Small-scale irrigation water use productivity and its role in diversifying rural livelihood options: case studies from Ndumo B and Makhathini irrigation schemes, KwaZulu-Natal, South Africa

By

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Submitted in fulfilment of the requirements for the degree

Master of Science in Agriculture (Agricultural Economics)

in the

Discipline of Agricultural Economics

School of Agricultural, Earth and Environmental Sciences

College of Agriculture, Engineering and Science

University of KwaZulu-Natal

Pietermaritzburg

March 2016

DEDICATION

To my Lord God Almighty, Thank you.

DECLARATION

I, **Phakathi Sandile,** declare that;

1. The research reported in this thesis, except where otherwise indicated, is my original research,

2. This thesis has not been submitted for any degree or examination at any other university,

3. This thesis does not contain other people's data, pictures, graphs or other information unless specifically acknowledged as being sourced from other people,

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Signed ______________________ Date________________________

As the candidate's supervisor, I, Edilegnaw Wale Zegeye, agree to the submission of this thesis;

Signed ______________________ Date________________________

ACKNOWLEDGMENTS

First and Foremost, I give all gratitude and honor to my Lord God Almighty who has given me strength to accomplish my studies. Lord, you are my pillar of strength, thank you.

Secondly, I am so deeply grateful to my supervisor, Prof Edilegnaw Wale Zegeye, for his supervision; without his comments, inputs and critiques, I wouldn't have been able to accomplish this work.

I also would like to thank Dr. Aidan Senzanje for his support and assistance in supplying with the equipment used to collect data and also for his technical contribution to my thesis.

I thank my family and Mr. Benjamin Awir for their continued support and encouragement, love you all!

My heart-felt thanks also go to Water Research Commission (WRC) for financial support and also to Weather South Africa for assisting with secondary data.

I deeply give thanks and acknowledge the farmers in the Makhathini and Ndumo area, who provided data and information that I used in this research. I would like to extend my thanks to Extension Staff in the KwaZulu-Natal Department of Agriculture based on uMkhanyakude district offices, for coordinating data collection for the entire period of the research.

I deeply give thanks to Unity Chipfupa, Sikhulumile Sinyolo and my friend Nkosiyapha Mpungose who have been always encouraging me to continually push during difficult times and supporting me in every way, thank you so much. Last but not least, I am also deeply grateful to every one of the many people who were involved in the successful completion of this thesis.

ABSTRACT

Small scale farming is recognized as an important vehicle for reducing poverty and increasing economic growth in developing countries. As a result, the South African government has prioritized small-scale irrigation schemes, and made large investments in their establishment, rehabilitation and revitalization. Regardless of government's huge investment in small-scale irrigation infrastructure, a growing body of literature reveals that they are still underperforming as they have not brought about expected social and economic development. Despite using large volumes of water, the average value product produced by the small-scale irrigation sector has been low. This is a cause for concern for policy makers, especially in the light of rising water scarcity. Whereas attention has been paid to the lack of physical, natural, financial, social and human capital assets as factors contributing to the weak performance of small-scale irrigation schemes, limited attention has been paid to the role of psychological capital.

In this study, based on field observations and literature, it is argued that psychological capital should be integrated to the sustainable livelihoods framework (SLF) to better explain and understand why some farmers are performing better than others, despite similarities in resource endowments and constraints. Positive psychological capital denotes individual mind-set and attitude, affecting motivation to take initiatives or otherwise which directly has an impact on farmer's productivity. Thus, the integration of this form of capital to the sustainable livelihoods framework (SLF) makes this study unique compared to previous studies. Furthermore, the study provides estimates of water values for four typologies of small-scale farmers. Reliable estimates of water value are crucial for investment decisions in water resources development, policy decisions on sustainable water use and water allocation. To the best of the author's knowledge, no study has investigated irrigation water value in the Makhathini and Ndumo B irrigation schemes.

Given this background, this study aims to investigate (1) water use productivity and water value per crop, among the different farmer typologies and (2) factors (including psychological capital) affecting irrigation water value. Stratified random sampling was used to obtain a sample of 82 scheme irrigators, 38 independent irrigators, 24 home gardeners and 15 community gardeners in the Makhathini and Ndumo areas. Water measurements were done using a standard rain gauge for crops grown by scheme irrigators using a sprinkler system over a single production cycle. Furthermore, the CROPWAT 8.0 model was used to generate

secondary data on irrigation water requirements for the major crops grown (cabbage, maize, beans, and tomatoes) and used to generate water values. The data were analysed using gross margin analysis, residual valuation method, principal component analysis and general linear model.

The results indicated that the water values of scheme irrigators were higher than the out of scheme irrigators, implying that the economic performance of scheme irrigators is better. The higher water values attained by scheme irrigators can be attributed to two main factors. Firstly, reduced transaction cost due to economies of scale obtained from transacting through cooperatives and reliable water supply compared to other farmer typologies. Secondly, and more importantly, the results from focus group discussions indicate that scheme irrigators receive more support in terms of training, funds, input procurements and market access which has a direct positive effect on water values. The results from CROPWAT estimates indicated that tomatoes and cabbage yielded the highest aggregate water value of ZAR8.60/m^3 and ZAR8.47/m^3, respectively. Maize and beans had the lowest aggregate water value of ZAR2.88/m^3 and ZAR2.22/m^3, respectively. Comparing water values based on crops grown, scheme irrigators had the highest cabbage water value of ZAR11.42/m^3 while community gardeners, independent irrigators, and home gardeners had the highest water values for tomato enterprises at ZAR12.95, ZAR11.03, and ZAR0.85, respectively. The results from actual water used by scheme irrigators revealed that cabbage presented a lucrative enterprise with an aggregate value of ZAR13.43/m^3, compared to ZAR3.55/m^3 and ZAR2.36/m^3 for maize and dry beans, respectively. The results further indicate that, on average, the value of water varies according to the type of farmer, irrigation technology, farming experience, the main occupation of a farmer, marital status, and psychological capital.

The study results show the importance of psychological capital in the success or failure of smallholder farming. The farmers with positive psychological capital (confident, hopeful, optimistic and resilient) were found to be more persistent and productive despite prevailing constraints and challenges (such as markets access). However, the results indicated that the majority of small farmers had less confidence in themselves (endowments and capabilities) because over time they have developed a dependency syndrome that government has to do everything for them. This obviously reduces their self-confidence and hinders their potential to grow and become large commercial farmers.

These results also showed the importance of institutional arrangements in the efficient utilization of water among small-scale farmers. Farmers that were more organized and structured in such a way that they can benefit from economies of scale and institutional support were more inclined to have higher water use productivity. The SLF stresses the importance of institutional arrangements and collective bargaining in improving the livelihoods of rural farmers. Organized farmers have a stronger voice in price negotiations in the input and output markets resulting in reduced cost and increased profits. Farmers’ occupation and type of irrigation technology greatly influence water values compared to other factors. This was attributed to the fact that full-time farmers devote more time to farming, attend most of the training even at short notices and are more willing to learn and adopt new methods of farming. Therefore, the study recommends that government and other stakeholders continue to support farmers through tailor-made training activities.

LIST OF ACRONYMS

ANOVA	Analysis of Variance
CWR	Crop Water Requirement
DAFF	Department of Agriculture, Forestry and Fisheries
DFID	Department of International Development
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussions
GDP	Gross Domestic Product
GLM	General Linear Model
GM	Gross Margin
IMT	Irrigation Management Transfer
IWR	Irrigation Water Requirements
PC	Principal Component
PCA	Principal Component Analysis
RVM	Residual Valuation Method
SA	South Africa
SEI	South African Environment Institute
SLF	Sustainable Livelihoods Framework
VIF	Variance Inflation Factors
WP	Water productivity
WUE	Water Use Efficiency

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CHAPTER 1. INTRODUCTION

1.1 Background to the problem

Agriculture is an important economic sector in developing countries as it provides livelihood support to 60-80% of the population and makes a significant contribution to national incomes and economic growth (Brown & Hansen, 2008; Hussain *et al.,* 2007). However, despite that rainfall is unreliable and insufficient in many areas, agricultural production in Sub-Saharan Africa is largely rain-fed (You *et al.,* 2011). About 93% of agriculture in Sub-Sahara Africa is rain-fed, meaning that only 9 million of about 183 million hectares of agricultural land in the region is under some form of water management (Brown & Hansen, 2008). Sub-Saharan Africa is the region with the least-developed water storage infrastructure that is required to manage the variability of rainfall (Brown & Hansen, 2008). Consequently, the region has experienced less poverty reduction compared to other regions due to, *inter alia*, its reliance on rain-fed agriculture (Lipton *et al*., 2003).

Irrigation is important in South Africa because rainfall is unreliable, droughts are common and crop production in most of the country is inherently risky (Cousins, 2013).The unreliability of rainfall means that there is a need to shift agricultural production from rainfed to irrigated crop production (Hussain *et al.,* 2007). While FAO (2003) anticipated that food production must increase by 70% internationally and that the emerging countries must double production to match a 40% increase in the world population by 2050, there is an agreement that this increase would not be achieved without significant irrigation development (Lipton *et al*., 2003; Mukherji *et al.,* 2009; You *et al.,* 2011). Since small-scale farmers provide up to 80 percent of the food supply in Sub-Saharan Africa, small-scale farming has been recognized as an important vehicle for addressing the future demand for agricultural produce through irrigation, reducing poverty and increasing economic growth (FAO, 2003; Gomo *et al.,* 2007; Hope *et al.,* 2008; Fanadzo, 2012 ; Muchara *et al.,* 2014; Sinyolo *et al.,* 2014a). While the need for small-scale irrigation development to produce enough agricultural products in response to market demand brought by rising population and increasing consumer income is important, this has to be accomplished amidst both physical and economic water scarcity problems (Rijsberman, 2006; Lautze *et al.,* 2014). This implies the need for strategies to enhance water productivity so as to produce more output with the same amount of water available (Hussain *et al.,* 2007; Hussain *et al.,* 2009; Molden *et al*., 2010; Cia *et al.,* 2011a).

South Africa has about 1.3 million hectares of land under irrigation and consumes an estimated 12.3 billion cubic meters of surface and groundwater per year (Woyessa *et al.,* 2004; Van Averbeke, 2008). Irrigated agriculture is the single largest user of water in the country as it accounts for almost 30 percent of the total crop production in South Africa (Yokwe, 2009; Speelman *et al.,* 2011; Fanadzo, 2012b). Of the total irrigated land, about 0.1 million hectares is in the hands of small-scale irrigation farmers (Van Averbeke *et al.,* 2011). According to Gomo *et al.* (2014), there are about 330 small scale irrigation schemes covering 50,000 hectares in rural South Africa. The location of this small-scale irrigation schemes in the rural areas where poverty and food insecurity are concentrated makes them a very important tool for the government to achieve its rural development goals (Vink and van Rooyen, 2009). Consequently, the government has made huge investments in smallholder irrigation schemes. According to Gomo *et al.* (2007), the government has made investments amounting to US$3500‑7200 (R38798 -79813) per hectare towards the revitalization of small-scale irrigation schemes.

Despite the large government investment in the scheme infrastructure, the growing body of literature reveals that smallholder irrigation schemes are still under-performing, while others have totally collapsed (Bembridge, 2000; Bos *et al.,* 2005; Perret, 2002; Hope *et al*., 2008; Laker, 2004; Van Averbeke, 2012). Socio-economic, institutional, technical, climate and human capital factors are reported as contributing to the weak performance of small-scale irrigation farmers in South Africa (De Lange *et al*., 2010; Fanadzo, 2012; Van Averbeke, 2008). Whereas irrigation infrastructure was regarded as the single most important constraint for the failure of small-scale irrigation schemes in the past years, several studies (e.g., De Lange *et al*., 2010; Fanadzo, 2012) have recently indicated the importance of human capital. The research done by De Lange *et al.* (2000), indicated that human capital has not been adequately harnessed to effectively utilize the maintenance of infrastructure and increase yields. According to De Lange *et al.* (2000) and Fanadzo (2012), lower yields in smallholder schemes are the result of poor water management practices.

As noted in Laker (2004), another reason for the failure of smallholder irrigation schemes is the nature of how their management was transferred to the farmers. While irrigation management transfer is a global trend, the process was rushed in South Africa (Laker, 2004).

As a result, most schemes, particularly the large ones, collapsed due to sophisticated design and complex management requirements (Laker, 2004). On the other hand, Fanadzo *et al.* (2010a) indicated that the schemes that have remained under the control of government agencies have also been characterized by poor performance. This is because the farmers in these agency-managed schemes have not been given the chance to take some responsibilities in running the schemes themselves so that they can get skills on how to collectively manage schemes in an effective way (Fanadzo *et al.,* 2010a).

Furthermore, not only have the existing smallholder irrigation schemes failed to produce the expected social and economic development (Bos *et al.,* 2005), but there is evidence that water is being misused (Walter *et al.,* 2011). Given the rising water scarcity, the misuse of water threatens sustainable development in South Africa (Lautze, 2014). Fanadzo *et al.* (2012) reported that there is a significant loss of water in many irrigation schemes due to over-irrigation and lack of proper irrigation management tools among the farmers. Over-irrigating is not only wasteful, in that it decreases the valuable water that can be allocated to other productive uses, but also decreases crop productivity of the irrigated crops due to water logging. Moreover, over-irrigation reduces water productivity as the water wasted could have been used in the production of other high-value crops, resulting in increasing water value.

According to Shatanawi (2005), agriculture consumes more water while its productivity is low as compared to other sectors. Other sectors such as industries and cities have, therefore, requested agriculture to give its share of water despite the increasing demand for food production due to increasing population. This situation has led to conflicts but it could be resolved and lessened by implementing different alternatives of water uses for sustainable agriculture. Increasing water use productivity and efficiency would be a prime options approach to water resource management (Shatanawi, 2005). However, in order to make informed decisions on how water should be allocated between sectors, information is required on the contribution of water in these sectors.

Water values are higher in the production of high valued crops while the majority of smallholder farmers produce low valued crops due to lack of resources and insecure land tenure (Hussain *et al.,* 2007). Strategies have to be implemented to produce multi-enterprises as a way for improving water value because water value tends to be higher in multiple use dimensions (Hussain *et al.,* 2007). This study seeks to investigate water use productivity in the Makhathini and Ndumo areas of KwaZulu-Natal to give insight into farmers' productivity and also gives an indication of government investment based on farmers' productivity since no study had been done to evaluate the economic value of water in these areas.

1.2 Justification of the study

Most small-scale irrigation schemes suffer from large water use inefficiencies due to many factors such as poor distribution systems, excess irrigation and lack of proper irrigation water management (Bos *et al.,* 2005; Molden *et al.,* 2010; Cia *et al.,* 2011a). This calls for developing alternative strategies and plans to design and carry out programs that will increase water use productivity and increase incomes. To achieve this goal, a combination of technology, extension services coupled with research programs, education, and effective policy framework are required to reflect the real opportunity cost of water. Furthermore, priority should be based on crop selection for better water use productivity and efficiency with the aim of improving market access and adding value to increase the returns on agricultural investments in irrigated agriculture (Shatanawi, 2005).

Whereas attention has been paid to lack of physical, financial, natural, social and human capital assets as contributing factors to weak performance of small-scale irrigation schemes (Gomo *et al.* 2007; Van Averbeke, 2008; Speelman, 2008; Yokwe, 2011; Fanadzo, 2012; Muchara, 2015), no attention has been paid to the role of psychological capital. In this study, based on field observations and literature, it is argued that psychological capital should be integrated to the sustainable livelihoods framework (SLF) to better explain and understand why some farmers are performing better than others, despite similarities in resource endowments and constraints. It is common knowledge that two farmers working in the same village, having a similar resource endowment (according to the five forms of capital) and faced with similar institutional and infrastructural constraints are making decisions differently and achieving different levels of productivity and incomes. While one is cautious, the other takes more risk; while one takes advantage of opportunities when they arise, the other doesn't; while one waits and expects the government to do everything, the other makes his own effort, takes action and mobilizes the resources available; while one is confident in farming as a means of livelihood, the other is not; while one is optimistic about the future of his farming operations, the other is not; while one is hopeful, the other is not; while one thinks he will succeed, the other does not; while one gives up easily when faced with challenges, the other doesn't. How best can one explain this difference?

The concept of psychological capital is introduced in to accomplish this task. As noted above, the traditional SLF is deficient and cannot explain such differences as similar asset endowment will predict a similar level of farmers' engagement and outcome. Hence, the integration of psychological capital to the SLF and its introduction in this study is meant to explain individual mind-sets beyond the human and social capital. It is meant to explain the mindset that induces or hinders individual initiatives to take advantage of opportunities like in small-scale irrigation schemes. Psychological capital can shade light on the question of why some farmers are exerting more effort and mobilizing resources than others to make the best out of what is available and accessible. The government has made large investments in the rural areas to uplift smallholder farmers but the performance is still unsatisfactory (Van Averbeke, 2008). Why is it that some are taking advantage of this resource and benefiting while others are not?

Positive psychological capital denotes individual mind-set and positive attitude towards farming, affecting motivation to take initiatives or otherwise which directly has an impact on farmer productivity. Thus, the integration of this form of capital to the SLF makes this study unique compared to previous studies (Chapter 2, Section 2.6.2 have more on psychological capital). Moreover, even though several studies have been done to evaluate water productivity and irrigation water value in South Africa (e.g., Gomo *et al.* 2007; Speelman, 2008; Yokwe, 2011; Fanadzo, 2012; Muchara, 2015), none of these were done in the northern region of KwaZulu-Natal. Water is a very scarce resource in the north of the province compared to the southern region, where water availability is less problematic due to abundant precipitation.

Furthermore, reliable estimates of water value are crucial for investment decisions in water resources development, policy decisions on sustainable water use and water allocation while no study has investigated irrigation water value in Makhathini and Ndumo B irrigation schemes. Knowledge about irrigation water values can provide indications about the soundness of the large government investments. Therefore, a study on water use productivity will play an important role in enhancing irrigation water use productivity and meet future water demand. Most small-scale irrigation schemes do not have flow meters to quantify water applied during their growing season. Therefore, this study will compute crop water requirements for the Makhathini and Ndumo areas which will help in planning future irrigation scheduling.

Maximization of yield per unit of water is the best strategy to achieve sustainable agriculture in light of rising water scarcity, and more efficient water management techniques must be adopted. Using water efficiently increases productivity and returns throughout the growing seasons, reducing water deficits now and in the future. Furthermore "Scientific understanding of water productivity can help in addressing water scarcity concerns through the more productive use of scarce water resource and higher socio-economic benefits from available water" (Al-Said *et al.,* 2012:477). In order to show the way forward, this study will assess water use productivity in the Makhathini and Ndumo areas in order to recommend best management practices that can be adopted for increasing water use productivity. The following section outlines the general and specific objectives of the study.

1.3 **Objectives of the study**

The general objective of the study is to evaluate the economic performance and water use productivity of small-scale irrigation farmers in the Makhathini and Ndumo areas of KwaZulu-Natal. This will be achieved through the following specific objectives:

- Investigate water use productivity and water value per crop, among the different farmer typologies, identified, and
- Investigate factors affecting irrigation water value including the psychological capital index generated as one of the factors.

1.4 **Organization of the thesis**

The study is organized into six chapters. The current chapter has outlined the background to the problem statement, justification of the study, and the study objectives. Chapter two presents a synthesis of the literature on the concept of water use productivity, its role in diversifying rural livelihoods in small-scale irrigation farming and the key factors enhancing or deterring water use productivity. Chapter three deals with the research methodology (study area, the conceptual framework and empirical models used). Chapter four presents the empirical results and discussions on socio-demographic characteristics of the sampled households for Makhathini and Ndumo. Chapter five presents the results and discussions on water productivity and value for the major crops grown among the typologies of farmers identified and the factors influencing the implicit value of water. The last chapter present the conclusions and recommendations drawn from the empirical results.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The chapter presents an overview of the literature on small-scale irrigation farming, from a South African perspective. It starts discussing the water use productivity concept and the sustainable rural livelihoods as the study is built upon these concepts. Then it narrows down and discusses the role of irrigation in rural livelihoods, factors hindering farmers' performance and factors influencing water use productivity, with a specific focus on small-scale farming. The sections that follow continue to review the limitations and controversies surrounding the water productivity concept and then an overview of the methodologies for valuation of irrigation water in small scale farming.

2.2 Concepts and definitions

2.2.1 Water use productivity

According to Dam *et al.* (2003), there are several definitions of the water use productivity concept, as it is not uniform and it changes with the background of the researcher and stakeholder involved. Economists are often interested in maximizing the economic value of water used while plant breeders are more interested in maximizing kilograms of dry matter production per unit of transpiration. Furthermore, productivity based on actual yield as harvested product in kg is less useful if the concern is to compare different crops or different regions. A definition based on economic value is, therefore, more appropriate for this study since the aim is to compare the productivity of various farmers. Thus, this study is based on the economic value of water.

The water productivity concept originated from the term irrigation efficiency in the late 1990s. Lautze *et al.* (2014) define it as the quantity of output per unit of water which is used to assess performance towards the end of maximizing production derived from water use. However, Molden *et al.* (2010:528) go further and define water productivity as the "ratio of net benefits from crop, forestry, fishery, livestock and other mixed agricultural systems to the amount of water used in the production process". The benefits can be measured in various terms such as physical mass, economic value, and nutritional value. Physical water productivity refers to the ratio of agricultural outputs to the amount of water consumed and economic water productivity refers to the value derived per unit of water used while the nutritional value is based on the energy and vitamins per unit of water consumed and used by the crop (Molden *et al.,* 2010).

Various reasons can be outlined why it is necessary to increase water productivity. Firstly, water should be used in a most productive way so to meet the rising demands for food from a growing, wealthier, and increasing urbanized population in the light of rising water scarcity. Secondly, to respond to pressures from agriculture to re-allocate water to other sectors and ensures that water is available for environmental users. Furthermore, improving water productivity can reduce poverty levels and contribute to economic growth in South Africa (Molden *et al.,* 2010). If water productivity is improved, investment cost can be reduced by using less cost to extract water to the field. It is, therefore, crucial to increase water use productivity because the more producers are able to produce with an equal amount of water, competition for water may be reduced, and the greater will be the local food security and increased water for agriculture, household and industrial uses. An increase in agricultural water productivity is the key approach to mitigate water shortages and to reduce environmental problems (Ali & Talukder, 2008; Cia *et al.,* 2011a).

However, in coming up with strategies for increasing water use productivity, there is a need to understand the water-energy-food nexus. Water and energy are coupled in intimate ways as many technical processes of extracting and producing energy utilize water. This inter-dependency, shown in Figure 1.1, is referred to as the water-energy nexus. It is a crucial issue for future planning and strategic policy considerations in an effort to increase water use productivity (Siddiqi & Laura, 2011; Rusul, 2014).

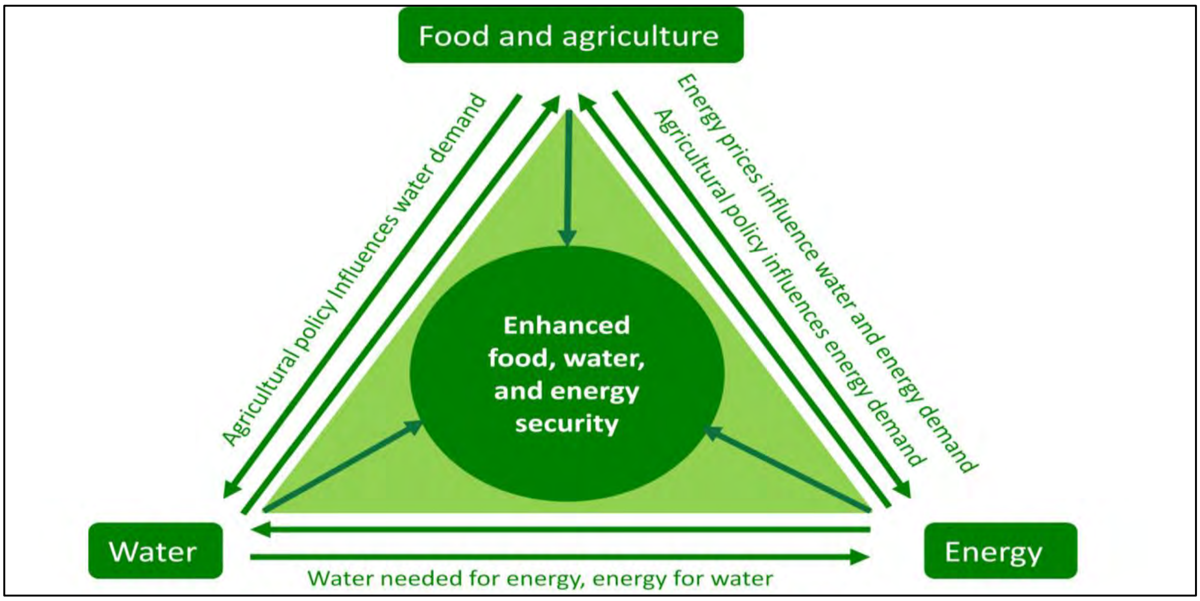


Figure 2.1 The water-energy-food nexus

Source: Rusul (2014)

Furthermore, strategies should take cognizance of the fact that the demand for water, energy and food is going to increase in future. Global projections have indicated that the demand for freshwater, energy, and food will increase significantly due to the pressure of population growth and mobility, international trade, economic development, diversifying diets, technological changes, and climate change. It is estimated that globally, total water withdrawals for irrigation will increase by 10 percent by 2050 while global energy consumption will increase by up to 50 percent by 2035 (FAO 2011). According to Ringler *et al.* (2013), in 2007 food prices increased by nearly 40 percent and further increased in 2008, while in 2011 prices flared up and it seems that they are unlikely to decline in the foreseeable future. Given the interdependence between natural resources and agriculture, higher food prices are an important signal of growing natural resource scarcity. It is indicated that, among other factors which lead to price increases (such as changes in demand, available technology *etc*.), the key factors are associated with water supply, energy, and land for production.

However, the water-energy-food nexus cannot present a complete picture of rural livelihoods on its own and it needs to be studied along with the SLF in order to know where best intervention can be made, to productively use water while not degrading the environment. By assimilating SLF and water-energy-food nexus, the inter-linkages among prices, energy, water, capital assets and the environment is identified. Figure 2.2 below brings together the water-energy-food nexus and the SLF.

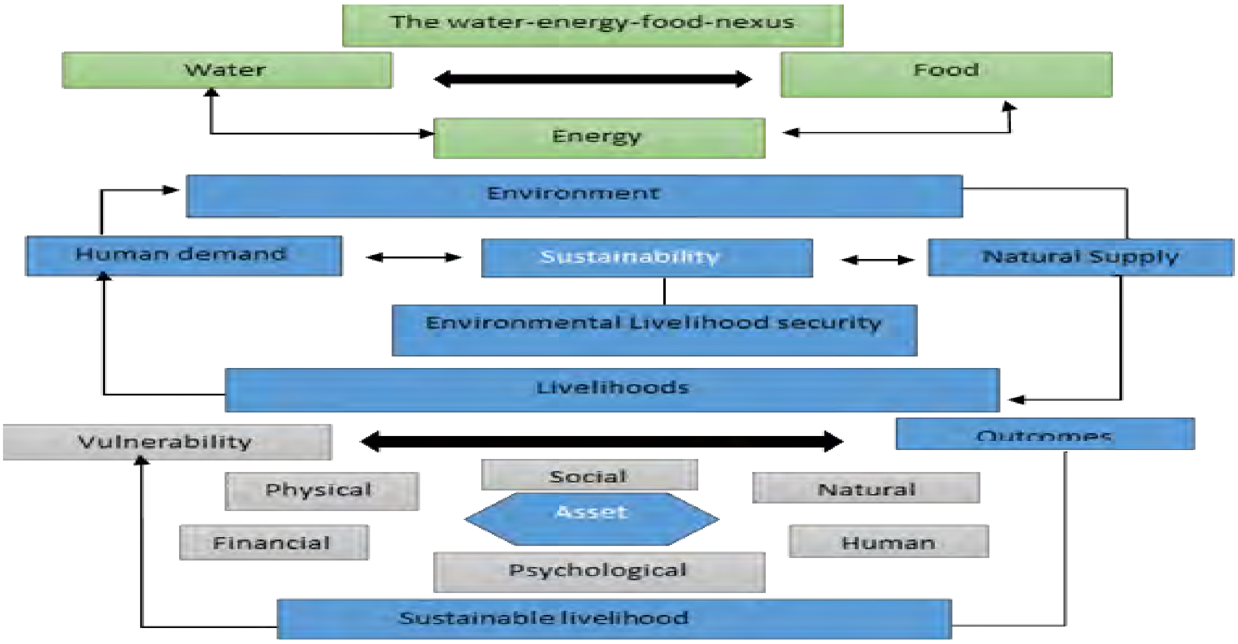


Figure 2.2 Inter-linkages between the water-energy-food nexus and the sustainable livelihood framework

Source: Adapted from Biggs *et al.* (2015)

The primary inter-linkage can be recognized as a mutually re-enforcing relationship between water and livelihoods as water is essential to support livelihoods in irrigated agriculture while livelihood activities and capital assets determine the preservation of water access and supplies (Biggs *et al.,* 2015). For example, "physical capital (infrastructure) may enable more efficient water extraction and transportation while financial capital (public or private funds) may assist in implementing more sustainable practices in water use or purchase access to alternative supplies" (Biggs *et al.,* 2015:393). Hence, these inter-linkages need to remain balanced and resilient under prevailing vulnerabilities which threaten the sustainable rural development.

2.2.2. Sustainable rural livelihoods

A sustainable livelihood is defined as an adequate stock and flow of food, cash and other resources to meet basic needs. It embraces people, their capabilities, assets including both material and social resources, and activities required for a means of living (DFID, 1999). For a livelihood to be sustainable, it has to be secured, meaning that households should have secure ownership or access to resources, opportunities and income earning activities in order to offset risk, ease shocks and meet contingencies. A household may be enabled to gain sustainable livelihood security through many ways such as ownership of land, livestock, the right to grazing, fishing, and hunting, *etc*. According to the sustainable livelihoods framework, capital assets denote the capabilities available to households to pursue different livelihood strategies (Chamber and Conway, 1992; Scoones, 1998; Carney *et al.*, 1999). They determine the capability of households to utilize available opportunities to improve their livelihoods. Even if an area has good soils and irrigation, but if a household does not have skills and capital required for production, it fails to utilize the available opportunities which reduce overall productivity. The SLF emphasizes the fact that rural livelihoods are diversified and farming alone does not account for the entire means of survival of rural families (Ellis, 2000; Barrett *et al.*, 2001). The framework is people-centered and it places much emphasis on external support to recognize the heterogeneity of smallholder farmers and their different aspirations for more dynamic livelihoods.

According to Levine (2014), individual perception is the starting point for understanding their rationality in the livelihoods options and what factors influences activities they are pursuing. The differences in people's perceptions are generally determined by their identity (age, gender, ethnicity, religion, education, class, political allegiance, *etc.*), their relative power and wealth and how they are treated by institutions and policies. These differences, in turn, significantly determine people's livelihood choices and outcome (Levine, 2014). Many rural livelihoods are predetermined by birth because a person may be born into an inherited livelihood such as a producer or farmer with land and equipment or a shopkeeper with a shop and stock. However, some livelihoods are less predetermined; being largely determined by the social, economic and ecological environment in which people find themselves in while others may choose a livelihood through education and migration to better places (Chamber & Conway, 1992). Rural families, through livelihoods diversification, create a diverse range of activities and social support proficiencies in their struggle for survival in order to improve their standards of living of which small-scale irrigation farming is one of the alternatives (Adato & Meinzen, 2003). A socially sustainable livelihoods have to cope with and recover from stresses and shocks and improve their capabilities and assets both now and provide for future generations while not over-utilizing the natural resource base (DFID 1999; Chambers & Conway, 1992, (Ellis, 2000; Barrett *et al.*, 2001). Livelihoods must generate income through the provision of goods and services that have an effective market and non-market demand at prices and costs that provide a satisfactory return (Dorward, 2001).

