The contribution of smallholder irrigation farming to rural livelihoods and the determinants of benefit distribution: The case of Limpopo Province of South Africa

by

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Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Agricultural Economics)

in the

Department of Agricultural Economics, Extension and Rural Development
Faculty of Natural and Agricultural Sciences
University of Pretoria

Pretoria

South Africa

July 2016

DECLARATION

I declare that the thesis, which I hereby submit for the degree of Doctor of Philosophy in Agricultural Economics at the University of Pretoria, is my own work and has not previously been submitted by me to this or any other university.

Name: Thinah Moyo

Signed:…….

DEDICATION

To: Behluli, Nokunqoba, Nodumo and my parents

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to my supervisor, Prof. Charles L. Machethe, for his invaluable dedication, time and patience with which he handled the work to ensure that high quality was attained throughout the study.

I gratefully acknowledge financial support from the Water Research Commission (WRC) through the K5/2179 research project. The WRC covered all the expenses associated with my PhD studies and the production of this thesis.

My sincere gratitude to Prof. Wim van Averbeke and the Umhlaba Consulting team (Jonathan Denison and Chenai Murata) for their immense contribution to the data collection process, data management and throughout all the stages of the study.

Sincere thanks is extended to Prof. Johann Kirsten, Head of the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria, for his constant concern and support throughout the study. I am also grateful to all lecturers and service staff in the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria who contributed in various ways to the success of this work.

I would like to acknowledge numerous people whose names I have not mentioned here but are gratefully remembered: the data collection team, who faithfully dedicated their time to ensure good quality data and also the smallholder farmers in the surveyed villages who volunteered information, making it possible to accomplish this research. I am also indebted to some of my classmates, who provided invaluable advice and encouragement.

All this work wouldn't have been possible without God's permission and guidance; to Him be the glory.

All possible shortcomings that remain in this study are my sole responsibility and should not be directed at any of the acknowledged persons.

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ABSTRACT

Smallholder irrigation farming is potentially transformative to poor communities. Although previous studies have examined the relationship between smallholder irrigation farming and livelihoods in South Africa, little has been done to quantify the contribution and to examine how benefits from smallholder irrigation are distributed across different types of households. It is often assumed that the benefits flowing from irrigation farming will be distributed evenly among the irrigators. Furthermore, previous studies have focused on farmers operating on irrigation schemes to the exclusion of independent smallholder irrigation farmers.

This thesis aims to examine the contribution of smallholder irrigation farming to rural livelihoods in South Africa, specifically the contribution of smallholder irrigation farming to improved household income and food security as pathways out of poverty for rural households. The study provides a more comprehensive analysis of the impact of smallholder irrigation farming on rural livelihoods by including independent irrigators. Specifically, the study addresses the following questions: How has smallholder irrigation farming contributed to household income and food security in the study area? Are household income and food security significant pathways through which smallholder irrigation farming contributes to rural

livelihoods? To what extent does smallholder irrigation farming contribute to household income and food security? What factors determine benefit distribution among irrigators?

The study was conducted in Mopani district in the Greater Tzaneen municipality of Limpopo Province of South Africa in 2013. Julesburg irrigation scheme, located in the former Gazankulu and Lebowakgomo homelands, formed the anchor of the study area. Data were collected through a survey of 180 rural households, 27 of which were smallholder irrigation scheme farmers, 35 smallholder non-irrigation scheme farmers (independent irrigators), 53 smallholder farmers practising home gardening and 65 other households that included dryland farmers and those who did not practise farming. The households were selected from villages in the vicinity of the irrigation scheme. Farming households represented three groups of farmers, namely, scheme irrigators, independent irrigators and home gardeners. Data were collected through face-to-face interviews with the sampled households.

Data analysis employed econometric regression models, semi-parametric propensity score matching techniques and the analysis of variance to compare livelihood outcomes between irrigating and non-irrigating households. Irrigation was the treatment and non-irrigators were used as a control group for propensity score matching.

Results of the survey identified substantial differences in the capital base among home gardener, scheme and independent irrigator households. Households involved in irrigation farming had a stronger capital base in terms of natural, physical and financial capital. Differences in the capital base existed even if income flows from agriculture were not considered, suggesting that participation in irrigation farming positively affects the overall capital base of rural households.

