable food supplies, at the household or intra-household level. The majority of producers in the former homelands are unable to feed their families from their narrow production base. Government reports, including the Diagnostic Review by the National Planning Commission and other household surveys reveal that South Africa has high levels of poverty, unemployment and inequality and cognisance should be taken of the causes of these, which include unemployment, low economic growth rate and the inability of Macroeconomic forces in meeting the basic minimums (NDA, 2016).

4.3.11a Months which families struggle to get enough food

In Ga-Nkwana village, out of 28% of the respondents who ran out of food, 91% of the respondents struggled to have enough food for 1 to 2 months in a year while 9% of the respondents struggled to have enough food for 3 to 4 months in a year (Figure 29). Out of the 35% of the respondents in Ga-Seroka village who struggled to have enough food, 94% of the respondents did not have enough food for 1 to 2 months in a year while 6% of the respondents experienced less food for 3 to 4 months in a year (Figure 29). A study by D'Haese et al. (2011) revealed that, most of the households (53%) in their survey did not experience any period of hunger throughout the entire year. However, for those households that experienced hunger, the period ranged between one to four months in a year, with the greatest number of households experiencing only one (13.2%) to two (10.2%) months of hunger.

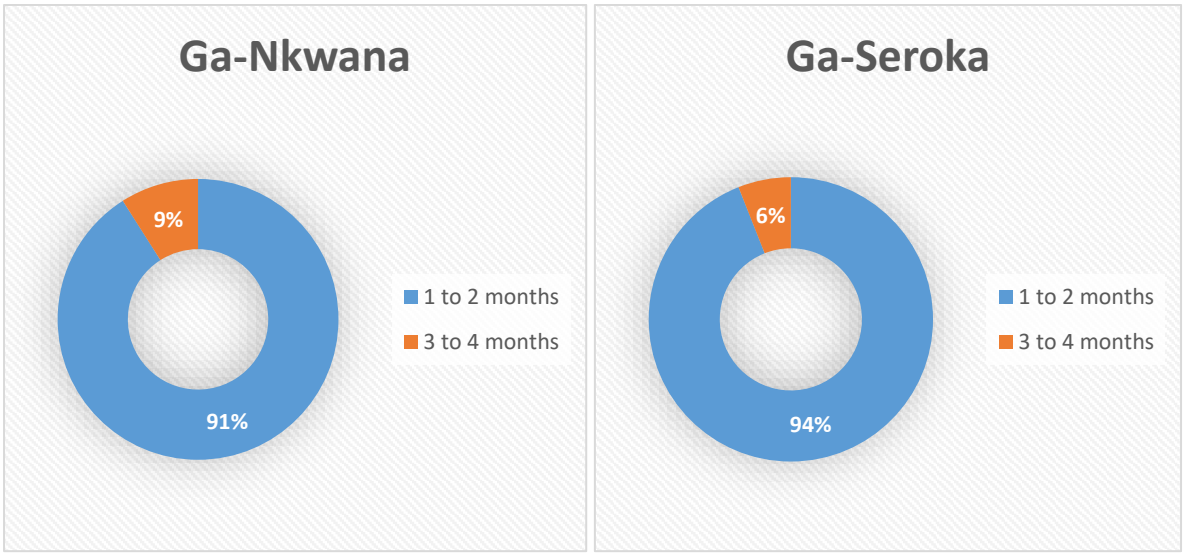

Figure 29: Months without enough food

4.3.12 Coping options used by households in the past 30 days when they did not have enough food.

Devereux (2001) defines coping strategies as a response to adverse events or shocks. The definition by Snel & Staring (2001) captures the broad notion of coping strategies, namely that “all the strategically selected acts that individuals and households in a poor socio-economic position use to restrict their expense or earn some extra income to enable them to pay for the basic necessities (food, clothing, shelter) and not fall too far below their society’s level of welfare”. The coping strategies are often identified by the person who is responsible for preparing or consuming the food (Ndobo, 2013). In Ga-Nkwana village, a total of 22 respondents (28% in Figure 28) lacked food sufficiency at certain times during the year. Out of these 22 respondents, some used one method of coping strategy while others combined different coping strategies and the results are illustrated in table 2. All households in Ga-Nkwana village relied on less preferred and less expensive foods as a coping strategy while 20 households borrowed food or relied on help from friends and relatives. Twenty (20) households in Ga-Nkwana village purchased food on credit while 5 households gathered wild food, went hunting and harvested immature crops as their coping strategy. Two (2) households consumed seed stock held for next season whereas 5 households indicated that they sent a household member to eat elsewhere as their coping strategy.

Table 2: Coping strategies used by Ga-Nkwana village respondents

Coping strategies	Number of households
Rely on less preferred and less expensive foods	22
Borrow food, or rely on help from friends and relatives	20
Purchase food on credit	20
Gather wild food, hunt or harvest immature crops	5
Consume seed stock held for next season	2
Send household member to eat elsewhere	5
Send household member to ask for food	0
Limit portion sizes at mealtimes	4
Restrict consumption of adults so children could eat	1
Feed working HH member at the expense of non-working members	0
Ration the available money	9
Reduce the number of meals eaten in a day	9
Experience some days without enough food	1
Sell livestock or farm implements to purchase food	0

In Ga-Nkwana village, no one sent their household member to go ask for food, fed working members at the expense of the non-working members nor sold livestock or farm implements to purchase food. Four (4) households in Ga-Nkwana village reported limiting portion sizes at mealtimes while 1 household restricted consumption of adults so children could eat. Nine (9) households revealed that they rationed the available money while another 9 households reduced the number of meals they ate in a day. One (1) household in Ga-Nkwana village experienced some days without enough food as a coping strategy when they did not have enough food.

Table 3: Coping strategies and frequency of use per week by Ga-Nkwana respondents

Coping strategies	Every day	3 to 6 times	Once to twice	Less than once	Never
Rely on less preferred and less expensive foods	3	6	7	6	0
Borrow food, or rely on help from friends and relatives	1	4	11	4	2
Purchase food on credit	2	9	7	2	2
Gather wild food, hunt or harvest immature crops	0	0	0	5	17
Consume seed stock held for next season	0	0	0	2	20
Send household member to eat elsewhere	0	0	1	4	17
Send household member to ask for food	0	0	0	0	22
Limit portion sizes at mealtimes	0	0	2	2	18
Restrict consumption of adults so children could eat	0	0	0	1	21
Feed working HH member at the expense of non-working members	0	0	0	0	22
Ration the available money	0	2	0	7	13
Reduce the number of meals eaten in a day	0	0	4	5	13
Experienced some days without enough food	0	0	0	1	21
Sell livestock or farm implements to purchase food	0	0	0	0	22

In Ga-Nkwana village, out of 22 households who relied on less preferred and less expensive foods, 3 households did so every day, 6 households did so 3 to 6 times in a week, 7 households did so once to twice a week and 6 households relied on these foods less than once a week (Table 3). One (1) household in Ga-Nkwana village borrowed food or relied on help from friends and relatives every day while 4 household did so 3 to 6 times in a week. Eleven (11) households borrowed food and relied on help from friends and relatives once to twice a week followed by 4 households who did so less than once a week while 2 households never used this coping strategy (Table 3). Two (2) households in Ga-Nkwana village purchased food on credit every day while 9 households did so 3 to 6 times in a week. Seven (7) households in Ga-Nkwana village purchased food on credit once to twice in a week followed by 2 households who did so less than once in a week while 2 households never used this coping strategy. Five (5) households in Ga-Nkwana village gathered wild food, went

hunting and harvested immature crops less than once a week while 17 households never used this coping strategy (Table 3). Two (2) households consumed seed stock held for the next season less than once a week while 20 households never used this coping strategy. In Ga-Nkwana village, 1 household sent their household member to eat elsewhere once to twice a week followed by 4 households who used this coping strategy less than once a week. Seventeen (17) households in Ga-Nkwana village never sent a household member to eat elsewhere as a coping strategy. Twenty two (22) households each in Ga-Nkwana village never sent a household member to ask for food, fed working household members at the expense of non-working members nor sold livestock or farm implements to purchase food, respectively (Table 3).

Two (2) households in Ga-Nkwana village limited portion sizes during mealtimes once to twice a week followed by another 2 households who did so less than once a week while 18 households never limited their portion sizes during mealtimes (Table 3). One household in Ga-Nkwana village restricted the consumption of adults for less than once a week so that children could eat while 21 households never effected this coping strategy. Two (2) households rationed the available money 3 to 6 times in a week while 7 households did so less than once in a week. Thirteen (13) households in Ga-Nkwana village never used this coping strategy (Table 3). Four (4) households in Ga-Nkwana village reduced the number of meals eaten in a day once to twice a week while 5 households did so less than once a week whereas 13 households never reduced the number of meals in a day as their coping strategy. In Ga-Nkwana village, less than once a day in a week, 1 household experienced some days without enough food while 21 households never experienced any days without enough food (Table 3).

Table 4: Coping strategies used by Ga-Seroka village respondents

Coping strategies	Number of households
Rely on less preferred and less expensive foods	27
Borrow food, or rely on help from friends and relatives	28
Purchase food on credit	28
Gather wild food, hunt or harvest immature crops	9
Consume seed stock held for next season	6
Send household member to eat elsewhere	3
Send household member to ask for food	1
Limit portion sizes at mealtimes	5
Restrict consumption of adults so children could eat	7
Feed working HH member at the expense of non-working members	4
Ration the available money	12
Reduce the number of meals eaten in a day	17
Experienced some days without enough food	2
Sell livestock or farm implements to purchase food	5

In Ga-Seroka village, a total of 33 respondents (35% in Figure 28) lacked food sufficiency at certain times during the year. Out of these 33 respondents, some used one method of coping strategy while others combined different coping strategies and the results are illustrated in table 5. Twenty seven (27) households in Ga-Seroka village relied on less preferred and less expensive foods as a coping strategy while 28 households borrowed food or relied on help from friends and relatives. Twenty eight (28) households in Ga-Seroka village purchased food on credit while 9 households gathered wild food, went hunting and harvested immature crops as their coping strategy. Six (6) households consumed seed stock held for next season whereas 3 households indicated that they sent a household member to eat elsewhere as their coping strategy.

In Ga-Seroka village, 1 of the households sent their household member to go ask for food while 5 households reported limiting portion sizes at mealtimes. Seven (7) households restricted consumption of adults so children could eat while 4 households fed working household members at the expense of the non-working members. Twelve (12) households in Ga-Seroka village revealed that they rationed the available money while 17 households reduced the number of meals they ate in a day. Two (2) households in Ga-Seroka village experienced some days without enough food

whereas 5 households sold livestock and farm implements to purchase food as a coping strategy when they did not have enough.

In Ga-Seroka village, out of 27 households who relied on less preferred and less expensive foods, 3 households did so every day while 18 households did so 3 to 6 times in a week (Table 5). Three (3) households in Ga-Seroka village relied on less preferred and less expensive foods once to twice a week followed by 3 households who did so less than once a week while 6 households never relied on less preferred or less expensive foods.