2.3 The role of irrigation in rural livelihoods

According to Reinders (2011), irrigated agriculture plays a central and dynamic role in the improvement of rural livelihoods, but is often subject to criticisms of inefficiency in water use, high capital and recurrent costs and lack of sustainability associated with inequity in the distribution of both land and water. One of the major constraints in agricultural production which is uncontrollable is the exposure to a high degree of climate risk which is the characteristic feature of rain-fed agriculture in the arid regions of sub-Sahara Africa. Climate change is a major barrier to economic growth in Sub-Saharan Africa as a result of the large fraction of economies that agriculture represents and its vulnerability to climate anomalies (Brown & Hansen, 2008).Thus, irrigation remains an important strategy in many developing countries, in increasing production, mitigating the effect of unpredictable rainfall and provide food security and employment to poor farmers (Chazovachii, 2012). Irrigation is vital for rural livelihoods where the poverty level is high and agricultural production is the main livelihood option. The main purpose of irrigation is to "apply the desired amount of water, at the correct application rate and uniformly to the entire field, at the right time, with least amount of non-beneficial water consumption and as economically as possible" (Reinders, 2011:766). Irrigated agriculture plays major role in rural livelihoods through four important inter-related mechanisms that can alleviate poverty (Smith, 2004; DFID, 2001);

- Improvements in the levels and security of productivity, employment and incomes for irrigating farm households and farm labour,
- Linkages in the rural economy,
- Increased opportunities for rural livelihood diversification, and
- Multiple uses of water supplied by irrigation infrastructure.

In irrigated agriculture where conditions are favourable, incomes for farmers can be increased through irrigation by ensuring that adequate water is supplied throughout the growing season. New crops or varieties for which market opportunities exist can be cultivated because water is available even during dry seasons. This may lead to higher quality yield by eliminating water deficits and providing, at least, a measure of drought protection. Moreover, farmers benefit through reduced risk and higher returns in the use of complementary inputs such as improved seed and fertilizer. Farm workers benefit through increased, more continuous and evenly spread farm employment. This increase in demand for labour has a direct relation to increase the wage rate. Furthermore, landowners benefit from the appreciation of the value of land that has access to irrigation. This appreciation often enhances access to credit and social standing (FAO, 1996; Smith, 2004; DFID, 2001).

Irrigated agriculture, if successful, can lower food prices for consumers through more quantity being produced which reduces the price per unit produced. However, lower prices may offset producers' gain from higher productivity unless gains in productivity are sufficient to sustain profitability through reduced cost per unit of output. Irrigation contributes to agricultural growth by raising the productivity of land and labour; these production linkages stimulate the farm input supply and output processing and distribution industries. Moreover, this effect leads to consumption linkages as rural households purchase more goods and services. Furthermore, if demands for goods and services increases, more jobs are created; this raises incomes in a virtuous circle that multiply benefits from the original gains in farm productivity. Smith (2004) noted that these linkages lead to improvement in human capital through better nutrition and increased ability to pay for health and education; also, financial capital can be increased as the ability to save, to borrow and to invest in capital can reduce vulnerability and contribute to productivity (FAO, 1996; Smith, 2004; DFID, 2001). Pro-poor rural households benefit from multiple uses of irrigation water supply as they may use water for drinking, washing and also for homestead gardens. This saves their time and energy for lifting water from the river, which could be far away from their homestead. (Smith, 2004).

2.4 **Overview of small-scale agricultural sector in South Africa**

In South Africa, the agricultural practice can be grouped into three categories, small-scale, emerging farmers and large-scale farming. When defining farming practice, the land alone is not adequate for classifying whether a farmer is a small scale or a large scale farmer. Classification should also be based on the general character of the business, with labour supply as the principal factor (Carver, 1911). Small-scale farmers are those who are mainly located in rural areas where agriculture is the main activity to alleviate poverty and they are challenged by a number of constraints to increase productivity (Kirsten & Van Zye, 1998). Small-scale farmers differ by individual characteristics, the size of the farm system, and proportion of crops sold, household expenditure patterns, distribution of factors of production between food crops and cash crops and off-farm activities. These differences make these farmers have different levels of contributions in different forms towards the South African economy (Machingura, 2007).

Small-scale irrigation schemes can be defined as multi-farmer irrigation projects that are serving farms larger than 5ha in size (Bembridge, 2000). In South Africa, about 1.3 million ha of land is under irrigation for both subsistence and commercial agriculture. Irrigation schemes in South Africa can be categorized into (1) bureaucratically managed small-scale schemes in which farming is carried out on behalf of farmers by the government or its agencies; (2) community or garden schemes which are usually very small in sizes and are maintained by community users with the main objective of subsistence farming. Community gardens share similar infrastructure for water supply where small dams are usually used for water supply; (3) corporation financed schemes in which government provides support from infrastructure down to farm gate while farmers only contribute toward a subsidized water fee and do operational service and management decisions. Lastly, the large estate schemes which are managed by agents with the objective of maximizing the use of resources through the production of high-value crops such as tea, coffee, *etc.* (Bembridge, 2000; Perret, 2002).The other significant group of small-scale farmers are independent irrigators. They have a private water supply such as own borehole and their primary objective is to make a living out of farming where it is usually considered as an additional source of income. Independent irrigators are usually not being supported through funds but use their own or family capital accumulated over a period of time. Moreover, there is a lack of support on specialized technical advice on cropping and irrigation management which reduces their overall productivity. According to Delgado, (1999) independent irrigators can be differentiated on the basis that they buy their own inputs and sell produce independently wherever they choose.

In South Africa, it is estimated that about two-thirds of small irrigation schemes are dedicated to food plots where about 200,000 to 230,000 rural black people gain livelihoods partly on such schemes (Perret, 2002). In irrigation schemes, sprinkler irrigation technology is widely used on about 53% of the area, flood irrigation on 28.5% and micro and drip irrigation on about 18.5% of the area. Home and community gardeners use low efficient technologies such as bucket system, hosepipes, flood irrigation, due to low maintenance cost. The country's most recent era of small-scale irrigation scheme development is the one known as the irrigation management transfer (IMT) and revitalization era which began in the 1990s and is currently underway (Van Averbeke, 2008; Fanadzo, 2012a). The central aim of the IMT alteration process is to improve the performance of the schemes through handing over of the ownership and collective management responsibilities to the farmers (Fanadzo, 2012a; Van Averbeke, 2012). Revitalization aims for socially uplifting profitable agribusinesses on the current irrigation schemes and in communities surrounding the schemes. This is characterized by building human capital, enhancing access to information, and financial support to revamp existing irrigation infrastructure for sustainable rural development.

According to Poulton *et al.* (2010), small-scale farmers enjoy low labour cost which has competitive advantage over large commercial farms in the form of low supervision and transaction cost because they are able to substitute cheap labor for hired labour and lumpy capital equipment (such as for land preparation, planting, weeding, and harvesting) using motivated family labour. However, these benefits are insignificant due to small scale farm size which leads to high transaction cost for almost all non-labor transactions such as accessing capital, market and technical support, output markets, *etc*. Table 2.1 below shows the main sources of the distinction between small scale and large scale farming.

Table 2.1 Comparison of small-scale farms and large-scale farms

Characteristics	**Small Farms**	**Large Farms**
Unskilled labour supervision, motivation, etc.	✓	
Local knowledge	✓	
Skilled labour		✓
Market knowledge		✓
Technical knowledge		✓
Inputs purchase		✓
Finance and capital		✓
Output markets		✓
Product traceability and quality assurance		✓
Risk management		✓

Source: Poulton *et al.* (2010)

The majority of small-scale farmers rely on family labour with women mostly involved in the production (Machingura, 2007). They either produce for household consumption or for informal markets if there is a surplus, due to high transaction costs to access formal markets (Machingura, 2007). Furthermore, small-scale farmers have access to both on-farm and off-farm income. On-farm income is procured from the sale of their agricultural products while off-farm income is from wages from off-farm employment and grants from social welfare. Tollens (2006) refers to small scale farmers as net buyers of food because their production is insufficient to meet their household needs. This permeates their poverty and vulnerability over time.

On the other side, large-scale farmers receive many critical services through telephones with market intermediaries while the same cannot be said for small-scale farmers as they have to walk miles in search of market information. (Poulton *et al.,* 2010). Product quality constrains their ability to access high valued markets because demand for goods has become more sophisticated with greater importance being placed on quality and safety attributes because of rising incomes of consumers (Louw *et al*., 2008). Access to market information is increasingly important to assure product traceability. To meet market quality requirements, specific inputs such as high variety seeds and fertilizer are vital to producing good quality products. Small-scale farmers do not have an advantage over these services and their products are usually of low quality. According to Louw *et al.* (2008), Baloyi (2010) and Poulton *et al*. (2010), economies of scale is largely observed in agro-processing and export markets while small-scale farmers do not have such comparative advantages. Poulton *et al*, (2010:1414) noted that "not only do smallholder producers lack market power but they also suffer from limited political voice, as a result of their limited education, limited economic power, and geographic dispersion". This led to the inability to put pressure on public sector service providers to effectively deliver services.

2.5 Factors restricting small scale farmers in expanding agricultural production

2.5.1 Access to land and the poverty of tenure security

Land tenure security is one of the most critical elements in eliminating poverty, promoting social equality and developing sustainable agriculture. In South Africa, small-scale farmers in rural areas do not have land rights as it is owned by the area's tribal authority. This signifies that a farmer does not have full ownership of land which makes it difficult to make a long-term investment. "There is no market for arable land under the communal land tenure system" (Ortmann & King, 2010:399). Secured tenure creates incentives to invest and use resources more efficiently. Wannasai & Shrestha (2008) define secure land tenure as the possession of private land with land titles issued and the landowners who hold this certificate possess unrestricted rights of sale, transfer and inheritance. According to Roth & Haase (1998:2), from an economic angle tenure insecurity is a "function of an inadequate number of rights or lack of key rights, inadequate duration or lack of assurance". Figure 2.1 below indicates the conceptual framework for tenure security.

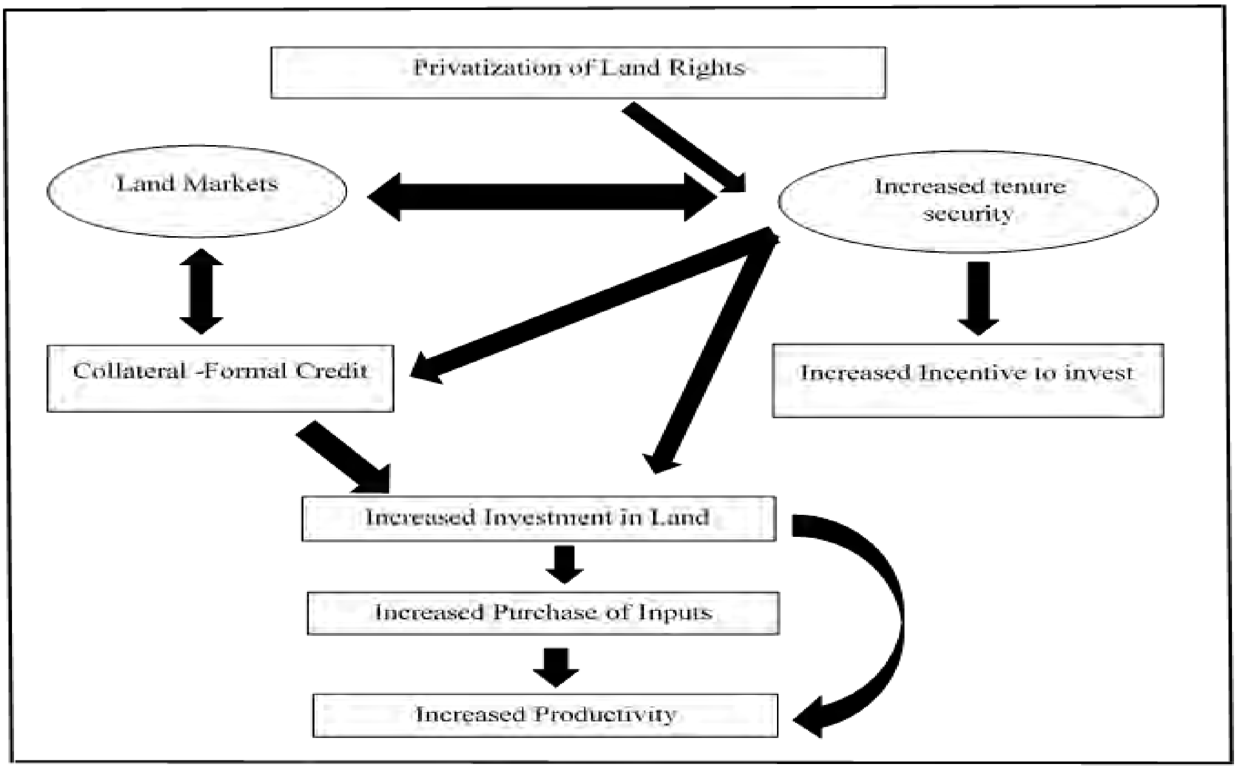


Figure 2.3 Conceptual model for tenure security

Source: Adapted from Place (2008)

Secure land tenure directly increases productivity by improving access to inputs through creditworthiness and collateral value of land (Roth & Haase 1998; Darroch & Mushayanyama, 2006). It also limits land disputes because there is a clear definition and protection of rights which increases productivity through increased agricultural investments (Roth & Haase 1998). Duration of the secured right to use land is critical in decision making in land use. To improve productivity, farmers require high tenure security before making fixed land improvements and investing in capital intensive technology. However, due to insecure tenure, it is impossible to access credit from formal lenders because they require clear and transferable title before lending while credit supply from informal lenders is insufficient. As a result, land ends up not being fully utilized, productivity decreases and the economy is negatively affected (Machingura, 2007). Hussain *et al.* (2007) state that water value is higher in production of high valued crops (such as tree crops, coffee, etc.) but due to poor land security, investment in high-value crops is limited and farmers have no option but to cultivate crops with lower value which even do not present opportunities for market access.

Despite insecure land tenure that hinders farmers' performance, small plot allocation is another major problem that hinders high productivity. In a South African nationwide survey, it was found that at least 25% of small-scale farmers are approaching landlessness as they control less than 0.11 ha per capita. According to Jayne *et al.* (2010:1386)," under the existing conditions, the ability of this bottom land quartile to escape from poverty directly through agricultural productivity growth is limited by their constrained access to land". Small plot (s) are insufficient for a producer to benefit from economies of scale and to access markets through being able to supply large quantities. Ortmann and King (2010) also found that small-scale households had small areas of arable land with averages of 1.8 hectares in Swayimana and 1.1 hectares in Impendle. From a survey of small-scale farmers of two Districts in Limpopo Province (Vhembe and Capricorn), it was found that vegetable profit margin per beneficiary was low because the total net profit was shared amongst all the 26 beneficiaries of the Ratanang project (Baloyi, 2010).

In 2011, the South African Cabinet approved the emerging farmers support facility which aimed at helping emerging farmers who are beneficiaries of the land reform programme to create sustainable agribusinesses (Land Bank, 2011).The programme was aimed at promoting efficient land use for agricultural production by small-scale farmers. Lack of access to sufficient land contrasts the vision of land reform which includes "ensuring all South African citizens, particularly rural blacks, have reasonable access to land with secure rights in order to fulfill their basic needs for productive livelihoods" (Government Gazette, 2011).The land redistribution for agricultural development (LRAD) grant of South Africa was aimed at improving tenure security and extending property ownership and access to productive resources mostly to black South Africans. One of the objectives of Land Bank is to promote access to and equitable ownership of land for agricultural use, in particular for historically disadvantaged persons (Land Bank, 2011). According to Machete (2004), the Land Bank has succeeded to reach more small-scale farmers with loans but the majority of these farmers still do not have access to land. However, according to Jayne *et al*. (2010), poverty reduction through addressing land inequality has been given little attention.

2.5.2 **High transaction cost and lack of market access**

When evaluating water use in agriculture and its productivity, other non-water factors of production are the key. Transaction cost problems often hinder access to these factors of production and reduce water use productivity. Transaction costs are serious considerations in value chains as processing and retailing companies express a preference for working with relatively fewer, larger and modern suppliers (Swinnen *et al.*, 2010). This is because, compared to large-scale farmers, small-scale farmers experience high transaction costs in their production and marketing activities. The findings by De Bruyn *et al*. (2001) illustrated that transaction cost variables (e.g. information cost, price uncertainty, transport costs, *etc*.) have a significant impact on the proportion of cattle sold to Meatco (a meat corporation parastatal of Namibia) and indirectly on the choice of a marketing channel. Swinnen *et al.* (2010) noted that large companies are extracting almost all the surplus because of their high bargaining power within the chains. According to Cia *et al.* (2011b), access to well-functioning markets is crucial in determining the overall value of agricultural production and net returns to farmers. Small-scale farmers in the Limpopo Basin are often obliged to sell their produce to large farmers because they have the resources and bargaining power to send it to distant markets. Lack of well-functioning markets leads to fewer farmers' share of the value added in the commodity chain due to their products being undervalued (Baloyi, 2010).

Moreover, in South Africa, markets are characterized by weak price information, lack of technology and high transaction costs of doing business as buyers and sellers try to protect themselves against the risk of transactions failing by searching for and screening potential suppliers (Brown & Hansen, 2008; Louw *et al.,* 2008; Kirsten *et al.,* 2009; Baloyi 2010). Low purchasing power in the domestic markets and poor access to global markets pose limits to market access because of trade distortions such as agricultural subsidies in rich countries which make it difficult for South African agricultural producers to compete globally (Kirsten *et al.,* 2009; Jayne *et al.,*2010). This hinders farmers' performance as market access determines farm profitability and value of output produced.

Small-scale farmers might choose to participate in spot mechanisms due to high transaction costs as they live in remote areas. In rural areas, infrastructure (e.g. roads) is still lacking. This makes it difficult for small-scale farmers to market their products and participate in value chains due to long distances to formal markets. In other words, lack of infrastructure results in high transaction costs thus creating disincentives for small-scale farmers to produce up to their highest potential because they do not have easy access to markets. Manona (2005) argues that in the former Transkei, marketing of agricultural produce when there is a marketable surplus available, is barely developed due to the limited nature of transportation and other infrastructural facilities. In the study of the impact of supermarkets on small contract farmers in Madagascar by Minten *et al.* (2005), it was argued that there is bad infrastructure which is strongly related to agricultural performance. This is a constraint that impedes the competitiveness of small-scale farmers.

Small-scale farmers end up producing for household consumption due to lack of marketable surplus and high transaction costs that discourage the need to commercialize. “There is no doubt that high transaction costs tend to discourage commercialization” (Baloyi, 2010:24). Access to information enhances farmers’ production capabilities and decisions on how to market the product as they get to know more about market prices and product quality required by the market (Masuku *et al.*, 2001). However, due to high transaction costs of accessing market information, small-scale farmers lack knowledge about the quality of products needed by consumers, who their potential consumers are and what prices they going to sell the products for. Lack of information reduces small-scale farmers’ ability to trade their products successfully while deriving full benefits from the marketable part of their production (Louw *et al.,* 2008; Baloyi, 2010). Lack of information does not only affect individual farmers but also the growth of small-scale agriculture as a whole. This implies that more is still required to be done to improve small-scale farmers’ access to information to enhance their participation in food value chains. According to Jayne *et al.* (2010), the size of the market is largely determined by marketing costs in which transport cost usually contributes more than other costs. The size of the market expands for farmers as transport cost declines and demand for goods becomes more elastic.

2.6 **Factors influencing water use productivity**

Various factors affect water value but the dimension of the value of water may be classified into four categories: use, time, impact and space dimension (Hussain *et al.,* 2007). Use dimension is based on the pattern of water use, where water value is higher in multiple cropping practices, with high valued crops and high valued multiple enterprises such as livestock, fish farming compared to single low valued crops like cereals. The value of water is influenced by time as most of the project impacts are realized over a long-term period which might increase or decrease water values. The longer the period in irrigation, the more the economic or investment in expansion might be made, such as land improvements, installation of water measuring devices, which might increase water value. However, on the negative side, the longer the period, the higher the chance that land degradation (loss of soil fertility) and soil acidity may happen and reduce water value (Hussain *et al.,* 2007). Space dimension of water productivity can be explained by the variation of water values at the local level or at the macro level. Local level generally looks at the availability and supplies and quality of water; macro level its looks at water policies, laws and regulations governing water use. For example, water values tend to be higher under improved institutional water management. Lastly, the impacts dimension is related to all dimension as water discussed above, as value tend to be higher over a long-term period where projects impact are more significantly in a long run, at higher spatial scale, under the production of multiple enterprises. Furthermore, improvement in institutional water management in a long-run signifies an improvement in water values. (Hussain *et al.,* 2007). Factors affecting water productivity can be sub-divided into capital asset-related factors, crop-related factors, agro-chemical related factors, water availability, farm management related factors, policy-related factors, *etc.* (Leutze *et al*., 2014; Hussain *et al.,* 2007).

2.6.1 **Capital assets from the sustainable livelihoods framework**

Farming inputs are basic and essential to any farm enterprise. The strategies attempting to link African farmers to markets and increase farm productivity must first consider how inequality in productive assets constrains the majority of small scale ability to participate in markets (Delgado,1999). In South Africa, small-scale farmers are characterized by lack or poor access to capital assets including physical, financial, social, human and natural assets, which are crucial in increasing productivity and alleviate poverty. Lack of these capital assets increases risk and creates disincentives to increase production (Sikwela, 2013). According to Pote (2008), production assets are the key requirements for increasing farm profitability and increase market access and that is why the majority of farmers are unable to participate in lucrative markets because of lack of specific household production assets. The sustainable livelihoods framework embraces that capital assets represent the capabilities available to households to follow different livelihood strategies (Chamber and Conway, 1992; Scoones, 1998; Carney *et al.,* 1999). They have a critical role in defining the ability of households to utilize available opportunities to improve their livelihoods. For example, an area might have good rains and soils which represent an excellent farming opportunity. However, if a household does not possess, through ownership or otherwise, the assets that make farming possible, the result is a failure to utilize the available opportunity.

Machete (2004), noted that lack of infrastructure (lack of storage facilities) severely limits productivity.This includes post-harvest storage facilities and cold rooms which help in maintaining the quality of the products due to the perishable nature of agricultural production. Magingxa *et al*. (2009:50) argue that "assembly and the storage point for farmers' produce are unsuitable for agricultural products". Moreover, small-scale farmers sell their produce immediately after harvest when prices are low due to lack of storage facilities, which directly reduce their output value and productivity (Tollens, 2006; Magingxa *et al.,* 2009). This is also triggered by cash flow problems as these farmers often do not have cash reserves to wait until prices recover. According to Katundu *et al.* (2010), small-scale farmers at Embo still use traditional storage methods, where traditional huts with earthen floors are primarily used as the farmers' storage. These huts are not suitable to be used as potatoes' storage and as a result due to poor storage capacity resulted in higher post-harvest losses due to greening and spoilage from exposure to indirect sunlight. Furthermore, due to lack of storage facilities, farmers cannot sale their surpluses and supply consistently during the off-season. Their inconsistency makes them less competitive in the value chain and this prevents them from participating successfully in the chain. Due to their inconsistency and low competitiveness, other role players in the chain (e.g. supermarkets) avoid working with them. According to Reardon (2005:29), cited by Baloyi (2010), supermarkets prefer to not work with small-scale farmers because they do not deliver regularly (start/stop) and they do not invest consistently. Henceforth, according to Delgado (1999), in order to increase small scale market access and productivity in Sub-Saharan Africa, strategies should focus on the four keys, namely, access to assets, access to information, access to services and access to remunerative markets.

Social capital is defined as one's ability to utilize social networks and institutions. Social capital is considered as an important capital because it determines access to other capital assets such as land little, credit access and equipment, all of which have implications for resource allocation and hence productivity (FAO, 2001). Njuki *et al*. (2008:10) state that social capital can be categorized into three, namely, binding, bridging and linking. Binding social capital is defined as a "cohesion that takes place between individuals of similar ethnic background and is reinforced by working together, whereas bridging social capital links networks requiring collaboration and coordination with other external groups to achieve set goals". Engagement of local groups with institutions or agencies in higher influential positions is considered as a linking social capital. Linking social capital enables poor households to have access to resources, information, and support from organizations and networks (Njuki *et al*., 2008).

In agriculture, especially in small-scale farming, most of the resources are considered as common pool resources, where non-excludability is difficult, which usually leads to resources being used more than the social optimum and ultimately being exhausted. This is commonly identified as the tragedy of the commons. One of the main characteristics of small-scale farming is heterogeneity in terms of farm size, income inequality, head-tail users, *etc*. The latter is regarded as the key problem as far as small scale irrigation scheme management is concerned. Head and tail users differ in terms of their access to irrigation water, where water use for end-tail is highly determined by head-user, often leading to conflicts in water allocation. Thus, social capital is considered to be an important instrument for common pool resources management through collective action management (Aida, 2011; FAO, 2001; Muchara *et al.,* 2014). Furthermore, the formation of collective action such as co-operatives or informal groups enables farmers to attain goals that are difficult to be achieved on their own as individuals. Farmers are able to benefit from economies of scale through sharing of transport to access inputs, purchasing of inputs, sharing of information and knowledge, and selling output as a group which increases market access and reduces transaction costs. However, the success is primarily based on the trust and cooperation between members as a result of which productivity can be increased (FAO, 2001; Aida, 2011).

To reduce farmers' vulnerability to short-term income, access to credit is a vital instrument for improving the welfare of the poor directly by reducing liquidity constraints. Farmers who are less risk-averse are more willing to take credit for productive investment to overcome liquidity constraints directly boosting production and income (Sebopetji, 2008). However, the majority of small-scale farmers do not have access to credit due to land tenure insecurity and collateral issues as was noted in section 2.5.1 above. Moreover, human capital assets are vital for sustainable agricultural productivity. Human capital refers to "knowledge, experience and skills possessed by people involved in the production process which is directly influenced by education and training" (FAO, 2001:28). Human capital is not only limited to education but also to the individual state of health. According to Okpachu *et al*. (2014:27) "increased agricultural productivity depends primarily on the education of the rural farmers to understand and accept the complex scientific changes which are difficult for the illiterate rural farmer to understand". To improve the production capacity of a population, the human capital theory postulates that formal education is highly instrumental and essential as it increases the level of cognitive stock of economically productive human capability which is a product of innate abilities and investment in human beings (Okemakinde, 2008 cited by Okpachu *et al*., 2014).

Training and education assist farmers in applying new methods required for improving irrigation water management and farming operations as a whole and training benefits farmers to understand guidelines on the use of agrochemicals and adopt innovative agricultural technologies. Human capital affects the adoption and utilization of technology which directly influences the decision making in resource allocation while directly influencing farm productivity (FAO, 2001). Montshwe (2006), further states that education levels also affect the level of market participation among small-scale farmers as they will be able to understand and utilize both technical and management operations. Delgado (1999) also agrees that in new commercial items and non-traditional exports, only those individuals with high levels of education, better access to management and technical advice and better knowledge of market opportunities are most likely to grow their operations compared to those without. Lastly, psychological capital is an important asset unique to individual farmers as to how they perceive and show commitment toward farming.

2.6.2 **Psychological capital**

The concept of psychological capital has been borrowed from psychologists to explain how it affects the productivity of small-scale farmers. As it has been noted before, the inclusion of psychological capital is meant to explain the mindset that induces or hinders individual initiatives to take advantage of opportunities available in small-scale irrigation farming. The government has made large investments in the rural areas to uplift smallholder farmers but the performance is still unsatisfactory (Van Averbeke, 2008). Why is it that some are taking advantage of this resource and benefiting while others are not? Psychological capital can shade light on this question and bring more insights on why some farmers are exerting more effort and mobilizing resources than others to make the best out of what is available and accessible. Psychological capital is defined as an "important composite construct that can assist in addressing human capital issues in organizations" (Simon & Buitendach 2013:2). It denotes individual mind-set and attitude, affecting motivation to take initiatives or otherwise which directly has an impact on productivity (Luthans *et al.,* 2004). Figure 2.3 below represents the four dimensions of positive psychological capital.

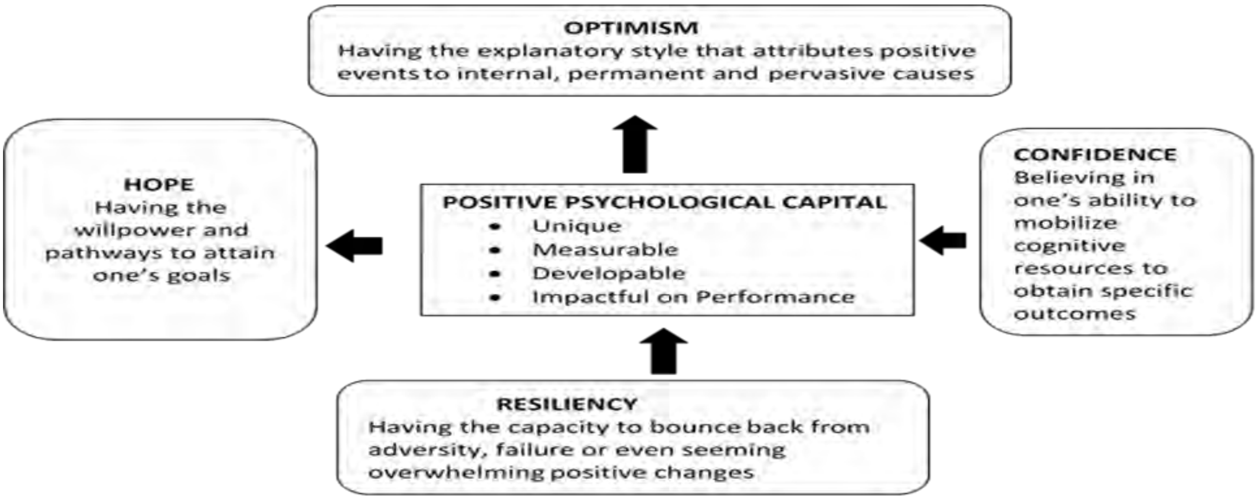


Figure 2.4 Dimensions of positive psychological capital

Source: Luthans and Youssef (2004)

Psychological capital is unique based on the individual characteristic, it can be measurable and can be developed and it directly impacts on the performance. It is categorized into four resource capacities, namely, hope, optimism, resilience and confidence (Luthans and Youssef, 2004; Luthans *et al.,* 2004). Individuals who have self-confidence persevere even when faced with obstacles which keep on drawing them back but they go extra miles to successfully accomplish their goals, making a positive attribution (optimism) about succeeding now and in the future. Optimistic individuals see obstacles as either challenges or opportunities that will eventually lead to success (Simon & Buitendach, 2013). They always bounce back (resilience) and through hope, they generate different pathways to accomplish goals (Sinha *et al.,* 2002; Luthans and Yousef, 2004; Luthans, 2007; Simon & Buitendach, 2013). According to Larson & Luthans (2006), resilience is usually influenced by assets, risk and adaptation processes. When resources are limited and individuals are faced with risky decisions, those with positive psychological capital are in a better position to make effective decisions and employ more resilient adaptation mechanisms. Hence, they try to shift the balance of protective and vulnerability forces into different risk contexts. When all forms of capital are in place, positive psychological capital is important to be effectively managed and developed so that agricultural productivity can be increased.

2.6.3 **Crop-related factors**

Genetic improvement has played a vital role in improving yield potential for crops. In the past, more emphasis has been on water use efficiency (WUE) as an important determinant of yield under stress conditions and even as a component of crop drought resistance. It has been used to imply that rain-fed plant production can be increased per unit of water used, resulting in ‘‘more crop per drop’. However, if biochemistry of photosynthesis is not improved genetically, greater genotypic transpiration efficiency and WUE will be low as it is mainly controlled by plant traits or genetics (Bouman, 2007). Another improvement in transpiration efficiency may be the conversion of C3 plants into C4 plants through genetic engineering, as C4 plants are more efficient in their photosynthetic pathway and also have higher water use efficiency than C3 plants (Bouman, 2007; Molden *et al.,* 2010). If the right combinations of crops are chosen, high economic return from production can be obtained with limited water resources.