The results also provide sufficient evidence that smallholder irrigation farming makes a significant contribution to rural livelihoods through its effect on household income and food security. Irrigators were found to have a significantly higher household income and were more food-secure than their non-irrigating counterparts, suggesting that smallholder irrigation contributed positively to rural livelihoods. This provides a strong motivation for continued

investment in smallholder irrigation farming in South Africa as part of a strategy to improve rural livelihoods and to grow the rural economy. However, the benefits from irrigation accrue unevenly for different types of farmers and, therefore, they are not equally successful. The main determinants of benefit distribution were: adequacy of source of water for farming, gender and marital status of the household head, ownership of transport means and access to financial services.

The contribution of smallholder irrigation to rural livelihoods can be further enhanced by focusing on policies that enhance female participation in irrigation farming, equip farmers with entrepreneurial skills, encourage membership of associations and enhance the effectiveness of the associations to allow more farmers to participate in irrigation farming. As independent irrigators benefit more from smallholder irrigation farming, independent irrigation should be promoted as an option for expanding smallholder irrigation farming. Such policies should be integrated into the overall strategy of growing the rural economy within the National Development Plan of the country.

Key words: smallholder farmer, irrigation, farming, poverty reduction, livelihoods, rural livelihoods, assets, propensity score matching, Limpopo, South Africa

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ACRONYMS

AfDB	African Development Bank
ADB	Asian Development Bank
ANOVA	Analysis of Variance
ATE	Average Treatment Effect
ATT	Average Treatment Effect on the Treated
CoE	Centre of Excellence
DFID	The Department for International Development
NDP	National Development Plan
PSM	Propensity Score Matching
PPS	Probability Propensity Scores
SANHANES	South African National Health and Nutrition Examination Survey
SLF	Sustainable Livelihoods Framework
WRC	Water Research Commission

CHAPTER 1

INTRODUCTION

1.1 Background

Irrigation farming has an important wealth-generating function, particularly in rural settings. Smallholder irrigation farming is an important factor in improving the lives of poor households and in determining opportunities for escaping poverty. In general, access to irrigation water allows farmers to increase production and incomes and to diversify income opportunities. This is because irrigation water makes possible the adoption of modern farming technologies (for example, seed, fertilizer and pesticides), which contributes to improved household welfare (Lipton *et al.*, 2001; Hussain *et al.*, 2003; Hussain & Hanjra, 2004). Regions with the largest proportion of irrigated land (for example East Asia, North Africa and the Middle East) have experienced a greater improvement in livelihoods than those depending on rainfall (Lipton *et al.*, 2001; Thirtle *et al.*, 2001; Lipton, 2005; Hanjra *et al.*, 2009a; Ghosh *et al.*, 2012). Also, Bacha *et al.* (2011) state that the incidence and severity of poverty is significantly lower for areas with access to irrigation. The largest production and highest incomes from irrigation schemes were therefore recorded in Asia and Latin America. Generally, little reduction in poverty has been experienced in Africa, partly because only three percent of cropland is under irrigation (McCartney *et al.*, 2010).

The importance of farming, however, is reflected in the large numbers of the world's poor who depend directly or indirectly on agriculture for their livelihood (International Water Management Institute [IWMI], 2001; Asian Development Bank [ADB], 2003). In South Africa, about 8.5 million people depend directly or indirectly on agriculture for their employment and income. Guided by government's New Growth Path, the agricultural sector has been identified as one of the sectors that have significant potential to create jobs (Economic Development Department, 2010). The New Growth Path targets job opportunities for 300 000 households in agricultural smallholder schemes and a further 145 000 jobs in agro-processing, which in turn will have the potential to upgrade conditions for 660 000 farm workers by 2020 (DAFF, 2012; Cousins, 2013). Smallholder irrigation farming, in particular, has played diverse roles in the livelihoods of farming households. These roles range from