Nine (9) households in Ga-Seroka village borrowed food and relied on help from friends and relatives 3 to 6 times in a week followed by 15 households who did so once to twice a week (Table 5). Four (4) households used this coping strategy less than once a week while 5 households never used this coping strategy. Five (5) households in Ga-Seroka village purchased food on credit 3 to 6 times in a week while 18 households did so once to twice a week. Five (5) households in Ga-Seroka village purchased food on credit less than once in a week while 5 households never used this coping strategy (Table 5). In Ga-Seroka village, 2 households gathered wild food, went hunting and harvested immature crops everyday while 3 other households did so once to twice a week. Four (4) households in Ga-Seroka gathered wild food, went hunting and harvested immature crops less than once in a week whereas 24 households never used this coping strategy. One (1) household in Ga-Seroka village consumed seed stock held for the next season 3 to 6 times in a week followed by 2 households which did so once to twice a week. Three (3) households consumed seed stock held for next season while 27 households never used this coping strategy. One (1) household sent their household member to eat elsewhere once to twice a week followed by 2 households which used this coping strategy less than once a week. Thirty (30) households in Ga-Seroka village never sent a household member to eat elsewhere as a coping strategy (Table 5).

Table 5: Coping strategies and frequency of use per week by Ga-Seroka respondents

Coping strategies	Every day	3 to 6 times	Once to twice	Less than 1	Never
Rely on less preferred and less expensive foods	3	18	3	3	6
Borrow food, or rely on help from friends and relatives	0	9	15	4	5
Purchase food on credit	0	5	18	5	5
Gather wild food, hunt or harvest immature crops	2	0	3	4	24
Consume seed stock held for next season	0	1	2	3	27
Send household member to eat elsewhere	0	0	1	2	30
Send household member to ask for food	0	0	0	1	32
Limit portion sizes at mealtimes	2	0	2	1	28
Restrict consumption of adults so children could eat	0	2	4	1	26
Feed working HH member at the expense of non-working members	0	0	2	2	29
Ration the available money	0	3	6	3	21
Reduce the number of meals eaten in a day	1	1	11	4	16
Experience some days without enough food	0	0	1	1	31
Sell livestock or farm implements to purchase food	0	0	5	0	28

One (1) household in Ga-Seroka village sent their household member to ask for food less than once a week while 32 households never sent a household member to ask for food (Table 5). Two (2) households in Ga-Seroka village limited portion sizes during mealtimes every day while another 2 households did so once to twice a week. One (1) household limited portion sizes at mealtimes less than once a week while 28 households never limited their portion sizes during mealtimes (Table 5). Two (2) households in Ga-Seroka village restricted the consumption of adults so children could eat 3 to 6 times in a week followed by 4 households which used this coping strategy once to twice in a week. One (1) household limited portion sizes at mealtimes in Ga-Seroka village while 26 households never effected this coping strategy. Two (2) households in Ga-Seroka village fed working household members at the expense of non-working members once to twice a week while another 2 households did so less than once in a week. Twenty nine (29) households in Ga-Seroka village never fed any working member at the expense of non-working members. Three (3) households

rationed the available money 3 to 6 times in a week while 6 households did so once to twice in a week. Three (3) households in Ga-Seroka village rationed the money they had less than once in a week while 21 households never used this coping strategy (Table 6). One (1) household in Ga-Seroka village reduced the number of meals eaten in a day everyday while 1 household did so 3 to 6 times in a week. Eleven (11) households reduced the number of meals eaten in a day once to twice a week while 4 households did so less than once a week whereas 16 households never reduced the number of meals in a day as their coping strategy. In Ga-Seroka village, 1 household experienced some days without enough food once to twice a week while another household (1) did so less than once in a week. Thirty one (31) households never experienced any days without enough food. Five (5) households sold livestock and farm implements to purchase food while 28 households never sold livestock or farm implements to purchase food (Table 5). Studies on coping strategies adopted by India's poor households highlights the change in food consumption pattern, diversification of income generation into non-farm activities, distress sale or mortgage of land and household assets, dependence of common property resources for rearing livestock, and seasonal migration to other areas as the most favoured (Banik, 2007; Mishra, 2007; Rani & Dodia, 2000). The most dispossessed communities like Musahars of Bihar and Eastern Uttar Pradesh search for undigested grain even in cattle dung and the stores of fields rats as survival strategies while coping with hunger (Mander, 2006).

4.4 Freshwater sources and greywater reuse

Freshwater is one of the basic resources, but the amount of water available for use on the planet is finite, and out of the available water, only 3% is freshwater and 2% of the freshwater is frozen in glaciers and polar ice caps and 1% is usable water (NASA, 2007). Population and economic growth increases the demand for water. Global demand for water has tripled since the 1950s, but the supply of freshwater has been declining (Gleick, 2003). The acute freshwater challenge facing humankind can be met only if action to conserve water is taken by following methods such as greywater reuse and practicing sustainability (FAO, 2012).

4.4.1 Sources of freshwater

A source of freshwater is a place or a facility that makes freshwater available for a community or region. Rural freshwater sources such as home and communal taps,

and rivers are often vulnerable to droughts and floods, leading to increased costs of obtaining freshwater at times when food prices typically are also likely to be high (Wenhold et al., 2007). Access to freshwater for livestock and particularly for the irrigation of crops, including food crops, is one of the ways poverty and food insecurity can be reduced in rural areas. This has resulted in freshwater being called the dividing line between poverty and prosperity, as it is a cross-cutting tool for the achievement of the Millennium Development Goals (Wenhold et al., 2007). Eighty five percent (85%) of the respondents in Ga-Nkwana village accessed their freshwater from an outdoor home tap followed by 14% of the respondents who fetched their freshwater from a community tap. The remaining 1% of the respondents harvested rainwater (Figure 30).

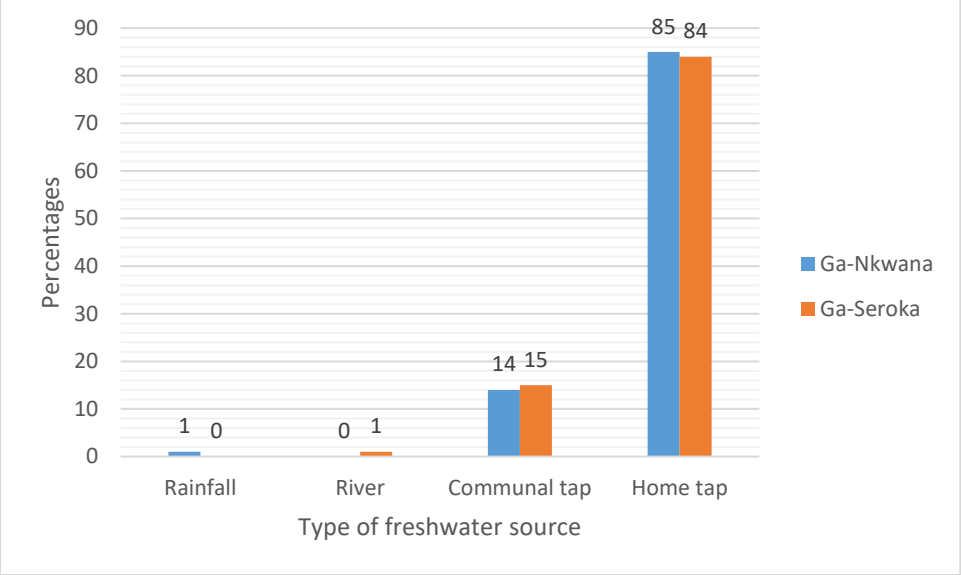

Figure 30: The sources of freshwater

In Ga-Seroka village, 84% of the respondents had outdoor home taps followed by 15% of the respondents who indicated that they fetched their freshwater from a communal tap. One percent (1%) of the respondents fetched freshwater from a river (Figure 30). Many communities in South Africa are still without water for long periods and are forced to spend about R1.50 to get 25 l of water and unemployed community members who cannot afford to pay for water resort to using water from wells, fountains and rivers (Manamela, 2010). According to WHO (2006), rural areas in Africa are the ones mostly with limited sources of water.

4.4.2 Distance to the nearest freshwater source

Distance to a freshwater source is the total length travelled by an individual to and from a freshwater source. In South Africa, freshwater is a human right, thus government introduced several measures to ensure that everyone has access to at least the basic level of services at no cost. In Ga-Nkwana village 86% of the respondents fetched their freshwater within a distance of 200 m, followed by 14% of the respondents who accessed their freshwater within a distance of between 201 m and 400 m (Figure 31). The reason for this might be because Ga-Nkwana village respondents are closer to an area of development whereby they benefit from the development of new services.

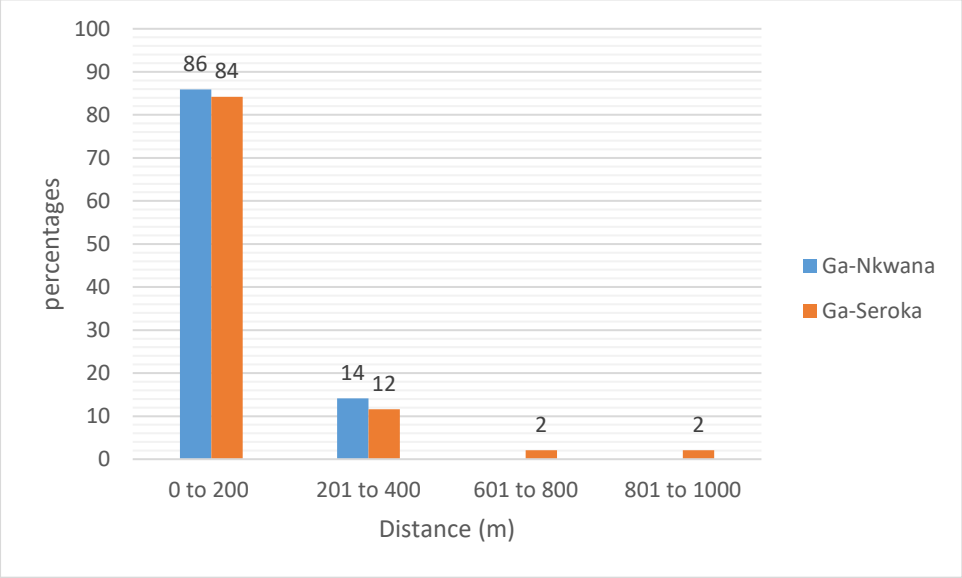

Figure 31: The distance to a freshwater source

Eighty four percent (84%) of the respondents in Ga-Seroka village fetched their freshwater from a distance of 200 m followed by 12% of the respondents who had their freshwater source at a distance of between 201 m to 400 m. Two percent (2%) of the respondents accessed their freshwater source at a distance of between 401 m and 800 m as well as between 801 m and 1 000 m, respectively (Figure 31). The reason for this might be because some respondents in Ga-Seroka village mentioned fetching their freshwater from a river and some communal taps are very far and the respondents had to walk long distances to get freshwater. According to the Department of Provincial and Local Government (DPLG) “municipalities must spend funds on the provision of infrastructure necessary to supply 25 l of potable water per person per day supplied within 200 m of a household and with a minimum flow of 10 l

per minute (in the case of communal water points), or 6 000 l of potable water supplied per formal connection per month (in the case of yard or house connections); or to upgrade and build new infrastructure up to a basic level of service in existing formal settlements" (DPLG, 2007). Distance to nearest water sources is important in the decision whether other means should be considered or not (Joseph & Botha, 2012). The lesser the walking distance to a water source, the less likely it is that a household could consider other means of accessing water (Monde & Aliber, 2007).