According to Ali & Talukder (2009), in mathematical modeling, water productivity is largely a function of the carbon dioxide and vapor concentration gradient between the inside and outside of the leaf. This process is regulated by stomata, so the stomata behavior determines the water productivity of a cultivar. In irrigated agriculture, an extensive volume of water is lost as evaporation or leakage during storage and transporting of water to the fields where the crops are grown (Qadir *et al.,* 2003; Wallace, 2010). If there are no improvements in water productivity, the average annual agricultural evapotranspiration could double in the next 50 years. Furthermore, with improvement in water productivity, the increase in global evapotranspiration could be reduced to 20-30 percent (Molden *et al.,* 2010). Evapotranspiration process is defined as the combination of two separate processes whereby water is lost from the soil surface by evaporation and from the crop by transpiration (FAO, 2000a). Transpiration rate is influenced by crop characteristics, environmental aspects and cultivation practices, crop development, and management practices. Factors such as soil salinity, poor land fertility, and limited application of fertilizers, the presence of hard or impenetrable soil horizons, the absence of control of diseases and pests and poor soil management may limit the crop development and lead to poor mechanization of the crop (FAO, 2000a; Karam *et al.,* 2009; Molden *et al.,* 2010). Therefore, it is important to develop farm management strategies to effectively increase crop productivity.

Better cultivars are required to increase crop yield per unit of scarce water. However, the challenge is to: improve genetic make-up in order to capture more of the water supply for use in transpiration, exchange transpired water for CO_2 more effectively in producing biomass, and convert more of the biomass into the harvestable product. Developing genotypes that are able to maintain adequate fertility despite severe water scarcity is a prime option for plant breeders (Bluum, 2009; Passioura, 2006).

2.6.4 **Agro-chemical-related factors**

Shortage of sufficient nutrient supply and poor soil structure are the principal constraints to crop production under low input agriculture. Soil organic matter management is very important for the development of sustainable low-input agriculture system and for the improvement of soil quality (Ouedraogo *et al.,* 2001). Fertilizer plays a crucial role in increasing overall productivity which directly increases soil cation exchange capacity and improves Soil pH, enabling farmers to harvest large quantities of produce (Ouedraogo *et al.,* 2001). The use of agrochemicals increases food production and increases profits for farmers as the high loss in food production caused by pest is combated, thus enabling farmers to sell more quality products. Moreover, using agrochemicals such as herbicides reduces the cost of labour for production as the amount of time required to manually remove weed and pest from fields is reduced (Aktar, 2009). However, in sub-Saharan Africa, the use of sustained fertilizer in small scale farming remains very low despite the fact that it is an important factor in increasing crop production (Freeman & Omiti, 2003). Adoption of fertilizer has remained low due to high risk of low variable rainfall patterns, inefficient input distribution, and unavailability of input in rural retail. Furthermore, farmers are uncertain about the returns from fertilizer use because of various risk associated with volatility in prices, pest infections and also restricted or lack of liquid capital to purchase them (Freeman & Omiti 2003; Morris *et al.,* 2007; Diiro, 2015).

Agrochemicals are essential agricultural inputs required to protect crops from disease, control pests, and weeds thus increasing overall productivity. It has been estimated that pre-harvest crop losses due to weed infestation, plant diseases and arthropods is around 30-35% but with the application of agrochemicals, losses can be significantly reduced (Kughur, 2012). Moreover, agricultural chemicals significantly increase crop yield by reducing damage by the pest, competition for water and nutrients from weeds and by providing large amounts of nutrients in a form that is easily available to plants. Agrochemicals contribute not only to crop growth but also reduce food waste, allowing consumers to consume a high-quality product that is free of insect blemishes and insect contamination. Moreover, due to reduced losses during production, the cost of food is reduced because high-quality yields are being produced thus increasing returns from water use (Kughur, 2012).

Despite the positive effect caused by agrochemicals, they significantly have negative effects on the environment and on human life. According to Hussain *et al.* (2007), water values are affected by time dimension as most of the project impacts are realised in a longer period where extensive use of agrochemicals may start to cause harm to the environment. Agrochemical use disrupts the balance of an ecosystem as they do not stay in a location where they were applied but can move through water, soil and air and cause harm if they come in contact with other organisms (Biswas *et al.,* 2014).

Extensive use of agro-chemicals and fertilizers in a long term period has a negative effect on soil fertility, water quality and air quality which directly reduces water values. Nitrate leaching (from ammonium-based fertilizer) causes soil acidification which reduces soil fertility and during runoff causes harm to aquatic ecosystems and impairs water use for humans and livestock (Morakinyo *et al.,* 2013; Biswas *et al.,* 2014). During run-off contaminated nutrients enter into water bodies and reduce oxygen levels of aquatic ecosystems. Livestock and humans directly consume contaminated water which immobilizes some of the hemoglobin in blood, reducing the ability to transport oxygen and eventually leads to chronic illness or even death. In irrigation schemes, inadequate drainage and over-irrigation cause waterlogging and salinization which degrades downstream ecosystems due to polluted run-off (Killebrew & Wolff, 2010). Furthermore, according to Killebrew & Wolff (2010:2)," during the microbial processes of nitrification and denitrification that take place in fertilized soils, nitric (NO) gas is released. Nitric emissions impact local and regional air quality by contributing to the formation of smog, ozone, and acid rain". Polluted air directly causes harm to human health by causing Asthma and other related diseases (Aktar *et al.,* 2009; Killebrew & Wolff, 2010, Morakinyo *et al.,* 2013; Biswas *et al.,* 2014).

2.6.4 Farm management-related factors

Crop rotation is one of the oldest farm management criteria for improving productivity and it is the most effective cultural control strategy for keeping soil quality and structure. Crop rotation has several advantages such as preventing soil depletion, maintaining soil fertility and reducing soil erosion. It is also a cultural means for controlling pest and reducing pest build-up thus preventing crop diseases and helping to control weeds. Reduced tillage also plays a significant role in improving water use productivity (FAO, 2000b). Reduced tillage helps in reducing the effect of raindrop impact on the soil surface; it also increases water infiltration into the soil while reducing runoff from the soil surface. Moreover, it helps in reducing rapid breakdown of the soil structure and reducing the formation of hard pan layers in the soil. This leads to a better soil environment for the crop growth thus increasing water use productivity (FAO, 2000b; Woyessa *et al.,* 2004). The other important management factor is related to water use or management in irrigation schemes. There is a significant loss of water in many irrigation schemes due to over-irrigation and lack of proper irrigation management tools that are required to assist a farm manager on how much and when to irrigate. This is known as irrigation scheduling. Furthermore, with accurate irrigation scheduling, there is a possibility of achieving high performance of irrigation schemes in terms of water productivity (Woyessa *et al.,* 2004). Water management in the agricultural sector cannot be applied without a precise and reliable method of crop water requirement determination, comprehensive information on the irrigation system, farming practice, appropriate measuring devices and information on return flows. Thus, a farmer is required to know the daily crop water use of each crop, to measure rainfall and the amount of water applied so as to make precise demand and application of irrigation water (Woyessa *et al.,* 2004). Crop water requirement is defined as the amount of water required to compensate the evapotranspiration loss from the cropped field. It basically represents the difference between the crop water requirement and effective precipitation; it also includes additional water for leaching of salts and to compensate for non-uniformity of water application (FAO, 2000b; Woyessa *et al.,* 2004).

Procedures for irrigation scheduling are based on soil, crop and weather monitoring. These determine the level of irrigation efficiency in the scheme as it depends on how crop water requirement is determined. Various methods have been proposed for determination of crop water requirement. These methods are SAPWAT and CROPWAT (Woyessa *et al.,* 2004). The CROPWAT model is proposed by the Food and Agriculture Organization of the United Nations. These methods have become the international standard used on the global scale for irrigation management. SAPWAT method was primarily developed for South African conditions with a link to further development on an FAO planning model. CROPWAT was developed as a planning and management aid that is supported by extensive South African climate and crop databases (Woyessa *et al.,* 2004).

Deficit irrigation can also help in increasing water use productivity and save scarce water by applying less water than cumulative evapotranspiration (ET). Root zones utilize stored soil water in the winter or pre-season irrigation. Deficit irrigation limits water application to drought-sensitive growth stages with an aim of maximizing water productivity and stabilizing yield. Water is saved because irrigation requirements in the early irrigation in the spring season can be less than that indicated by ET. Deficit irrigation saves water without reducing the yield; however, critical periods should be avoided (Shatanawi, 2005).

Supplemental irrigation is one of the highly efficient practices for improving water use productivity and improving livelihoods, especially in dry rain-fed areas. "Supplemental irrigation is defined as the addition of small amount of water to essentially rain-fed crops during times when the rainfall fails to provide sufficient moisture for normal plant growth, in order to improve and stabilize yields'' (Oweis & Huchum, 2006:62). Supplemental irrigation is scheduled not to provide moisture-stress-free conditions throughout the growing season but to ensure a minimum amount of water available during the critical stages of crop growth that would permit optimal instead of maximum yield. Supplemental irrigation increases not only yield but also water productivity.

2.6.5 **Policy-related factors**

In addressing rural poverty and inequalities inherited from the past apartheid regime, the South African government has put forward various reform measures. Water legislation is among other programs which are developed to promote "equity, sustainability, and efficiency through water management decentralization, new local and regional institutions, water user registration and licensing, and the emergence of water right markets" (Perret, 2002:284). Rising water scarcity due to population growth and economic development has resulted in formulating appropriate water institutions which include well-defined water rights. Water institutions are defined as "the humanly devised constraints that regulate water development, allocation, and utilization" (Zhang *et al.,* 2014:71).

The main objective of the new water resource management regulation is to promote equal access to water, where farmers and rural communities should form "Water User Associations" with an aim of enabling communities to pool financial and human resources for carrying out more effectively water-related activities. Moreover, only members of WUAs apply for a license and then they are given the right to use water under specified conditions. However, those who fail to become members of WUAs are limited to the right to use water, particularly irrigation on a commercial or subsistence scale while individuals at the household level and rural people are granted free and unregistered right to use water for irrigation (Perret *et al*, 2002).

These institutions are able to achieve an efficient allocation of water among the users to maximize total net benefits. The central government introduced the adoption of a system of volumetric surface-water pricing as an incentive for using water more efficiently and productively. Finney (2013) defines water management charges as a form of economic instruments where government licenses water users the right to abstract water and charges are based on either licensed volume of abstraction, regardless of the volume actually used, or on the volume abstracted and measured in cubic meters. Water abstraction management charges usually include components such as the environmental value of water, the opportunity cost which is the economic value or scarcity value of water and the administration cost of water resource management (Finney, 2013).

Water fees were introduced to meet the cost of water supply and improve water efficiency. However, many authors (such as Young *et al.,* 2003; Wang *et al.,* 2010) further argue that the current prices charged for irrigation water are well below the market levels and are, therefore, inefficient. These fees do not even cover the costs of operating and maintaining the irrigation system. As a result, this hinders the efficient allocation of water under the prevailing water institutions. Moreover, water abstraction charges are widely adopted by high-income and some middle-income countries including South Africa, while they are employed only by few low-income earners because low-income countries have limited managerial and technical capacity (Rogers *et al.,* 2002; Nieuwoudt & Backeberg, 2011; Finney, 2013).

2.6.6 **Water availability**

South Africa is regarded as the 30th driest country in the world since it receives about half of the average annual rainfall in terms of available water per capita (Schreiner *et al.,* 2010). Over 60 percent of the country receives less than 500 mm rainfall per annum and about 21 percent receives less than 200 mm (Perret, 2002; Sinyolo *et al.,* 2014).Water use in agriculture has steadily declined from around 80% in 1980 to 61.3% in 2011 (Zhang *et al.,* 2013). Most of the basin in Africa and South America are not the driest but they have poor access to water due to lack of appropriate storage and diversion infrastructures which expose them to drought (Cia *et al.,* 2011b). Water availability is limited due to physical and economic scarcity and thus reducing agricultural production and productivity. Lautze *et al.* (2014:58) define water scarcity as the "point at which the aggregate impact of all users impinges on the supply or quantity of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment cannot be fully satisfied".

Water scarcity can be categorized into two: physical and economic scarcity (Cia *et al.,* 2011a; Lautze *et al.,* 2014). Physical scarcity occurs when the demand for water exceeds the available water resource while economic scarcity occurs when resources required to extract water are limited due to financial, human and institutional capacity. Economic scarcity is recognized by Lautze *et al.* (2014) as a more appropriate concept because it looks beyond physical availability by integrating the concept of water access. According to Zhanga *et al.* (2014)**,** water has an economic value in all its competing uses and therefore it should be treated as an economic good. To humans when water is available in abundant quantities it is considered as non-rival and non-excludable but it stops being a pure public good when the consumption or its use by one individual has negative effects on the production possibilities of others (Zhanga *et al.,* 2014).

One of the most noted problems leading to the limited or reduced availability of irrigation water is the fact that in a typical irrigation scheme, it is costly to exclude others from drawing water and even excluding others from drawing more water than the allotted amount, the case of head and tail problem. The other problem is the issue of water theft, where some illegally draw water and distort resource allocation to those who are legally entitled to use water (Kähkönen, 1991). Furthermore, the m^3 of water is underpriced as farmers are charged an annual flat rate which is unable to cover the cost of operation and maintenance. A lower value is placed on water for agriculture as compared to the value placed on industries, cities, and the environment. Some argue that while water is scarce in many areas, the price of agricultural water is low and this underestimates water scarcity to farmers. There is also little evidence that charging for water use can increase water use productivity because the "responsiveness to higher water prices is limited by existing systems of water rights, inadequate measurement and monitoring of water deliveries, and strong opposition to higher water prices in agrarian societies" (Finney, 2013:478). Increasing water charges can be seen as a further penalty for producers who are already struggling to make a living (Molden & Sakthivadive, 1999). However, relatively cheap pricing of agricultural water creates inefficiencies; farmers over-irrigate which directly reduces water values. As farmers continue to add more and more litres of water, the law of diminishing returns states that output gradually decreases at an increasing rate and output is reduced.

Moreover, the types of irrigation system used have an effect on production as other systems are more efficient than others. A study conducted by Al-Said (2012), in Oman, revealed that a drip irrigation system had higher returns to water use than a sprinkler irrigation system mainly because it delivers the proper amount of water directly into the soil, reducing water waste and protecting the plants' leaves and stems. However, this does not necessarily mean that farmers should install drip irrigation, but assuming that economic resources are abundant, a drip irrigation system would be a prime option to increase water productivity. The disadvantage of a drip irrigation system is that it is more expensive than other systems and needs regular maintenance (Reinders, 2011).

Investment in improvement for water productivity is essential through a range of technical and management practices. Drip and sprinkler irrigation and canal lining influences productivity and increase yield. Many strategies exist for improving water use productivity but the adoption rates remain low due to several reasons such as costs, profitability, risk, and access to markets, water availability, education, incentives and institutional structures (Molden *et al.,* 2010). Incentives for increasing water productivity are rarely in place; farmers are more interested in making their entire enterprise profitable and enhancing household food security than increasing water use productivity. Water quality is also a major concern due to the limited quantity of water left in river channels and aquifers. Degradation of water quality is caused by emission from cities, rural households and in agriculture, especially in areas of intensive irrigation by over-application of fertilizer. Degraded water quality will gradually lead to low water use productivity (Cia *et al.,* 2011a).

2.7 **Limitations and controversies surrounding the water productivity concept**

According to Gleick *et al.* (2011), several authors, water scientists and water managers have debated and explored how to define, measure and evaluate water use productivity of both urban and agricultural water uses. There are several problems being outlined which complicate definitions of water use productivity, which among others include confusion about its assumptions and the inappropriate application of narrow disciplinary tools to a complex inter-disciplinary topic. Water productivity (WP) values are affected by many factors including natural and management conditions such as seeds, labour and fertilizer and hence the application of WP in isolation fails to capture the relative contribution of diverse factors (Cia *et al*., 2011).

The water productivity concept is better understood in conjunction with specific system settings, i.e. whether it is a water-abundant or water-scarce area; whether WP is constrained by yield or water use; whether it is an irrigated or a rain-fed system. WP is scale-dependent, which is related to specific geographic extents as well as the types of farming systems involved. The interpretations are thus restricted by the boundary conditions. As WP has variable forms, the user needs to make sure to use the same form when making intra- or inter- system comparisons (Cia *et al*., 2011b; Molden *et al*., 2010).

When the WP indicator fails to generate measures to improve agricultural productivity or water efficiency, no directly actionable recommendations are evident. According to Cia et al. (2011b), WP results in isolation typically fail to enable tailored-recommendations. Moreover, the WP concept fails to provide any specific guidance on how to improve conditions. To identify that an area possesses low productivity certainly designates that productivity can be improved in that area but WP fails to expose whether to apply water management measures or agricultural tools. Thus, this shortfall raises a question as to whether the use of the WP concept adds additional value to the joint use of water efficiency and agricultural productivity (Zoebel, 2006). If WP is low due to physical constraint, it may be used as a useful guide to allocate resources where high return to water value may be achieved, but if low WP is due to poor decision making associated with manageable parameters, allocating more water to areas of higher WP would seem to dismiss the potential to raise WP where it is low (Molden et al., 2010).

The WP concept appears as if it does not add value over and above joint use of Water Use Efficiency (WUE) and agricultural productivity. According to Zoebl (2006), the WP concept violates the opportunity cost of saved or lost water. Therefore, high water productivity values may not be a suitable target because the values do not say much about the economic wise use of this resource. Moreover, irrigation efficiency remains a valuable and significant parameter provided it is well defined and used at the level of individual farmers or irrigation projects (Zoebl, 2006). In contrast, others argue that WP does add value to joint use because the WP concept enables comparison of the production benefits associated with the use of water in one location to another. It also serves as a decision-making guide to water allocation compared to WUE (Molden *et al.,* 2009; Molden *et al.,* 2010, Hussain *et al.,* 2007). However, the WP concept may have its short-fall but the bottom line remains that it holds value if used as a qualified guide to production derived from water use in various locations and industries when applied in combination with other indicators because if it is used in isolation it holds the potential to mislead.

2.8 An overview of the methodologies for valuation of irrigation water in small scale farming

There are various approaches that are used in the valuation of irrigation water. According to Hussain *et al*. (2007), in economic terms, valuation refers to quantifying goods and services provided by water, whether or not market prices are available for the goods and services being valued. Methods used to value goods and services can be classified into two categories, namely, revealed preferences approaches (demand function, hedonic pricing, residual valuation method (RVM), change in net income, production function approach, mathematical programming models, *etc*) and stated preference approaches (contingent valuation method, conjoint analysis, choice experiments). Hedonic pricing and demand function are based on observed sales of water, which means that all inputs including water have a market price while the latter is based on market behavior. The stated preference approach is applicable where people's preferences or willingness to pay cannot be inferred directly or indirectly from the actual behavior in the market. It is based on surveys that ask people to state the value they attach to water (Young, 2005; Langa & Hassan, 2006).

Economists are often more interested in valuing water using techniques based on market behavior (Young, 2005; Langa & Hassan, 2006; Hussain *et al.,* 2007). However, application of each method is based on the objectives of the study and most important on the availability of data. The demand function approach and hedonic pricing are not applicable in this study due to the absence of water markets as water is mostly used for free or subsidized. Furthermore, the demand function approach requires accurate data in such a way that charges for water should be based on volume consumed, not on a lump sum for services (Langa & Hassan, 2006). Thus, it is not applicable in this study because water is not paid for and in Makhathini water charges are based on a flat rate which is highly subsidized by the government. The production function approach is not applicable because a major limiting factor is a lack of accurate data on actual water applied as water was only measured in irrigation schemes and it is more applicable to experimental studies where other variables can be controlled.

On the other side, one of the key shortcomings of the contingent valuation method is that it does not rely on market behavior. The residual valuation method is widely used in irrigation to determine the value of water as an intermediate good in production. It is a deductive technique of non-market valuation deriving prices from the model of individual economic decisions made by firms and households (Young, 2005; Lange & Hassan, 2006). According to Young (2005), this method is better applicable in the production of staple agricultural crops, where the production process is standardized and irrigation water has a substantial impact on the value of output. In this study, the residual valuation method is employed since both irrigation schemes are homogenous in nature in terms of production practices and they are located in a very dry area where irrigation has highly significant impacts on the value of products where water scarcity is the major problem compared to other regions (Woyessa, 2014), which is the case for the study areas.

Furthermore, to address some of the shortcomings of the water productivity concept, this study evaluates water productivity based on the economic water values to determine farmers' performance. The residual valuation method captures all the costs in production and the returns are attributed to water claimant. Focus group discussions with farmers and management will give insights on where interventions can be best made based on the empirical results.

2.9 **Summary**

The chapter presented a literature review on small scale farming on various factors influencing water productivity. The literature review revealed that small-scale farmers are still underperforming in terms of production despite large government investment. Many challenges have been outlined which hinder farmers success such, as a high transaction cost, lack of market access and poor tenure land security. High transaction costs of accessing information and transporting outputs create disincentives to participate in high valued markets. Furthermore, poor land tenure creates disincentives to invest in land which directly reduces productivity. Several factors on the other hand directly reduce water use productivity such as lack or shortage of capital assets required by a household to follow different livelihood strategies. Without these assets in place, farming becomes difficult and unsustainable over the long term. Moreover, the government had put in place institutions to govern the use of natural resources such as water to improve allocation efficiency. These institutions determine and govern the use of water. Several methods have been used to investigate the value of irrigation water in small scale farming but the residual valuation method is widely used where water contributes a substantial amount to the production of outputs.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the research methodology. Firstly, the study area is described followed by the data collection methods and instruments that were employed. It also provides a description of the sustainable livelihoods framework, which is the foundation upon which the study is built. Data analytical approaches used in the study are also explained and the justification for their inclusion is given. The study employs four empirical approaches to data analysis including gross margin analysis, principal component analysis (PCA), residual valuation method and general linear model. These empirical methods are discussed subsequently.

3.2 Description of the Study area

The study was conducted in the Makhathini and Ndumo B Irrigation schemes. The two schemes are located in the Makhathini and Ndumo rural communities in Jozini local municipality. Jozini, which covers a land area of 3082 km^2, is within the uMkhanyakude district in the far North of KwaZulu-Natal Province, latitude 27° 37' 21.63" South and longitude 32° 01' 47. 14", East (UMkhanyakude District, 2012). The district, which has five local municipalities, shares its borders with Swaziland and Mozambique and is the second largest district in KwaZulu-Natal, in terms of size, with a population totaling 614,046. The majority of the population resides in Jozini with the total of about 95,918 males and 111,330 females, making 38,530 household**s** (UMkhanyakude District, 2012). The district is one of the poorest not only in the province but also in the country as it is characterized by chronic poverty, with 85.2 percent of households within the municipalities earning less than R1, 600 per month. Jozini local municipality area has a humid subtropical climate with most rainfall falling in summer from December to March (Schulze, 1965 cited by Lankford *et al.,* 2011).

Ndumo B and Makhathini irrigation schemes were established under the Makhathini Master Project Plan put in place to increase agricultural production and productivity (uMkhanyakude District Municipality Reports, 2003). This area is recognized as having the potential to supply more food because the crops that are only grown during the rainy season in the summer rainfall areas of South Africa can be cultivated throughout the year under irrigation, given its rich soil and climate conditions (uMkhanyakude District Municipality Reports, 2003). The two schemes were selected because they are located in the north region where water scarcity is a major problem compared to other regions; they experience very hot weather condition almost throughout the year, and irrigation is the dominant practice. According to Woyessa (2004), water use productivity studies are more relevant in areas where water scarcity is a major problem. Makhathini and Ndumo communities are predominantly rural and extremely isolated as they are bounded to the east by the Indian Ocean, to the west by the Lebombo mountain range, and to the north by the border with Mozambique. These boundaries leave agricultural producers with restricted access to South African markets (Witt *et al.,* 2007). Figure 3.1 below is a map showing the two study areas.

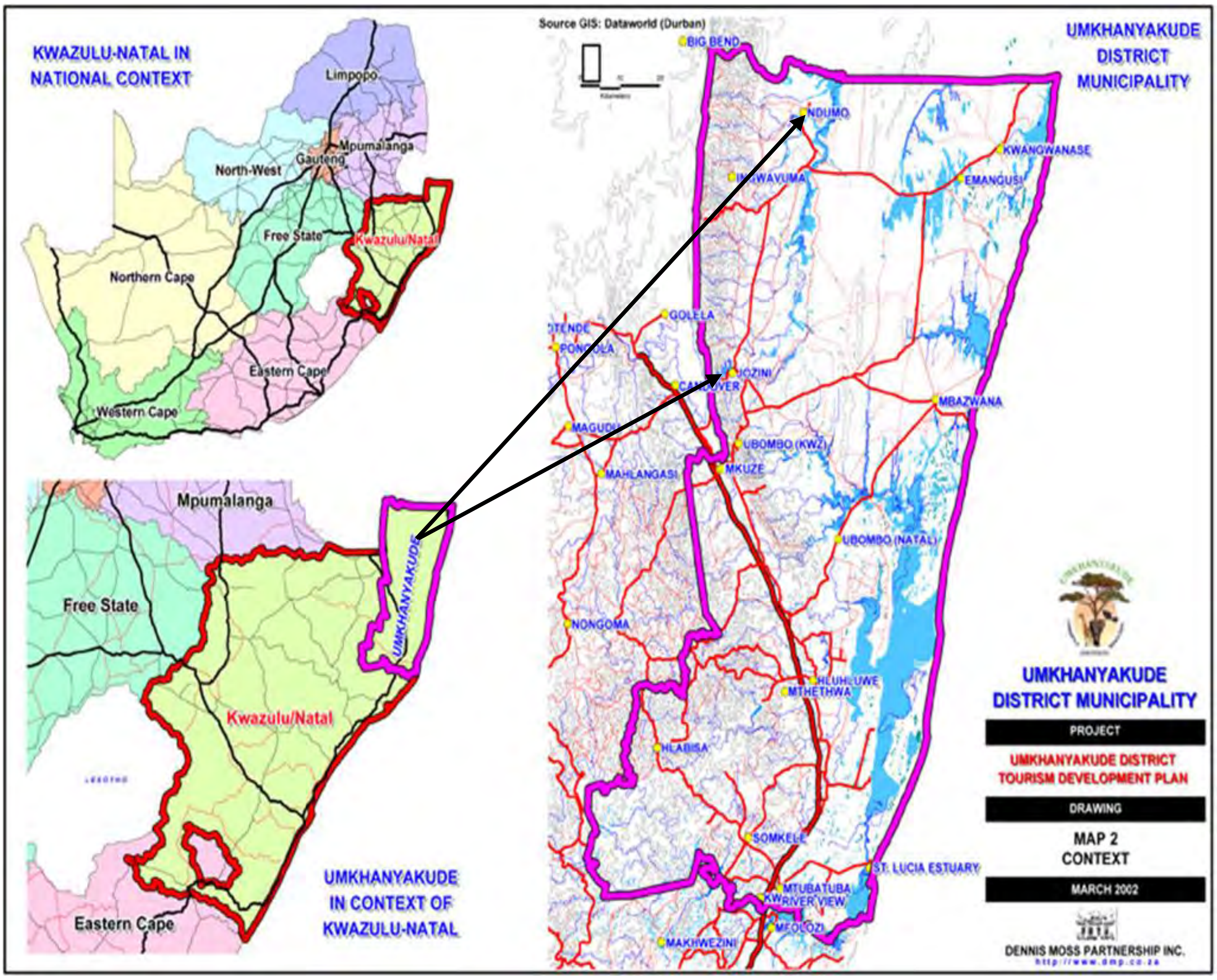


Figure 3.1 Map showing the study areas

Source: UMkhanyakude District (2012)

Makhathini comprises of the low-lying areas east of the Ubombo Mountains, covering some 13,000 hectares (Lankford *et al.,* 2011; Witt *et al.,* 2007). Makhathini covers the floodplains on either side of the Pongola River, extending from just below the Jozini dam to the confluence of the Pongola and Usutu Rivers on the Mozambique border.

The primary source of water for irrigation in both Makhathini and Ndumo B is the Pongola River. The source of the Pongola River is on the "eastern scarp at the border of Mpumalanga and KwaZulu-Natal near Wakkerstroom, from where it flows eastwards carving a gorge through the Lebombo Mountains before joining the Usuthu River just before the Mozambique border and flowing into the Maputo Basin" (DWAF, 2001:19). Furthermore, in Makhathini, there is the Pongolapoort or Jozini dam, which supplies water to the Makhathini irrigation scheme. The dam was built in the early 1960's primarily to control floods and provide an assured supply of water for irrigation (Lankford *et al.,* 2011). The dam, which is managed by the Department of Water Affairs and Forestry (DWAF), was constructed at the eastern end of a narrow gorge between the Lebombo and Ubombo mountain ranges (DWAF, 2001; Witt *et al.,* 2007; Lankford *et al.,* 2011). It has a catchment area of 7831 km^2 with the mean annual runoff of 1059 million m^3 and mean annual precipitation of 871 mm. The full supply capacity is 2446 million m^3 with the full supply area of 133 km^2. Only 315 million m^3 per annum is utilizable after ecological or social releases. Moreover, Swaziland makes a small abstraction from the dam for domestic use, and there is a natural flow to Mozambique (DWAF, 2001). DWAF reports that the Pongolapoort dam is a very large dam but with very little allocable water; the allocable amount might even match some smaller dams. Figure 3.2 below shows the Pongola-poort dam and Jozini River, the main supply of water for irrigation.

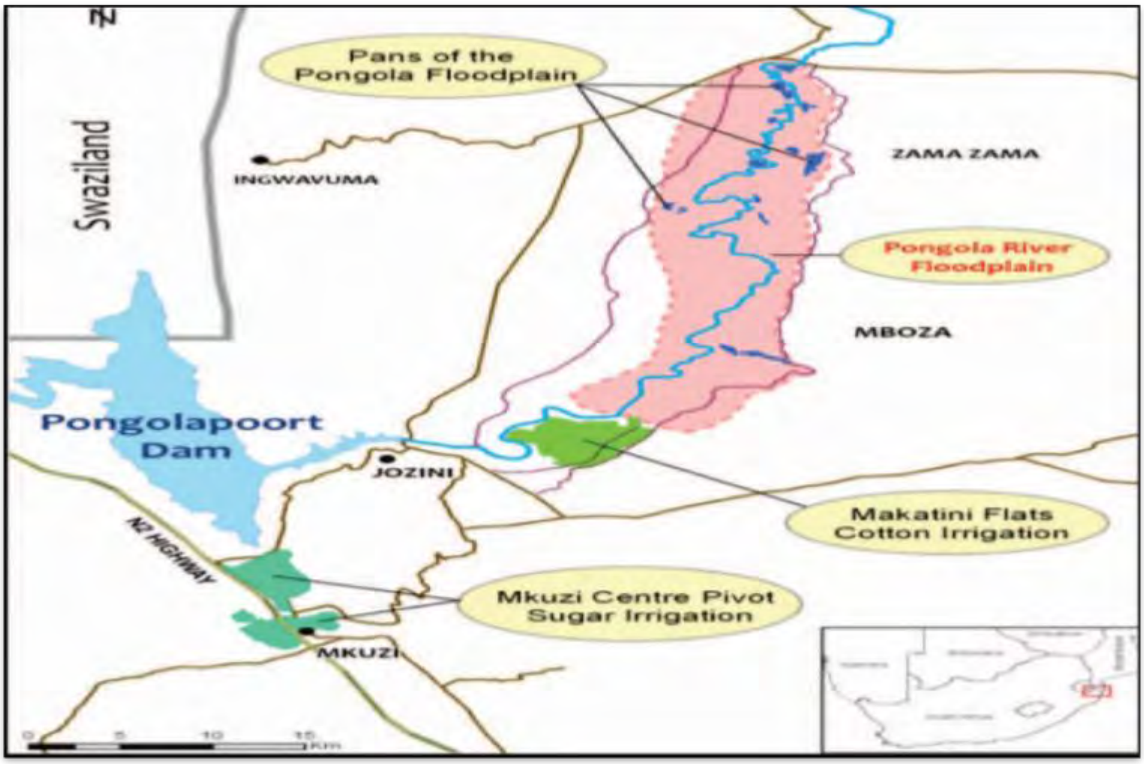


Figure 3.2. Pongolapoort dam and Pongola River

Source: Lankford *et al.* (2011)

Most of the water in Makhathini is used for agricultural crop production. The Makhathini irrigation scheme, which is situated downstream of Pongolapoort dam, is managed by Mjindi Farming (DWAF 2001). The Makhathini irrigation scheme uses a canal system for extracting water from the Pongola River and Pongolapoort dam to the scheme while Ndumo B directly extracts water from the Pongola River using electric pumps. In Ndumo B most independent irrigators and community gardeners are located near the Pongola River where they extract water for production. Pongola River is the primary source of water for most farmers in Jozini; only a few farmers, mostly community gardeners, use small dams.