smallholder irrigation farming being the primary livelihood activity to complementing livelihoods based on other activities (Van Averbeke & Mohamed, 2006; Water Research Commission, 2011). In South Africa, irrigation is seen as a crucial input into smallholder farming and therefore a potentially important poverty reduction strategy, although it is estimated that the amount of arable land under irrigation is about 1.3 million ha (Van der Stoep *et al.*, 2008; Department of Government Communication and Information System, 2015). Factors such as water scarcity, unevenly distributed low rainfall and large tracks of semi-arid to arid land make the provision of irrigation farming facilities necessary (Whyte, 1995; Oosthuizen, 2005). For that reason, smallholder irrigation schemes nationally continue to attract huge amounts of government investment annually (Denison & Manona, 2007). Irrigation revitalisation investment costs, in particular, ranged between R90 000 and R212 000 per hectare in 2012 for both capital and operation costs (Department of Agriculture, Forestry and Fisheries, 2012).

Irrigation development in South Africa has been extensive since the 1920s and revitalisation of irrigation schemes intensified in the 1990s (M'Marete, 2003; Department of Agriculture, Forestry and Fisheries, 2012; Johnston *et al.*, 2012). The Limpopo Province, in particular, undertook to revitalise smallholder irrigation schemes between 2001 and 2004 under the Revitalisation of Smallholder Irrigation Schemes Programme (Department of Agriculture, Forestry and Fisheries, 2012). Over time, the number of smallholder irrigation schemes in the country increased. In 2003, there were 287 smallholder irrigation schemes and 31 000 farmers, representing about 15% of the total smallholder population in South Africa (Gibb, 2008). The area occupied by smallholder irrigation schemes represented about 47% of the total smallholder irrigation area and about four percent of the total area under irrigation in 2006 (Backeberg, 2006). According to Van Averbeke *et al.* (2011), the number of smallholder irrigation schemes had risen to 302 by 2010, although about 34% were not operational. Of the current 1.3 million hectares of irrigated land, smallholder irrigation schemes represent about three percent (Department of Agriculture, Forestry and Fisheries, 2012; Department of Government Communication and Information System, 2015). The farming population on operational irrigation schemes (estimated at 34 158) is substantial in view of the total number of smallholder farmers in South Africa (Van Averbeke *et al.*, 2011).

Regardless of all government efforts, poverty has persisted in South Africa and the country has experienced a growing rural-urban divide since the 1990s (Department of Social Development, 2010; African Development Bank [AfDB] *et al.*, 2012; Stats SA, 2012). The share of South Africa's poor population living in rural areas stands at 70%, although less than 50% of the population live in rural areas (Armstrong *et al.*, 2008; Hérault & Thurlow, 2009; National Planning Commission, 2011). For a long time, Limpopo and the Eastern Cape Provinces lead the country as the poorest provinces, with 74% and 66% of their populations being poor, respectively (HSRC, 2012 & 2014; Stats SA, 2008 & 2012). Extreme poverty, coupled with hunger and malnutrition, continues to be a rural phenomenon, more so in developing economies (Chen & Ravallion, 2008; Kubzansky *et al.*, 2011; Burney & Naylor, 2012)[1].

Despite the high levels of poverty, progress in reducing poverty remains strong. Poverty reduction is a core policy agenda of the South African government and evidence has indicated that poverty is declining (Van der Berg *et al.*, 2005; Bhorat & Kanbur, 2006; Bhorat *et al.*, 2011; AfDB *et al.*, 2012). As a result of several interventions, including active government intervention in poverty reduction, the proportion of people living on less than US$2 per day has reduced from 48% in 2008 to 39% in 2011, which is, however, a high level of poverty for a middle income country (ReSAKSS, 2010; National Planning Commission (NPC), 2011). With these poverty reduction achievements, South Africa more than halved the population living in extreme poverty, thus meeting Millennium Development Goal 1.