4.4.3 Quality of water

Conceptually, water quality refers to physical, chemical and biological characteristics of a water supply that will influence its suitability for a specific use such as how well the quality of the water meets the needs of the user (FAO, 1994). South Africa is a semi-arid country and, as in the rest of Africa, "urbanization, industrialization and agriculture has led to deterioration in the quality of water in streams and lakes near urban centres" (Moyo & Phiri, 2002). Deteriorating water resource quantity and quality is likely to become a serious restriction to future socio-economic development (Peart & Govender, 2001).

In 2011, Greater Sekhukhune District Municipality (GSDM) had a Blue Drop Score of 59.05% showing an average performance when coming to water quality. From a regulatory point of view, Drinking Water Quality (DWQ) management by GSDM presents a high-risk situation to public health. The microbiological quality of water in 6 of the evaluated 11 supply systems showed non-compliances with South African National Standard (SANS 241) for drinking water.

All respondents (100%) in Ga-Nkwana village mentioned that they received potable water from home and communal taps. In Ga-Seroka village, 92% of the respondents received potable water from their home and communal taps while 6% of the respondents received salty water from communal taps followed by 2% of the respondents who had access to dirty water which they fetched from the river and sometimes the water was faecally contaminated by the livestock. Communities' attitude towards their raw or drinking water and towards their drinking water supply entities is strongly affected by the appearance of the delivered water. This has a negative effect on the drinking water consumption in the study areas, as in case of drinking water, neither of these two parameters applies as quality indicator (Rojas &

Megerle, 2013). In South Africa, government initiated a Blue Drop scheme in 2009, which uses media releases to inform the public about the water quality-related performance of Water Service Providers and Authorities.

4.4.4 Availability of freshwater

According to the Water Services Act (108 of 1997) availability of water is the right of access to basic water supply from taps and boreholes, with a minimum quantity of potable water of 25 l per person per day or 6 kl of water per household of 8 people per month.

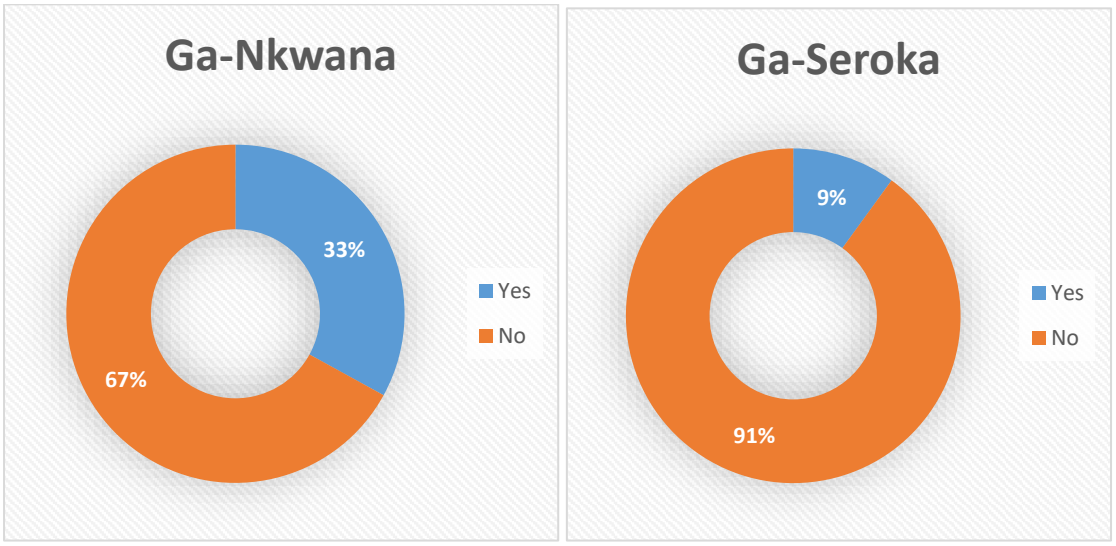

Figure 32: Availability of freshwater on a daily basis

This water must be at a minimum flow rate of not less than 10 l per minute and within 200 m of a household with effectiveness such that no consumer is without a supply for more than seven full days in any year. Most of the rural communities in South Africa are poverty-stricken, lack access to potable water supplies and rely mainly on rain and river water sources for their daily water needs (Dzwairo et al., 2006). Water from rivers is used directly by humans and their livestock.

Figure 32 illustrates water availability in the selected villages. In Ga-Nkwana village, 67% of the respondents mentioned not having tap water daily while 33% mentioned that water is always available. Ninety one percent (91%) of the respondents in Ga-Seroka village mentioned that tap water is not always available while only 9% mentioned that they always have water.

4.4.4a Supplementing available freshwater

Sixty two percent (62%) of Ga-Nkwana village respondents stated that they bought their water from water tankers and people selling water with bakkies while 21% of respondents got water from boreholes. Seventeen percent (17%) of the respondents in Ga-Nkwana village supplemented their water with river water (Figure 33).

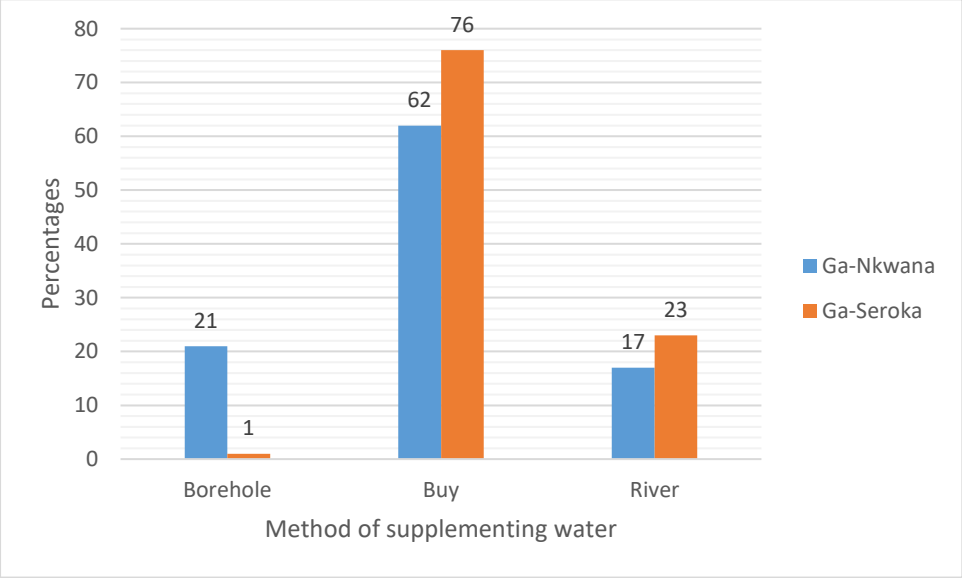

Figure 33: Methods of supplementing water

In Ga-Seroka village, 76% of the respondents mentioned that they bought water from people who fetch freshwater from other communities or the river with donkey carts and bakkies to supplement the water they have, followed by 23% of the respondents collecting water from the river to supplement that which they have. One percent (1%) of the respondents mentioned supplementing their water with borehole water (Figure 33). Rainwater harvesting from rooftops is one method of supplementing freshwater in many rural households and the harvested water can be used for irrigation and consumption, thus conserving freshwater (NASA, 2007). The demand of increasing population and widespread droughts since 1980s, made people aware of the potential of rainwater harvesting to solve water shortage problems (Li et al., 2002).

4.4.5 Water storage

Most of the people in rural areas use 25 l, 250 l, 5 000 l and 10 000 l containers to store their water. The containers can either be 25 l or 250 l drums while others use tanks commonly known as Jojo tanks which can either be 5 000 l or 10 000 l. Eighty

one percent (81%) of the respondents in Ga-Nkwana village use 5 000 l tanks to store their water while 19% of the respondents use 250 l drums to store their water.

In Ga-Seroka village, 80% of the respondents use 5 000 l tanks to store their water, followed by 19% of respondents who store their water in 250 l drums while 1% use 25 l buckets as their water storage containers. The reason why most of the respondents in both villages use tanks to store their water might be because tanks are bigger and when they are full the water can last for a long period. The tanks are not only sold at supermarkets but also during days when people are receiving their social grants at the royal offices, and they receive same day delivery. This makes it easier for people to buy as they even save money for transport costs. Water can be stored either in containers which can be closed with a lid in households or those which do not have lids. Water stored in containers which do not have lids have a high chance of being contaminated, either by insects, dipping contaminated hands or smaller containers when fetching water (eThekwini Municipality, 2005). In developing countries, many traditional types of water storage methods employing vessels of various compositions and sizes are still widely used. Metal containers such as aluminium, steel and iron as well as other materials primarily plastics, in the form of buckets, drums and other vessel types have come into widespread use for water storage.

4.4.6 Use of freshwater for household garden irrigation

Freshwater is the naturally occurring water on the earth's surface containing less than 1 000 mg per litre of dissolved solids, most often salts. The amount and location of surface water changes overtime and space, whether naturally or with human help (USGS, 2016). In Ga-Nkwana village, most of the respondents (65%) stated that they used freshwater to irrigate their household gardens while 35% of the respondents did not use freshwater in their household gardens (Figure 34).

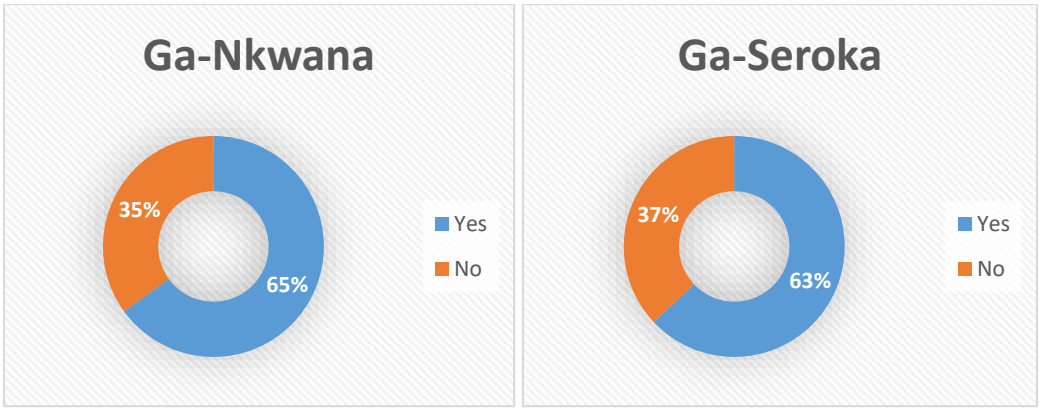

Figure 34: Freshwater use in household garden

Sixty three percent (63%) of the respondents in Ga-Seroka village irrigated their household gardens using freshwater while 37% of the respondents did not use freshwater in their household gardens (Figure 34). Access to water for occasional irrigation, particularly at planting is often also available through rooftop harvesting of water or as a result of the proximity of standpipes (Wenhold et al., 2007). Water is the main limiting resource in South African crop production, and this limits the potential to increase food production in the dry rural regions where the prevalence of under-nutrition is high (Laker, 2004).

4.4.6a Freshwater sufficiency for household garden irrigation

Freshwater sufficiency is the ability of the available freshwater to meet the demand of the users. Baiphethi & Jacobs (2009) reported that almost four million people in South Africa are involved in smallholder agriculture and for several reasons most of these households are in the former homeland areas. Water is a critical factor in food production and important for subsistence production especially in rural areas where it could be considered non-negotiable. Seventy eight percent (78%) of respondents in Ga-Nkwana village stated that the freshwater they had was not sufficient for their irrigation needs, while 22% of the respondents mentioned that their freshwater was sufficient for their irrigation needs (Figure 35).