Current evidence from Jozini shows that Ndumo B scheme irrigators and all independent irrigators, home and community gardeners do not pay for water. They only pay their share of capital, operation, and maintenance expenditure. However, in the Makhathini irrigation scheme, farmers are charged R2700 per hectare per year for water-related services, and only 10% of this amount is for water fees while the rest is for operational and maintenance expenditure. In Makhathini irrigation scheme, a significant amount of water and water-related services are being subsidized by the government through Mjindi Farming, which manages the scheme. This might make the water artificially cheap and reduce water productivity values in

Makhathini irrigation scheme, which might be biased downward owing to the government subsidy. Economic theory predicts that under such conditions, a farmer will employ the irrigation water resources inefficiently. In Ndumo B irrigation scheme farmers pump water directly from Pongola River using electric pump; they only pay for the cost of electricity directly to Eskom. They do not enjoy the same subsidy as their counterparts in Makhathini and their water services fee per month are significantly higher.

3.3 Justification of the schemes selected

The selection of the schemes was done as part of the activities for the Water Research Commission's project (Project Number K5/2278//4). Selection of the schemes were based on the following criteria:

- The schemes that have plot-holders running smallholder farming and/or food gardening in surrounding villages,
- The schemes that are big enough (in terms of maximum capacity, land size irrigated and number of irrigators benefiting from the scheme) in terms of having some critical mass of smallholder growers to be able to study the opportunities and constraints producers face to expand their farming operations,

The important factor that has influenced the choice of the two schemes is their suitability to demonstrate ways and means of enabling small-scale farmers to ultimately become commercial farmers. These schemes and the surrounding areas are actively involved in farming activities that to serve as illustrative case studies in the move from home gardening to smallholder farming and then to commercial farming. Home gardening appeared to be crucial to food security in the surrounding areas of the schemes. Both schemes are serving small-scale farmers and food gardening is important in both schemes. Furthermore, the extent of water reliability was considered as both schemes are located in extreme hot weathers, making irrigation an important vehicle in rural livelihoods in farming. Hence, strategies for increasing water productivity had to be studied further. What was also evident across all the study areas visited during the course of this study was the 'dependency culture' amongst the members of the schemes i.e. community members expect the local municipality, the department of agriculture, and government, in general, to do everything for them (eg. supplying inputs and services such as machinery, fertilizer, and other chemicals, scheme maintenance, etc.). Thus, these study areas were suitable for studying farmers' psychological capital. The visit to the schemes made it apparent that there are large and small irrigators as well as successful and unsuccessful irrigators in both schemes which gave the study an opportunity to examine the drivers of success (enabling factors), inhibitors and opportunities for further expansion.

3.4 Data collection method

A combination of purposive and stratified random sampling was employed in this study. The study purposively selected farmers who are engaged in food crop farming. This was done to allow for comparisons between the four types of farmers: scheme irrigators, independent irrigators, community gardeners and home gardeners. Moreover, farmers cultivating sugarcane in the scheme were not selected since it takes a relatively long time for it to be harvested which will have delayed data collection due to time constraints. Most smallholder farmers in the two schemes use the sprinkler system of irrigation with only a few, mostly sugarcane farmers, in Makhathini using the center pivot. As a result, only farmers who are using the sprinkler system were selected from the schemes to enable comparison between the two schemes while minimizing variations that can be introduced by differences in irrigation technology.

Stratification was done according to farmers' plot position along the primary canal in the Makhathini scheme as they use the canal system. According to Bos *et al.* (2005), the performance assessment in the schemes should be designed to take a representative sample to enable an adequate analysis to be carried out. Therefore, samples were drawn from head, middle and tail of the irrigation scheme in order to assess variation in water use values and productivity. Moreover, as the data were collected in phases, only permanent farmers, those who own land were selected rather than those who are renting. This is mainly because those who rent for a short period do so only for one season and do not necessarily farm the following season. Hence, it was not convenient to work with the renters, as one of the main purposes of the project is to monitor farmers' development paths during the project period. Makhathini Irrigation Scheme has about 314 beneficiaries compromising of owners and renters and Ndumo has above 60 beneficiaries, with the majority renting the land from land owners and only 21 households owning land. The list of permanent beneficiaries was obtained from the Department of Agriculture and Environmental affairs. Only 21 households were sampled in Ndumo B irrigation scheme as they are the farmers who are permanent according to the list obtained and 61 households were selected in Makhathini irrigation scheme. In Makhathini more households were selected because it has more permanent beneficiaries compared to Ndumo B. The two sites are located only about 60 km apart, thus enabling close field monitoring.

Primary data were collected using a pre-tested questionnaire and focus group discussion in phases, in September 2014, March 2015 and June 2015. The questionnaire had five sections, which included household socio-demographics, agricultural production data (crops grown, input usage including labour and yields), irrigation issues, water measurement, and marketing of produce. Data were collected by local enumerators who speak isiZulu, the local language. The enumerators were trained in data collection methods and the contents of the questionnaire before conducting the survey. During the first phase, data were collected on farmers' socio-demographic features and capital assets (natural, physical, financial, social, human and psychological). Furthermore, data on inputs usage were collected during the second phase in March 2015. Data on input usage including fertilizer, pesticides, labour, cost of all inputs used and water measurements were collected on a weekly basis to reduce recall problem and improve data quality. Moreover, focus group discussions and key informant interviews were held with farmers and extension officers to supplement quantitative data collected using structured questionnaires.

Water was measured only in irrigation schemes involving 82 plots sampled in the study. Only measurements were taken for farmers in irrigation schemes because of cost reasons in including other types of farmers as they were far from each other. All farmers sampled for water measurement did not have metering devices. Therefore, each sampled plot was fitted with a water measuring device, a standard rain gauge for the sprinkler irrigation method, to measure physical quantities of water released by a sprinkler in millimetres (mm) which was then converted to cubic meters. For cost reasons, a standard rain gauge was used in the study because it was the cheapest method although there are other methods (such as remote sensing) that are more appropriate. The data collected included the number of operating sprinklers in an area under production, sprinkler lateral, area covered by a sprinkler, sprinkler stand time per day (hours of irrigation), amount of water released by a sprinkler per hour and the number of irrigation cycles in the season, calculated at the end of the season.

3.5 Conceptual framework

3.5.1 On-farm water use estimation procedures

Following the household data collected, various empirical formulae were used to estimate the total amount of water applied during the season. To calculate the area covered by each operating sprinkler, an assumption was made that half of the distance between sprinklers in a row is equal to the radius (r) of the operating area of each sprinkler. The distance between each sprinkler in a row was 16 meters. According to the Rain Bird Sprinkler Manufacturing Corporation (2001) and Solomon *et al.* (2006), the area covered by each sprinkler depends on the pressure of the water released by the sprinkler. Therefore, it is crucial to know whether the sprinkler system is functioning at the optimal levels, in terms of the pressure of water released, to ensure application uniformity. Due to wear and tear and other factors, the pressure of sprinklers might be different. Hence, in this study, pressure measurements (P_o) were taken from farmers' plot(s) at the beginning of the farming season and at the end using a pressure gauge. Average pressure of sprinklers per farmer was calculated. This was used to calculate the efficiency ratio (E) of sprinklers per farmer. Using the efficiency ratio, an adjusted radius (r_a) irrigated by a sprinkler was computed. The steps in the computations are shown below:

Let:

r = Radius

P_o = Average pressure of sprinkler per farmer

P_n = Pressure when sprinkler is new or working at 100% efficiency

E = Ratio of efficiency of sprinklers computed as follows;

$$E = \frac{P_O}{P_n} \tag{1}$$

The ratio of efficiency of the sprinkler is assumed to range from $0 \leq E \leq 1$

To compute adjusted radius (r_a) irrigated by a sprinkler, the sprinkler efficiency ratio (E) was multiplied by radius (r).

$$r_a = E * r \tag{2}$$

In order to compute the irrigation area covered by all sprinklers, there was a need to first compute the length covered by operating sprinklers:

$$L = \psi * D \tag{3}$$

Where:

L = Length in meters

ψ = no of operating sprinklers per plot

D = distance between sprinklers in mm

To compute the area covered by operating sprinkler (s) in hectares, the length covered by all sprinklers was multiplied by two times the adjusted radius and divided by 10000 to convert the area to hectares as follows,

$$A = \frac{L * 2r_a}{10000} \tag{4}$$

Where:

A = Area covered by all sprinklers in hectares

L = Length in meters

r_a = Adjusted radius

In the study water depth was measured in millimeters (mm) per hour. This is the amount of water that was collected by each rain gauge per hour. Thus, necessary conversion was done to convert depth (mm) per hour to flow rate (depth in litres per second) using the following procedures. The average depth in mm per hour for the whole season was first converted to average depth in millilitres (ml) per hour. This was done by multiplying average depth in mm per hour by 0.1. The average depth in ml per hour was divided by 1000 to convert it into average depth in litres per hour. To calculate the flow rate (average depth in litres per sec), the average depth in litres per hour was multiplied by 360.

The next step was to compute the quantity of water applied in the covered area per crop per season for irrigation using the following steps. The irrigation cycle of each crop was calculated and then multiplied by the average hours of irrigation per day for the whole season to get the total time per spot per season *(TSP)* using the formula below:

$$TSP = N * T \qquad (5)$$

Where:

TSP = Total time per spot per season

N = number of cycles per crop, per season

T = average hours of irrigating per day per season

Then the volume of water applied per crop in m^3 per season was computed by multiplying the flow rate (FR), i.e., the average depth in litres per second, by the total time per spot per season and dividing all by 1000 using the following formula:

$$V = \frac{(FR * TSP)}{1000} \qquad (6)$$

Where V = volume of water applied in m^3

FR = flow rate of water in litres per sec

Lastly, the total volume of water applied per hectare per season *(Vh)* for each crop was calculated by dividing volume of water applied in m^3 (v) by area (A) in hectares as follows;

$$V_h = \frac{V}{A} \qquad (7)$$

The CROPWAT model was used to estimate crop water requirements at the plot, per crop and scheme levels since there were no irrigation measurements for home gardeners, community gardeners, and individual irrigators. CROPWAT is used to estimate irrigation requirements of crops under varying production systems and climates. For scheme irrigators, both the

CROPWAT model data and actual water measured using standard rain gauges was used to calculate water productivity and estimate water values per crop per type of farmer. Table 3.1 summarizes how plot-level data were collected.

Table 3.1 Example of plot-level data collection schedule (how, where and when)

Data required	Units	How	Where	When
Irrigable area	Ha	Interviews with farmers and using GPS to measure area under production	In selected samples	Beginning of season
Rainfall /Irrigation	Mm/day	Using rain gauge	In selected samples	During season
Crop water demand	Mm/day	By calculation using standard procedures (CROPWAT model)	In selected samples	During the season
Crop yield	Kg/ha	Crop cuttings	In selected samples	At harvest time
Crop production	Kg	Interviews with farmers	In selected samples	End of the season
Crop market price	$/kg	Interviews with farmers and traders	Villages and markets	End of the season

Source: Bos *et al.* (2005)

3.5.2 **The sustainable livelihoods framework**

The framework represented in Figure 3.3 below was developed from the concept of sustainable livelihoods framework. It is an analytical structure for evaluating the complexity of livelihoods, understanding influences on poverty and identifying where interventions can best be made (DFID, 1999; DFID, 2001). This framework is fundamentally an incorporating method, assisting to form and bring together the perceptions which contribute to the people-centred sustainable livelihood approach (Ellis, 1998; Ellis 2000 & Niehof, 2004). The underlying assumption of this framework is that people pursue a wide range of livelihood strategies such as crops, vegetables, and livestock production. This wide range of activities are drawn from a range of capital endowments including natural, physical, financial, human, and social capital.

Natural capital is defined as natural resources such as soil and water used to support livelihood outcomes. Good quality soil is important in increasing water use productivity from each drop of water consumed by a crop since it will be easy for the crop to absorb nutrients. Physical capital encompasses infrastructure, equipment, and other long-lived physical goods that households can bring into use to produce outputs. Financial capital is defined as a pool of economic assets such as cash, savings, and access to credit. Human capital encompasses "individual skills and knowledge, as well as health and physical ability" that can be mobilized in implementing livelihood strategies (SEI, 2009:3). Knowledge and skills may have been acquired through education or from past experience such as in farming activities. Social capital is defined as a set of relationships and the set of networks that support and coordinate strategies for achieving livelihood goals.

While the other forms of capital are part of the original SLF, psychological capital (Luthans *et al.,* 2004a) is a new integration into the SLF in this study. The inclusion of this form of capital makes this study unique compared to previous studies such as Yokwe (2004); Speelman (2008) and Molden (2010). Positive psychological capital is more than human and social capital. It denotes of who you are rather than what or who you know (Luthans *et al.,* 2004). Psychological capital denotes individual mind-set and attitude, resulting in more motivation to take initiatives or otherwise. It comprises of confidence, hope, optimism and resilience (Luthans *et al.,* 2004b). According to Debertin (2012), goals of the farmers are closely intertwined with a person's psychological capital. An individual farmer has unique goals and objectives, *i.e.* one farmer may be more interested in obtaining ownership of the largest farm in the county while another farmer has a goal of owning the best set of farm machinery and others might be interested in minimizing debt burden (Debertin, 2012). In this study, it is assumed that if a farmer possesses positive psychological capital he or she would be confident to try and exert extra effort to succeed even though there are challenges, vulnerabilities, and shocks jeopardising higher water use production measured in economic terms (profit earned from yield produced). It is envisaged that positive capital will indirectly lead to higher returns to water use. Henceforth, the psychological capital of irrigators was evaluated to determine factors impeding them from attaining higher water use productivity for production including other inputs.

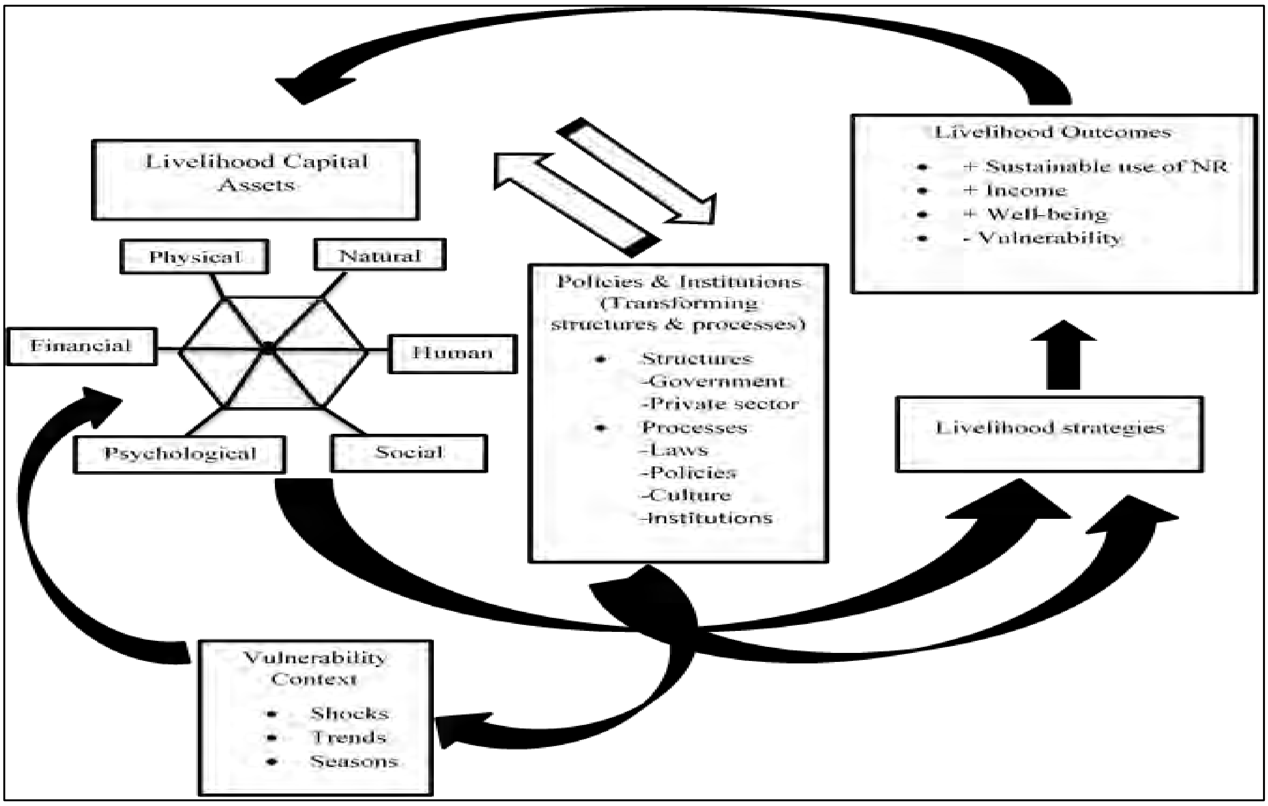


Figure 3.3 The modified sustainable livelihoods framework

Source: Adapted from DFID (1999)

Using the SLF, it is assumed that if a farmer has got all the vital forms of assets for production, returns to water use productivity may be increased (Cia *et al.,* 2011). Such assets may include necessary skills on how to produce and manage their farming operations; physical assets for land preparation; adequate irrigation water; and access to enough financial capital for the purchase of recommended inputs (seeds, fertilizers, pesticides, *etc.*). Increasing water productivity through better technology and improved water use helps to enhance crop production, generate and stabilize income, boost employment, reduce consumer prices and reduce costs (Cia *et al.,* 2011).

According to Sikwela (2013), financial constraints affect farm input decisions and efficiency for small-scale farmers due to delays in timely conducting critical farm operations (such as cultivation, planting, and weeding). He further states that timing of input usage is more important in affecting the yield; farmers facing financial constraints may not be able to optimize production and thus directly reducing water use productivity. In the case of smallholder irrigation, lack of financial resources leads to economic scarcity of water which, according to Cia *et al.* (2011) and Lautze *et al.* (2014b), occurs when resources required to extract water are limited due to financial and human capacity constraints. Thus, water might be physically available, but due to economic scarcity farmers will not have access to it. In this study, the inclusion of financial capital helped in determining the type of water scarcity farmers' experience. A crop water productivity framework (Figure 3.4), developed by Stockholm Environment Institute SEI (2009), just as in the SLF states that water availability is affected by natural water availability and water infrastructure, social capital and by institutions through their role in distributing scarce resources. According to SEI (2009:4), "the extent to which production is converted to livelihood outcomes depends in part on the assets available to households and the strategies they employ".

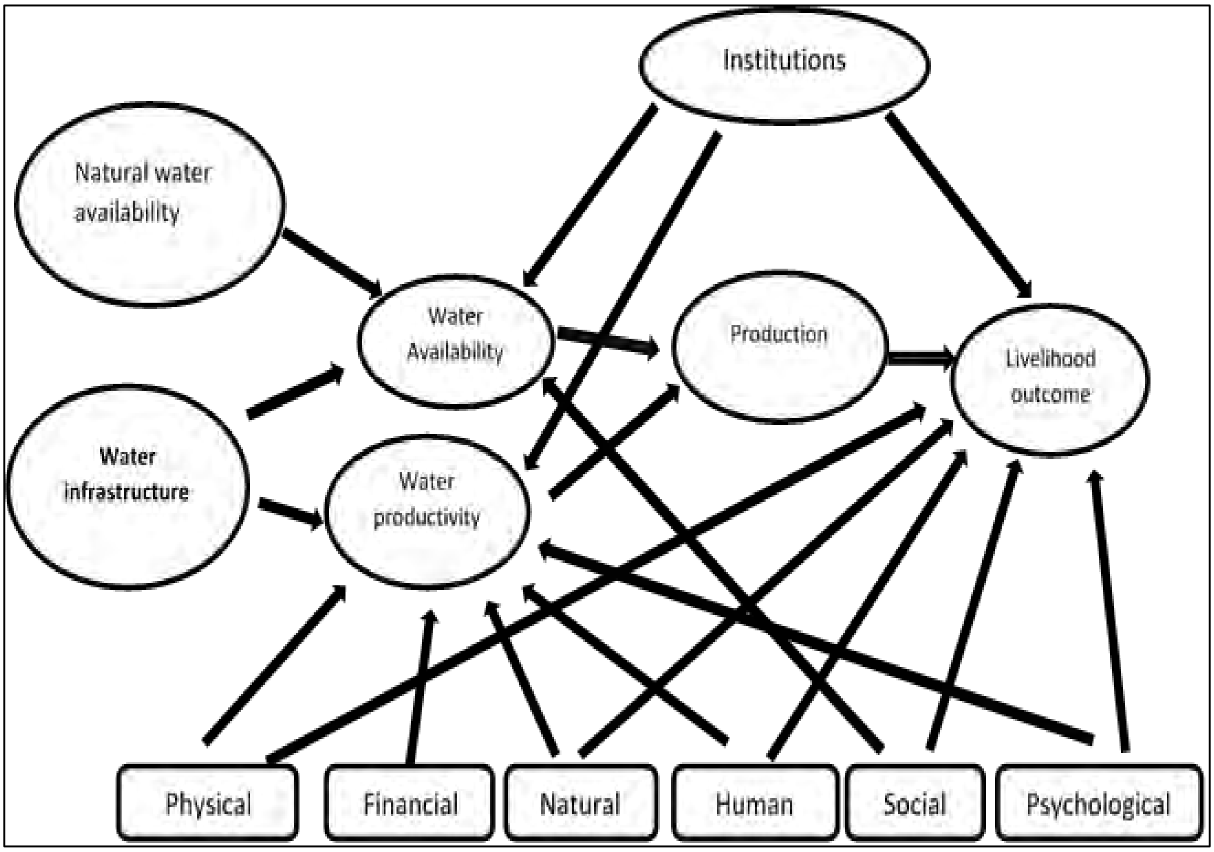


Figure 3.4 Basic links between water productivity and crop-supported livelihoods

Source: Adapted from SEI (2009)

Access to natural capital (such as land and water for irrigation) will enable farmers to expand production in terms of area under cultivation and also make it possible to produce throughout the year. Access to inadequate water for production is termed physical water scarcity. It occurs when the demand for water exceeds the available water resources (Lautze *et al.,* 2014). Physical capital is also quite critical to the livelihoods of smallholder farmers. If farmers have access to physical capital (equipment for production such as enough sprinklers for irrigating, proper storage facilities and transport) their returns may be increased which will directly lead to a higher value of water. Proper storage facilities and also the availability of equipment for processing of products before selling in the market means that farmers have higher chances of earning more from good quality produce, off-season selling when prices are high and high value processed products.

Even though assets and incomes are the fundamental aspects of the SLF, formal or informal institutions within which people operate are of particular importance. People with their livelihood assets and strategies are viewed as embedded within a network of policies and institutions (DFID 2001). They determine the rules of engagement and hence influence the alteration of incomes and resources into capabilities and opportunities (SEI, 2009; DFID 2001). For sustainable livelihoods to be achieved through the productive use of water, the future of irrigation farming in alleviating rural poverty lies not only in farmers themselves but in the development of appropriate institutional support systems (Farrington *et al*., 1999). Similarly, livelihoods are affected by several types of vulnerability factors, including shocks (such as drought), resource stocks and seasonal variations especially price and climate (DFID, 1999). These are sometimes called livelihood stressors and include declining available labour work, declining yields, declining water table, and declining rainfall (Chambers and Conway, 1992). These stresses extremely influence small-scale irrigation schemes negatively in their production operations while sustainable livelihood options should enable farmers to absorb such stresses and shocks.

3.6 **Variable description**

Data collected included physical quantities of input, cost of inputs and output produced for the 2015 production season. Inputs included land (measured in hectares), labour (measured in hours per day), chemicals (measured in litres), fertilizer and kraal manure (measured in kilogram), and water (measured in cubic meters). The actual prices charged for crops were used to estimate the revenue during each harvesting turn. The total revenue for each farmer was estimated by adding up the revenues obtained from crop harvest per season.

Idle land owned by farmers was excluded and a piece of land under perennial crops such as sugarcane was also excluded. Global positioning system (GPS) was used to measure the area under selected plots in hectares. Therefore, the variable land is not the total area of land farmers are operating as a whole but only the plot (s) under study. Chemicals used by farmers were of various types including herbicides and pesticides. Data on chemicals were in the form of application rates in litres per hectare.

Labour was the amount of time spent by family and hired individuals working on the farm. In Ndumo B, labour was divided into two categories, seasonal and permanent. Seasonal labour was further divided according to the task for which it is hired such as weeding, spraying, and fertilizer application. Permanent labour, on the other hand, involved changing irrigation sprinklers on a daily basis from one plot to another. At the time of the survey, the daily wage rate in the study areas was R30 and this rate was used to impute family labour since they are not paid.

The quantity of water in the irrigation schemes was measured in cubic meters, for crops grown in the 2015 cropping season. All farmers in the study areas did not have metering devices, so rain gauges were used to measure physical quantities of water released by a sprinkler. The data collected included the number of operating sprinklers in an area under production, sprinkler stand time (hours of irrigation) and the number of irrigation cycles in the season and pressure of sprinklers. The CROPWAT model was used to generate secondary data for crop water requirements for the Makhathini weather station. The data were gathered from the South African Weather Services. Secondary data from CROPWAT was used to calculate water value for independent irrigators, community gardeners, and home gardeners. This is mainly because actual water applied was not measured for these typologies of farmers due to cost reasons and because they were far from each other which made it difficult to monitor. However, for farmers in the irrigation schemes, water value was estimated using both actual and secondary data from CROPWAT for comparison among all typologies of farmers in the study areas.

3.7 **Empirical methods of data analysis**

In pursing the study objectives, the following analytical tools have been employed:

- Descriptive statistics which were used to supplement the other quantitative techniques and understand farmers' access to livelihood assets,
- Gross margin analysis,
- Residual valuation method,
- Principal components analysis, and
- General linear model.

3.7.1 **Gross margin analysis**

The gross margin was calculated to evaluate economic performance and profitability of major crops grown by four typologies of small-scale farmers in the study. Gross margin is defined as the difference between the gross income and variable costs of growing a crop. Variable costs include those associated with variable inputs like fertilizer, harvesting, and marketing. Gross margin does not include overhead costs such as rates, insurance, and interest that must be met whether a crop is grown or not (Al-Said, 2012). Electricity rate was not included in the computation of gross margin because farmers have to pay flat electricity rates even if they have not cultivated the land.

The sum of all variable costs of production was calculated as:

$$V = \sum_{i=1}^{k} P_{ij} X_j \qquad (8)$$

Where:

V = variable cost,

P_{ij} = price of the j^{th} input in the i^{th} time period,

Xj = quantity of the j^{th} input and

k=number of inputs used in the production process

Gross margin was computed as:

$$GM = \sum_{i=1}^{n} P_i Y_i - \sum_{k=1}^{k} P_{ij} X_{ij} \qquad (9)$$

Where:

GM = Gross margin per hectare,

P_i = price of the i^{th} crop,

Y_i = quantity of the i^{th} crop,

P_{ij} = price of the j^{th} input used in the i^{th} crop, and

X_{ij} = quantity of the j^{th} input in the i^{th} crop.

3.7.2 **Residual valuation method**

The residual valuation method is widely used in irrigation to determine the value of water as an intermediate good in production. It is a deductive technique of non-market valuation deriving prices from the model of the individual economic decision made by firms and households (Young, 2005).The method is applied based on two primary postulates (i) producers maximize profit by adding productive inputs until the point where the value of marginal productivity equals the marginal input costs of the respective inputs. This postulate assumes that farmers are rational actors as they aim to maximize profit specific to the value of irrigation by employing productive inputs optimally; and (ii) the total value of production can be divided into shares such that when each factor is paid according to its marginal productivity, the total value of production is completely exhausted (Young, 2005; Lange & Hassan, 2006).

When all the factors of production and corresponding costs are taken into account, the total economic value of services and goods can be estimated (Renwick, 2001). The Residual valuation technique assumes that if all markets are competitive except for water, the total value of production exactly equals the opportunity cost of all the inputs. Moreover, when the opportunity cost of non-water inputs is given by their market prices, the shadow price of water is then equal to the residual difference between the value of output and the cost of all non-water inputs to production (Young, 2005). Furthermore, it also postulates that all factors, except water, have a price tag and in the case where factors are being owned such as family labour, the shadow price has to be estimated (Young, 2005; Lange & Hassan, 2006). It is important to consider all factors of production and their corresponding cost in order to assess the total economic value of goods and services. The inclusion of all crucial factors of production is fundamental in avoiding estimation biases in the residual value (Speelman, 2008). In employing the residual value technique, production costs are subtracted from revenue and then that residual amount is divided among other non-market resources used in the production process. This method yields the average value of irrigation since the total share of resources is divided by the total amount of resources used (Young, 2005). If the model is accurately specified, then all input and product prices should be carefully examined, particularly family labour as it is generally not paid. Furthermore, government interventions (such as taxes, subsidies, trade protection, *etc*.) may lead prices to diverge significantly from their marginal value. Therefore, a researcher must make a judgment to determine whether non-water inputs require shadow prices and how shadow prices will be estimated since inaccuracies in the estimation mainly arise from two levels: individual crops and aggregation to a representative farm (Young, 2005; Lange & Hassan, 2006).

Debertin (2012:246), describes a "production function as the technical relationship that transforms inputs or resources into outputs". Product (Y) is produced using four factors of production: capital (K), labour (L), other inputs (Z) and water (W). The range of output level is determined by the input being used (Debertin, 2012). A production function can be expressed in its general form as follows:

$$Y = f(K, L, Z, W) \tag{10}$$

The multiple production function for this study is thus stated as follows:

$$Y = f(X_{ld}, X_m, X_c, X_f, X_l, X_w, X_t) \tag{11}$$

Where variables are as follows; (Table 3.2)

Table 3.2 Variables used in the residual valuation method

Variable	Variable description
DEPENDENT VARIABLE:	
Y	Output (Yield/ha)
INDEPENDENT VARIABLES:	
X_{id}	Land (ha)
X_m	Machinery / ha
X_c	Other non-fertilizer chemicals / ha
X_f	Fertilisers / ha
X_l	Labour / ha
X_w	Water / ha
X_t	Transport / ha

The residual method is estimated based on the average value of irrigation water which is postulated from the theory that the value of output produced is the sum of the values of inputs employed in production. Henceforth, total value of output from equation (12) below can be written as follows:

$$Y*P_y = (VMP_{ld}*X_{ld}) + (VMP_m*X_m) + (VMP_c*X_c) + (VMP_f*X_f) + (VMP_l*X_l) + (VMP_w*X_w) + (VMP_t*X_t) \quad (12)$$

Where Y = output; P = price; VMP = value of marginal product of inputs; and X = quantity of inputs and their respective subscripts.

Furthermore, based on the assumption of profit maximization behaviour, the preceding equation can be expressed as:

$$Y*P_y = (P_{ld}*X_{ld}) + (P_m*X_m) + (P_c*X_c) + (P_f*X_f) + (P_l*X_l) + (Pw*X_w) + (P_t*X_t) \quad (13)$$

This can be simplified as:

$$Y*P_y = \sum_{i=j}^{n} P_i X_i + P_w * X_w \quad (14)$$

On the right-hand side, the sum of the values denotes all marketable inputs while the second term denotes irrigation value with an unknown term (*Pw*) while the left-hand side denotes the total value product (TVP).