The drop in poverty levels cannot be attributed to any one particular intervention. One of the important contributors to poverty reduction has been smallholder irrigation farming (FAO, 1996b; IWMI, 2000; Hussain & Hanjra, 2004; Ghosh *et al.*, 2012). Although water is only one element in the poverty equation, it plays an important role through its wide impact on factors such as food production, food security, the environment, etc. Several researchers have recognised the important role that water can play in poverty reduction (Asmal, 2001; Water Supply and Sanitation Collaborative Council, 2000; Lipton *et al.*, 2001). Within the water and poverty debate, agricultural water holds a unique place (Hussain *et al.*, 2003). Irrigation

[1]The World Bank defines extreme poverty as living on less than US$1.25/day (purchasing power parity) and moderate poverty as less than US$2/day.

water, like land, has been found to have an important wealth-generating function in agriculture, particularly in rural settings. For instance, in many countries, the incidence of chronic poverty is highest in areas without access to agricultural techniques such as irrigation (Lipton *et al.*, 2001; Thirtle *et al.*, 2001; Hanjra *et al.*, 2009a; Gosh *et al.*, 2012). Approximately 40% of the world's food production occurs on the 260 million hectares of irrigated land being farmed. In South Africa, irrigated agriculture contributes more than 30% of the gross value of the country's crop production (FAO, 2002; Department of Government Communication and Information System, 2015).

The complexity of rural livelihoods and poverty in the developing world has led to a need for in-depth research into understanding the role that smallholder farming plays in improving the lives of the poor. Livelihoods of poor rural households of South Africa are known to be diverse and in many of these livelihoods, farming does not occupy central stage. According to the 2011 Census figures, 19.9% of households nationally were engaged in agriculture (Stats SA, 2013a). The Eastern Cape Province had the highest proportion of agricultural households (35.4%), followed by the Limpopo Province (33.0%). Such provincial and household disparities have implications for the impact of agricultural policy in that households with livelihoods in which farming plays a limited role are less likely to respond to agricultural policy measures aimed at promoting the intensification of farming activities than those with livelihoods in which farming is central.

The importance of smallholder irrigation farming in South Africa arises primarily from the number of participants involved. Most smallholder irrigation schemes are found in the former homelands of South Africa, where the incidence of poverty peaks (May, 2000; Aliber, 2003; Machethe *et al.*, 2004). Smallholder irrigation schemes were established either in the former homelands or in resource-poor areas by black people or agencies assisting their development (Van Averbeke, 2008). In these particular socio-economic environments, smallholder irrigation farming presents an attractive opportunity for enhancing rural livelihoods.

The fact that smallholder irrigation farming contributes to improved household welfare, therefore, is definite. The effectiveness of smallholder irrigation farming as a poverty-reducing strategy has long been recognised in many developing countries (Hussain & Hanjra, 2004; Machethe *et al.*, 2004; Hanjra *et al.*, 2009a; McCartney *et al.*, 2010; Ntai, 2011;

Burney & Naylor, 2012). The South African government has adopted the strategy of the National Development Plan (NDP) of reviving the rural economy through expanding irrigation farming (NPC, 2011). This is based on the potential that smallholder irrigation farming has for improving household welfare worldwide. Diversity of rural livelihoods and the variable importance of farming in the rural livelihoods of poor households have been documented in communities that practised dryland farming. However, information on livelihoods and farming of households holding plots on smallholder irrigation schemes is limited. In general, livelihoods of smallholder irrigation farmers in South Africa have received inadequate research attention. Therefore, the extent to which smallholder irrigation contributes to rural livelihoods remains unknown. Furthermore, it is not clear what needs to be done to realise the full potential of smallholder irrigation farming to enhance its potential to improve livelihoods.

In South Africa, a few studies have established that there is a positive association between participation in smallholder irrigation farming and improved livelihoods and poverty reduction (Ntsonto, 2005; Phiri, 2008; Mudau, 2010, Tekana & Oladele, 2011; Sinyolo *et al.*, 2014). Such evidence has justified continued government investment in irrigation farming across the country. However, quantified evidence of the contribution of smallholder irrigation farming to livelihoods is limited.