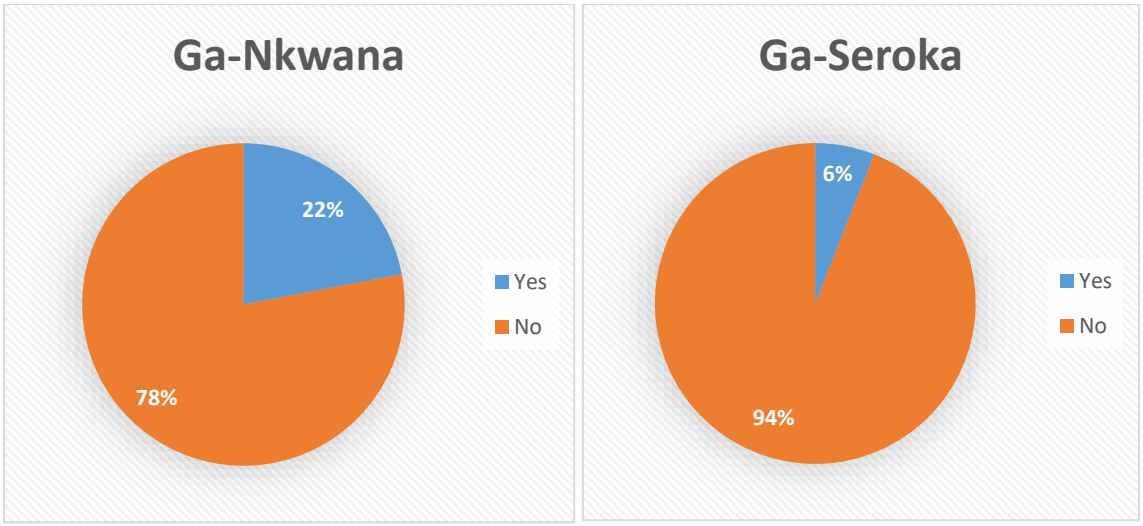

Figure 35: Freshwater sufficiency for home garden use

In Ga-Seroka village, 94% of the respondents had freshwater that did not cover their irrigation needs while 6% stated that their freshwater was sufficient for their irrigation needs (Figure 35). During rainy seasons, respondents used harvested rainwater to bridge the gap between sufficient and non-sufficient freshwater for home gardens irrigation, while during seasons of little or no rainfall, respondents used greywater. Because freshwater is not always available in the study areas, reuse of greywater can help displace demand for water, thus reducing conflicts over water and reducing the demand for new water supply projects. Increasing greywater reuse can help provide more resilience to the insecurity of water supply as a result of climate change (Pacific Institute, 2010).

4.4.7 Sources of greywater

Greywater is household wastewater that originates from the following: showers, laundry, baths, kitchen and untreated spa (Queensl, 2003). The respondents in the two villages obtained greywater from washing dishes (Figure 36a), washing clothes (Figure 36b), bathing (Figure 36c).

Figure 36a: Greywater generated from washing dishes

Figure 36b: Greywater generated from washing clothes

Figure 36c: Greywater generated from bathing

In Ga-Nkwana village, 51% of the respondents reported that bathing was the source of their greywater followed by 34% of the respondents stating that their greywater was generated by washing dishes (Figure 37). Fifteen percent (15%) of the respondents acquired greywater from washing clothes (Figure 37).

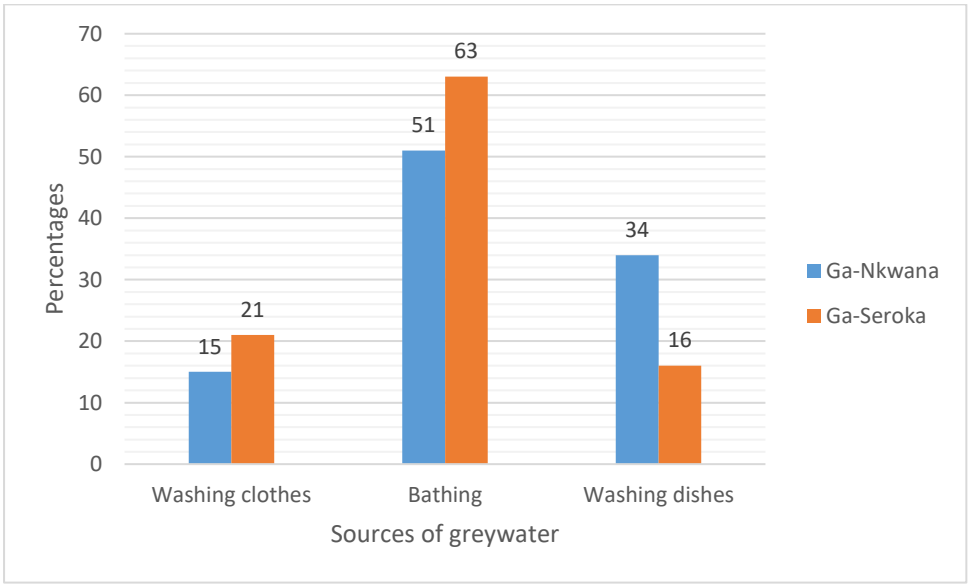

Figure 37: The sources of greywater

In Ga-Seroka village, 63% of the respondents attained their greywater from bathing while 21% of the respondents generated their greywater from washing clothes (Figure 36). Sixteen percent (16%) of the respondents in Ga-Seroka village got their greywater from washing dishes. According to Chaggu (2011), generation of greywater will be relatively higher where in-house tap water is available as compared to those who have to travel longer distances. Most of the respondents mentioned their greywater sources as bathing as well as washing clothes and dishes. Rodda et al. (2010) states that greywater includes water from bathroom sinks, kitchen and showers and may also include water from laundry facilities and dishwashers.

4.4.7a Drainage of greywater

Drainage of greywater is simply where greywater is or might be taken to after generation. In Ga-Nkwana village, 54% of the respondents had sewerage systems that drained their greywater, followed by 44% of respondents who drained their greywater directly into their household gardens. Two percent (2%) of the respondents mentioned directly collecting greywater into storage container (Figure 38) such as buckets.

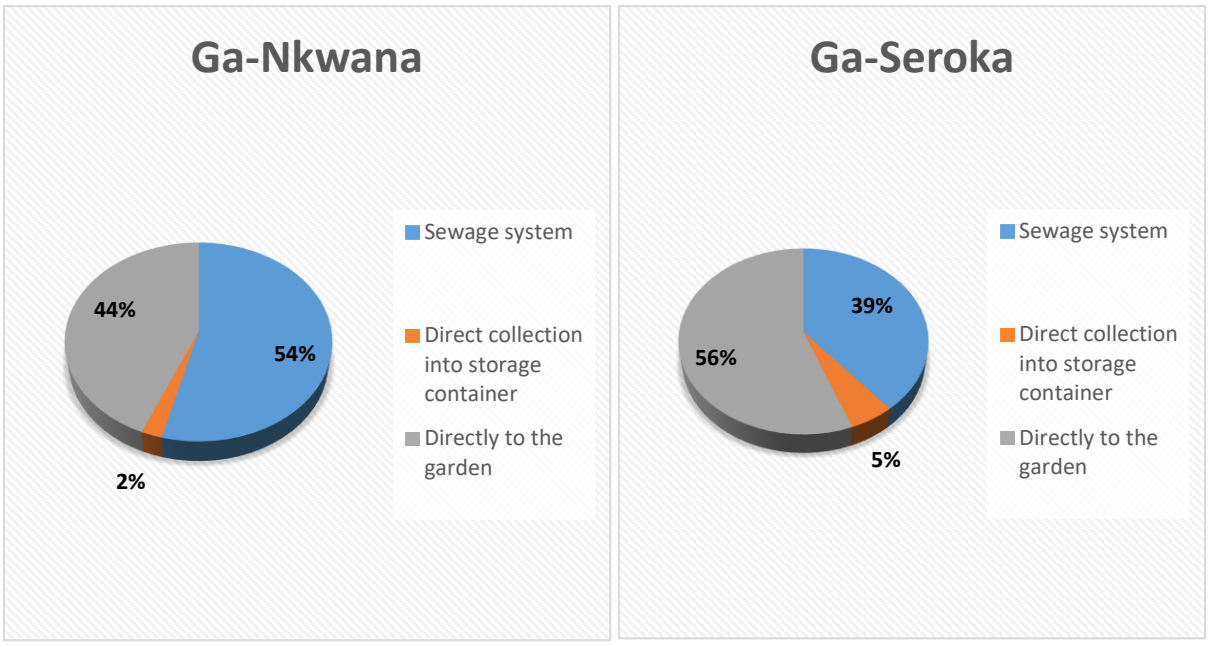

Figure 38: Drainage of greywater

In Ga-Seroka village, 56% of the respondents drained their greywater directly into their household gardens followed by 39% of the respondents reporting that their greywater is drained directly into a sewerage system (Figure 38). Five percent (5%) of the

remaining respondents mentioned collecting their greywater directly into storage containers (Figure 38) and those who collected greywater mentioned using buckets to do so. In non-sewered areas of South Africa, the disposal of household wastewater arising from activities such as bathing, washing clothes and washing dishes (greywater) is commonly disposed off to the ground in the vicinity of the dwelling (Salukazana et al., 2004). In the absence of suitable conveyance systems, greywater that is produced from household processes without input from latrines (Ludwig, 1997) is generally disposed of onto the ground outside the dwellings (Carden et al., 2007).

4.4.8 Reuse of greywater

Reuse of greywater is the recycling of water generated from bathtubs, kitchen sinks, showers etc. for other uses such as flushing toilets, irrigation, washing cars etc (Queensl, 2003). Fifty three percent (53%) of the respondents from Ga-Nkwana village reused greywater in their household while 47% of the remaining respondents did not reuse their greywater. In Ga-Seroka village, 61% of the respondents reused their greywater in their households while 39% of the respondents did not reuse their greywater. Greywater can be reused for purposes that don't require potable water such as landscaping, agriculture, or for flushing toilets thereby reducing potable water use. Greywater can also be allowed to seep into the ground to recharge aquifers and reduce the volume of wastewater needing to be treated (Pacific Institute, 2010).

4.4.8a Uses of greywater

From the 41 households (53%) in Ga-Nkwana village reusing greywater, 27 households (66%) reused their greywater for irrigation, while 3 households (7%) used their greywater to wash cars (Table 6). Two (2) households (5%) used their greywater for house decoration whereas 9 households (22%) used their greywater for other uses (Table 6).

Table 6: Greywater uses in Ga-Nkwana village

Reuses of greywater	Number of households
Irrigation	27
Washing cars	3
House decoration	2
Other uses	9

Out of the 58 households (61%) in Ga-Seroka village that reused greywater, 34 households (59%) used their greywater for irrigation purposes, while 6 households (10%) washed their cars with greywater. Households reusing greywater for house decoration were 16 (28%) while 2 households (3%) used their greywater for other uses.