When all the variables in equation (14) are known, the unknown P_w can be solved to impute the value of the residual claimant (water) P_w (Equation 15):

$$VMP_w = \frac{TVP - \sum_{i=j}^{n} PiX_w}{X_w} \qquad (15)$$

Where:

$VMPw$ = Value of marginal product of water,

TVP = Total value of the product Y,

$P_i X_w$ = The opportunity costs of non-water inputs used in production,

i *and* j = Number of marginal products and quantities of resources,

X_w = The cubic meters of water used in production.

Even though it may be simple to employ the residual valuation method, it should be used with caution due to its sensitivity to small variations in the specification of the production function and its postulation about markets. The inclusion of all crucial factors of production is fundamental in avoiding estimation biases in the residual value (Speelman, 2008). However, the challenge is that all costs can never be accounted for. If a variable or fixed input is excluded, the value of water will be over-estimated or under-estimated otherwise. According to Young (2005) and Lange & Hassan (2006), underestimation of the contribution of other inputs or omitted inputs in a production function may wrongly attribute more value to water. Moreover, if the value of other inputs is over-estimated, the value of water will be under-estimated. All inputs included in the production function should be priced at their marginal economic value to obtain results close to the real value of water. The major challenge may arise from assigning prices to inputs and outputs and measuring family labour as it is not paid for in small scale farming. Henceforth, to improve reliability and accuracy of data collected, the study employed Machara's (2015) methodology where data were collected on a weekly basis from selected plots over a full cropping season to reduce recall problems, thus improving the reliability of data. However, due to the fact that all costs (such as family labour and operational cost of management) cannot be accounted for (Muchara 2015), this could lead to over or underestimation of water values. However, it can be reasonably assumed that the effect will be distributed equally among the sampled plots, thus having no effect on the residual value attained.

3.7.3 **Principal component analysis**

Principal component analysis (PCA) was used to generate a psychological capital index, and this index was used as an independent variable in the general linear model (GLM) to determine the factors that affect the value of water productivity of the irrigators. It is a widely used multivariate technique for analyzing data observations described by several independent variables which are normally inter-correlated (Abdi & Williams, 2010; Zuwarimwe & Kirsten, 2007; Yeung & Ruzzo, 2000). According to Abdi & Williams (2010), PCA has got four main objectives in a given empirical analysis: (1) extract the most important information from the data; (2) reduce the size of the data set by keeping only important information; (3) simplify the description of the data set; and (4) analyse the structure of the observations and the variables. The new information is expressed as a set of new orthogonal variables called principal components which are obtained as linear combinations of the original variables (Zuwarimwe & Kirsten, 2007).

The principal components are ordered so that PC_1 contains the largest possible variance to explain the largest part of the inertia of the original data set while PC_2 is computed under the constraint of being orthogonal to PC_1, having the second largest possible inertia (Yeung & Ruzzo, 2000). The other components are computed likewise and explaining smaller and smaller variation of the original variables (Abdi &Williams, 2010). "The values of these new variables for the observation are called factor scores which can be interpreted geometrically as the projection of the observation onto the principal components" (Zuwarimwe & Kirsten, 2007:3). PCA was used to evaluate if farmers possess positive psychological capital as being self-employed which will directly have an impact on their livelihood outcomes. As explained in the conceptual framework, water productivity is indirectly affected by the psychological makeup of each individual as each farmer possesses different levels of confidence towards farming as a means of enhancing livelihoods of households. According to Kosi & Bojnes (2012), for self-employed businesses, the remuneration directly depends upon the business profits. Self-employed individuals make the operational decisions affecting the enterprise. Thus, in this study, decisions made by individual farmers have a direct link in determining water use productivity.

3.7.4 General linear model

The value of water may vary when evaluated at different spatial and temporal scales due to influencing factors such socio-economic, farming methods, institutions governing water use, *etc*. (Rosegrant *et al.,* 2002). Factors that influence variation in water values was investigated applying the analysis of variance using the General Linear Model technique in IBM SPSS statistics 23. This model was employed in this study because of its unique features which ensure that both continuous and categorical variables are not problematic whether the sample is balanced or unbalanced (Green and Wind, 1973, cited by Muchara, 2015). Furthermore, partial eta squared, which measures the proportion of variance, was used to determine how big the effect is in the dependent variable explained by an independent variable controlling for all the other independent variables. Effect size allows a researcher to communicate the practical significance of the results rather than only reporting statistical significance (Laken, 2004). Partial eta squared calculated in the study is based on the marginal sums of squares (type III). "These are preferred since they correspond to the variation attributable to an effect after correcting for any other effects in the model" (Speelman, 2011:17). The model employed is specified as follows;

$$W_v = \beta_0 + \beta_1 X_1 + \beta_2 X_2 = \ldots\ldots\ldots\ldots\ldots \beta_n X_n + \varepsilon \qquad (16)$$

Where:

W_v = value of water (R/m^3)

β_0 = a constant

$\beta_1 \ldots \beta_n$ = coefficients of the regression equation

$X_1 \ldots X_n$ = explanatory variables

ε = is the deviation between the observed and predicted.

The errors are assumed to be independent and normally distributed with zero mean and constant standard deviation, σ. Table 3.3 summaries the explanatory variables used in a regression analysis

Table 3.3 Explanatory variables specified in the regression analysis of the factors explaining the value of water.

Variable	Variable description
DEPENDENT VARIABLE	
W_v	The value of water in ZAR / m^3
INDEPENDENT VARIABLES	
FARM_TYPE (X_1)	1= Scheme irrigators, 0= Otherwise
FARM_EXP (X_2)	Number of years in farming
EDUCATION (X_3)	Highest level of education in grades
MART_STATUS (X_4)	1=Married, 0= Otherwise
OCCUPATION(X_5)	Main occupation of a farmer 1= Full time, 0= Otherwise
PSYCH_INDEX (X_6)	The psychological capital index generated through PCA
IRRG_TECH (X_7)	Type of irrigation method used 1 = Sprinkler, 0 = Otherwise
TOT_NUM_CROP (X_8)	Total number of crops cultivated per farmer

The type of farmer (FARM_TYPE) is categorized into scheme irrigators, independent irrigators, community gardeners and home gardeners. This variable was meant to capture different characteristics of farmers' typologies such as their location in terms of their source of water supply, agro-ecology and other location-specific variables. Farming experience (FARM_EXP) is a continuous variable capturing the number of years the farmer has been in farming which signifies the level of knowledge from past experience. Education level (EDUCATION) is a continuous variable which was meant to capture the level of human capital since it is expected that education would aid the farmers to interpret instructions on the use of agrochemicals and adopt modern agricultural technologies on farming operations. Marital status (MART_STATUS) of a farmer was included to capture the dynamics that are introduced by marriage regarding decision making in farming affecting water productivity.

The variable main occupation of a farmer (OCCUPATION) is a categorical variable meant to capture the time devoted to farming. Psychological capital index (PSYCH_INDEX) is a continuous variable capturing the four pillars of positive psychological capital (confidence, hope, resilience and optimism) which are important in building up a positive attitude towards farming to productively use water and be successful in farming. The variable irrigation technology (IRR_TECH) is a categorical variable capturing the difference attributed to water values due to different types of irrigation methods (sprinklers, flood irrigation, hosepipe, and bucket system) employed by farmers. The variable total number of crops (TOT_NUM_CROPS) is a continuous variable capturing the total number of crops a farmer cultivated. According to Hussain *et al.* (2007), water values are high where multi-cropping is practiced especially the high valued crops. Multicollinearity amongst independent variables will be tested using the Variance Inflation Factor (VIF) together with the Tolerance (TOL).

3.8 **Summary**

The study area is located in Jozini at UMkhanyakude district. The area is extremely hot and dry and irrigation plays a major role in crop production.A combination of purposive and stratified random sampling was employed to select a group of farmers engaged in food crop farming for comparison reasons as community and home gardeners mainly grow vegetables. On-farm water estimation was measured using a standard rain gauge on a weekly basis in irrigation schemes only under a sprinkler system. The CROPWAT 8.0 model was used to generate crop water requirements for major crops grown and was used to estimate water values. Sustainable rural livelihood was adopted to explain how interventions can be best made with the aim of increasing water productivity. The SLF framework outlines that without capital assets in place, a household is not able to utilize resources available such as land and water, thus, interventions have to first address inequalities of capital assets among farmers'. Furthermore, psychological capital has been integrated into a SLF to explain how individual farmers mindset influences productivity. Gross margin analysis and the residual valuation method were used to determine farmers' performance based on their economic productivity and water values. The residual valuation method is widely used to evaluate irrigation water value in small scale farming due to absent of water markets as water is used as a free gift in small scale farming. Residual valuation method captures all the cost of inputs and the remaining claimant is attributed to water. Even though it is simple and easy to employ residual valuation but it is sensitive to errors and thus needs special attention in assigning the cost of production. Principal component analysis was employed to generate a psychological capital index that was used as one of the independent variables in a general linear model in determining factors influencing the explicit value of irrigation water. Chapter 4 below represents the results of the descriptive analysis with an aim of understanding the characteristics of sampled households among farmers' typologies in the study.

CHAPTER 4. DESCRIPTIVE ANALYSIS RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the main findings of the descriptive analysis among farmers' typologies. The analysis of descriptive statistics is employed to summarize data gathered from farmers and to understand the characteristics of sampled households. Data are analyzed based on capital asset endowments that are required by a household to follow different livelihood options as explained above in section 2.6.1. The descriptive analysis involves the use of percentages, frequencies, means, t-tests and chi-square tests. The analysis compares differences among farmers' typologies, identifying farmers with better access to capital asset that are required in order to fully utilize natural resources and increase productivity. The key factors analyzed include households' demographics, various sources of income, livestock ownership, ownership of movable assets, land holding and state of land tenure and aspects of water availability among farmer typologies.

4.2 Types of small-scale irrigation farmers

The total sample size of the study was 159, comprising of different typologies of small-scale farmers at Makhathini and Ndumo B. The types of farmers were categorized into four groups, *i.e.* scheme irrigators, independent irrigators, home gardeners and community gardeners. Table 4.1 below shows the frequency and percentage of each type of farmers.

Table 4.1 Typology of small-scale farmers (n=159)

Typology	Frequency	Percent
Scheme irrigators	82	52
Independent irrigators	38	24
Home gardeners	24	15
Community gardens	15	9
Total	159	100

Source: Own survey (2015)

Scheme irrigators comprised farmers from Makhathini and Ndumo B irrigation schemes. The total sample for scheme irrigators was 61 and 21 in Makhathini and Ndumo B irrigation schemes, respectively. Only 24, 15 and 9 percent were independent irrigators, home gardeners and community gardeners located in the study areas, respectively. The main reason for including various types of small scale farmers was to compare and contrast their diversified rural livelihood options. Moreover, this was also done so as to assess the constraints that limit their farming operations and ability to expand from being "home gardeners" to "subsistent farmers", from "small-scale subsistent farmers" to "small scale commercial farmers" and from "small-scale commercial farmers" to "large-scale commercial farmers". The farmer characteristics were examined using continuous and categorical variables. The results of the descriptive analyses of these variables constitute the rest of the chapter.

4.3 Household demographics and socio-economic characteristics

Level of education: Educational level among farmers determines the level of human capital of households. People with a higher level of education are capable of interpreting and utilizing information better compared to those with limited education. Educational levels also affect the level of market participation among small-scale farmers (Montshwe, 2006). The results show that the level of education among small-scale irrigation farmers in the study is very low with the highest level being grade 5 at primary level (Table 4.2). On average, home gardeners had the highest level of education compared to other groups of smallholder irrigation farmers, followed by scheme irrigators, independent irrigators and then community gardeners. It is, therefore, expected that the adoption of innovative technology among small-scale farmers in the study will be low, especially for community gardeners and independent irrigators as they have fewer years of schooling. Farmers in the Makhathini irrigation scheme are more educated (on average 5 years of schooling) compared to Ndumo B (on average 3 years of schooling) farmers. During a focus group discussion with farmers in Makhathini, the majority of farmers were able to communicate and converse in English compared to Ndumo B scheme, hence the descriptive results obtained concur with the observation from focus group discussions.

Age: The farmer's age affects overall labour productivity and adoption of agricultural innovation which is crucial in increasing overall water productivity. The study reveals that, on average, the age of farmers in the study is above 45 years. However, the results show that elderly farmers (61%) constitute a significant proportion of farmers involved in small-scale irrigation. Thus, given the aging nature of the sampled farmers, there might be a reduction in the effective labour force for agricultural productivity in the study area. This means such households might rely on hired labour as an option, with a resulting effect of increased variable cost and thus reduced enterprise net revenue. Independent irrigators and community gardeners had the highest average age of 50 years. They also had the highest average years of farming experience of 17.3 years followed by community gardeners with a mean of 15.7. In a focus group discussion, some independent irrigators mentioned that they were once part of the irrigation scheme, indicating that most of such farmers started farming early in their life time. Scheme irrigators and home gardeners have the lowest farming experience of 12 years.

Household size: A mean household size of 5.5 members was recorded for farmers in the study. This figure is slightly above the average household size of UMkhanyakude district which is 4.9 according to the 2011 KwaZulu-Natal Provincial Census Report (Statistics South Africa, 2014). Given the labour intensiveness of small-scale irrigation farming, particularly for scheme irrigators and independent irrigators, and a high dependency ratio among sampled farmers, farmers have to rely more on hired labour for their farming operations. This tends to increase their costs and reduce returns to water use through lower gross margins.

Table 4.2 Characteristics of farm households (continuous variables) (n=159)

	Type of farmer								T-test	Irrigation Scheme				T-test
	Scheme Irrigators (n=82)		Independent Irrigators (n=38)		Home Gardeners (n=24)		Community Gardeners (n=15)			Makhathini Irrigation Scheme (n=61)		Ndumo B Irrigation Scheme (n=21)		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**		**Mean**	**SD**	**Mean**	**SD**	
Household size	5.9	2.7	5.3	2.4	5.4	1.7	4.4	1.7	1.8	5.6	2.6	6.7	3.1	2.2*
Household head age (in years)	48.2	11.2	50.7	13.9	49.1	10.1	50.5	11.8	0.5	47.7	11.8	49.4	9.5	0.4
Level of education	4.9	4.3	3.7	4.8	5.0	5.4	3.1	3.9	1.2	5.4	4.5	3.6	3.6	2.8*
Farming experience (years)	12.9	9.8	17.3	15.8	12.8	9.7	15.7	13.7	1.3	12.9	9.8	12.8	10.1	0.1
Family labour (days per week)	6.5	1.2	6.3	1.1	5.9	1.7	4.5	2.5	8.2***	6.4	1.2	6.7	0.7	1.4

Notes: *** and * means significant at 1% and 10% levels, respectively. SD refers to standard deviation
Source: Own survey (2015)

Availability of family labour: There is a statistically significant difference at 1% between the four typologies of small-scale farmers in terms of availability of family labour within each week. The results show an average of 6 days in a week for both scheme and independent irrigators. This is expected since small-scale irrigators rely on family labour mostly for irrigation, changing of sprinklers from one plot to another on a daily basis. Moreover, scheme and independent irrigators operate bigger land compared to other groups, so they irrigate plots on different days, leading to more working days in a week. There was no statistically significant difference in the availability of family labour between farmers in Ndumo B and Makhathini irrigation schemes. Community and home gardeners have an average of 4.5 and 5.9 days in a week for family labour, respectively.

Table 4.3 Characteristics of farm households (Categorical variables, %) (n=159)

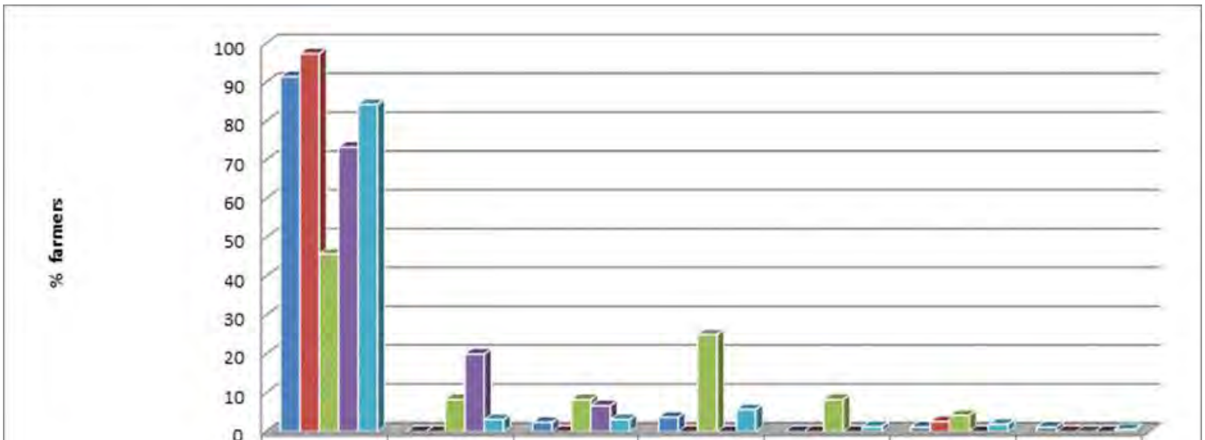
		Types of farmers				**χ^2 test**	**Irrigation Scheme**		**χ^2 test**
Variable	**Category**	**Scheme Irrigators (n=82)**	**Independent Irrigators (n=38)**	**Home Gardeners (n=24)**	**Community Gardeners (n=15)**		**Makhathini (n=61)**	**Ndumo B (n=21)**	
Gender of farmer	Female	54.9	57.9	66.7	60	1.1	65.6	23.8	11.0***
	Male	45.1	42.1	33.3	40		34.4	76.2	
Marital status of the farmer	Single	46.3	57.9	45.8	33.3	3.1	54.1	23.8	8.81***
	Married	48.8	39.5	50	60		39.3	76.2	
	Widowed	4.9	2.6	4.2	6.7		6.6	0	

Notes: *** means significant at 1%

Source: Own survey (2015)

The results in Table 4.3 above indicate that women play a dominant role in farming among all typologies of small-scale farmers and more women are involved in home and community gardening compared to scheme or independent irrigation. Backeberg and Sanewe (2011) show that 56.5% of households in South Africa are headed by women and these constitute 61% of those involved in farming (Cousins, 2013). This could be related to their limited access to resources required for farming as a scheme or independent irrigator. The 2009 World Survey on the Role of Women in Development report shows that women still face challenges relating to resources which limit their capacity to agricultural productivity, security of livelihoods and food security, among other issues (Department of Economic and Social Affairs., 2009). Moreover, these results could indicate that in a cultural setting women usually stay behind in rural areas, taking care of children while men go to cities searching for other work. However, the results show a statistical difference between scheme irrigators for gender and marital status of farmers. In Ndumo B irrigation scheme, there are more male farmers (76.2%) compared to female farmers (23.8%) while in Makhathini only 34.4% are males. This result conforms to the cultural setting where men have more access to farmland and other farm inputs.

Main occupation of farmers: Figure 4.1 below summarizes the main occupation of the four typologies of small-scale farmers in the study. The results indicate that the majority of the sampled farmers in the study have no other occupation other than farming. This implies that most of the farmers depend entirely on farming for survival. Farmers who engage in full-time farming are expected to be more receptive to new methods and technologies that enhance overall productivity, compared with those who engage in farming on a part-time basis.



	Fulltime farmer	Salaried job	Temporary job	Unemployed	Self-employed	Retired	Aged
scheme irrigators	91.5	0	2.4	3.7	0	1.2	1.2
independent irrigators	97.4	0	0	0	0	2.6	0
home gardeners	45.8	8.3	8.3	25	8.3	4.2	0
community gardeners	73.3	20	6.7	0	0	0	0
Total	84.3	3.1	3.1	5.7	1.3	1.9	0.6

Figure 4.1 Main occupation of typologies of farmers (n=159)

Source: Own survey (2015)

In the scheme, 91.5% are full-time farmers and 2.4% are temporarily employed. No farmers in the scheme have a regular salaried job. This concurs with findings from focus group discussions both in Makhathini and Ndumo B, that farming is their major source of income for those in the schemes. "We are the ones who are also responsible for creating job opportunities in the area as there are no other means of living except farming because there are no factories nearby," said one of the farmers in Ndumo B irrigation scheme. Among the independent irrigators, the trend is also similar with 97.4% indicating that they are full-time farmers. According to the uMkhanyakude District report (2003), unemployment is one of the major problems facing the district with Jozini being the most affected municipality. Furthermore, among the group of 79,981 people in the district who are able and willing to work, only 36,939 are employed while about 43,042 are unemployed and are actively looking for work. This figure excludes the housewives and people who are not looking for work. This situation leaves farming as the main livelihood option available to most rural households in Jozini.

However, differences are observed with regards to home gardeners. Home gardeners had the lowest percentage of full-time farmers (45.8%) and the largest percentage of unemployed farmers. This corresponds with the nature of home gardeners as they usually cultivate small plot mainly for subsistence reasons and they do not necessarily need to be full-time farmers. Comparing community gardeners from other groups, they had the highest percentage of employed farmers, 20% and 6.7% having a regular salaried job and temporary employment, respectively.

4.4 **Sources of income**

Figure 4.2 below present percentage of households receiving different sources of income. Farm income is earned from selling of crop and livestock products while non-farm income is earned from employment (temporary and permanent), remittances from relatives and migrants, arts and craft, and welfare grants. Among farmers in the schemes, 96.3% indicated irrigated crops as major sources of income, followed by welfare grants with 81.7%. Only 4.9% farmers earn income from rain-fed farming. The results in Figure 4.2 show social grants as an important source of income for small-scale irrigation farmers in Makhathini and Ndumo, in total receiving a mean income of R 22,348.80 from social grants per annum. The major types of social grants received by farm households are child support and old age grants. Many studies have shown that small-scale farmers depend on social grants as their main source of livelihoods (Bradstock, 2006; Backeberg & Sanewe 2011; Daniels *et al.,* 2013; Sikwela, 2013). During focus group discussions, the majority of farmers mentioned that social grants play a largely positive role in their livelihoods as most of the time they use it to purchase inputs such as seeds, fertiliser and pesticides. Even though it is not sufficient to meet all the basic needs, it still helps to relax some of their cash flow constraints and facilitate farming operations.

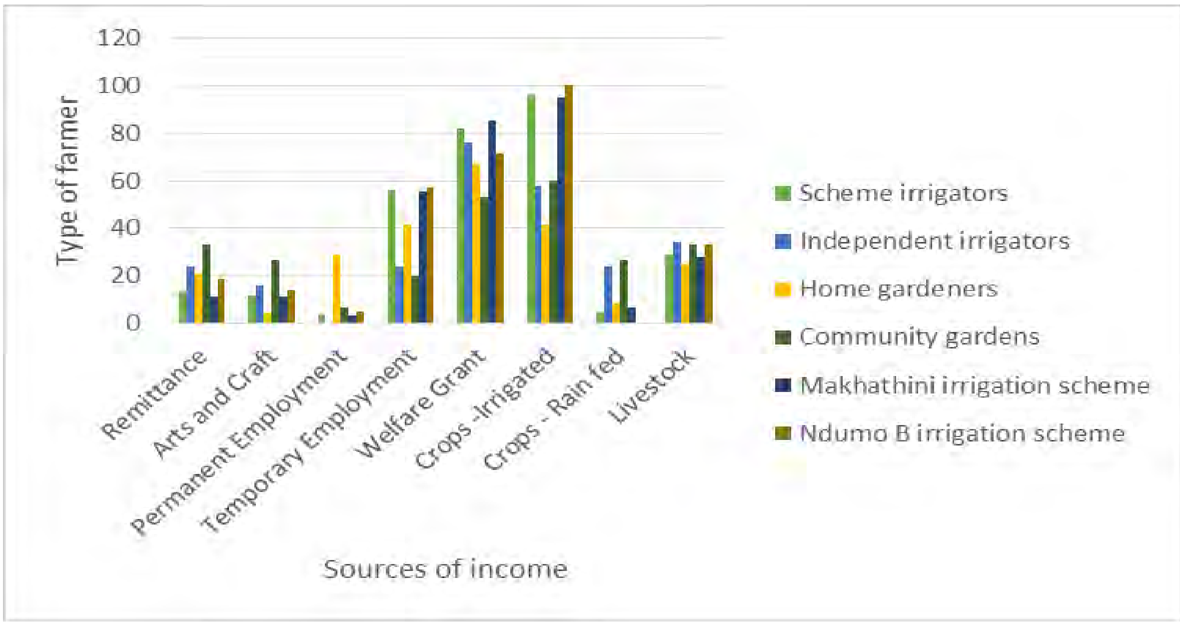


Figure 4.2 Sources of income

Source: Own survey (2015)

Among the sample size of 24 home gardeners, only 41.7% indicated that they receive income from irrigated crops while 66.7% receive income from welfare grants. Independent irrigators had the highest percentage of farmers receiving income from livestock followed by community gardeners while home gardeners had the lowest percentage of farmers receiving income from livestock. It can be concluded from the results that welfare grants and irrigated crops are the major sources of income for small-scale farmers in the study areas.

Figure 4.3 below shows the percentage of farmers who had access to credit in the last 12 months.

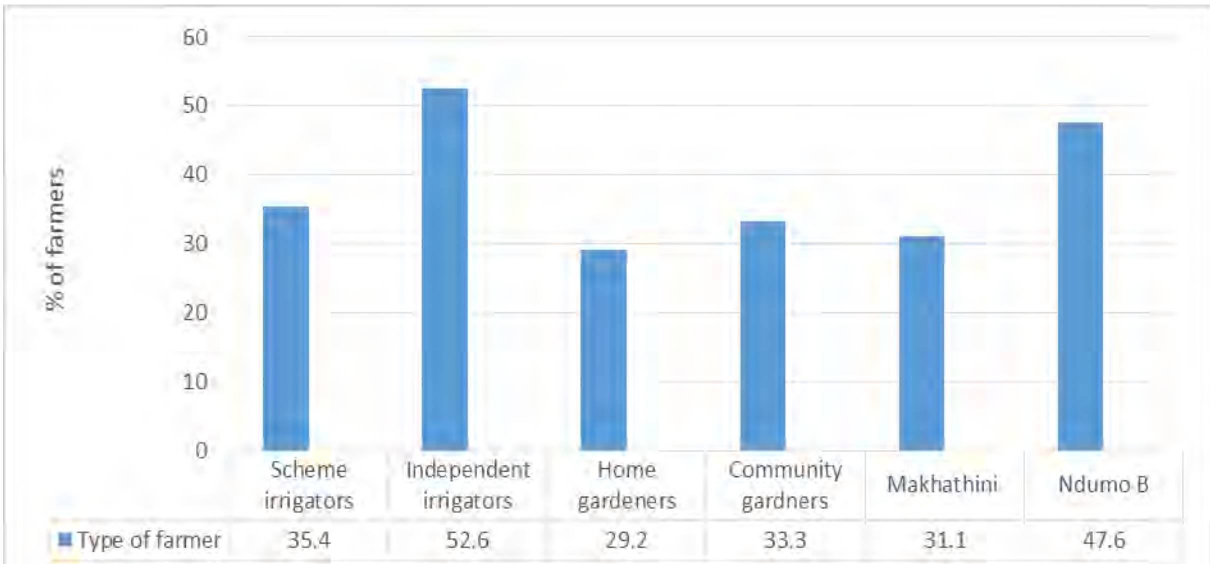


Figure 4.3 Access to credit

Source: Own survey (2015)

The majority of farmers do not have access to credit either for production or for family emergencies. Independent irrigators (52.6%) had the highest proportion of farmers with access to credit, followed by scheme irrigators (35.4%). Independent irrigators have the highest percentage of farmers with access to credit because they have various sources of income including livestock sales which could have made them have better chances to access credit either from formal or informal credit providers compared to other groups. Access to credit by home gardeners is very limited. The results show that home gardeners had the highest percentage of farmers without access to credit. Comparison of irrigation schemes shows that the Makhathini irrigation scheme had a lower proportion of farmers with access to credit compared to Ndumo B irrigation scheme. According to Sikwela (2013), financial constraints such as limited access to credit affect farm input decisions and efficiency for small-scale farmers. This effect exists because the timing of inputs usage is more important in affecting the yield rather than the quantities of input used. Thus, farmers facing financial constraints may not be able to optimize production.

4.5 Livestock ownership

Table 4.4 below shows the percentage of farmers owning cattle, sheep, goats and domestic poultry, which are mostly used as a measure of wealth in rural areas. Livestock ownership is one of the most valuable physical capitals for small scale farmers that can be easily converted to cash through livestock sales. Farmers who possess livestock especially cattle and goats can sell their livestock during difficult periods to generate income and reduce their farming cash flow constraints. This allows them to timeously start farming operations and hence increase chances of obtaining higher yields and higher returns on water use.

Table 4.4 Percentage of farmers owning livestock (n=159)

	Type of farmer				χ^2 test	Irrigation scheme		χ^2 test
Livestock Ownership	Scheme Irrigators (n=82)	Independent Irrigators (n=38)	Home Gardeners (n=24)	Community Gardens (n=15)		Makhathini (n=61)	Ndumo B (n=21)	
Cattle	37	40	29	40	0.9	36	38	0.3
Sheep	2	3	4	0	0.7	3	0	0.7
Goats	43	58	29	53	5.6*	39	52	0.01
Domestic poultry	44	76	42	73	14.7***	44	43	1.1

Notes: *** and * means significant at 1% and 10% levels, respectively

Source: Own survey (2015)

Independent irrigators and community gardeners had the highest percentage of farmers owning cattle (40%) whilst home gardeners had the lowest percentage of households (29%) owning cattle. Among all the farmer typologies in the study, sheep is not an important livestock as it is owned by a very small percentage of farmers. Independent irrigators had the highest percentage of farmers owning goats (58%) followed by community gardeners (53%), scheme irrigators (43%) and home gardeners (29%). The majority of farmers in the study areas own domestic poultry because it is not expensive to keep and it is usually kept mainly for consumption purposes. Based on the results of Table 4.4 above, livestock ownership is more important for independent irrigators and community gardeners compared to the other two groups of farmers. Paradoxically, it plays the least important role to home gardeners.

4.6 Movable assets ownership

Physical assets are vital in rural livelihoods as they determine the capabilities of a household to follow different livelihood strategies. Given proper physical assets, a household is able to utilize available opportunities to improve livelihoods (Chamber & Conway 1992). An area might have good rains and soils which represent an excellent farming opportunity but if a household does not possess, through ownership or otherwise, the physical assets that make farming possible, they fail to utilize the available opportunity.