1.2 The problem statement

Studies in other countries have demonstrated that smallholder irrigation farming improves livelihoods and contributes to poverty reduction. Some of the studies have also shown the various pathways through which irrigation farming contributes to improved household welfare. Whilst it is widely accepted that irrigation farming, particularly smallholder irrigation, contributes to improved livelihoods and poverty reduction (e.g. Ntsonto, 2005; Phiri, 2008; Mudau, 2010; Tekana and Oladele, 2011), little has been done to (a) quantify the contribution; and (b) examine how benefits from smallholder irrigation are distributed. It is often assumed that the benefits flowing from irrigation will be distributed evenly among the irrigators. Furthermore, previous studies have focused on farmers operating on irrigation schemes to the exclusion of independent smallholder irrigation farmers (Denison & Manona, 2007; Van Averbeke *et al.*, 2011; WRC, 2012). Van Averbeke *et al.* (2011) pointed out that

little was previously known about independent irrigators in South Africa. In the reports where South African independent irrigators are mentioned, analysis of the data often does not single them out as a distinct category. This study examines the contribution of smallholder irrigation farming, both irrigation scheme and independent irrigation farming, to improved rural livelihoods. In particular, the study addresses the following questions: How has smallholder irrigation farming contributed to household income and food security in the study area? Are household income and food security significant pathways through which smallholder irrigation farming contributes to rural livelihoods? To what extent does smallholder irrigation farming contribute to household income and food security?

Existing studies attempted to demonstrate the importance of smallholder irrigation farming as a rural development investment strategy that can have both direct and indirect impacts on rural household income and food security in South Africa. However, the benefits from irrigation accrue unevenly for different types of farmers. As a result, all irrigation farmers are not equally successful (ADB, 2003; Hussain *et al.*, 2003; Smith, 2004). Related to the above point, previous studies that have examined the relationship between smallholder irrigation farming and livelihoods in South Africa have not quantified the contribution smallholder irrigation farming has made to rural livelihoods in South Africa, but have established a positive relationship between the two. However, to understand the contribution of smallholder irrigation farming to the livelihoods of the rural poor clearly, it is important to be cognisant of the role of smallholder farming in rural livelihoods and income strategies of the different types of smallholder irrigation farmers, with different social and economic statuses, engaged in a wide range of livelihood strategies and operating under different conditions of vulnerability and in different environments. The current study contributes to filling these knowledge gaps.

Furthermore, the significance of smallholder irrigation farming as a way of stimulating the rural economy is recognised in the NDP. However, it is not clear what needs to be done to realise the full potential of smallholder irrigation farming to improve rural livelihoods owing to the paucity of reliable data on smallholder farming. This study is especially timely as the National Planning Commission and debates on agrarian reform in South Africa require information to guide future investment strategies and policy reforms. Although there is enormous evidence of the positive contribution of smallholder irrigation farming to improved

rural livelihoods from other countries, this study offers valuable, previously unavailable knowledge specific to South Africa.

Against this background, there is strong justification for an exploration of the contribution of smallholder irrigation farming to rural livelihoods in Limpopo Province of South Africa, particularly to explore why smallholder irrigation farmers do not benefit equally from irrigation farming, using comparative quantitative approaches on the different typologies of smallholder irrigation farmers. In view of the enormous investment that has been directed towards smallholder irrigation farming, it is crucial for policy makers to be informed of the extent to which that investment has translated to better quality of life in Limpopo Province. Quantifying the relationship between smallholder irrigation farming, household income and food security will provide an indication of the extent to which investment in smallholder irrigation has addressed the country's priority area of reducing rural poverty. Furthermore, the study informs policy on both the potential of smallholder irrigation farming and the debate on whether South Africa should invest more in smallholder irrigation in pursuit of the country's key strategic objectives of eliminating poverty and reducing inequality.

1.3 Research objectives

The overall objective of the study is to determine the contribution of smallholder irrigation farming to rural livelihoods and to identify factors determining how benefits from smallholder irrigation farming are distributed across households.

The specific objectives of the study are:

(i) to determine whether smallholder irrigation farming has contributed to household income and food security;
(ii) to quantify the contribution of smallholder irrigation farming to household income and food security;
(iii) to identify factors that determine how income, food security, access to financial services and employment opportunities are distributed; and
(iv) to explore the role of household income and food security as pathways through which smallholder irrigation farming contributes to rural livelihoods.

1.4 Statement of hypotheses

The hypotheses of the study are as outlined below.