Table 7: Greywater uses in Ga-Seroka village

Reuses of greywater	Number of households
Irrigation	34
Washing cars	6
House decoration	16
Other uses	2

Madungwe & Sakuringwa (2007), reported that the uses of greywater is crop irrigation which allows households the opportunity to grow crops during the times when water is not readily available, leading to less water stress and increased food security. According to Al-Jayyousi (2004), families in Jordan who adapted to greywater reuse were able to reduce food expenditures by consuming garden produce. Salukazana et al. (2004) reported that greywater has nutrients which are good for plant growth.

4.4.8b Types of plants irrigated with greywater

The respondents in Ga-Nkwana and Ga-Seroka villages used their greywater to irrigate fruit trees (Figure 39a and 39b), vegetables (Figure 39c), flowers (Figure 39d).

Figure 39a: A pomegranate tree irrigated with greywater.

Figure 39b: A grape tree irrigated with greywater

Figure 39c: A household garden with spinach and beetroot irrigated with both freshwater and greywater obtained from rinsing dishes.

Figure 39d. Flowers irrigated with greywater.

Thirty nine percent (39%) of respondents in Ga-Nkwana village used their greywater to irrigate fruit trees, while 24% of the respondents irrigated their vegetables with

greywater. Twenty percent (20%) of the respondents used their greywater to irrigate their flowers followed by 15% of the respondents who irrigated their crops with greywater. The remaining 2% of the respondents used their greywater for irrigating other non-fruit plants (Figure 40).

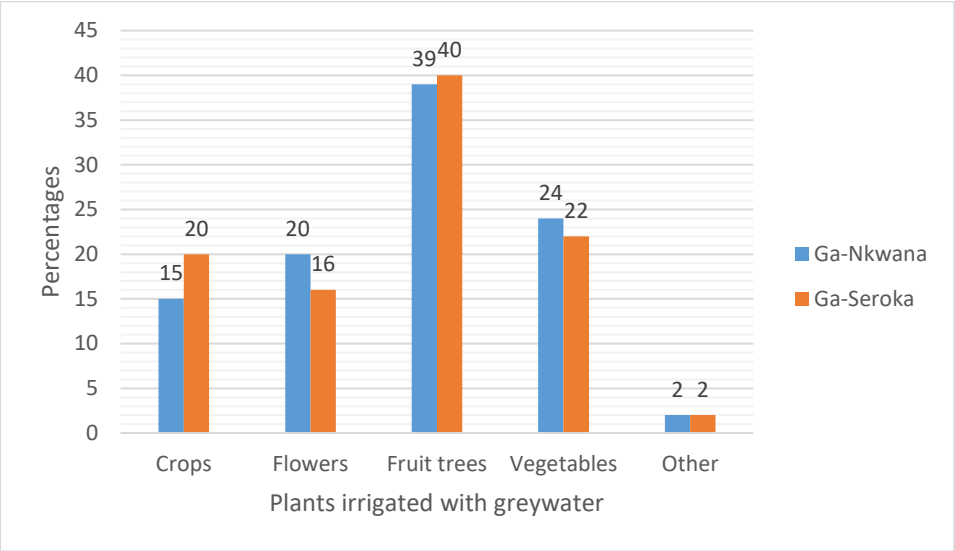

Figure 40: Plants irrigated with greywater

In Ga-Seroka village, 40% of the respondents reused their greywater to irrigate fruit trees while 22% of the respondents used their greywater when irrigating their vegetables. Twenty percent (20%) of the respondents in Ga-Seroka village irrigated their crops with greywater followed by 16% of the respondents who used their greywater to irrigate flowers. Two percent (2%) of the respondents in Ga-Seroka village used greywater to irrigate other plants (Figure 40). In a study by Rodda et al. (2011), greywater was reused when irrigating an above-ground crop Swiss chard and a below-ground crop carrot and the vegetables increased in growth. Mzini (2013) used greywater to irrigate vegetables such as spinach, onion and beetroot. The results on the spinach showed high yields although they developed leaf-spot disease and the onions and beetroots yields were also higher and were not affected by the greywater.

4.5 Perceptions on the reuse of greywater

Greywater is a widely-used method of conserving freshwater especially since climate change is affecting water sources of many countries. Manufacturers of detergents that are normally used in the households are already producing environmentally friendly detergents making it easier to reuse greywater onsite without any form of treatment (Deshmukh et al., 2014). In rural households, people directly reuse greywater to

irrigate vegetable gardens in order to supplement their food with household garden produce to sustain their livelihood (Rodda et al., 2011). From the two villages in the study area, many respondents (73% and 85%) in Ga-Nkwana and Ga-Seroka villages respectively, mentioned reusing greywater for irrigating their food crops and other plants as a supplement for freshwater. The respondents reuse greywater because they hardly have any flowing tap water on a daily basis. The respondents also mentioned that, greywater is always available to meet their daily irrigation needs. However, some respondents mentioned that they were sometimes afraid to reuse greywater on their crops as the water might kill their plants. Most respondents from both villages mentioned avoiding the reuse of greywater on small plants as it in most cases kill the plants. On the other hand, they also stated that greywater acts as a pesticide because it kills some of the pests that eat their plants and repels some of them.

Seventeen percent (17%) and 15% of the respondents in Ga-Nkwana and Ga-Seroka villages, respectively, indicated that they do not irrigate any plants with greywater from bathtubs because it might have too much detergents that could end up killing the plants, but instead they use water from washing dishes and clothes especially the water that has been used to rinse the dishes and clothes. They use rinsing water that has no chemicals such as fabric softener and jik. The respondents who reuse greywater for irrigation, also mentioned alternating irrigation of vegetables with greywater and freshwater in order to reduce the amount of chemicals from the greywater being absorbed by the plant. The respondents also made note that they do not in most cases irrigate crops that are eaten raw with greywater. They however irrigate those crops that need to be cooked first in order to remove any chemical that might have a negative impact on their lives. Most of the greywater generated in the household is used to irrigate grown fruit trees (Figure 40) as it does not kill these plants and in turn aid in production of more fruits. In one study on community receptivity to greywater reuse in northern Sydney, Australia, 95% of the respondents indicated that they were receptive to watering a garden with greywater. Positive perceptions were directly the inverse of the level of physical contact with the water, for example, there was higher receptivity of using water for toilet flushing than washing a car or washing clothes with it (Brown & Davies, 2007). Concerns about health, water pricing signals, and a belief that using recycled water represented a decrease in the standard of living

were key reasons for the lack of acceptance of greywater reuse in this study (Brown & Davies, 2007). A study in Barcelona, Spain found that factors determining the level of public acceptance of greywater reuse include: perceived health risk, perceived cost, operation regime, and environmental awareness (Domenech & Sauri, 2010). In his work on local acceptance of greywater, Laban (2010) identified four important questions people raise regarding greywater reuse: acceptability with regard to religious and cultural values; affordability and financial benefits; difficulty; and ability to improve access to sufficient quality and quantity of water.

4.6 Key informant interviews on water supply and greywater reuse

Key informant interviews are qualitative in-depth interviews with people who know what is going on in the community. The purpose of key informant interviews is to collect information from a wide range of people including community leaders, professionals, or residents who have first-hand knowledge about the community. These community experts, with their particular knowledge and understanding, can provide insight on the nature of problems and give recommendations for solutions (Toy et al., 2006). The key informants in this study included a royal committee member of Ga-Seroka village, a royal committee member of Ga-Nkwana village and an official member of the Fetakgomo Local Municipality who deals with water service delivery.

4.6.1 Ga-Seroka village royal committee member

The royal committee member from Ga-Seroka village raised concern about the service delivery, especially water, in the village. He emphasised that, the community lacks freshwater daily as water is only available from Monday to Friday (5 days) and not throughout the week. Although they have water for five days, the water does not run for the whole day and sometimes some taps do not have water at all. The committee member further stressed that, there should be a more improved interaction between the community members and their ward councillor or municipal officials. The officials should be able to attend community meetings in order to help address the issues regarding water service delivery. When the committee member was asked whether he has a household garden and knows what greywater is and how it can be used to supplement freshwater, he responded that he does have a garden but has been struggling to irrigate it because of lack of freshwater. Although he does irrigate it every now and then with freshwater, the water is just not enough for his irrigation needs. He indicated that he is afraid to irrigate his vegetable garden with greywater as he does

not have any knowledge about reusing greywater and the negative impacts thereof. He therefore opt to only use greywater on his trees (fruit and non-fruit).

4.6.2 Ga-Nkwana royal committee member

The royal committee member of Ga-Nkwana village also raised a concern about water service delivery in his village and accentuated that they only get running water for three days then again after three weeks while other residents get water on a daily basis for seven days a week. He went on to say that all households who are situated on a low lying area receive running water better than those in a high lying area including his. Although Ga-Nkwana community has a ward councillor who is from their village, those who are struggling with water delivery do not see the benefits of his election. The royal committee member further went on to say that, the only people who are situated in a high lying area benefiting from the ward councillor when coming to water supply are those closest to him (family and friends) as he updates them only and not the whole community of days when water will be available. The closest people to him will always be the first to fetch water even if it means fetching it at night. When everybody wakes up, the water will no more be enough as everyone will be trying to fill his or her own drums and tanks. He also went on to explain that, the village has home taps which do not have water at all as the construction of these taps was without proper planning. The storage dam is located higher up a mountain and these results in households who live along the mountain including the royal house not having running water at all. This is because when main pipes are opened, the water runs downhill and starts taking different directions when they reach a flat surface downhill. Since the water is not enough, it does not have enough power to go uphill, thus leaving some households with no water. He further explained that the royal house receives water from the municipality through a tanker on a monthly basis. The community members are not allowed to store water in Jojo tanks since the quantity of water being released from the dam has no much power to flow from the tap through a hosepipe into a tank. The royal committee member went on to inform the researcher that he only uses greywater to irrigate non-fruit trees as he has no household garden because it will be a waste of time as they struggle with water.

4.6.3 Municipal official of Fetakgomo Local Municipality

Water Service Authority and Water Service Providers of the Fetakgomo Local Municipality are located in the Sekhukhune District Municipality, although they deal

with matters related to water delivery in the FLM. This implies that FLM does not have enough capacity to act as a Water Service Authority within its area of jurisdiction. The water service delivery official of the FLM indicated that, Ga-Nkwana village receives a bulk of water from the Lepelle Northern Water Scheme on a daily basis for seven days a week. He also specified that, they do have a problem with some sections of the community who do not get consistent water supply due to high demand of water as well as the problem of elevation. The official went on to indicate that those households who encounter elevation as a barrier to their water supply receive water using tankers during the day and some at night every month. When coming to Ga-Seroka village, he specified that the infrastructure that distributes bulk water from Lepelle Northern Water Scheme does not reach the area and only supplies water to Tswereng village. Although Ga-Seroka village and Tswereng village are not far apart, the reason the water scheme does not reach Ga-Seroka village yet, is because the area is very elevated. The municipal official, however, also indicated that Ga-Seroka village also receives water for seven days a week from two boreholes. One borehole is diesel operated while the other uses electricity and they are in a process of converting the diesel operated borehole into an electric operated borehole. They are still busy trying to work on the issue of Lepelle Northern Water infrastructure reaching the area. When asked if the municipality has any greywater treatment system, the official indicated that FLM does not have any greywater treatment system although other local municipalities such as Ephraim Mogale and Greater Tubatse do have such treatment systems. He went on to say that a better way to understand the needs, problems and delivery of certain services to the community will be to engage with the affected communities in order to resolve the matters.