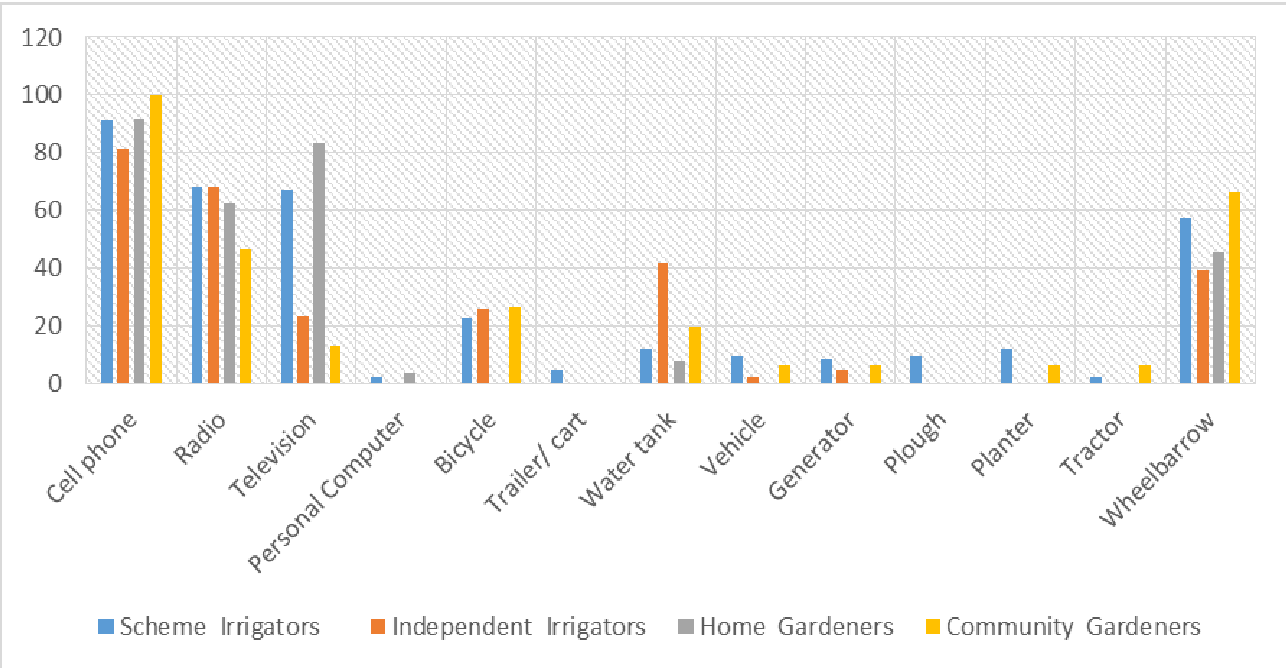


Figure 4.4 Percentage of farmers owning movable assets (n=159)

Source: Own survey (2015)

The results reflected in Figure 4.4 above indicate that only a small percentage of farmers own equipments that are important in farming such as a trailer, tractor, plough, etc. During the interview, the majority of sampled farmers indicated that they have access to these assets through hiring or borrowing which usually is relatively costly, while few farmers, mainly those in the irrigation scheme, and own these assets as a group. According to Pote (2008), production assets such as tractors, machinery and vehicles to transport produce to markets are the key requirements that also determine the profitability of small-scale farmers as these factors play a significant role in reducing transaction costs. Barriers to market entry are reduced when farmers possess such assets. Normally, poor small-scale farmers are unable to participate in lucrative agricultural markets due to lack of household specific productive assets (Pote, 2008). During focus group discussions, farmers stressed that their major problem that leads to poor markets participation is high transportation costs as profitable markets are far away, and they end up obtaining lower prices for their produce as buyers charge for providing own transport. In Ndumo B Irrigation Scheme some farmers mentioned that the price of cabbage was R5 in the 2015 season and they were charged R3 per head of cabbage for transportation to Durban by hawkers. Thus, they ended up selling cabbage at R2 per head on average, making a loss due to lack of own transport.

Cell phone ownership among all sampled farmers is quite high and it is the major means of communication and source of information for farmers in the study areas. The study also sought to assess personal computer ownership. The results show that most farmers do not own personal computers with only 2.4 and 3.3 percent of scheme irrigators and home gardeners owning a personal computer, respectively. Those who do not own computers at all mentioned that they didn't even have access to it through borrowing or hiring. Current markets use the internet as a source of advertisement for inputs and outputs required but small-scale farmers are not familiar with and do not have access to these technologies. Even those who have information about using the internet are not using it because they are located in rural areas where connection to this technology is difficult. Henceforth, this limited access to market information determines the level of accessing markets while commercial farmers are in a better position of accessing such information.

Table 4.5 below reports the percentage of sampled farmers who had received training for various farming activities. The results show that scheme irrigators and community gardeners have the highest percentage of farmers who have access to training services. The majority of farmers indicated that they receive training from extension officers from the Department of Agriculture and Mjindi farming while others get training from non-governmental organisations such as Lima Rural Development Foundation and others from private organisations mostly from contractors such as Technosave and Spar.

Table 4.5 Percentage of farmers who received training (n = 159)

	Land preparation	Vegetable production	Fertiliser application	Herbicide application	General irrigation practice	Irrigation scheduling	Irrigation water management	Agricultural commodity marketing	Packaging of fresh produce	Processing of farm produce	Pricing of produce
Scheme irrigators (n=82)	68	68	71	67	62	60	63	57	46	40	40
Independent irrigators (n=38)	29	32	32	29	21	11	16	16	24	16	21
Home gardeners (n=24)	29	25	25	25	21	17	21	25	25	25	21
Community gardens (n=15)	67	67	67	67	67	67	67	60	60	60	67
Makhathini (n=61)	67.2	67.2	68.9	63.9	59.0	55.7	60.7	54.1	42.6	34	32.8
Ndumo B (n=21)	71.4	71.4	76.2	76.2	71.4	71.4	71.4	66.7	57.1	57	61.9

Source: Own survey (2015)

The results indicate that farmers need to be trained to increase their returns to production especially on irrigation water management, pricing, packaging and processing of farm produce since few sampled farmers have received these trainings. According to Louw *et al*. (2008), the majority of small-scale farmers do not add value to their farm produce owing to lack of processing technology and some due to lack of information and understanding its importance as a way of increasing their profitability. Thus, farmers do not benefit from their own produce as they are selling raw agricultural products with little value addition. Henceforth, value addition and agro-processing are missing due mainly to lack of the required infrastructure.

4.7 Land holdings and land tenure security

Table 4.6 below indicates the mean operated irrigated land by type of farmers. On aggregate, the mean size operated is relatively small (1.1 hectares).

Table 4.6 Mean operated irrigated land by type of farmer

Farmer type	N	Mean (ha)	Std. Deviation
Scheme irrigators	82	1.4	2.5
Independent irrigators	38	1.4	1.5
Home gardeners	24	0.1	0.1
Community gardeners	15	0.6	0.6
Total	159	1.1	2.0

Source: Own Survey Data (2015)

The operated land is significantly different at the 5% level across the types of farmers with an F-value of 3.4. Scheme and independent irrigators operate the same size (1.4) hectares while home and community gardeners, on average, operate smaller sizes, 0.1 and 0.6 ha, respectively. Therefore, the size of the land operated is insufficient for a producer. The results are comparable to Ortmann and King (2010) whose study revealed that small-scale households had very small arable land with averages of 1.8 hectares in Swayimana and 1.1 hectares in Impendle.

Table 4.7 below indicates that some farmers are dissatisfied with the present security of their land and the difference between the types of farmers is significant at $p < 0.000$. Twenty-nine percent (29%) of farmers are dissatisfied or strongly dissatisfied.

Table 4.7 Present state of land tenure security

Farmer type	**Strongly satisfied**	**Satisfied**	**Neutral**	**Dissatisfied**	**Strongly Dissatisfied**
Scheme irrigators	35.4	11.4	20.3	13.9	19.0
Independent irrigators	12.1	42.4	18.2	24.2	3.0
Home gardeners	9.1	77.3	4.5	4.5	4.5
Community gardeners	6.7	6.7	46.7	33.3	6.7
Total	**23.5**	**27.5**	**20.1**	**16.8**	**12.1**

Source: Own survey (2015)

In the Ndumo B scheme land is owned by the Tembe tribal authority while in Makhathini some of the land is owned by the state. Dissatisfaction among scheme irrigators, independent irrigators and community gardeners mostly come from the fact that land in the community is owned by the tribal authorities. This means that farmers do not have secured ownership of land which makes it difficult to invest. Hence, insecure tenure limits farmers' capacity to produce up to their highest productivity potential (Machingura, 2007). According to Darroch and

Mushayanyama (2006), inadequate enforcement of property rights leads to lack of collateral to access investment capital which creates disincentives to make fixed improvements to land. Most home gardeners are satisfied with the present security of their land. This is because gardens are situated near the homestead and the land is usually part of the homestead and belongs to the household.

4.8 **Aspects of water availability**

Table 4.8 below indicates farmers' perceptions regarding water availability and supply for irrigating. The results indicate that 46.6% of farmers in the study feel that they have secured rights to claim water. This applies mostly to the irrigation schemes as the availability of water is determined by their ability to pay a flat rate (Makhathini Irrigation Scheme) or pay for electricity in Ndumo B Irrigation Scheme. On aggregate, the majority of farmers (70.1%) indicated that lack of availability and security of water constrains performance.

Table 4.8 Water availability and supply

Aspects of water security	**Scheme Irrigators**	**Independent Irrigators**	**Home Gardeners**	**Community Gardeners**	**Total**	**Makhathini**	**Ndumo B**
My right or claim to water is secure	31.7	49.5	34.7	46.6	42.4***	29.5	38.1
Water is sufficient for my cropping requirements	52.6	60.5	50.0	40.0	52.8**	57.7	42.9
Availability and security of water constrains my performance	64.2	86.4	62.5	73.3	70.1*	67.2	55.0

Notes: *** and * means significant at 1% and 10% levels, respectively

Source: Own survey (2015)

Home gardeners and community gardeners indicated that the source of water supply is not reliable as it usually dries up while for Ndumo B and independent irrigators, the cost of extracting water from the Pongola River is too high, leading to economic scarcity. In Makhathini Irrigation Scheme it was noted that water availability is also negatively affected by those farmers who draw water illegally from the canal at the expense of other farmers who are paying a flat rate of ZAR2700 per year. The Figure 4.5 below shows how farmers are illegally drawing water from the canal.

Figure 4.5 Farmers illegally drawing water from the canal in Makhathini Irrigation Scheme

Source: Own survey (2015)

4.9 **Summary**

The chapter has presented descriptive results of the study. The results revealed that small-scale farming in the study areas is mainly dominated by women, especially in community and home gardeners. Thus, since women dominate in the study it was assumed that water productivity might be lower because global surveys on the role of women in development report Department of Economic and Social Affairs (2009), indicated that women still face challenges relating to access to resources which limit their capacity to ensure agricultural productivity. Furthermore, the average education level among farmers was very low with the highest education level of 5 years which is grade 5 at primary level. Thus, water productivity is expected to be low as the level of human capital is relatively low. Human capital is crucial for farmers to be able to interpret and utilize information thus increasing chances to participate in market access. Moreover, due to lower education level adoption of innovative technology will be low thus reducing overall water productivity. Also, elderly farmers dominate in the study areas with an average age of 48 years thus indicating the deteriorating labour productivity and output. Furthermore, aging of farmers will also affect the adoption of innovation in traditional farming that is crucial in increasing overall water productivity.

The results indicated that sampled farmers depend on farming as a source of income as most of them are full-time farmers. Farmers who engage in full-time farming are expected to be more efficient and prepared to explore new methods that offer increases in farm incomes that will directly increase overall productivity. Moreover, social grants were noted to be the most important source of income for farmers, relaxing some of their cash flow constraints and assisting them to start with the farming operation. Based on the modified sustainable livelihoods framework, farmers also lack proper assets such as tractors, plough, and vehicles that are vital for them to increase overall productivity. Furthermore, a lower percentage of farmers had access to credit that will have assisted farmers in increasing their financial capital to purchase inputs such as improved quality seeds, pesticides, *etc*. Farmers also indicated dissatisfaction with the security of land, which reduces their incentive to invest on the land which in turn, restricts overall productivity. In summary, the overall socio-economic characteristics of farmers are relatively weak. Thus, it is expected that overall water productivity and value will be low among sampled farmers in the study areas.

The next chapter presents the results on water use productivity and value analysed using gross margin analysis and the residual valuation method for the major crops grown by farmers, namely; cabbage, maize, beans and tomatoes. Factors affecting water values are also presented and analysed using a general linear model.

CHAPTER 5. WATER USE PRODUCTIVITY AND VALUE: RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents empirical findings on water use productivity for the main crops grown in and around Makhathini and Ndumo B irrigation schemes, based on the economic returns. Gross margins and residual water values were computed for the four major crops (maize, cabbage, beans and tomatoes) to evaluate the economic performance of each crop enterprise for the different typology of farmers. Gross margins in ZAR/per hectare of land cultivated were analysed using yield and variable production costs of each enterprise. To ensure the reliability of data used and hence value obtained in the computations, input cost and prices were collected on a weekly basis. Water values for scheme irrigators were computed using both actual measurements taken during the season and CROPWAT crop water requirement (CWR) estimates. However, since the study did not collect data on actual water applied by independent irrigators, home and community gardeners, residual water values for crops grown by farmers outside of the schemes were computed using CROPWAT estimates.

Furthermore, factors affecting water values for major crops grown are presented, as indicated in Chapter 3, that there are several factors assumed to affect water productivity including the psychological capital. The multi-dimensionality of psychological capital indicated that there was a need for a composite index to get its proxy, integrating several questions asked in the questionnaire on its different dimensions. Thus, a psychological capital index was generated using PCA and was used as an independent variable to examine the extent to which it affects water values of major crops. The general linear model was employed in investigating the factors affecting irrigation water value and partial eta squared was used to measure the effect of each variable included in the model. This chapter starts by giving a brief description of the distribution of crops grown and of climatic data obtained from Weather South Africa for Makhathini station during the period when production data were collected.

5.2 Descriptive overview of the weather in the study areas

This section gives a brief description of weather data obtained from Weather South Africa from September 2014 to July 2015, the period when data were collected. The climatic data were obtained from Makhathini station, the nearest weather station to the study areas. The average rainfall from September 2014 to July 2015 was recorded at 346.2 mm. More rainfall was concentrated during January to February 2015. Most farmers started planting at the end of February since most are aware that during the period covering January to mid-February there are usually heavy rains which destroy crops in the initial stage of development. It was noted that those who planted during these months of heavy rains suffered this fate and hence made a huge loss. The mean minimum and maximum temperatures recorded during the same period, *i.e.* September 2014 to July 2015, were 17 and 29.8 degrees Celsius, respectively. The study areas have extremely hot weather throughout the year but from June to July maximum temperatures were below 30 degrees. On average, the humidity percentage was 64% and wind was traveling at 7 km/day. The average evapotranspiration (ET_o) was recorded at 4.04 mm/day.

Figure 5.1 below presents the distribution of crops grown by the four typologies of farmers for the 2014/2015 season. The results are presented according to the importance of the crops grown by farmers.

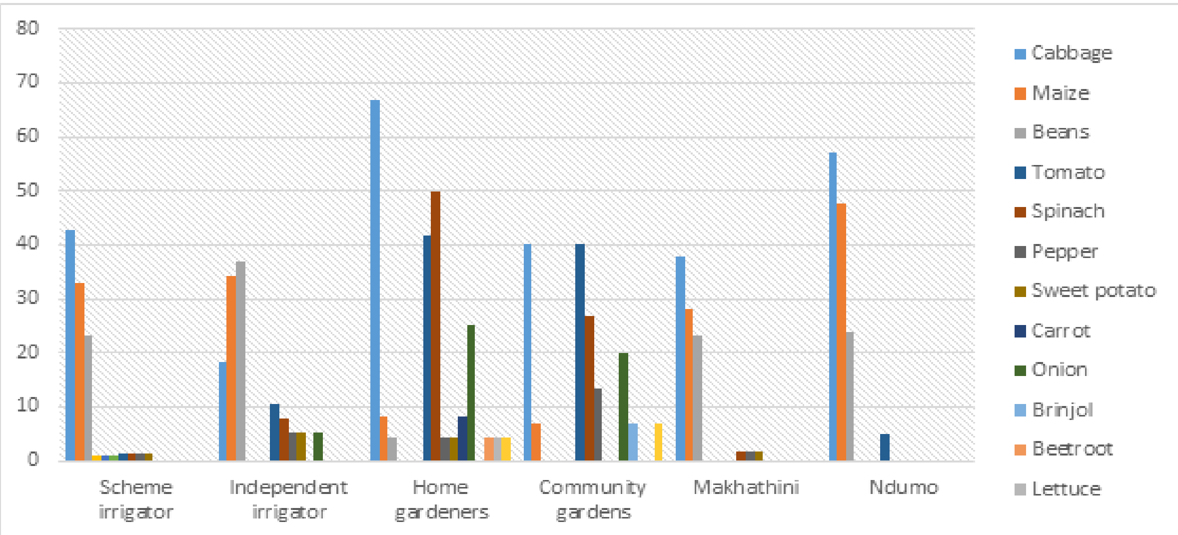


Figure 5.1 Distribution of crops grown by the sampled farmers (n=159)

Source: Own survey (2015)

The results showed that home and community gardeners mainly grow similar major crops (cabbage, tomatoes, spinach, etc.) whilst scheme and independent irrigators also grow similar crops (mainly cabbage, maize and beans). Cabbage was the most important crop grown among the four typologies of farmers in the study areas. Home and community gardeners are mainly growing vegetable crops while scheme and independent irrigators also cultivate crops.

5.3 **Economic returns to the main crop enterprises**

5.3.1 **Cabbage productivity**

Table 5.1 below presents gross margin analyses for cabbage for four types of farmers. Amongst the crops grown, cabbage has the highest gross margin. Scheme irrigators had the highest gross margin with an average value of ZAR34, 681 per ha per year while home gardeners had the lowest negative gross margin of ZAR369 per ha per year. Negative gross margin attained by home gardeners is attributed to the shadow price estimated for family labour as it is not really paid for. The main components of variable costs among all types of farmers for cabbage were seedling and labour costs. Labour cost consisted of labour used in land preparation, planting, weeding, spraying, irrigating, packaging and harvesting. This was divided into family and hired labour. The results show that small-scale farmers are highly dependent on family labour, hence, the study results support Muchingura (2007), who found that the majority of small-scale farmers rely on family labour with women mostly involved in the production. The results indicate that few farmers used donkey or oxen for land preparation in an attempt to cut the cost of hiring tractors.

Variation in gross margins was due to different prices obtained and marketing channels used by farmers. Cabbage is usually sold in 50kg bags that usually contain between 10-12 heads of cabbage. Community gardeners received the highest price of R44 per bag while home gardeners received the lowest (ZAR23 per bag), a difference of ZAR21 per bag. The difference between the prices received is due to marketing channels used by farmers, where community gardeners sell directly to consumers in town by the road-side while home gardeners sell their output to their neighbour’s at lower prices. Due to the low price received by home gardeners, they have a negative gross margin which implies that the income they obtain from selling their cabbage produce is not enough to cover all variable costs.

Table 5.1 Cabbage gross margins by farmer typology

Cabbage							
	SI (n=34)	II (n=5)	HG (n=9)	CG (n=6)	Makhathini (n=23)	Ndumo B (n=11)	Total (n=54)
Gross income (ZAR/ha)							
Yield (kg)	1433	896	423	1139	1371	1564	1182
Output price (50kg bag)	35	36	23	44	40	26	34
Average Gross Income (R/ha)	50623	32077	9599	50551	54229	41369	40516
Total variable cost (ZAR/ha)							
Seed	5233	3128	5181	8508	5195	5312	5393
Basal fertiliser	1615	300	133	1796	1713	1409	1266
Top Dressing fertilizer	1678	1070	178	1050	1825	1370	1302
Manure	30	655	1481	442	41	8	376
Herbicides	50	20	44	150	57	36	57
Pesticides	1033	2520	252	2492	981	1140	1202
Hired oxen/ donkeys	59	120	0	333	43	91	85
Tractor hire	1763	600	444	1083	1591	2121	1360
Family labour	2071	675	2128	1640	2393	1396	1926
Hired labour	1566	2518	101	0	1086	2569	1236
Transport	337	0	0	458	152	724	268
Other materials	508	0	25	0	645	220	330
Average total variable cost (ZAR/ha)	15942	11606	9968	17953	15724	16397	14802
Average Gross Margin (ZAR/ha)	34681	20471	-369	32599	38505	24972	25715
% with Negative Gross Margins	8.8	20	87.5	0	8.7	9.1	20.8
Minimum Gross Margin	-4730	-2260	-9700	8888	-4730	-4325	-9700
Maximum Gross Margin	78546	79625	77792	44325	78546	47980	79625

Source: Survey Data (2015)

Notes: SI, II, HG, and CG refer to Scheme irrigators, Independent irrigators, Home gardeners, and Community gardeners, respectively.

Scheme irrigators in Makhathini had a secure market for cabbage as the majority signed contracts with uMhlosinga, an organization that holds the school feeding programme tender with the government. Farmers sell as a group to uMhlosinga due to the large quantities requested which they cannot supply as individuals. Farmers indicated that as long as uMhlosinga hold the tender, it offers a guaranteed market for cabbage at market prices. The results support Cia *et al.* (2011) who revealed that access to well-functioning markets is crucial in determining the overall value of agricultural production and net returns to farmers. Baloyi (2010) further discusses that lack of well-functioning markets leads to less farmers' share of the value added in the commodity chain due to their products being undervalued.

However, further analysis shows that 8.8% of scheme irrigators had negative cabbage gross margins. During the study, it was noted that negative gross margins for some of the farmers were due to an unknown pest attack that destroys the cabbage. Farmers noted that the pest attacks the outer most leaves of cabbage at a later stage of development and started two years ago. Despite several efforts by extension officers working with other relevant government departments and agro-chemical companies, they have failed to find a solution to this unknown pest which continues to reduce production and productivity. Figure 5.2 below shows a picture taken during the survey of a farmer, whose cabbage was destroyed due to the pest, leaving only a small harvestable quantity for sale to uMhlosinga. The harvest lost was around 20% of the total produce.

Figure 5.2 Cabbage destroyed after being affected by an unknown pest in Makhathini Scheme

The results also indicate that pest was a major problem for all types of farmers as the variable cost for pesticides was relatively high. This, however, is expected in irrigation schemes due to the continuous cultivation of the same crop by many farmers in the same area. However, it was revealed that some farmers have found a solution to this pest attack but do not want to share the solution with others as a way of capitalizing on the situation through attracting customers away from those farmers whose cabbage is affected. These farmers are taking advantage of the power of information and want to succeed at whatever cost, even at the cost of fellow farmers.

Comparing scheme irrigators, Makhathini scheme farmers had the highest cabbage gross margin compared to Ndumo B. This can be attributed to better prices and reduced transport cost for scheme farmers in Makhathini. Mjindi farming, which manages the Makhathini scheme, acted as a middleman in assisting farmers with the marketing of cabbage with the uMhlosinga scheme feeding programme. Farmers indicated that the uMhlosinga scheme feeding programme does not charge them for transport. The only cost incurred was for transporting cabbage to Mjindi farming, which was used as a pickup point for output sold. Some farmers received support from DAFF in transporting their cabbages for free. The same cannot be said about farmers from Ndumo B irrigation scheme. Farmers in this scheme indicated in 2015 season, the farm gate price of cabbage was ZAR5 per head and they were charged R3 per head for transporting cabbage to Durban by hawkers. Thus, they ended up on average selling cabbage at ZAR2 per head, making losses due to high transport costs. Even though they are aware that transport cost was not reasonable, they do not have any option as they have neither own transport or any other alternatives market.

5.3.2 Maize productivity

Maize is the most important cereal crop in the world for various reasons. It provides nutrients in compact form; it is easily transportable; it stores well if properly dried, and it can be harvested over a long period. Table 5.2 below presents the survey results on maize enterprise productivity. The results show that maize is mainly produced by the scheme and independent irrigators because, on average, they operate larger plots of land as compared to home and community gardeners. Thus, comparison on maize will be made based on these two groups of farmers. Operating larger plots' of land for maize helps in earning more revenue because farmers can produce more quantity and are able to benefit from economies of scale. Scheme irrigators had the highest gross margin of ZAR10, 415 per ha.

Table 5.2 Maize gross margins by farmer typology

Maize							
	SI (n=27)	II (n=14)	HG (n=2)	CG (n=1)	Makhathini (n=17)	Ndumo B (n=10)	Total (n=41)
Gross income (ZAR/ha)							
Yield (kg)	3208	2604	1975	1250	3037	3528	2893
Output price (kg)	7.2	5.7	6.3	4	7.9	6	6.6
Average Gross Income (ZAR/ha)	23076	14826	12527	5000	24068	21080	19031
Total variable cost (ZAR/ha)							
Seed	1920	1060	750	500	1853	2034	1561
Basal fertiliser	1504	1280	1313	0	1452	1593	1450
Top Dressing fertilizer	1593	635	369	0	1330	2040	1197
Manure	7	26	0	25	7	6	13
Herbicides	368	32	0	0	207	641	236
Pesticides	696	227	2175	0	1006	171	607
Hired oxen/donkeys	74	171	0	0	59	100	100
Tractor hire	1974	1119	1975	1200	1959	2000	1685
Family labour	2866	3428	4288	245	3624	1579	3032
Hired labour	1537	1627	250	1155	1149	2197	1498
Transport	62	71	0	0	0	167	59
Other materials	60	0	500	0	99	0	69
Average total variable cost (ZAR/ha)	12662	9677	11619	3125	12744	12527	11507
Average Gross Margin (ZAR/ha)	10415	5149	908	1875	11324	8553	7524
% with Negative Gross Margins	17.4	30.8	50	0	13.3	25	23.1
Minimum Gross Margin	-5285	-7070	-7686	1875	-5285	-1850	-7686
Maximum Gross Margin	25704	27704	9588	1875	25704	25704	27704

Source: Survey Data (2015)

Notes: SI, II, HG, and CG refer to Scheme irrigators, Independent irrigators, Home gardeners, and Community gardeners, respectively.

The main component of variable cost for maize production was labour, with family labour contributing more than hired labour. Negative gross margin does not mean that farmers are practically earning no positive net cash flow since the computation of gross margin puts a shadow price to family labour which is not actually paid. For maize produce, the majority of farmers indicated that they sell directly from farm gate thus incurring lower transport cost.

However, the major challenge cited as regards maize is the lack of market access. Unlike cabbage maize does not have a guaranteed market which is prepared to pay higher prices. Thus, most of it is sold to local consumers and hawkers from Durban and surrounding towns.

During focus group discussions, it was noted that scheme irrigators set a price level that each farmer should charge for maize. However, due to mistrust, some farmers still sell at lower prices allowing hawkers to take advantage of their disorganization. This highlights a key challenge with smallholder farming. During the discussions in Makhathini, the farmers marketing committee for maize and vegetables indicated that such challenges are worsened by those who do not attend farmers' meeting, negatively affecting collective management and bargaining. Furthermore, psychologically, for some farmers, the opportunity cost of foregoing a small profit in the short-run for higher profits in the long-run is much higher given the uncertainty in the market. Moreover, most smallholder farmers directly depend on income from crops to take care of their daily expenses such as buying necessities for their children in school and buying food or medication. Hence, they appear as if they are not willing to abide by prices set by the committee. Furthermore, negative gross margins among farmers may also be attributed to the use of traditional seed varieties or recycled seed as 32% of farmers indicated that they still used these seeds. This reduces the overall productivity as traditional seeds are less productive and often susceptible to pest attack.

5.3.3 **Beans productivity**

Table 5.3 below reports the results of beans enterprise productivity. Beans are mainly produced by scheme irrigators (19) and independent irrigators (14) thus comparison will be based on these two groups. Scheme irrigators had the highest gross margin of ZAR9, 480 while independent irrigators earned ZAR8, 996.

Table 5.3 Bean gross margins by farmer typology

	Beans					
	SI (n=19)	HG (n=1)	II (n=14)	Makhathini (n=14)	Ndumo B (n=5)	Total (n=34)
Gross income (ZAR/ha)						
Yield (kg)	1422	469	1200	1531	1118	1023
Output price (kg)	15.5	16.4	16.0	13.9	19.2	15.8
Average Gross Income (ZAR/ha)	21977	7682	19200	21219	21428	16208
Total variable cost (R/ha)						
Seed	1052	625	2400	1288	390	916
Basal fertiliser	1342	400	600	1440	1068	957
Top Dressing fertilizer	993	289	0	998	978	674
Manure	19	34	4	26	2	25
Herbicides	184	180	0	179	200	106
Pesticides	474	82	0	590	150	299
Hired oxen/ donkeys	0	0	0	0	0	0
Tractor hire	1633	1023	0	1667	1540	1387
Family labour	3742	2241	7200	3660	3972	3226
Hired labour	3057	1741	0	3359	2213	2837
Transport	0	0	0			0
Other materials	0	0	0			0
Average total variable cost (ZAR/ha)	12497	1067	10204	13206	10513	10426
Average Gross Margin (ZAR/ha)	9480	51	8996	6722	9879	5782
% with Negative Gross Margins	35.3	69.2	0	38.5	25	48.4
Minimum Gross Margin	-8750	-15710	8996	-8750	-6330	-15710
Maximum Gross Margin	36600	19530	8996	36600	19527	36600

Source: Survey Data (2015)

Notes: SI, II, HG, and CG refer to Scheme irrigators, Independent irrigators, Home gardeners, and Community gardeners, respectively.

The results reveal that the low use of agricultural inputs (such as fertilizer, pesticides) for beans in the study area may be the primary reason for low average gross margins. This may be attributed to the poor distribution of channels for these inputs in rural areas as farmers noted that markets are far away and hence accessibility is limited. Moreover, it was noted that lack of knowledge about the optimal application rate of the inputs is the major issue. Hence, low level of use of the inputs limits farmers to gain higher yields and gross margins. Use of pesticides and fertilizers has become ever necessary and yet the costs are high and unaffordable for small farmers, reducing water productivity. According to Ortmann and King (2007), high transaction cost to access production resources is one of the key challenges of smallholder farmers in South Africa.

5.3.4 **Tomato productivity**

Table 5.4 below presents the results of tomato gross margins for independent irrigators, home and community gardeners. The results show that for the tomato enterprise the main variable cost among farmers is seedling cost followed by family labour for land preparation, weeding, irrigating, harvesting and marketing.

Table 5.4 Tomato gross margins by farmer typology

	Tomato				
	SI (n=1)	II (n=3)	HG (n=6)	CG (n=6)	Total (n=16)
Gross income (ZAR/ha)					
Yield (kg)	2000	11056	2083	10313	6846
Output price (kg)	8.0	2.9	4.8	4.3	4.5
Average Gross Income (ZAR/ha)	16000	32430	10000	44688	30637
Total cost					
Seed	4800	333	4983	4750	4013
Basal fertiliser	156	267	183	623	362
Top Dressing fertilizer	0	400	0	600	300
Manure	0	44	533	13	213
Herbicides	0	0	0	0	0
Pesticides	0	67	0	573	228
Hired oxen/ donkeys	0	0	0	0	0
Tractor hire	1000	1133	500	483	644
Family labour	2040	520	1583	3603	2170
Hired labour	0	793	0	150	205
Transport	0	0	0	0	0
Other materials	0	0	0	0	0
Average total variable cost (ZAR/ha)	7996	3558	7783	10796	8134
Average Gross Margin (ZAR/ha)	8004	28872	2217	33892	22503
% with Negative Gross Margins	0	0	50	0	18.8
Minimum Gross Margin	9004	500	-9500	1225	-9500
Maximum Gross Margin	9004	65870	37000	80000	80000

Source: Survey Data (2015)

Notes: SI, II, HG, and CG refer to Scheme irrigators, Independent irrigators, Home gardeners, and Community gardeners, respectively.

The results show that community gardeners had the highest average gross margin of ZAR33, 892 per ha, while home gardeners had a mean gross margin of ZAR2, 217 per ha. The highest aggregate component of variable cost for tomato production among farmers was seedling cost totalling to ZAR4013 per ha. Hired labour cost constituted the lowest variable cost in production (ZAR205). The majority of farmers indicated that they mainly sell their produce at the farm gate.

5.4 **Residual valuation based on CROPWAT water estimates**

The results in Table 5.5 below show water value estimates for cabbage, maize, beans and tomatoes based on 2015 prices and CROPWAT water estimates. CROPWAT estimated CWR values of 3,036, 2,613, 2,601 and 2,617 m^3/ha for cabbage, maize, beans and tomatoes, respectively. Cabbage had the highest water value of ZAR8.47/m^3 while beans had the lowest water value of ZAR2.22/m^3 in the study, which is expected as cabbage is more of a commercial crop. Comparing water values based on crops grown, scheme irrigators had the highest cabbage water value of ZAR11.42/m^3 while community gardeners, independent irrigators and home gardeners had the highest water values for tomato enterprise at ZAR12.95, ZAR11.03 and ZAR0.85/m^3, respectively. Muchara (2015) reported a marginally higher water value of ZAR11.78/m^3 for tomato compared to the current study aggregate water value of ZAR8.60/m^3 for tomatoes.