(1) *The contribution of smallholder irrigation farming to household income and food security varies between types of farmers and these benefits are unequally distributed among households.* Although smallholder irrigation farming allows households to increase production and household income and enhances income diversification opportunities, the nature of benefits from irrigation farming are not uniform across different sites. These benefits also accrue unevenly to different types of farmers. As a result, all irrigation farmers are not equally successful (Hussain *et al.*, 2003; Smith, 2004). For example, according to the ADB (2003) and Hussain *et al.* (2003), household well-being is affected most by irrigation farming where landholdings are equitably distributed. In addition, possession of and equitable access to the necessary human, social, financial and physical assets play a role in determining the extent to which a farmer benefits from irrigation farming (Smith, 2004).

(2) *The distribution of benefits from smallholder irrigation across rural households is dependent on resource endowment and socio-economic characteristics of the household head.* For example, the better asset-endowed farmers will benefit more from smallholder irrigation farming than the less asset-endowed ones. Poverty reduction impacts of irrigation farming were found to be greater in households that invested more in human capital (Hanjra *et al.*, 2009a; Hanjra *et al.*, 2009b). Also, farmers with larger landholdings have been found to benefit more from smallholder irrigation farming than those with smaller parcels of land (ADB, 2003; Hussain *et al.*, 2003). In this study, this may suggest that independent irrigators have benefited more from irrigation than farmers on irrigation schemes, as the size of the former's land is relatively larger.

Regarding the effect of the farmer's entrepreneurial attitudes on benefit distribution, evidence provided by Gibb (2008) and Herrington *et al.* (2009) has shown that a positive entrepreneurial spirit fuels innovation and can have an

impact on a farmer's level of success and growth. Gender has also shown an influence on the level of farmers' success in that female farmers tend to benefit less from farming, unless they have external support, as they usually lack capital to invest (Jordans & Zwarteveen, 1997; Peterman *et al.*, 2010).

(3) *Smallholder irrigation farming affects rural livelihoods largely through increased household income and improved household food security*. Irrigation farming makes food available and affordable to the poor, who tend to be net buyers of food and spend a major part of their monthly income on basic food (Van Koppen, 1998). Irrigation farming increases a household's consumption from own production and reduces expenditure on bought-in food. Better and affordable food is expected to improve nutrition and health, which in turn has a favourable impact on the learning capabilities and skills of the poor. Given higher incomes, households are likely to invest in human capital formation, which in turn may have a favourable effect on productivity and returns to human capital and physical endowment (ADB, 2003; Hussain & Hanjra, 2004).

1.5 Thesis outline

The remainder of the thesis is outlined as follows: Chapter 2 outlines smallholder farming in South Africa. Chapter 3 presents the conceptual frameworks for understanding rural livelihoods and pathways out of poverty. Sampling and data collection procedures are described in Chapter 4. The analytical techniques and estimation procedures are outlined in Chapter 5. Chapter 6 presents socio-economic characteristics of the sample. The nature of benefits from smallholder irrigation farming are discussed in Chapter 7. The contribution of smallholder irrigation farming to household income and food security is quantified in Chapter 8. Factors determining the distribution of benefits from smallholder irrigation farming and the effect of irrigation farming on household income and food security are discussed in Chapter 9. Chapter 10 presents a summary of the study, major findings, recommendations and suggestions for future research.

CHAPTER 2

SMALLHOLDER FARMING IN SOUTH AFRICA

2.1 Introduction

This chapter provides the context of the study by presenting background information about South Africa's agricultural sector. An overview of literature on smallholder irrigation farming is given, focusing on the definitions provided by various analysts of the different types of smallholder farmers. The chapter serves to review literature on the development of smallholder irrigation farming in the country. Literature presented will enable better understanding of the significance of smallholder irrigation farmers in the country.

2.2 South Africa's agricultural sector

South Africa has a dual agricultural economy, with both a well-developed commercial farming sector and a developing subsistence-based production sector in the rural areas. The commercial sector is vibrant, well integrated and highly capitalised compared to the other sector. It is estimated that there are 39 982 commercial farming units in the country, producing about 90% of the agricultural output (Stats SA, 2012). Most of the commercial farms are situated on 87% of the total agricultural land. Smallholder farmers are found in former homelands and cultivate the remaining 13% of agricultural land. They operate under traditional tenure, leasehold, quitrent and trust systems created during the apartheid era (Lahiff, 2008; Manona *et al.*, 2010; Van Averbeke & Maake, 2010; DAFF, 2012). Huge inequalities exist in land ownership in South Africa and the government is in the process of implementing a land reform programme to address these imbalances in land ownership.