4.7 Household food security status

A household is food secure when it has access to the food needed for a healthy life for all its members and when it is not at undue risk of losing such access (Bikombo, 2014). Household food security statuses of Ga-Nkwana and Ga-Seroka villages were calculated using the Household Food Insecurity Access Scale (HFIAS).

The General Household Survey (GHS) coupled with HFIAS from the South African study (StatsSA, 2012) was adapted and used to classify the households in this study. Considering the number of occurrence questions, the researcher classified the households according to the following 3 categories:

17 – 24: Severe food insecure households

12 – 16: Medium food insecure households

0 – 11: Least food insecure households.

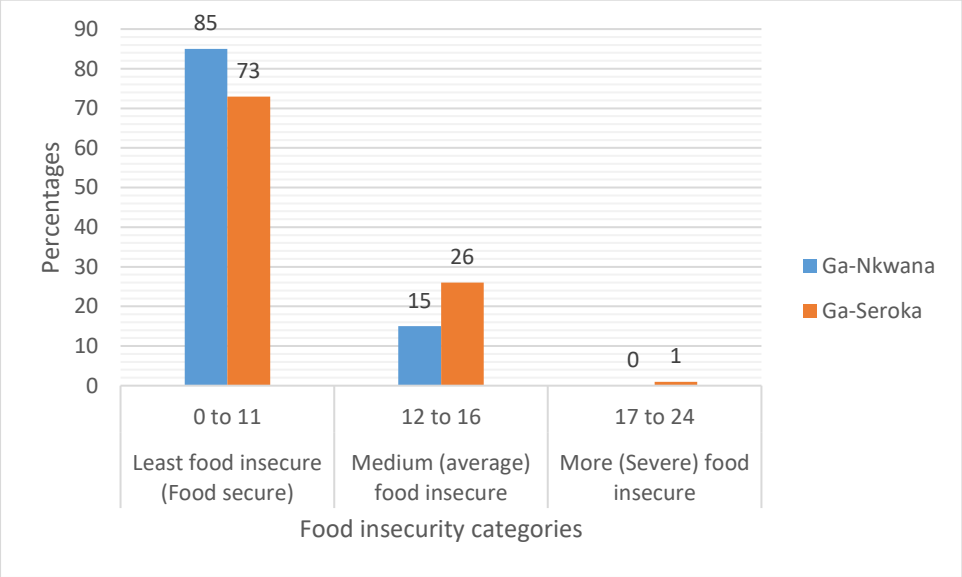

Figure 41: The food insecurity categories

The classification results of the study (Figure 41) indicated that in Ga-Nkwana village, no household (0%) was severely food insecure; while 12 households (15%) were medium food insecure and 66 households (85%) were least food insecure. In Ga-Seroka village, 1 household (1%) was severely food insecure whereas 25 households (26%) were medium food insecure and 69 households (73%) were least food insecure.

After calculating the HFIAS score for each household in each village, the next and final step was to calculate the average HFIAS score for all 173 households, with 78 households in Ga-Nkwana village and 95 households in Ga-Seroka village. This was done according to the formulae by Coates et al. (2007) and it was calculated as follows:

$$\text{Average HFIAS Score (Ga} - \text{Nkwana village)} = \frac{\text{Sum of HFIAS Scores}}{\text{Total number of households in sample}}$$

$$= \frac{256}{78} \qquad \text{(Equation 3)}$$

The average HFIAS score in Ga-Nkwana village is 3.28, and

$$\text{Average HFIAS Score (Ga} - \text{Seroka village)} = \frac{\text{Sum of HFIAS Scores}}{\text{Total number of households in sample}}$$

$$= \frac{481}{95} \qquad \text{(Equation 4)}$$

The average HFIAS score in Ga-Nkwana village is 5.06.

The average HFIAS scores of 3.28 and 5.06 in Ga-Nkwana and Ga-Seroka villages respectively, is an indication that the households in both villages are least food insecure. Ga-Seroka village has a higher average HFIAS score as compared to Ga-Nkwana village which means that although it is least food insecure, it is not the same as Ga-Nkwana village. A higher average HFIAS score is an indication of poorer access to food and greater food insecurity (FAO, 2008). This study therefore does not compare well with a study by Bikombo (2014) which shows an average HFIAS score of 13.20 with most street traders in Durban being classified as medium food insecure. Based on the HFIAS classification measure of household food security, Ndobo (2013) revealed that a large proportion of the surveyed households were food secure at 51%. According to StatsSA (2012), in 2011 21% of the households in the country were food insecure.

4.8 Potential of greywater reuse to improve household food security.

A Pearson Chi-Square test was conducted to assess whether reusing greywater for irrigating household gardens can improve the amount of produce made and improve household food security. The Pearson Chi-Square value for the association between greywater reuse for irrigation and produce made was obtained as 52.028^{a} with 8 degrees of freedom and a significance probability of less than 0.001 in Ga-Nkwana village whereas it was obtained as 61.772^{a} with 2 degrees of freedom and a significance probability of less than 0.001 in Ga-Seroka village, indicating a very highly significant result in both villages.

Table 8: Pearson Chi-Square test on the relationship between greywater reuse and increase in food production

Variables	Village	
	Ga-Nkwana	Ga-Seroka
	n (%)	
Reuse of greywater	41 (53%)	58 (61%)
Increase in the amount of food produced	24 (31%)	24(25%)
P value	0.000	0.000

n: Number of respondents

%: Percentage of households

P value: 0.05

Chi-Square value: 52.028[a] (Ga-Nkwana) and 61.772[a] (Ga-Seroka)

Degree of Freedom: 8 (Ga-Nkwana) and 2 (Ga-Seroka)

Based on this data (Table 8), there would appear to be an association between greywater reuse for irrigation and the amount of produce made in both villages. It can be concluded that irrigating home gardens with greywater can improve the amount of produce made and thus improve household food security through availability. The fact that some of the plants irrigated with greywater did not die and the greywater killed and repelled some of the insects eating plants could be an added advantage of reusing greywater. Greywater has been identified as a widespread problem in all categories of dense informal settlements in South Africa, exacerbated by poor or absence of solid waste management (Wood et al., 2001). However, grey water contains nutrients that are beneficial to the growth of most plants, but could be harmful if it entered waterways (Jeppesen, 1996). Therefore, one way to improve food security, and contribute to environmental improvement in poor communities, is to reuse greywater for irrigation of food crops in a small-scale agriculture. Therefore, even if greywater reuse poses public health and environmental concerns, with adequate guidelines and education, issues around water saving, food shortage and malnutrition could be resolved (Salukazana et al., 2004).

4.9 Summary

This chapter provided the results and discussions on background characteristics of the respondents, household food availability and accessibility, freshwater sources and greywater reuse, perceptions of the respondents on greywater, key informant

interviews, household food security status of the respondents and the potential reuse of greywater to improve household food security. The next chapter focuses on the summary, conclusions and recommendations of the study.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

5.1 Introduction

This chapter presents a summary and conclusions of the findings on the background characteristics, food availability and accessibility, freshwater sources and greywater reuse, perceptions on greywater reuse and key informants' views on water supply and greywater reuse. The chapter also presents the household food security status of the respondents and the possible reuse of greywater to improve household food security. Additionally, the chapter also provides recommendations based on the conclusions of the study. Lastly, this chapter also makes useful recommendations on the reuse of greywater as a way of combating water scarcity, locally, nationally and globally.

5.2 Summary

The results show that although water is a scarce resource, greywater has a potential of improving household food security through irrigation of household gardens. Communities' perceptions on greywater reuse have an impact on their reuse of greywater. Furthermore, the results also indicate that food security is the outcome of many interrelated factors such as land, household size, their income and water which are essential to attain food availability and accessibility. As a result, the study reveals that Ga-Nkwana village is more food secure and has better access to freshwater as compared to Ga-Seroka village, and therefore water conservation methods such as rainwater harvesting and greywater reuse should be practiced on a regular basis to supplement the water they have in Ga-Seroka and Ga-Nkwana villages.

5.2.1 Background characteristics

Ga-Nkwana and Ga-Seroka villages consist generally of youth, middle aged and elderly individuals. Most of the households in these villages are male headed. Respondents from these two villages were mostly married. The literacy level, employment, and household income of these two areas differed. In Ga-Nkwana village, most of the respondents have reached tertiary level as compared to Ga-Seroka village. Ga-Seroka village contributed to a high unemployment rate with most of the respondents earning below R5 000 per month as compared to the employed

respondents of Ga-Nkwana village who earned above R15 000 per month. Income expenditure of these villages did not vary and the income was spent mostly on food.

5.2.2 Household food accessibility and availability

The results show that in Ga-Seroka village, accessibility and availability of food is a problem as compared to Ga-Nkwana village due to larger household sizes, unemployment and low incomes. Household members of Ga-Nkwana village, who worked away from home brought food when they came home or assisted in buying the necessary food items required in the household as compared to Ga-Seroka village respondents. Households from both villages consumed mostly food which was purchased from supermarkets and shops in town even though they have access to land for farming. Ga-Seroka village respondents have access to larger pieces of land as compared to Ga-Nkwana village and therefore agriculture is practiced more. Crop production inputs were not always available in Ga-Seroka village and this hindered the respondents in maximising their produce and resulted in the respondents experiencing periods/days of hunger as compared to Ga-Nkwana village where respondents had enough money to purchase food. When households ran out of food, the most common coping strategy that was used in Ga-Nkwana village was “relying on less preferred and less expensive foods” while Ga-Seroka village respondents “borrowed food, or relied on help from family and relatives as well as purchasing on credit”.

5.2.3 Reuse of greywater in relation to home gardening activities

Results clearly demonstrate that households in Ga-Seroka village struggle to access freshwater as compared to those in Ga-Nkwana village. Sources of freshwater, distance to a freshwater source and quality of freshwater did not vary. The respondents from both villages accessed water from a home tap and they sometimes encountered periods/days without running water, especially respondents in Ga-Seroka village; and this tempered with their irrigation of home gardens. The results further show that greywater was reused mostly onsite in Ga-Seroka village as they drained their greywater directly into their gardens as compared to Ga-Nkwana village where respondents have sewerage systems.

5.2.4 Perceptions on greywater reuse

Ga-Seroka village respondents preferred to reuse greywater more as compared to respondents in Ga-Nkwana village. The respondents also mentioned that, although

greywater in most cases acts as a pesticide, they still avoid using it on crops that can be eaten raw as they are afraid of chemicals that are contained in the detergents that are used. Views of the Water Service Authority informant and key informants of the two villages differed. The key informants in Ga-Nkwana and Ga-Seroka villages mentioned experiencing periods of no running water in their villages. The WSA informant mentioned that the two villages were having access to water daily and that those who were struggling to access water due to elevation receive water through tankers.

5.2.5 Household food security status

The overall household food security status of the two villages is good, although Ga-Nkwana village has and Average Household Food Insecurity Access Scale which is low as compared to Ga-Seroka village. When assessed individually, Ga-Nkwana village is more food secure as compared to Ga-Seroka village with 1 household being severely food insecure.

5.2.6 Possible reuse of greywater to improve household food security

A Pearson Chi-Square test revealed that greywater has a potential to increase the amount of produce if used for irrigation and thus improve household food security.