It is important to note that water values computed in this study do not designate the price of water if water pricing has to be put in place because not all the cost, such as management, land and other overhead costs have been accounted for due to lack of data. The values do not necessarily show the contribution of water to the value of the crop because not all input costs have been accounted for. The water values/m^3 stated above are based on estimated gross margin and did not consider all costs, such as land and management costs.Thus, the values are meant to show the productive use of water across enterprises, in relative terms. Since the value of water is over-estimated across the board, the variation of the estimates across farmers is not affected. That is why the regression results are valid to reflect how productive use of water is affected by different variables considered to explain the response variable. Thus, the estimates are valid to be compared across crop enterprises because the mistake of not accounting for all inputs can be assumed to be uniform and cancel out.

Table 5.5 Crop water values based on 2015 prices and CROPWAT water estimates

Farmer typologies	Irrigation water requirement (m^3/ha)	Average Gross Income (ZAR/ha)	Average total variable cost (ZAR/ha)	Average Gross Margin (ZAR/ha)	Water Values (ZAR/m^3)
Cabbage					
Scheme irrigators (n=34)	3036	50623	15942	34681	11.42
Independent irrigators (n=5)	3036	32077	11606	20471	6.74
Home gardeners (n=9)	3036	9599	9968	-369	-0.12
Community gardeners (n=6)	3036	50551	17953	32599	10.74
Makhathini (n=23)	3036	54229	15724	38505	12.68
Ndumo B (n=11)	3036	41369	16397	24972	8.23
Total (n=54)	**3036**	**40516**	**14802**	**25715**	**8.47**
Maize					
Scheme irrigators (n=27)	2613	23076	12662	10415	3.99
Independent irrigators (n=14)	2613	14826	9677	5149	1.97
Home gardeners (n=2)	2613	12527	11619	908	0.35
Community gardeners (n=1)	2613	5000	3125	1875	0.72
Makhathini (n=17)	2613	24068	12744	11324	4.33
Ndumo B (n=10)	2613	21080	12527	8553	3.27
Total (n=44)	**2613**	**19031**	**11507**	**7524**	**2.88**
Beans					
Scheme irrigators (n=19)	2601	21977	12497	9480	3.64
Home gardeners (n=1)	2601	7682	7631	51	0.02
Independent irrigators (n=14)	2601	19200	10204	8996	3.46
Makhathini (n=14)	2601	21219	13206	6722	2.58
Ndumo B (n=5)	2601	21428	10513	9879	3.80
Total (n=34)	**2601**	**16208**	**10426**	**5782**	**2.22**
Tomatoes					
Scheme irrigators (n=1)	2617	16000	7996	8004	3.06
Independent irrigators (n=3)	2617	32430	3558	28872	11.03
Home gardeners (n=6)	2617	10000	7783	2217	0.85
Community gardeners (n=6)	2617	44688	10796	33892	12.95
Total (n=16)	**2617**	**30637**	**8134**	**22503**	**8.60**

Note: Exchange rate was US$1: ZAR12.4058 as at June 2015.

Source: Survey Data (2015)

Product prices received by the different typologies of farmers was a fundamental reason for variations of water value. According to Ali & Talukder (2009), the level of water productivity is influenced by economic factors such as the type of irrigation technology used. Moreover, Hussain *et al.* (2007) note that possible causes of variation could be due to different irrigation management styles and a wide range of institutional factors governing water resource management, household demographics as well as different approaches in costing production and marketing activities. Differences in water values among typologies of farmers in the study areas can also be attributed to different technologies that farmers use to irrigate crops as scheme irrigators use a sprinkler system, independent irrigators use sprinklers, flood irrigation and hosepipe while home and community gardeners use a bucket and hosepipe system. Thus, the efficiency of irrigation technologies varies.

The results show that while some farmers are performing better as shown by positive gross margins, others are attaining negative gross margins. Negative gross margins designate that small-scale farming still requires government support, especially on inputs as the results indicated the low level of use of agro-chemicals such as fertilizer due to high cost. Furthermore, training on agricultural farming should be equally accessible to all farmers' typologies in order to increase their human capital, increase their ability to make profitable decisions in farming and thus increasing productivity. The results further indicate that cabbage, beans and maize are not necessarily suitable for home and community gardeners because more income is earned when it is produced on a larger scale of land. Given other alternatives, community and home gardeners should continue to grow vegetables to increase water values.

5.5 Residual valuation results based on actual water applied by scheme irrigators

Table 5.6 below presents the results of the returns to actual water use by scheme irrigators in Makhathini and Ndumo B for three major crops (cabbage, maize and beans). The results on water values between the two schemes are comparable because the same irrigation technology was used, minimizing variations in water use owing to variation in technology. On aggregate, cabbage had the highest water value of ZAR13.43/m^3. The results show that maize and dry beans production generated the lowest residual value of water at ZAR3.55/m^3 and ZAR2.36/m^3, respectively. This finding concurs with a study by Muchara (2015) which also recorded that maize and dry beans production had the lowest residual values among the crops grown in Mooi River (ZAR1.31/m^3 and ZAR1.09/m^3, respectively).

Table 5.6 Returns to actual water use for scheme irrigators in Makhathini and Ndumo B (N=80)

Cabbage	Makhathini (n=23)	Ndumo B (n=11)	Total (n=34)
Actual Water Use (m^3/ha)	2416	3061	2582
Average Gross Income (ZAR/ha)	54229	41369	50623
Average Total Variable Cost (ZAR/ha)	15724	16397	15942
Average Gross Margin (ZAR/ha)	38505	24972	34681
Minimum Water Values (ZAR/m^3)	-2	-1	-2
Maximum Water Values (ZAR/m^3)	33	16	30
Water Values (ZAR/m^3)	15.94	8.16	13.43
Maize	**Makhathini (n=17)**	**Ndumo B (n=10)**	**Total (n=27)**
Actual Water Used (m^3/ha)	2707	3544	2933
Average Gross Income (ZAR/ha)	24068	21080	23076
Average Total Variable Cost (ZAR/ha)	12744	12527	12662
Average Gross Margin (ZAR/ha)	11324	8553	10415
Minimum Water Values (ZAR/m^3)	-1.95	-0.52	-1.80
Maximum Water Values (ZAR/m^3)	9.50	7.25	8.76
Water Values (ZAR/m^3)	4.18	2.41	3.55
Beans	**Makhathini (n=14)**	**Ndumo B (n=5)**	**Total (n=19)**
Actual Water Use (m^3/ha)	3908	4351	4025
Average Gross Income (ZAR/ha)	21219	21428	21977
Average Total Variable Cost (ZAR/ha)	13206	10513	12497
Average Gross Margin (ZAR/ha)	6722	9879	9480
Minimum Water Values (ZAR/m^3)	-2	-1	-2
Maximum Water Values (ZAR/m^3)	9	4	9
Water Values (ZAR/m^3)	1.72	2.27	2.36

Note: Exchange rate was US$1: ZAR12.4058 as at June 2015.

Source: Survey Data (2015)

The estimated water values for crops differ from some studies. Muchara (2015) reported a lower water value for cabbage (ZAR 5.13/m^3), maize (ZAR1.31/m^3) and beans (ZAR1.09/m^3) for Mooi River Irrigation Scheme compared to this study's water values of ZAR13.43/m^3, ZAR3.55/m^3 and ZAR2.36/m^3 for the same crops, respectively. However, Bongole (2014) reported a close water value of (ZAR2.61/m^3) for maize in Tanzania's Moshi Irrigation Scheme. Speelman (2008) reported higher beans value of (ZAR10.37/m^3) compared to a lower value of ZAR2.36/m^3 in this study. Moreover, lower values of cabbage ZAR4.57/m^3 and tomatoes (ZAR 2.87/m^3) were reported (Speelman, 2008) compared the values reported in the current study.

The results show that Makhathini farmers are applying less (2416 m^3/ha) water than the crop water requirement for cabbage while Ndumo B farmers are over-irrigating with an excess of 25 m^3 for the same crop. This is because, in Ndumo B, farmers directly extract water from Pongola River for free and they irrigate as much as they need because their time for irrigating is not controlled by any institution. The results support the economic theory that predicts that when resources are made artificially non-scarce, a farmer will employ the resource inefficiently. However, in Makhathini irrigation scheme, Mjindi farming controls irrigation time and farmers irrigate only from 5 a.m. to 6 p.m. Moreover, as they use a canal system other farmers complained that they do not get enough water due to head and tail issues, leading to overall under-irrigating.

The results reveal that, on aggregate, cabbage had a water value of ZAR13.43/m^3 for scheme irrigators. However, Makhathini scheme had the highest returns to water used in cabbage of ZAR15.94/m^3 compared to the value of ZAR8.16/m^3 for Ndumo. Makhathini scheme irrigators earned ZAR7.78/m^3 more. In Makhathini, cabbage water value calculated using actual water applied was higher by ZAR15.94/m^3 compared to the value obtained using CROPWAT estimates (ZAR12.68/m^3). However, for Ndumo B water values obtained from actual water applied was slightly lower (ZAR8.16/m^3) compared to the value obtained from CROPWAT (ZAR8.23/m^3). The results suggest that even though Makhathini farmers are applying less water, their returns to water are relatively higher due to the better price they received from the uMhlosinga scheme feeding programme. Furthermore, according to the law of diminishing marginal returns, the water value will increase at a decreasing rate until it reaches an optimal point, where they will apply exactly 3036 m^3 (CROPWAT CWR). Diminishing returns will occur as farmers keep on adding more inputs after the optimum level has been reached, given that other inputs are held constant. If Makhathini farmers can continue to add more volume of water, they reach the optimum water requirement of 3036 m^3/ha, their water value may be increased even more.

Table 5.6 above shows that Makhathini scheme irrigators had the highest returns to actual water value of ZAR4.18m^3/ha while Ndumo had ZAR2.41m^3/ha for maize. However, the same farmers from both schemes were over-irrigating as the crop water requirement for maize was estimated at 2,613 m^3/ha (Makhathini 2,707m^3/ha and Ndumo B 3,544 m^3/ha). On average, Makhathini farmers were irrigating in excess of 94m^3/ha while Ndumo in excess of 931m^3/ha.The key reason noted for over-irrigating beside the lack of metering devices was the distance between schemes and home stands. The distance between irrigation scheme and homestead is far and the majority of farmers just come to open up (sprinklers) irrigation and go back without monitoring if water applied is enough until Mjindi closes the main pump later after 6 pm. Moreover, it was found that as farmers are applying more water than the actual recommended, the water values decrease. In Makhathini as farmers continue to increase the volume of water while other inputs are held constant, an additional volume of water diminishes water value by ZAR0.15/ha and in Ndumo by ZAR0.89 /ha.

Beans had the lowest aggregate returns to water (ZAR2.36/m^3) compared to cabbage and maize. However, for Ndumo B scheme irrigators, beans had the highest water value of ZAR 2.27/m^3 compared to Makhathini (ZAR1.72/m^3). Since beans irrigators in both schemes are applying more water than the required, their water values diminish by ZAR0.86/m^3 and ZAR1.53/m^3 for Makhathini and Ndumo, respectively. Table 5.7 below presents the results comparing irrigation water requirements with actual water applied by scheme irrigators. The irrigation performance measured in crop water requirement computed using CROPWAT 8.0 is 85%, 112% and 99% for cabbage, maize and beans, respectively. However, the results indicate that the majority of farmers are over-irrigating, particularly Ndumo B farmers.

Table 5.7 Comparison of irrigation water requirements and actual water applied

	Irrigation water requirement (m3/ha)	**Actual water used (m3/ha)**	**Irrigation performance (Actual/ IWR)**	**Irrigation performance (below 50%)**	**Irrigation performance (above 100%)**
Cabbage					
Makhathini (n=17)	3036	2416	80%	15.4%	26.9%
Ndumo B (n=10)	3036	3061	101%	11.1%	44.4%
Total (n=27)	3036	2582	85%	14.3%	31.4%
Maize					
Makhathini (n=17)	2613	2707	104%	23.5%	47.1%
Ndumo B (n=10)	2613	3544	136%	0%	71.4%
Total (n=27)	2613	2933	112%	16.7%	54.2%
Beans					
Makhathini (n=17)	2601	2416	93%	0%	76.9%
Ndumo B (n=10)	2601	3061	118%	0%	100%
Total (n=27)	2601	2582	99%	0%	83.3%

Source: Survey Data, (2015)

More farmers are under-irrigating in Makhathini scheme compared to Ndumo B farmers. As explained in Chapter 3, in Makhathini, scheme farmers use a canal system and pay less for water. However, it was noted that canal water theft reduces the availability of water (physical water scarcity) for farmers who have a legal right to irrigate, thus under-irrigating. Furthermore, in Makhathini, some co-operatives are facing physical water scarcity challenges due to location-related institutional problems (head and tail) where some farmers ended up not being able to irrigate their plots unlike those co-operatives at the head. In contrast, Ndumo B scheme irrigators directly extract water from the Pongola River using electric pumps and only pay for electricity while using water for free; and water is always readily available provided that they have paid the electricity bills in full to Eskom. Otherwise, they cannot irrigate owing to economic water scarcity. Thus, based on the results above, it can be concluded that in Ndumo B irrigation scheme there is no physical water scarcity but economic water scarcity owing to financial constraints as they pay more on electricity bills. During focus group discussions, it was noted that, on aggregate, the average cost of production in Ndumo B scheme irrigators is higher as farmers pay more on electricity charges for pumping water from the Pongola River. The electricity cost was not included in the computation of gross margin because it was assumed to be a fixed cost. Furthermore, farmers noted this as a major constraint in their farming operations because, on average, they end up paying more than ZAR10, 000 per annum per hectare just for electricity bills as these are continually increasing. This limits the overall use of agro-chemicals as a way to save for water electricity bills. Thus, water productivity as a whole is being reduced due to high production costs.

Moreover, farmers also mentioned that even if they irrigate for few hours as a way of minimizing electricity bills, it does not help because they always pay more. Thus, it is better for them to irrigate more to make up for the high electricity bill. Hence, the majority end up over-irrigating which directly reduces water values as indicated by the results above. The results support Woyessa *et al.* (2004), who revealed that there is a significant loss of water in many irrigation schemes due to over-irrigation and lack of proper irrigation management tools that are required to assist farm managers on how much and when to irrigate. In contrast, Makhathini scheme farmers only pay R2700/ha for water-related services regardless of whether they have grown crops, which is far less than what Ndumo B farmers pay per year.

It was also noted during group discussions that farmers are under-irrigating due to a shortage of proper irrigation sprinklers as, on average, farmers have only three sprinklers per hectare. Farmers revealed that they end up stealing sprinklers from each other. Furthermore, the pressure from some of the sprinklers was too low in such a way that the distribution of water was not formal to irrigate the areas covered by an operating sprinkler. Fanadzo *et al.* (2010b) also assessed crop production management practices as a cause for low water productivity at

Zanyokwe irrigation scheme. The results revealed that farmers face economic scarcity as the majority of them cited inadequacy of pipes as a major constraint for effective irrigation of crops which limits returns from the water. The results indicate poor monitoring rules for Mjindi farming since other farmers are drawing water illegally from the canal in Makhathini at the expense of other farmers who are paying for water-related services such as canal maintenance.

5.6. Results and discussion on factors affecting water value

5.6.1 Psychological capital index: PCA results

A psychological capital index was extracted using PCA. Farmers were asked their perceptions regarding farming and the variables were encoded in a five Likert scale. The variables included were capturing the four pillars of psychological capital (optimism, hope, resilience and confidence). Six principal components were generated but only two components were extracted, applying the Kaiser criterion which states that only PCs with Eigen values greater than one can be retained, using Pearson correlations. Table 5.8 below shows the results of the two retained PCs, where PC_1 explained 54% and PC_2 explained 13% of the variation in the variables.

Table 5.8 Psychological capital generation: PCA results

Variables	**Principal Components**	
	PC_1	**PC_2**
How high is your confidence in farming as a means of sustainable livelihoods	**-0.729**	0.086
I have hope that the quality of life will get better	**0.850**	-0.008
I like to think about future farming opportunities	**0.836**	0.015
I have a very clear plan for my farm	**0.829**	-0.111
I enjoy new challenges and opportunities	**0.779**	0.138
When there are obstacles, I keep on trying to accomplish what I need	**0.844**	-0.139
I would not be farming if I had an alternative source of income	0.285	**0.544**
I am willing to take more risks than other farmers in my community	**0.592**	**0.621**
I am willing to forgo a profit opportunity in the short-run in order to benefit from potential profits in the long-run	-0.070	**-0.847**
I look for things that need to be done in the scheme / farming	**0.749**	-0.212
I am hopeful regarding the future of agriculture in my area	**0.884**	-0.129
I feel confident that I will succeed in farming	**0.830**	-0.182
Eigen Value	**6.424**	**1.551**
% of variance explained	**54%**	**13%**

Source: Own survey (2015)

PC_1 represents a farmer who has a positive psychological capital towards farming as a means of maintaining household livelihoods. The negative sign of the first variable (PC_1) is emanating from the way the variable was measured on a Likert scale, *i.e.* where farmers had to choose between very high, high, neutral, low and very low. Thus, the results indicate that positive psychological capital is decreasing with decreasing state of confidence. Farmers who are hopeful about farming as a means of sustainable livelihoods will be motivated to achieve success in spite of any hindrances and will be more committed to exert more effort in farming. According to Snyder (2002), hope helps to protect individual perceptions of vulnerability, uncontrollability and unpredictability as smallholder agriculture is highly susceptible to these calamities, owing to its nature dependence. Moreover, PC_1 captures a farmer who is confident and does not give up easily when there are obstacles but keeps on trying to accomplish the goals set. This farmer is always thinking ahead to take advantage of future opportunities and willing to take risks to achieve the plans for the future. Overall, PC_1 represents a farmer who is an optimist, hopeful, resilient and confident about the future prospect of making a living out of farming. PC_2 represents a farmer who does not have an interest in farming or has little hope that farming can be a means of sustainable livelihoods since he or she would not be farming given other means of living. Therefore, PC_1 was then used in a general linear model because it captures most of the attributes and pillars of positive psychological capital.

5.6.2 General linear model results and discussion

To make informed decisions, reliable estimates of water value are crucial for investment decisions in water resources development, policy decisions on sustainable water use and water allocation (Hussain *et al.,* 2007). Moreover, the knowledge about irrigation water values and factors influencing variability can provide indications about the soundness of the large government investments in the sector (Al-Karablieh *et al.,* 2012), which is the case in South Africa for small-scale irrigation schemes. Therefore, factors affecting the implicit irrigation water values were investigated to help policy makers and farmers on where interventions can be best made to further increase water productivity. As noted in Section 5.4, the water values estimated do not exactly measure the Rand value of water, in terms of its contribution to the values of crop products considered. However, while the average value of water has to be cautiously interpreted, as noted in Section 5.4, the regression results are not severely affected.

Table 5.9 below presents the results of the factors influencing irrigation water values. Partial eta squared was used to determine how big the effect of an independent variable is, controlling for all the other independent variables. Effect size or marginal effect allows a researcher to communicate the practical significance of the results rather than only reporting statistical significance (Laken, 2004). Partial eta squared values are preferred since they represent the variation attributable to an effect after correcting for any other effects in the model (Speelman, 2008). Multicollinearity was tested using variance inflation factor (VIF) for variables included in the model. The results suggest that multicollinearity was not a problem since VIF mean value (1.4508) was far lower than the threshold (Gujarati and Potter 2005).

The variables included in the GLM model explain 58% of the variability in water values. According to the regression results, variation in water values in the study areas is mainly influenced by the type of farmer (scheme or independent irrigators, home gardeners or community gardeners), the main occupation of the farmer, irrigation technology, and a number of years of experience in farming, marital status and the psychological capital index.

Table 5.9 Factors affecting water values (n=118)

	DF	**F**	**Sig.**	**Partial Eta Squared**
Intercept	1	8.528***	0.004	0.079
TYPE_FARMER	3	3.283**	0.024	0.09
IRR_TECH	3	4.047***	0.009	0.108
NUMBER_CROPS	1	2.129	0.148	0.021
EXP_FARMING	1	2.900*	0.092	0.028
EDUCATION	2	1.665	0.2	0.016
OCCUPATION	5	22.037***	0.000	0.524
MART_STATUS	1	5.448***	0.006	0.098
PSYCHO_INDEX	1	3.093*	0.082	0.03
Error	100			
Total	118			
Corrected Model	17	8.109	0.00	0.580
Corrected Total	117			
R-Squared	0.58			
Adjusted R-Squared	0.508			

Notes: ***, ** and * mean statistically significant at 1%, 5% and 10% levels, respectively. Partial Eta squared calculated here is based on the marginal sums of squares (type III).

The results indicate that occupation of a farmer (OCCUPATION) is highly significant at 1% and has the largest effect, accounting for 52% of the variability in the water values in the study.

This is based on the fact that full-time farmers devote more time and exert more effort in farming and are always available to attend training, workshops and farmers' days, platforms to exchange and share knowledge and experiences on farming (new agricultural technology, input and product prices, production and marketing opportunities).Investment in new knowledge and skills is required to enhance production and productivity.

Irrigation technology (IRR_TECH) is highly significant at 1% with an F-value of 4.047. It contributes about 11% of the variability in water value. This is because farmers use different technologies of which sprinklers are more efficient compared to the low-efficiency technologies like flood irrigation, hosepipe and bucket system. These results are in contrast to Speelman (2008) who found that irrigation technology was not significant and only accounted for 0.2% to the variation in the water value. This was because irrigation technology used were uniform within a scheme and only four farmers used sprinkler irrigation. However, a study by Al-Karablieh *et al.* (2012) in Jordan, estimating the economic value of irrigation water, revealed a high level of variability in irrigation water values. This was mainly attributed to the characteristics of the irrigation system used and the types of crops grown. The study results also found that irrigation system or technology used is important in determining irrigation water values among types of farmers.

The type of farmer (TYPE_FARMER) is statistically significant at 5% and accounts for 9% in explaining the variation in water values. The type of farmer signifies the characteristics of each group such as the size of land operated, institutions governing them, the source of water for irrigation *etc*. In this study, it was noted that scheme and independent irrigators operate bigger plots which enable them to produce more quantity. Operating larger plots is beneficial in increasing chances of market access because farmers are able to supply in larger quantities. Well-functioning markets directly determine the market value of marketable surplus and farm productivity as they affect the profitability of farming, outlets, and input access and they help farmers acquire and use improved inputs and profitably sell outputs which directly increase water values. The government has been implementing programmes aimed at increasing small-scale agricultural productivity through the provision of inputs, mechanization and other support services (Mudhara, 2010). However, the results from focus group discussions indicated that scheme irrigators are getting more support compared to non-scheme irrigators because they work as co-operatives compared to those who farm as individuals. It is relatively easy for them to get support as they are registered co-operatives. This creates variation in water values among farmers because non-scheme irrigators end up applying low agro-chemicals, which reduces yield and delays the planting period due to lack of resources. Moreover, in the irrigation scheme, extension officers always collect soil samples before planting to recommend inputs required such, as lime for controlling soil acidity, which improves the soil quality. However, non-scheme irrigators do not usually take soil samples and because of limited knowledge about the status of their soils, they end up using fertilizer that is not suitable for their soil. Hence, high support received by scheme irrigators improves water productivity compared to other types of farmers. Thus, farmers' typology influences the level of productivity.

Marital status (MARIT_STATUS) is highly significant at 1% and contributes about 9.8% of the variability in water value. This is because farmers who are married tend to have larger household sizes and hence have better access to family labour. Chowdhury (2013), in his study on relative efficiency of hired and family labour in Bangladesh, indicated that family labour generates higher marginal product compared to hired labour because family labour is more motivated and needs less supervision as they have the incentive to exert the necessary effort as they are, in a way, shareholders of the farm business. However, hired labour performs better under supervision, but transaction cost of supervision increases, making farm production based on hired labour more expensive, which directly increases the cost of production and reduces gross margins which lead to low water values. Moreover, Yokwe (2002) noted that hired labour shows a negative effect on output because family members working on a plot are more likely to be knowledgeable about their farming operations than hired labour.

Years of farming experience (EXP_FARMING) is significant at 10% and accounts for 2.8% of the variability in water values. More years of farming experience indicates that a farmer is more knowledgeable about farming operations received through training and lessons learnt through years of farming practice. Al-Karablieh *et al.* (2012) investigated the economic value of irrigation water in Jordan and the results revealed that farmers' current decisions are subject to the results of past decisions and past events such that decisions can be either extensive (land devoted to a crop) or intensive (application of fertilizers and other agro-chemicals). Hence, the experience is used as a pathway which will lead to success because farmers possess more skills on how to tackle different challenges in farming. Muchara (2015) used age as a proxy for farming experience and the results indicated that age only accounted for 0.8% in water variation.

The psychological capital index (PSYCHO_INDEX) is significant at 10% and accounts for 3% of the variability in water value. Given the prevailing constraints and available resource and capability endowments, a farmer who has positive psychological capital will perceive challenges as manageable and see setbacks as challenges and opportunities that can eventually lead to success (Luthans *et al*., 2007). Skills received through training build farmers' confidence toward farming. Extension officers mentioned that lack of market access is now highly linked to the mindset of farmers since after signing a contract with certain buyers, farmers fail to meet their obligations to supply accordingly by selling some produce to hawkers because they want to receive cash immediately and hence opt to sell at lower prices which directly lead to lower water values. Moreover, some farmers end up selling part of their fertilizer to others and apply lower rates than recommended, resulting in lower yields. Hence, farmers are expected to try and exert extra effort, be committed to succeed in spite of the prevailing challenges to enhance productive use of water.

5.7 **Summary**

The objective of this chapter was to evaluate water productivity and value per crop using gross margin analysis and the residual valuation method. The range of crops that farmers grow is widely diversified but cabbage and tomatoes are the most important in terms of income generation. The results showed that the main component of variable cost in small scale farming is labour for almost all crops. While most farmers were making positive gross margins, others had negative gross margins mainly due to high labour cost per hectare compared to area planted. The results reveal that there is a relatively low level of use of agricultural inputs such as fertilizer and pesticides. This may be attributed to unaffordability of these inputs and poor distribution channels in rural areas. Moreover, it was noted that lack of knowledge about the optimal application rate of the inputs is a major problem. Hence, low use of inputs limits farmers' capacity to achieve higher yields and earn better gross margins.

Scheme irrigators had the overall highest gross margin and returns to water value because of the irrigation system they are using. According to Yokwe (2004), water productivity is relatively better in irrigated crops using a sprinkler system. The variation in water values may also be ascribed to lack of proper marketing channels for smallholder farmers as they are receiving low prices. Cabbage presents a lucrative enterprise for scheme irrigators while tomato is more profitable for independent irrigators, community and home gardeners. The results further revealed that as farmers over-irrigate and continue to add more water per hectare, water values decrease which accords with the law of diminishing marginal returns.

The results showed the majority of scheme irrigators suffer from economic water scarcity and in Makhathini, some co-operatives are faced with physical water scarcity due to the location of their plots (those at the tail) where some farmers ended up not being able to irrigate their plots when those co-operatives allocated at the head are irrigating. Moreover, independent irrigators, home and community gardeners face physical water scarcity as their farming operation is highly dependent on the amount of rainfall in that season and this, in turn, determines the amount of water in dams. Small-scale farmers still need support in order to increase overall performance especially in marketing their products.The results indicated that socio-economic factors (such as farmers' occupation, experience in farming, marital status and psychological capital) determine variability in water values. However, only three factors are related to policy and agricultural extension practice: type of farmer, type of irrigation technology and psychological capital. Farming as the main occupation was found to have the largest effect on a variation in water values compared to the other variables included in the model. The next chapter provides conclusions and policy/management implications of the dissertation.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Recap of the research objectives and methodology

The general objective of the study was to evaluate the economic performance and water use productivity of small-scale irrigation farmers in Makhathini and Ndumo areas. To make informed decisions, reliable estimates of water values are crucial for investment decisions in water resources development, policy decisions on sustainable water use and water allocation decisions on-farm. Moreover, the knowledge about irrigation water values and factors influencing variability can provide indications about the soundness of the large government investments in the sector. With this background, the specific objectives include (1) to investigate water productivity and value of crops per type of farmer; and (2) to investigate factors affecting water values.

In this study, it is argued that the physical, human, financial, social and natural are not adequate in explaining the weak performance of small scale farmers in terms of productivity. Hence, a new form of capital (psychological capital) has been integrated into the sustainable livelihood framework to explain variation in water productivity and value. The inclusion of this form of capital makes this study unique compared to similar studies in the past. The analytical and empirical approaches employed in the study to achieve the above-mentioned objectives were descriptive statistics, gross margin analysis, Residual Valuation Method (RVM), Principal Component Analysis (PCA) and General Linear Model (GLM). Primary data on water applied were collected using rain gauge in the irrigation schemes for sprinkler systems and secondary data were generated using the CROPWAT model for computing crop water requirements. This chapter presents the main conclusions and recommendations of the study based on the empirical results.

6.2 Conclusions and recommendations

The empirical results indicated that the water values for scheme irrigators were higher than the dependent irrigators, home and community gardeners, implying that the economic performance of scheme irrigators is better. This can be attributed to reduced transaction costs due to economies of scale obtained from transacting through cooperatives. More importantly, the results from focus group discussions indicate that scheme irrigators receive more support in terms of training, funds, input procurements and market access which have a direct positive effect on water values. Scheme irrigators typically possess better capital assets that are vital in following different livelihood strategies. Among others, scheme irrigators use an irrigation technology (sprinklers) which is more efficient and time saving compared to bucket system, hosepipe and flood irrigation used by non-scheme irrigators.

These results show the importance of institutional arrangements in the efficient utilization of water among small-scale farmers. Farmers that are more organized and structured in such a way that they can benefit from economies of scale and institutional support tend to have higher water productivity. The SLF stresses the importance of institutional arrangements and collective bargaining in improving the livelihoods of farmers. Organized farmers have a stronger voice in price negotiations in the input and output markets resulting in reduced cost and increased profits. It can be recommended that home gardeners, community gardeners and independent irrigators should be organized in a similar way to scheme irrigators to increase their water productivity. This can be done through the transformation and integration of the three typologies of farmers into small-scale irrigation schemes. The study results can be used to build a case for this transformation. This process should be accompanied by the promotion of own entrepreneurship among small-scale farmers through the operation of small farms as businesses. Farmers need training on the importance of farm record keeping and distinguishing farming and family operations. These are the pre-requisites to run small farms as businesses and enable farmers to use irrigation water productively and produce a marketable surplus. Mjindi Farming should also continuously monitor the quality of products and timeliness of inputs supplied by tender holders.

The empirical results indicated that irrigation performance of scheme irrigators is relatively low compared to CROPWAT 8.0 crop water requirements. Analysis based on actual water applied revealed that scheme irrigators in Ndumo B are over-irrigating for all crops grown while Makhathini farmers are only over-irrigating for beans and under-irrigating for other crops. Under-irrigation in Makhathini is a result of physical and economic water scarcity due to irrigation infrastructure that is no longer working as the canal has areas that are leaking substantial volumes of water, hence affecting tail-end farmers. Furthermore, some pipes and sprinklers were not working efficiently as expected and the uniformity of water application was negatively affected. While there is Mjindi Farming as an independent arbitrator on water use in Makhathini, there is no such institutional arrangement in Ndumo B. Farmers in Ndumo B manage their own water use and the water control system is weak, making the resource seemingly in abundance and artificially cheap. In addition, lack of knowledge on crop water requirements contributes to under or over irrigation in both schemes.

It is recommended that Mjindi Farming should monitor water use through installing water metering devices so that farmers can irrigate responsibly. Farmers can then pay an annual fee for using metering devices to cover up for maintenance cost; hence, scarce water can be saved and used more productively. Moreover, training on collective management of irrigation water use and crop water requirements is recommended. It is also recommended that Mjindi Farming has to tighten up its monitoring services and rules at Makhathini (e.g. establishing social sanctions), as it was noticed frequently that many farmers free-ride at the expense of others by stealing water from the canal. Furthermore, the leaking canal has to be fixed as it creates physical water scarcity to end-tail farmers.