The actual numbers of smallholder farmers are far from clear (Cousins, 2010). A 1998 Eskom survey identified 2.1 million smallholder and emerging farmers in South Africa. According to Aliber and Hart (2009), by 2007 approximately 240 000 black farmers provided a livelihood to about a million household members while employing up to half a million workers. Aliber and Hart (2009) also reported that there were about three million smallholder farmers who produced food to meet household consumption needs in South Africa.

The country covers a total of 1 223 201 square kilometres of land and 2 798 kilometres of coastline. The total land area consists of 82.3% of farmland and 10% nature conservation, about 1% of forestry and 7% of land for other uses (DAFF, 2012). About 12% of the country's surface area can be used for crop production. High-potential arable land comprises only 22% of total arable land. Of the 1.3 million hectares under irrigation, the Western Cape has the largest irrigated area for both commercial and smallholder farming (20%) and Gauteng the smallest, while the rest of the provinces each has a share of about 10% of the total area (Department of Government Communication and Information System, 2015).

The country's land area is divided into various regions according to climate, natural vegetation and land capability (Schoeman *et al.*, 2002). The climatic classes in turn influence the regional land uses, including suitability of crop and livestock production activities and hence the type of farming practised. Grazing land is the dominant land use type in all the provinces, except Gauteng, where other uses, such as mining, form the dominant land use type. This has made the livestock industry the largest national agricultural sector. The second major land use type is arable land, followed by nature reserves and then other uses. Forestry is the least prevalent land use form and does not exist in some provinces, such as the Northern Cape and the Free State. The regional distribution of agricultural land by type of farming practised to a great extent reflects key regions (provinces) responsible for the production of certain exportable commodities in South Africa. Primary agriculture contributes about 3% to South Africa's gross domestic product (GDP) and about 7% to formal employment. However, there are strong linkages with the economy, so that the agro-industrial sector comprises about 12% of GDP (DAFF, 2012; DAFF, 2013).

2.3 Smallholder irrigation farming in South Africa

Agriculture is the world's largest user of water, consuming 80-90% of annually used supplies. In developing countries alone, agriculture accounts for more than 85% of water utilisation (IWMI, 2001; ADB, 2003). Sixty-three percent of South Africa's water is used for agriculture (M'Marete, 2003; Reinders, 2010; Johnston *et al.*, 2012). Smallholder farming takes up a significant proportion of the available water in South Africa (Fanadzo *et al.*, 2010). In the South African context, the term smallholder irrigation is used when referring to irrigation farming practised by black farmers. However, smallholder irrigation farmers are

not homogenous. Smallholder irrigators were generally classified and differentiated among themselves according to control over water supply, i.e. source and distribution infrastructure and scale of operation (Van Averbeke *et al.*, 2011). They have been categorised into four groups by different analysts, as described in Van Averbeke (2008). These are: scheme irrigators, independent irrigators, community gardeners and home gardeners.

De Lange (1994) referred to scheme irrigators as 'scheme farmers'. An irrigation scheme is defined as an agricultural project involving multiple holdings that depend on a shared distribution system for access to irrigation water and, in some cases, on a shared water storage or diversion facility (Van Averbeke *et al.*, 2011). Scheme irrigators have to work collectively in order to achieve their individual objectives. Working collectively also positions them well for collective action in relation to access to input and output markets and markets for services such as mechanised land preparation.