5.3 Conclusions

Five main stakeholders were identified at this level on possible reuse of greywater to improve household food security, namely: respondents from Ga-Nkwana and Ga-Seroka villages, royal council member in each village and Water Service Authority representative of Fetakgomo Local Municipality. The study therefore concludes that:

- Background characteristics such as household size, monthly income and educational level were important factors affecting household food security.
- Accessibility and availability of food was more of a challenge in Ga-Seroka village as compared to Ga-Nkwana village due to the rate of unemployment, larger household sizes and low incomes in Ga-Seroka village.
- The reuse of greywater for home gardening was practised more and successfully in Ga-Seroka village than in Ga-Nkwana village and the perceptions on greywater reuse in this study were different as Ga-Seroka village respondents preferred to reuse greywater more as compared to Ga-Nkwana village respondents.

- Household food security status of the two villages revealed that Ga-Seroka village is more food insecure as compared to Ga-Nkwana village.
- There is a potential in the reuse of greywater for household garden irrigation to improve household food security.

Water service provision for rural communities is faced with several challenges ranging from lack of capacity and skills at the municipalities to provide consistent water supply on a daily basis.

5.4 Recommendations

The results from the study will be useful to the local municipality of Fetakgomo in policy and decision making especially when coming to greywater reuse for home gardening activities. The study will also be used to encourage communities to reuse their greywater as a way of alleviating freshwater shortages and thus improving household food security. The study recommends the following:

- There should be gender equality especially on land ownership. It is important that the government also assist the local communities to empower women in agriculture through education with regards to ways of improving food accessibility by reusing greywater.
- The municipality should provide water to all regions following the Reconstruction and Development Plan (RDP) standards where each household should get 25 l per person per day, or 6000 litres per household (of 8 people) per month and have regular meeting with them to avoid communities going long periods without running water.
- There should be wastewater treatment plants for water recycling and Water Services Providers in Fetakgomo Local Municipality to work directly with the communities.
- There is a need for incentives such as quality seeds and fertilizers to be provided to households to encourage them to engage in subsistence farming.
- The researcher hopes that the findings of this study will form a basis for future research on onsite greywater reuse in home gardens as a way of improving food security.
- Future research should be done on ways to improve greywater quality for irrigation of household gardens inclusive of vegetables that can be eaten raw.

- There is a need for incentives such as quality seeds and fertilizers to be provided to households to encourage them to engage in subsistence farming.
- The government and research institutes need to come up with workshops to train people about home gardens and benefits of engaging in agriculture to improve household food security.
- Informal training of household members could also be of importance by sending extension officers to educate households about food security.

5.5 Summary

Despite some significant contributions made by home gardening on household food security in Ga-Nkwana and Ga-Seroka villages, some households failed to meet their household food needs due to low productivity and poor resources as well as lack of proper farm inputs. Nonetheless, irrigating home gardens with greywater has great potential in enhancing food security at household level.

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APPENDIX 1

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	**03 November 2016**
PROJECT NUMBER:	**TREC/216/2016: PG**
PROJECT:	
Title:	Potential reuse of greywater to improve household food security: A Case Study of two villages in Fetakgomo Local Municipality, Limpopo Province of South Africa
Researcher:	Ms MP Radingoana
Supervisor:	Dr MHN Mollel
Co-Supervisor:	Ms JM Letsoalo
School:	Agricultural and Environmental Sciences
Degree:	Masters in Geography

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**

ii) **The budget for the research will be considered separately from the protocol.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

APPENDIX 2

FETAKGOMO LOCAL MUNICIPALITY

TO: Mrs Radingoana MP

Student No: 200814693

SUBJECT: APPROVAL TO CONDUCT RESEACH WITH FETAKGOMO LOCAL MUNICIPALITY

Dear Student

1. The Fetakgomo Local Municipality acknowledged receipt of your request dated 18 March 2016.

2. Your request to conduct research is hereby granted

3. We wish you well in your work

Kind Regards

Mr Matumane ND

Municipal Manager

BAROKA BA NKWANA
TRIBAL AUTHORITY

PO Box 01, Ga Nkwana 0740 Tel.: 082 660 0943 Cell: 073 598 2450

P.O. BOX 1

Ga-Nkwana

0740

24 March 2016

ENQ: 0826600943

0735982450

UNIVERSITY OF LIMPOPO

DEPARTMENT OF WATER AND SANITATION

PRIVATE BAG X1106

SOVENGA

0727

DR. MOLLEL M.H.N.

P.O. BOX 1 - GA-NKWANA - 0740
BAROKA BA-NKWANA TRIBAL AUTHORITY
2016 -03- 24
Tel: 013 246 2998
Fax: 013 246 2973
LIMPOPO PROVINCE - SOUTH AFRICA

Baroka Ba Nkwana Traditional Authority and Baroka Ba Nkwana Royal Family gives Mrs. Radingoana M. P. (student number 200814693) permission to conduct interviews in our community and their leaders. Interviews are for research on " Potential of greywater reuse to improve household food security"

We hope you will complete your work without any disturbances. Thanking you in anticipation.

Yours faithfully

Phasha TJ — 2016-03-24

Chief Council — **Date**

Phasha MA — 2016-03-24

Mokgoma — **Date**

APPENDIX 4

Roka-Lebea Traditional Council

Ref : Traditional Council
Enq: Phala L.S
Cell: 082 556 3994

Ditlou Tsa Magokolo

P O Box 6001
Sekhukhune
1124

To: Dr Mollel M.H.N

From: Kgoshigadi Seroka T.M

Date: 23 March 2016

Sir /Madam

PERMISSION TO CONDUCT INTERVIEWS

We the community members of the above mentioned traditional council, under the traditional leadership of Kgoshigadi Seroka T.M granted permission for Mrs M.P Radingoana student number 200814693 to conduct her research work at Ga-Seroka village on " Potential of greywater reuse to improve household food security".

Banking on your cooperation

Yours faithfully

Seroka T.M.
Kgoshigadi

Seroka M.J.
(Senior Council)

Phala L.S.
(Finance Clerk)

DEPARTMENT OF CO-OPERATIVE GOVERNANCE, HUMAN SETTLEMENTS & TRADITIONAL AFFAIRS
ROKA LEBEA
TRADITIONAL COUNCIL
23 MAR 2016
P.O BOX 6001 SEKHUKHUNE
1124
SEKHUKHUNE DISTRICT SUPPORT CENTRE

CONSENT FORM

Project title: **Potential reuse of greywater to improve household food security: a case study of two villages in Fetakgomo Local Municipality, Limpopo Province of South Africa.**

Project leader: **Makgalake Pabalelo Radingoana (200814693)**

I, hereby voluntarily consent to participate in the following project: "Potential reuse of greywater to improve household food security: a case study of two villages in Fetakgomo Local Municipality, Limpopo Province of South Africa."

I understand that:

1. My responses will be treated with confidentiality and only be used for the purpose of the research.
2. No harm will be posed to me.
3. The research project aim has been explained to me.
4. I do not have to respond to any question that I do not wish to answer for any reason.
5. Access to the records that pertain to my participation in the study will be restricted to persons directly involved in the research.
6. Any questions that I may have regarding the research, or related matters, will be answered by the researcher.
7. Participation in this research is entirely voluntary and I can withdraw my participation at any stage.
8. I understood the information regarding my participation in the study and I agree to participate.

Signature of interviewee **Signature of interviewer**

---------- ----------

QUESTIONNAIRE

I am Makgalake Pabalelo Radingoana, a registered student at the University of Limpopo studying towards an MSc in Geography in the department of Geography and Environmental Studies. My research is titled **"Potential reuse of greywater to improve household food security: a case study of two villages in Fetakgomo Local Municipality, Limpopo Province of South Africa".**

Please mark your answer with an **X**

IT IS IMPORTANT TO NOTE THAT THE INFORMATION WILL ONLY BE USED FOR PURPOSES OF THE RESEARCH AND WILL BE HELD CONFIDENTIALLY.

A. BACKGROUND CHARACTERISTICS

1. Name of village _____
2. Gender of interviewee | Male | | Female | |
3. Age of interviewee (Years) | < 25 | 26 - 35 | 36 – 45 | >45 |
4. Are you head of the family? | Yes | No |
5. Relationship to household head if not head | Spouse | Sibling | Child | Other |
6. Marital status | Single | Married | Widowed | Divorced |
7. Educational level | None | Primary | Secondary | Tertiary |
8. Employment status | Employed | Unemployed | Self-Employed | Pensioner |
9. Occupation _____
10. Monthly income level (Rands) | < 5 000 | 5 000 – 10 000 | 10 001 – 15 000 | >15 000 |
11. How do you spend your income? | Food | Clothing | Fees | Other |
12. Which of the above (#11) do you spend most of your income on? _____

B. HOUSEHOLD FOOD ACCESSIBILITY AND AVAILABILITY

13. How many people live and eat in your house? | 1 - 2 | 3 - 4 | 5 - 6 | More than 6 |
14. How many people in your household are employed? | |
15. Do they contribute to buying food that is needed in the household? | Yes | No |

Subsistence Agriculture	

16. Where does your family get most of their food?

Buy from supermarket or town	
Government parcels	
Other	

17. If other, specify _____

18. Do you own land?

Yes	No

19. If yes, what is the type of tenure on which land is allocated?

Permit to occupy	
Private land	
Rented land	
Other	

20. How much land (ha) do you have access to the following?

Residential	
Agricultural	
Other	

21. Is land for agricultural purposes always available?

Yes	No

22. Are other production inputs such as fertilizers, pesticides, seeds and water available?

Yes	No

23. If yes, where do you get them? _____

24. If no, how do you get about accessing them? _____

25. Do you supplement your food with household garden produce?

Yes	No

26. If yes, what type of garden plants do you grow?

Beans	
Maize	
Sorghum	
Cabbage	
Carrots	
Spinach	
Tomatoes	
Other	

27. How much of the above crops do you produce per year? _____

28. Does your family save some of the produce to eat during a certain time of the year?

Yes	No

29. Do you buy most of your food?

Yes	No

30. If yes, how much do you spend on food per week? _____

31. Are there times during the year that your family does not have enough food?

Yes	No

32. If yes, how many months a year does your family struggle to get enough food?

1 - 2	3 - 4	5 - 6	7 - 8

33. Do you have family members that work away from home?

Yes	No

34. Do they bring extra food when they come home? | Yes | No |

35. What are your coping strategies if you run out of food?

_____

_____

36. In the past 30 days, if there have been times when you didn't have enough food or money to buy food, how often has your household (HH) had to:

Coping option	Times per week				
	Every day	3-6 times	Once/ twice	Less than 1	Never
Rely on less preferred and less expensive foods?					
Borrow food, or rely on help from friends and relatives?					
Purchase food on credit?					
Gather wild food, hunt or harvest immature crops?					
Consume seed stock held for next season?					
Send household member to eat elsewhere?					
Send household member to beg?					
Limit portion sizes at mealtimes?					
Restrict consumption of adults so children could eat?					
Feed working HH members at the expense of non-working members?					
Ration the money you had?					
Reduce the number of meals eaten in a day?					
Skip entire days without eating?					
Sold livestock or farm implements to purchase food?					