Farmers' occupation and type of irrigation technology greatly influence water values compared to other factors. This was attributed to the fact that full-time farmers devote more time in farming, attend most training even at short notices, and are more willing to learn and adopt new farming techniques and practices. Moreover, it was noted that elderly and uneducated farmers dominate, indicating the deteriorating labour productivity, output and motivation to adopt innovative technologies that can increase overall water productivity. To ensure sustainable agricultural farming, the youth needs to be encouraged to join farming as they are better educated, innovative and willing to learn. It is, therefore, recommended that government and other stakeholders continue to support farmers through tailor-made training activities to enhance human capital.

The results indicated that farmers who possess positive psychological capital were more persistent and productive despite prevailing constraints and challenges (such as market access). It was noted, however, that the majority of farmers had less confidence in themselves (endowments and capabilities) because over time they have developed a dependency syndrome, expecting that government has to do everything for them. This reduces self-confidence of small-scale farmers, depletes positive psychological capital and hinders their potential to become large commercial farmers. It is recommended that government should re-visit the modalities of the 100% financial support or farming support and let farmers contributes towards the financial capital in order for them to show commitment to farming. Furthermore, it is recommended that platforms with successful farmers should be created for experience sharing and motivating them which will change their negative mind-set and reduce the dependency syndrome to achieve the objectives of transforming homestead gardening and small scale subsistent farming to potential small-scale commercial farming. It is also recommended that farmers should have mentors, where experienced, established, industrious and resourceful farmers mentor young farmers. The mentorship program in other areas of South Africa has to be implemented in and around the small-scale irrigation schemes.

6.3 Areas for further research

Due to time and resource constraints, this study had to depend on data collected for only one season. The results would have been more robust if the study was conducted in more than one season in order to compare water productivity during various seasons in the year. Moreover, the study results would have been more informative if the sample size was larger and if data were collected in the province from various small scale farmers. Furthermore, the water value estimates would have been more informative if data on overhead costs were included such as land and management. Thus, further research on testing the residual valuation method with more data on other inputs, not captured in this study, is recommended. To check the robustness of the residual value estimates, future studies can estimate water values using other methods such as a production function approach and choice experiments.

Furthermore, if remote sensing was used to collect primary data rather than using a rain gauge, water measurement would have been more reliable. If water was measured from all farmer typologies, it would have been possible to make complete comparisons. Further studies will be required on how psychological capital impacts water productivity of small-scale farmers to get more insights relevant for farmers, government, and other stakeholders in the small scale irrigation scheme sector.

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APPENDICES

A. The household questionnaire

University of KwaZulu- Natal

The information to be captured in this questionnaire is strictly confidential and will be used for research purposes by staff and students at the University of KwaZulu-Natal to examine **sources of livelihoods and opportunities to improve contribution by farming within available food value chains on the selected irrigation schemes.** There is no wrong or right answers to these questions .You are free to be or not part of this survey.

Would you like to participate in this survey? 1 = Yes 2 = No

Date		Farmer ID*	
Village name		Ward No.	
Irrigation scheme		Type of farmer	
Questionnaire code		Enumerator	

**Farmer code: 1-Scheme irrigators 2-independent irrigators 3-home gardeners 4- community gardens (specify name____) 5-non irrigators*

A. HOUSEHOLD DEMOGRAPHICS

1. What is the total number of your household members?

____

Please complete table below *Record household head*details in the first row*).

Household member	Relationship to household head[1]	Age	Sex[2]	Marital status[3]	Level of education *(indicate level reached)*	Main occupation[5]	Availability in the household for family labour (*Days per week*). If zero, please indicate (*i.e.* sickness)
2	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	1						
	2						

Key

Relation to household head[1]	**Age**[2]	**Marital status**[3]	**Main occupation**[5]	
1=Household head 2=Spouse 3=Daughter /son 4=Other (specify e.g., cousin)	1=Male 0=Female	1=Single 2=Married 3=Divorced 4=Widowed	1=Fulltime farmer 2=Regular salaried job 3=Temporary job 4=Unemployed 5=Self-employed 6=Student	7=Retired 8=Aged/permanently sick 9=Infant(under age) 10=Other (specify)

* *Household head refers to the household head that stays in the household for 4 or more days per week*

10. How many years of experience in farming do you have? ____

11. What kinds of knowledge have you acquired (inherited) over the years from other farmers, your own experience and from your forefathers?

Have you ever taken training/education related to irrigation listed below?

Skills	**12.** 1=Yes 0=No	**13.** If Yes, who offered the training?
a. General crop/vegetable production		
b. Land preparation		
c. Fertiliser application		
d. Herbicide application		
e. General irrigation practices		
f. Irrigation scheduling		
g. Irrigation water management		
h. Agricultural commodity marketing		
i. Packaging of fresh produce		
j. Processing of farm produce		
k. Pricing of products		
l. If other (please specify)		

Complete table below and indicate extent to which you agree with the following statements

Statement	**14.** Indicate extent to which you agree with the statement
a. I attend all training sessions that are held in Makhathini/Ndumo B	
b. I fully understand the information provided in the training sessions	
c. I am able to put into practice all the advice I receive from the training	

1= Strongly agree 2= Disagree 3= Neutral 4= Agree 5 = strongly agree

B. FARMING IMPLEMENTS, INFRASTRUCTURE AND OTHER HOUSEHOLD ASSETS

Infrastructure	**1.** Are you satisfied with the state of the following infrastructure in your farming area?
a. Road accessibility	
b. Markets	
c. Electricity	
d. Agricultural water supply	
e. Drinking water supply	
f. Drinking water supply	

1=Strongly dissatisfied 2=Dissatisfied 3=Neutral 4=Satisfied 5=Strongly satisfied

Complete following table on ownership and access to assets

Assets	**2.** Own the asset as individual 1=Yes 0=No	**3.** Own the asset as a group 1=Yes 0=No	**4.** Current value per unit (R)	**5.** Have access to asset through hiring and borrowing?
a. Cell phone				
b. Radio				
c. Television				
d. Personal computer				
e. Block , tile house				
f. Block, zinc house				
g. Block, thatch house				
h. Round pole and mud or shack				
i. Fridge/freezer				
j. Bicycle				
k. Motorbike				
l. Trailer/cart				

Assets	**2.** Own the asset as individual 1=Yes 0=No	**3.** Own the asset as a group 1=Yes 0=No	**4.** Current value per unit (R)	**5.** Have access to asset through hiring and borrowing?
m. Water tank				
n. Motor vehicle in running order				
o. Generator				
p. Plough				
q. Planter, harrow or cultivator				
r. Wheelbarrow				
s. Tractor				
t. Other (specify)				

Complete table below on livestock ownership

Type of livestock	**6.** Number owned	**7.** Current value per unit (R)
a. Cows		
b. Calves		
c. Oxen		
d. Sheep		
e. Goats		
f. Domestic chickens		
g. Others (please specify)		

C. INCOME AND FINANCIAL STATUS

1. Are any of your household members receiving a government grant? 1=Yes 0= No

If yes complete the table below

Grant	**2.** Number of people receiving	**3.** Number of years receiving grant
a. Child grant		
b. Old persons grant		
c. Disability grant		
d. Foster child grant		
e. Care dependency grant		

Complete table below on sources of household income

	4. Source of income 1=Yes 0= No	**5.** Rank of income source (see codes below)	**6.** Estimate % of total household income
a. Remittances			
b. Arts and craft			
c. Permanent employment			
d. Temporary employment			
e. Welfare grant			
f. Crops - irrigated			
g. Crops – rain fed			
h. Livestock			
i. forestry			
j. fishing			
k. Other (please specify)			

Rank codes1. Always 2. Often 3. Sometimes 4. Rarely 5. Not at all

7. If Yes on 4h and/or 4i, do you pay fees to utilize these resources? 1=Yes 0 =No
8. Please specify amount and unit/duration. **Amount**............................**Unit/Duration**.......................................
9. If No, do you need permission to utilize these resources? 1=Yes 0 =No
10. Do you have any form of savings? 1=Yes 0 =No
11. If yes to **10 above,** which type of saving? 1=Formal 2= informal (i.e stokvela) 3=both

12. Have you ever taken credit or used any loan facility in the past 12 months? 1=Yes 0=No

13. If yes in what was the main source of credit/loan? 1= Relative or friend 2= Money Lender 3= Savings club (stokvel) 4= Input supplier 5=Output buyer 6= Financial institution (Specify name of institution…………………………………………………………...)

14. If No to **12 above,** please specify the reason(s) (multiple answers possible*)*1= The interest rate is high 2= I couldn't secure the collateral 3= I have got my own sufficient money 4= It isn't easily accessible 5= I am risk averse 6=other, please specify…………………………………………………………………………..

15. If you took credit or loan what was the purpose of the loan/credit? 1= Family emergency 2= Agricultural purposes 3= Other (specify……………………………………………………………………….)
16. Were you able to pay back the loan/credit in time? 1=Yes 0=No
17. Did you receive funding or any other sources of credit support from government in the past 12 months? 1=Yes 0=No

D. WATER AVAILABILITY AND IRRIGATION

Complete section for farmers in irrigation schemes and independent irrigators

	Questions		**Response**
1	How far away is your household to the irrigation scheme? (km)		
2	What type of irrigation system are you using for crop grown? 1=Sprinkler 2=Flood irrigation 3=bucket system 4=Center pivot 5=other please specify		
3	How is water pumped to reach your irrigation plot(s)? 1 = Gravity 2 = Electric pump 3 = Diesel pump 4-Hosepipe 5- Watering can/bucket, etc 6-Other (specify)…………………………		
4	How many functional sprinklers do you own?		
5	If you are a member of irrigation scheme, what is your position along the primary canal? 1 = Head 2 = Middle 3 = Tail		
6	What effect does your position in **5** have on you operation? 1. Very Positive 2. Positive 3. Neutral 4.Negative 5.Very Negative		
7	How do you rate water accessibility to your plot(s)? 1. Very Good 2. Good 3. Neutral 4. Bad 5.Very Bad		
8	Indicate months of the year when you are able to do irrigation, i.e., when water is available in the main canal?	1 - Jan 2 - Feb 3 - Mar 4 – Apr 5 – May 6 – June 7 – July 8 – Aug 9 – Sept 10 – Oct 11 – Nov 12-Dec	
9	On average how many days per week do you irrigate your crops? (indicate number) [__|__]		
10	What are the average irrigation hours per day (this week)?		
11	Amount paid for water fee during this season (Rand per year)		
12	How much are you willing to pay irrigation water for hectare of irrigated land? **A**. 600-800 **B.** 801-1000 **C**. 1001-1200 **D.** 1201-1400 **E.** 1401-1600 **F.** 1601-1800		
13	How do you feel about the water distribution schedule in general? 1 = Strongly satisfied 2 = Satisfied 3 = Neutral 4 = Dissatisfied 5 = Not satisfied		
14	Do you participate in the maintenance of the canals in the scheme? 1=Yes 0=No		
15	If Yes to 13**,** how do you contribute? 1= management 2=labour 3= funds contribution		

E. CROPPING PATTERNS AND AGRICULTURAL PRODUCTION

	Question		**Response**
1	Total size of land operated **(hectares)**?	Irrigated land	
		Rain-fed (dryland) land	
2	Of the irrigated land please indicate land area per means of ownership (in ha)	owned	
		leasing or renting	
		borrowed	
		received from the chief on a temporary basis	
		any other (please specify	
3	Of the rain fed please indicate land area per means of ownership (in ha)	owned	
		leasing or renting	
		borrowed	
		received from the chief on a temporary basis	
		any other (please specify	

4. Generally, are you satisfied with the present security of ownership of your own land?
a) Dryland……………………… b) Irrigated land…………………….. 1=Strongly dissatisfied 2=Dissatisfied 3=Neutral 4=Satisfied 5=Strongly satisfied
5. Do you find it difficult to make land use decisions due to the land tenure system? 1= Yes 0= No
7. If yes, please give details……
………..
6. Have you experienced any land dispute issues before? 1= Yes 0= No
7. If yes, please give details……

Did you experience the following natural hazards in the last production season? (Circle all applicable)

Natural hazard	**8.** How frequent have you experienced natural hazards in the last 10 years *1=never 2 =rarely 3=sometimes 4=often 5= never*	**9.** If experienced any hazard, what impact does this have on crop production
Drought		
Floods		
Hailstorm		
Floods		
Any other (please specify)		

10. How interested are you in farming perennial crops? Very interested =1 Interested=2 Neutral =3 Slightly interested=4 Not interested at all =5
11. What is the reason for your answer?____

Complete table below for all crops grown in the 2015

				Seed				Fertilizer (If not used, put Zero)				Manure	Herbicides		Pesticides			Oxen days	Total cost of hired oxen	Total cost of hiring tractor for ploughing
Crop grown **(Codes A)**	Day planted	Month planted	Area under production (hectares)	Amount of (Kg)	Variety of crop **(Code B)**	Main seed source **(Codes C)**	Total cost if bought(Rand)	Amount of basal fertilizer	Total costs of basal if bought (Rands)	Top dressing (Rands)	Total cost of top dressing if bought	Amount applied (Kg)	Litres	Total cost (Rand)	Did you use homemade 1-Yes 2-No	Litres (bought)	Total cost (Rand)	Total ploughing days		
12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**

Code A
1-Maize
2-Beans
3-Cabbage
4-sugercane
5-Carrot
6-Spinach
7-Butternut
8-Calabash
9-Pepper
10-Sweet potato
11-Tomato
12-Chillies
13-Other (specify)

Code B
1-Improved hybrid and/or OPVs
2-Unimproved/ recycled

Code C
1-Own saved (recycled)
2-Local agrodealers
2-Individual community members
3-Government (Department of Agriculture)
4-NGO
5-Contract farming agency
6-Cooperative
7- Other specify...................................

Complete table below for FAMILY LABOUR use for all crops produced in 2015

Crop grown (Code A)	Land preparation		Planting		Weeding		Fertilizer application n		Pest control		Mechanical control		In field fallow maintenance		Harvesting		Packaging		Marketing	
	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days	No of people	Number of days
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52

Complete table for HIRED LABOUR for all crops produced in 2015

Crop grown (Code A)	Land preparation			Planting			Weeding			Fertilizer application n			Pest control			Mechanical control			In field fallow maintenanc e			Harvesting			Packaging			Marketing		
	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day	No of people	Number of days	Cost per day
	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82

83. What are your average working time in hours for family labour in the field per day (this week)?__________________ hour per day

84. Are there periods in the production season when hired labour is not available? 1=Yes 2=No

85. If Yes, which months in the season is hired labour not available or difficult to find? 1= Dec-Mar 2= Apr –July 3= Aug-Nov

86. How much total cost is incurred by farmer for canal maintenance?____

87. How much total cost is incurred by farmer for pump maintenance?____

F. STORAGE FACILITIES

1. Do you have access to farm storage facilities for fresh produce within the scheme? 1=Yes 0 = No

2. Do you have access to storage facilities for long storage of produce like maize grain? 1 = Yes 0 = No

3. What type of storage do you have for grain produce?

1= house 2=granary 3= store in the open 3= spread on the floor 4=crib 5= Other (specify)

4. What type of storage do you have for vegetable produce? 1= shed 2= cold room 3= cool place 4= Other (specify)

5. What is the adequacy of fresh produce or long term storage facilities that the farmer has? 1=not adequate 2=neutral 3= moderately adequate 4=adequate 5 =very adequate

6. What do you use to preserve your produce before selling?

a. Grain produce?____

b. Vegetables/Tomatoes?____

G. MARKETING OF AGRICULTURAL PRODUCE

1. Generally, how would you rate your level of market access? 1=very poor 2=poor 3= average 4=good 5=very good

2. Compared to other farmers in the district, please rate to what extent do you agree with following statements.

Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5

a.	I receive poor prices	
b.	I often find it difficult to market and sell my products	
c.	I often find it difficult to access market information	
d.	I have established networks or contacts to market my products	

3. To what extent do you consider the following as constraints to your farming operations?

Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5

a.	Lack of access to inputs (fixed and variable inputs)	
b.	Large (unaffordable) increase in input prices	
c.	Production shortfall below normal	
d.	Market price decline for outputs sold	
e.	Market price increase for purchased food	
f.	If any other please specify_______________________________________	

4. Have you ever failed to sell your produce due to lack of buyers? 1=Yes 0=No

5. If yes, how often do you fail to sell your farm produce due to lack of market?

1= Never 2= Occasionally 3= Sometimes 4= Often 5= Always

6. What is the distance from your homestead to the nearest road? _________________Minutes

7. What alternative mechanisms are there for you to transport your produce to the selling points?____
____.

H. SOCIAL CAPITAL

1. Are you a member of any agricultural cooperative / group? 1=Yes 0 = No
2. If Yes, please specify the name of co-op
____
3. In what form do you practice farming? 1= As an individual OR household 2 = As member of informal group 3= As member of cooperative 4= other (please specify) _____________________________

4. Can you rank the following sources of information relevant for your farming activities, based on how you have used them in the past year (e.g. where to sell, market prices, *etc*.)
1. Have never used the source 2. Don't know /Neutral 3. Not important 4. Important 5. Very important

Information Source	**5.** Rank of source of information
a. Extension officers	
b. Media (newspapers, radio, TV)	
c. Internet (emails, websites, etc)	
d. Fellow farmers	
e. Community meetings	
f. Irrigation / Scheme committees	
g. Cooperative leaders	
h. Traditional leaders	
i. Non-governmental organizations (NGOs)	
j. Private organizations	
k. Phone (sms, text)	
l. Other (Please specify)	

6. How difficult is it to access agricultural information? 1= Very easy 2= Easy 3= Neutral 4= Difficult 5= Very difficult

Complete table below indicating whether the activity is done as a group

	7. Which activities do you do in groups? 0= Not at all 1= at times 2= regularly
a. Land preparation	
b. Planting	
c. Weeding	
d. Irrigation	
e. Harvesting	
f. Securing output market for commodities	
g. Hiring of transport for marketing	
h. Hiring of tractors/machinery for agricultural activities	
i. Marketing of agricultural produce	
j. Input procurement	
k. Negotiating market prices for the produce	
l. Canal maintenance	
m. Pump maintenance	
n. Any other (please specify)	

8. How often do disputes occur among farmers or between blocks on water issues?
1= Very Often 2= Often 3= Neutral 4= Occasionally 5= Never
9. Where do you report problems with the canal? 1=Department of Agriculture 2= Block Committee
3= Other (please specify)…………………………………………………………………………

I. PSYCHOLOGICAL CAPITAL AND ENTREPRENEURIAL CHARACTERISTICS

1. What is your main reason for farming? 1=Income 2=Extra food 3= Leisure time 4=Employment 5=Other_______________

2. You consider farming as a business and can be managed as such**?** 1= Strongly agree 2= Agree 3= Neutral 4=Disagree 5= Strongly disagree

3. Do you distinguish (separate) your farming operations from family operations? 1. Always 2. Often 3. Sometimes 4. Rarely 5. Not at all
4a. You are interested in expanding your farming operations (including increasing plots) 1= Strongly agree 2= Agree 3= Neutral 4=Disagree 5 = Strongly disagree

4b. If disagree or strongly disagree, what are the factors holding you up?____
____

5.Do you see yourself as a potential commercial farmer one day? 1=Yes 0=No

6. You feel confident to contribute to discussions about the irrigation scheme strategy 1= Strongly agree 2= Agree 3= Neutral 4=Disagree 5 = Strongly disagree
7. How satisfied are you with the performance of the scheme? 1=Very satisfied 2=Satisfied 3= Neutral 4= Dissatisfied 5= Very Dissatisfied

8. How interested are you in being a scheme committee member? 1= Very interested 2= Interested 3=Neutral 4= Slightly disinterested 5= Not interested at all
9. How interested are you in taking part in training in collective management of irrigation scheme?1= Very interested 2= Interested 3=Neutral 4= Slightly disinterested 5= Not interested at all
10. How high is your confidence in farming as a means to a sustainable livelihood? 1 =Very high 2= High 3= Neutral 4= Low 5= Very low
11. How high is your confidence in yourself as a farmer? 1 =Very high 2= High 3= Neutral 4= Low 5= Very low

13. In your opinion, who should pay for water services? 1= No one, government only 2= Everyone participating in irrigation schemes 3= Only those irrigating a lot 4= Only those that are making more money
14. Please indicate the extent to which you agree with following statements pertaining to your constraints to farming operations? Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5

a. lack of access to inputs	
b. large unaffordable increase in input prices	
c. production below normal	
d. declining market prices for outputs	
e. increasing food prices	
f. land tenure not secure	
g. no enough land	
h. local and political conflict	
i. lack of support services	
j. high pump and maintenance cost	
k. Water availability	
l. Other (specify)	

15. **Iffarmer is not in an irrigation scheme**, is the farmer willing to join an irrigation scheme if the opportunity arises? Yes=1 No= 0

16. If No to **15**, please give reasons?
____
____
17. If Yes to **15**, would you like to irrigate individually =1 or collectively =2
18. What are the reasons for your answer?____
19. If farmer is not irrigating, please rate the extent to which you agree for the reasons why you are not irrigating: Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5

m. Irrigation system is under construction	
n. There is no water source	
o. Irrigation scheme is far away from my plots	

p.	I produce only for the household	
q.	I can’t pay (financial constraint)	
r.	Other (specify)	

20. If farmer is an independent irrigator, please rate the extent to which you agree with the following reason(s) for irrigating independently: Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5

a.	There are no available plots in irrigation schemes	
b.	There is a lot of red tape involved in land allocation in irrigation schemes (e.g. waiting list)	
c.	Being a member of an irrigation scheme deprives one of individual decision-making powers	
d.	Being a member in a group of farmers limits members' flexibility in terms of irrigation.	
e.	Irrigation schemes are too far from homestead	
f.	There is a lot of free riding in collective irrigation schemes	
g.	Water theft is a major concern for irrigation schemes managed collectively	
h.	Lack of enforceable rules in collectively managed irrigation schemes is a challenge	
i.	Other (specify)	

21. If farmer is a home gardener, please rate the extent to which they agree with the following reasons for sticking to home gardening: Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5

a.	Lack of farming experience	
b.	Shortage of finance	
c.	Shortages of resources (land and other nonfinancial resources)	
d.	Land tenure issues	
e.	Other (specify)	

Household Crop Marketing Questionnaire

University of KwaZulu- Natal & WATER RESEARCH COMMISSION

The information to be captured in this questionnaire is strictly confidential and will be used for research purposes by staff and students at the University of KwaZulu-Natal to examine **sources of livelihoods and opportunities to improve contribution by farming within available food value chains on the selected irrigation schemes.** There is no wrong or right answers to these questions .You are free to be or not part of this survey.

Would you like to participate in this survey? Yes____________ No_____________

Date		Farmer ID*	
Village name		Ward No.	
Irrigation scheme		Type of farmer	
Questionnaire code		Enumerator	

**Farmer code: 1-Scheme irrigators 2-independent irrigators 3-home gardeners 4- community gardens (specify name___________________________) 5-non irrigators*

J. MARKETING OF AGRICULTURAL PRODUCE

Complete table for crops grown in the 2014/2015 production season

Crops **(Code A)**	Output produced (indicate unit) (kg)	Quantity sold (kg) this season	Given as gifts to others (kg) this season	Output used as seed (kg)	Output consumed (kg) from this season production	If sold, what was your main markets (indicate at most 2 major ones) **Code B**	Walking distance to 1st major market (minutes) *Farmgate=0*	Walking distance to 2nd major market (minutes) *Farmgate=0*	Are these the preferred markets *1-Yes 2-No*	Reason for selling in the indicated markets **Code C**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Code A 1-Maize 2-Beans 3-Cabbage 4-sugercane 5-Carrot 6-Spinach 7-Butternut 8-Calabash 9-Pepper 10-Sweet potato 11-Tomato 12-Chillies 13-Other (specify)……………………………………………………………….
Code B 1-Farm gate; 2 = Hawkers 3= Local shops 4 = Shops in town; 3 = Contractors; Roadside 5 = small informal agro-dealer 6= large agro-dealers 6= Others (Please specify)………..........................
Code C 1- Only market available 2- Low quality 3-Have a contract 3-Better prices 4- Good markets are far away 5-Don't have transport 6-other (specify)……………………………………………………………………

For crops sold as shown in table above, please indicate the price for each output per unit in Rand

Crops **(Code A)**	Unit of output	Time of selling **Code D**	Price/ unit peak	Price/ unit off season	Total Revenue		Did you know the price prior to going to the market *1-Yes, 2-No*	Source of market price information **Code E**	Days taken to sell crop in the market? **Code F**
					Peak	Off			
	11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**

Code D 1-Immediate after harvest (within one week) 2- between 2-4 weeks 3- between 5-12 weeks 4-more than 12 weeks
Code E 1-Radio 2-TV 3-Dept of Agriculture Extension Officer 4-Fellow farmer 5-Cooperative 6-NGO 7-Contracting agency 8-Hawker 9-Other (specify)___________________________
Code F 1= up to 1 day 2= 2-3 days 3= 4-5 days 4= more than 5 day

For crops sold this season as shown in table above, please indicate actual marketing and other cost incurred per crop in Rand

Crops **(Code A)**	Transport of produce to market (include fares and transport hire)	Cost of materials (e.g. bags)	Other costs (specify)
	20	**21**	**22**

23. Did you sell some of your produce collectively or as a group? 1= Yes 0= No

24. If you sell your produce collectively, how much money do you pay as subscriptions for you to sell through the group or cooperative?

a) Frequency of payment 1= once off payment per season 2= monthly 3= yearly 4= other (specify)____

b) Amount (Rand)____

25. How much do you pay for your tv/ radio licenses per year? ____

26. How many days do you spend negotiating with traders for selling of your crops? 1= anything up to a day 2= 1-3 days 3= 4-7 days 4= 8-11 days 5= 12-14 times 6= above two weeks

27. Did you spend time looking for price information prior to selling? 1= Yes 0= No

28. How are your predictions of crop prices compared to the final selling price? 1= always lower 2= often lower 3= equal 4= often higher 5= always higher

29. Is accessing transport to markets a problem? 1= no problem 2= minor problem 3= problem 4= significant problem 5= major problem

30. Is a fee payable to sell in local or urban markets? 1= Yes 0= No

31. If Yes, how much do you pay each time you visit the market? ____

32. How many times do you visit the market per year? 1= 1-2 times 2= 3-4 times 3= 5-6 times 4= 7-8 times 5= 9-10 times 6= above 10 times

33. Is the risk that the product/ produce will not be bought a problem? 1= no problem 2= minor problem 3= problem 4= significant problem 5= major problem

34. Do you sell some of your crop produce on credit? 1= Yes 0= No

35. If Yes, on average how many days does it take to get paid? 1=less than 30 days 2=30-59 days 3= 60-89 days 4= 90 and above

Do you do any value addition to the crops before selling and if yes what are the costs of value addition in Rands?

Crops **(Code A)**	Value addition *1-Yes 0-No*	Washing (Cost)	Packaging (Cost)	Shredding (Cost)	Drying (Cost)	Grading (Cost)	Other (specify) (Cost)
	36	**37**	**38**	**39**	**40**	**41**	**42**

B. Focus group discussion checklist

University of KwaZulu- Natal & WRC

The information to be captured from this discussion is strictly confidential and will be used for research purposes by staff and students at the University of KwaZulu-Natal to examine **water use productivity and its role in diversifying rural livelihood options: case studies from Ndumo B and Makhathini irrigation schemes, UMkhanyakude District, KwaZulu-Natal Province.**

Are you willing to participate in this study? Yes ____ No _________

FOCUS GROUP DISCUSSION AND KEY INFORMANT CHECKLIST QUESTIONS

1. What are the major sources of income for farmers in and outside the irrigation schemes?
2. How important is farming compared to other sources of income? 1=not important 2=neutral 3=moderately important 4=important 5=very important
3. Which farming enterprises or crops have significant contribution to the livelihoods of farmers?____
4. Which crops are working best (in terms of production and marketability) for farmers in the irrigation schemes ____
   and those outside of the scheme?____
5. What are the most important production constraints for the above mentioned crops?
   ____
   ____
6. What are the most important marketing constraints for the above mentioned crops?
   ____
   ____
7. Where do farmers access the different inputs required for producing the above crops?
   ____
   ____
8. Who are the major economic agents selling the inputs to farmers?__________________
   ____

9. How affordable are the inputs to the farmers in and outside the irrigation schemes?
   1=not affordable 2=neutral 3=moderately affordable 4=affordable 5=very affordable
10. What are the other major non-price constraints in accessing the inputs?________________
    ____
    How accessible is hired labour in and out of the irrigation schemes? 1=not accessible
    2=neutral 3=moderately accessible 4=accessible 5=very accessible
11. Are there any differences in hired labour availability depending on the time of the year? Yes ________ No _________
12. If Yes, which time of the year is labour abundantly available?_______________________
13. If Yes, which time of the year is labour scarce?___________________________________
14. Does variation in labour availability have an impact on the cost of hired labour?
    Yes _____ No ________
15. Does the wage rate vary across periods in a year? Yes _____ No ________
16. What are some of the natural hazards affecting farming that farmers often experience?
    ____
    ____
17. At what periods of the year do farmers experience such hazards?_____________________
18. What mitigation strategies are in place to assist farmers to cope with the effect of the hazards?____
    ____
19. How do farmers sell their produce? 1 = Individually? 2= Cooperatives or Associations? 3= Contracts?
20. Is there value addition that is done by farmers before they sell their produce?
    Yes ____ No ________ (Probe only for the major crops in question 4 above)
21. For the most important crops, what are the common marketing channels?
    a) Farmer – Consumer____
       ____
    b) Farmer – Middleman Including Hawker – Consumer____________________________
       ____
    c) Farmer – Retailer____
    d) Farmer – Wholesaler – Retailer – Consumer _________________________________
    e) Other Channels

22. a) Which channel does benefit the farmer the most?___________________________________

b) Why?____

23. Who are the major buyers and players involved in the selling/ marketing of major crops?

____

____

24. Do the prices offered by different buyers differ and why?_________________________
25. What are the prices of major crops offered by different buyers along the value chain?

____

____

26. What are the major marketing costs incurred by farmers in marketing their produce?

____

27. Are the costs significantly different across farmers? Why?_________________________

____

28. Are there markets where farmers would like to sell but cannot?__________________

____

29. Why are farmers failing to sell in their preferred markets?______________________

____

30. What do you think needs to be done to increase farmers' production output and income from the identified key crops on irrigation schemes and/ or outside of the scheme?

____

____

31. Are farmers interested to be part of a small scale irrigation scheme? Yes _____No______
32. If Yes, Why ____
33. If No, Why not? ____
34. If participation in irrigation farming means changing enterprise combination, are farmers prepared to do so? Yes _____ No _______

For scheme irrigators only

1. How much are farmers paying for water? _____________________________________
2. Are the fees paid monthly? Yearly? Or at what interval?

____

3. Are farmers charged based on the amount of water they use or a flat rate?

A. Amount of water used___________ **B.** Flat Rate_______________

4. If flat rate how are farmers over-irrigating monitored?____________________________

   ____

5. What are the farmers' opinions on the water charging system?______________________

   ____

6. Are most farmers willingly paying water fees? Yes ____ No _____
7. If No, why are some not paying?____
8. If No, what could make farmers not pay their water fees?_________________________

   ____

9. Do you know the purpose the fees are used?________________________

   ____

10. Are you aware of the process the fees are allocated to different purposes?

    ____

11. Who is responsible for maintenance of irrigation infrastructure in the scheme?_________

    ____

12. What is the farmers' contribution in the maintenance of irrigation infrastructure?

    ____

13. What is the water use/ sharing arrangement?___________________________________
14. Are there any conflicts that arise between farmers regarding water use/ sharing?

    Yes ________ No ___________

15. If Yes, what are those conflicts?____

    ____

16. What are the underlying common causes of such conflicts?_________________________

    ____

17. What is the source for water used for irrigation?_________________________________
18. What are the other major competing uses of water from the same source?_____________

    ____

19. Do farmers recognize that water is a scarce resource? Yes _______ No ________
20. If No, what do you think needs to be done so that farmers can realise that water is a scarce resource? ____