C. FRESHWATER SOURCES AND GREYWATER REUSE

37. Where do you collect your water from?

Home tap	
Community tap	
Spring	
River	
Borehole	
Rain	
Other	

38. How long does it take you to get to the nearest water source?

Distance (M)	
0 - 200	
201- 400	
401 - 600	
601 – 800	
801 – 1000	
> 1000	

39. What is the quality of the water? _____

40. Is the water always available?

Yes	No

41. If not, how do you supplement the available water? _____

42. What type of container(s) do you store your water in? _____

43. Do you use freshwater for irrigation of your household garden?

Yes	No

44. Is the freshwater sufficient for your irrigation needs?

Yes	No

45. Where does your greywater come from?

Washing dishes	
Bathtubs	
Kitchen sink	
Washing clothes	
Showers	
Other	

46. Where does your greywater drain to?

Sewage system	
Cesspool	
Direct collection into storage container	
Directly to the garden	

47. If direct storage, what type of container do you use? _____

48. Have you ever reused greywater in your household?

Yes	No

49. If yes, what do you normally reuse greywater for?

Irrigation	
Flushing toilet	
Washing cars	
House decorating	
Other uses	

50. If you reuse greywater for irrigation, what type of plants do you irrigate?

Crops	
Flowers	
Fruit trees	
Vegetables	
Other	

51. Why do you reuse greywater for irrigating your garden?

_____

_____

D. PERCEPTION

52. What are the challenges that you come across when reusing greywater?

_____

_____

53. Are you worried that your family members might get sick from irrigating crops with greywater as compared to irrigating with fresh water?

_____

_____

54. Have you ever been reluctant to use greywater in your garden in case it has negative impacts on your plants?

_____

_____

55. Do you think the reuse of greywater will increase the amount of food you produce?

Yes	No

56. If so, why?

_____

_____

DIPOTŠIŠO-NYAKIŠIŠO

Ke nna Makgalake Pabalelo Radingoana. Moithuti yo a ngwadišitšwego Yunibesithing ya Limpopo a ithutelago MSc ya Geography. Nyakišišo ya ka e bitšwa **"Potential reuse of greywater to improve household food security: a case study of two villages in Fetakgomo Local Municipality, Limpopo Province of South Africa".**

Ka kgopelo swaya karabo ya gago ka **X**

GO BOHLOKWA GO LEMOGA GORE TSHEDIMOŠO YE E TLO ŠOMIŠWA FEELA GO MABAKA A NYAKIŠIŠO EBILE A TLA SWARWA KA SEPHIRING.

A. TSHEDIMOŠO-DIKATŠHUPO

1. Leina la motse _____
2. Bong bja mmotšišwa | Monna | | Mosadi | |
3. Mengwaga ya mmotšišwa | < 25 | 26 - 35 | 36 – 45 | >45 |
4. O hlogo ya lapa? | Ee | Aowa |
5. Tswalano le hlogo ya lapa gaeba ga o yona | Molekani | Kgaetsedi | Ngwana | Engwe |
6. Seemo sa lenyalo | Ga se ka nyalwa | Nyetšwe | Mohlolo/gadi | Ke hladile/lwe |
7. Maemo a dithuto | Ga ke a tsena sekolo | Thuto-motheo | Thuto-phagama | Thuto-godimo |
8. Seemo sa mošomo | Ke a šoma | Ga ke šome | Ke ya itšhoma | Ke gola tšhelete ya mphiwafela |
9. Maemo mošomong _____
10. Tšhelete yeo e golwago ka kgwedi (Diranta) | < 5 000 | 5 000 – 10 000 | 10 001 – 15 000 | >15 000 |
11. O e šomiša bjang tšhelete yeo? | Dijo | Diaparo | Tshelete ya sekolofisi | Tše dingwe |
12. Ke efe ya tše tša ka godimo yeo o šomišago tšhelete ye ntšhi go yona? _____

B. PHIHLELELO LE KHWETŠAGALO YA DIJO KA LAPENG

13. Ke batho ba bakae bao ba dulago le goja ka mo lapeng? | 1 - 2 | 3 - 4 | 5 - 6 | Godimo ga 6 |

14. Go šoma batho ba bakae ka mo lapeng? ☐

15. Ba ntšha setseka sa tšhelete ge go rekiwa dijo?

Ee	Aowa

16. Bontšhi bja dijo tša ka mo lapeng di hwetšwa kae?

Go lema	
Rekiwa	
Diphuthelwana tša mmušo	
Tše dingwe	

17. Ga ele "tše dingwe", hlalosa _____

18. Lena le lefelo la lena?

Ee	Aowa

19. Ga eba ore "ee", naa ke mohuta ofe wa tumelelo-bodudi woo lefelo le abilwego gona?

Setlankana tšhupatumelelo-bodulo	
Naga-mong	
Naga-lefelwa	
Tše dingwe	

20. O na le tumelelo ya lefelo le lekae (ka dihekere) mabapi le tše di latelago?

Bodulo	
Temo	
Tše dingwe	

21. A naa lefelo la mabaka a tša temo le a hwetšagala ka mehla?

Ee	Aowa

22. A naa di dirišwa tša go thuša ka puno bjalo ka manyora, dipeu, meetse le tše dingwe di a hwetšagala ka mehla?

Ee	Aowa

23. Ga eba ore "ee", le di hwetša kae? _____

24. Ga eba ore "aowa", le dira bjang gore le di hwetše? _____

25. Le hlaološa dijo tša lena ka dijo tša gotšwa serapaneng sa ka mo gae?

Ee	Aowa

26. Ga eba ore "ee", le bjala dibjalwa tša mohuta mang ka mo serapaneng?

Dinawa	
Mafela	
Mabele	
Khabetšhe	
Dikherotse	
Sepenitšhe	
Ditamati	
Tše dingwe	

27. Le buna dijo tše e ka bago tše kaakang ka ngwaga go tše dingwadilwego ka godimo?
_____

28. Ka mo lapeng, le boloka tše dingwe tša dijo tše le di bunago gore le di je ka nako yeo e itšego mo ngwageng?

Ee	Aowa

29. A bontšhi bja dijo tša lena le a di reka?

Ee	Aowa

30. Ga eba ore "ee", le reka tša bokae ka kgwedi? _____

31. Go na le nako yeo e lego gore mo ngwageng le na le go hloka dijo ka mo lapeng? | Ee | Aowa |

32. Ga eba ore "ee", go tšea dikgwedi tše kae mo ngwageng lelapa la geno le hlaka go humana dijo tšeo di lekanetšego? | 1 - 2 | 3 - 4 | 5 - 6 | 7 - 8 |

33. Ka mo lapeng gona le batho bao ba šomago kgole le gae? | Ee | Aowa |

34. Ba tla le dijo ge ba etla gae? | Ee | Aowa |

35. Ke maano afe ao le a šomišago ge le feletšwe ke dijo?

_____

_____

36. Go matšatši a masometharo (30) ao a fetilego, ga eba go ile gwa ba le nako yeo leilego la hloka dijo tša go lekanela goba tšhelete ya go reka dijo, ke ga kae moo lelapa la gago le ilego la swanela ke (gore):

Maano ao a šomišitšwego	Ga kae ka beke				
	Tšatši ka tšatši	Ga raro go iša ga tshela	Ga tee goba gabedi	Go se fete ga tee	A re a ka
Go kgotlelela dijo tšeo di sa ratwego le tšeo e sego tša theko ya godimo?					
Go adimiša dijo, goba go kgotlelela thušo gotšwa go bagwera goba ba leloko?					
Go reka dijo ka mokitlana?					
Go kgoboketša dijo tša nageng, go tsoma goba go buna dijo esale tše nanana?					
Go jewa ga dipeu tšeo di bego di beetšwe nako yeo e latelago ya temo?					
Go romelwa ga wo mongwe wa lelapa gore a ye goja go gongwe?					
Go romelwa ga wo mongwe wa lelapa gore a yo kgopela dijo?					
Go fokotša dijo tšeo di lewago ka mehla ka nako ya dijo?					
Dijo di fiwa bana feela kantle le batho ba bagolo?					
Dijo di fiwa bao ba šomago legatong la bao ba sa šomego?					
Le kgoboketše setseka seo se itšego go tšhelete yeo le nago nayo?					
Fokotša palo ya dijo tšeo di jewago ka letšatši?					

Go ikhumana le sena dijo tšeo di lekanetšego?					
Go rekiša leruo le dišomišwa tša ka mašemong go reka dijo?					

C. METHOPO YA MEETSE AO A HLWEKILEGO LE TŠHOMIŠO YA MEETSE AO A ILEGO A ŠOMIŠWA PELENG

37. Le kga kae meetse?

Pompi ya ka lapeng	
Pompi ya motseng	
Sedibeng	
Nokeng	
Meetse a go epiwa	
Meetse a pula	
Tše dingwe	

38. Go le tšea nako ye ekabago e kae go fihlelela lefelo la kgwauswi la go kga meetse?

Bokgole (di metara)	
0 - 200	
201- 400	
401 - 600	
601 – 800	
801 – 1000	
> 1000	

39. A naa meetse a lena a hlwekile? _____

40. A naa meetse a phela ale gona?

Ee	Aowa

41. Ga eba ore "aowa", le hlaološa meetse a lena bjang? _____

42. Le šomiša magapa/dipakete/diteramo tša mohuta mang go boloka meetse? _____

43. Le šomiša meetse ao a hlwekilego go nošetša serapana sa lena sa ka gae?

Ee	Aowa

44. Meetse ao a hlwekilego a lekanela dinyakwa tša lena tša go nošetša?

Ee	Aowa

45. Meetse a lena ao a šomišitšwego a tšwa kae?

Go hlatswa dibjana	
Go hlapa	
Ka sinking	
Go hlatswa diaparo	
Dišawareng	
Tše dingwe	

46. Meetse a lena ao a šomišitšwego a ditšhila a tšhelwa kae?

Bo elela-tšhila	
Bo tšhollela-tšhila	
Ka magapeng/dipaketeng	
A nošetša serapana	

47. Ga eba le beya meetse a lena ao a šomilego ka morago ga go šomišwa, a naa le a tšhela ka gare ga magapa/dipakete tša mohuta mang? _____

48. Le kile la šomiša meetse ao a ilego a šomišwa peleng ka mo lapeng?

Ee	Aowa

49. Ga eba ore "ee", gantšhi le a šomiša go dira eng?

Go nošetša	
Ka ntlwaneng	
Go hlatswa dikoloi	
Go kgabiša dintlo	
Dišomišwa tše dingwe	

50. Ga eba le šomiša meetse a lena ao le a šomišitšego peleng go nošetša, le nošetša mehlare ya mohuta mang?

Dibjalwa	
Matšoba	
Mehlare ya dienywa	
Merogo	
Tše dingwe	

51. Ke ka lebaka la eng le šomiša meetse ao a šetšego a šomišitšwe peleng go nošetša?

_____

_____

D. DIKAKANYO/DIKGOPOLO

52. Ke di tšhitišo dife tšeo o kopanago le tšona ge o šomiša meetse ao a ilego a šomišwa peleng?

_____

_____

53. A naa o tshwenyega gore ba lelapa la gago ba ka lwatšwa ke di dibjalwa tšeo di nošeditšwego ka meetse ao a ilego a šomišwa peleng ge di bapetšwa le tšeo di nošeditšweng ka meetse ao a hlwekilego?

_____

_____

54. O kile wa lakalela go šomiša meetse ao a šomišitsweng peleng ka serapaneng sa gago ka lebaka la gore mohlomongwe a tla se sware dimela tša gago gabotse?

_____

_____

55. A naa o nagana gore go nošetša ka meetse ao a ilego a šomišwa peleng go ka oketša puno ya gago?

Ee	Aowa

56. Ga eba ore “ee”, hlalosa gore go reng o realo?

_____

_____