Independent irrigators have been given a variety of names. Independent irrigation refers to irrigation initiated and financed by farmers individually, mostly without any support from external agencies, such as government, donors or non-governmental organisations. Some of the terms used to refer to independent irrigators include 'atomistic irrigation', 'mini irrigation systems' (Faurés & Mukherji, 2009), 'individual irrigation', 'informal irrigation' and 'small private irrigation' (De Fraiture, 2014), 'private smallholder systems' (Namara *et al.*, 2010), 'individual small-scale irrigation and 'individual micro-scale irrigation' (Fiebiger *et al.*, 2010). This type of farmer is referred to as an 'independent irrigator' in South Africa (De Lange, 1994; Crosby *et al.*, 2000). The group of 'independent irrigators' comprised households that directly accessed a source of irrigation water and extracted, conveyed and applied this water using privately owned equipment in the production of crops. Independent irrigators have a private water supply, such as pumping directly from a river, or own a borehole. The farmers have complete control over irrigation scheduling. This characteristic distinguishes independent irrigation farmers from the other two categories of smallholder irrigators, who rely on a communal water supply infrastructure for access to irrigation water. Independent irrigators have been described as farmers who aim at making a living out of farming, which is not always the case with farmers on irrigation schemes (De Lange, 1994; Crosby *et al.*, 2000). Purchasing, operating and maintaining one's own irrigation system is expected to have substantial financial, institutional and water-security implications.

De Lange (1994) identified 'community gardeners' as people farming in irrigated group gardens. Scheme farmers, as opposed to community gardeners, farm on irrigation schemes, have larger plots and produce a wider range of crops. Community gardeners focus almost completely on vegetables.

Du Plessis *et al.* (2002) adopted the three categories of smallholder irrigators identified by De Lange (1994), but added a fourth group, whom they labelled 'home gardeners'. They pointed out that as in the case of 'independent irrigators', home gardeners did not form part of a group for the purpose of access to water, but in terms of the scale of their operations, home gardeners resembled the 'vegetable gardener' category.

This study adopts the above definitions by De Lange (1994) and Du Plessis *et al.* (2002) of the different types of smallholder irrigators, namely, scheme irrigators, independent irrigators and home gardeners, and explores their livelihoods. In terms of landholding in South Africa, where about 1.3 million ha is irrigated land, it is estimated that a total of about 100 000 ha of land is in the hands of smallholder irrigation farmers (Van der Stoep *et al.*, 2008; Van Averbeke *et al.*, 2011). Van Averbeke *et al.* (2011) and WRC (2012) reported that smallholder irrigation schemes covered 48 000 ha of land in 2011, while independent irrigators irrigated about 52 000 ha. Average plot sizes for irrigation schemes are as low as 0.2 ha, while independent irrigators are farming up to 20 ha plots (Denison & Manona, 2007; Van Averbeke *et al.*, 2011).

2.4 Management of irrigation schemes

South Africa is faced with water scarcity and capacity problems in water management. Over many years, irrigation schemes were established in South Africa with the main objective of improving rural livelihoods through sustainable crop production for food security and poverty alleviation (FAO, 2001). However, the development goal of irrigation schemes has largely been unfulfilled. The general consensus among researchers and stakeholders in agriculture is the need for efficient use of water (Fanadzo *et al.*, 2010). The creation and funding of the smallholder schemes have necessitated the continuous monitoring of their performance (Gomo, 2010). As documented by FAO (2001), smallholder irrigation also includes small individual farms and groups where the farmers have taken on the responsibility for managing

the distribution of water among members of their group. Since smallholder irrigation farms in South Africa are located in the former homelands, the majority of the farms are owned by historically disadvantaged races and groups (Denison & Manona, 2007). These schemes are under local responsibility, controlled and operated by the local people in response to their felt needs, and using a level of technology which they can operate and maintain effectively. Irrigation schemes vary in size and in the number of farmers supported by a particular scheme. For effective smallholder irrigation management, farmers should participate in collective activities at scheme level, regardless of the size of the scheme (Muchara *et al.*, 2014).

The South African government embarked on an irrigation sector reform in the 1980s in an effort to improve performance of irrigation schemes. The reform was in two forms. First, an irrigation management transfer exercise where irrigation schemes were handed over to farmers with the assumption that resource use efficiency would increase (Garces-Restrepo *et al.*, 2007; Perret, 2002). According to Van Averbeke (2008), irrigation management transfer refers to the transfer of the responsibility of managing, operating and maintaining irrigation schemes from the government to the farmers. The process of irrigation management transfer includes government withdrawal, formation of water users associations, development of local management institutions, and transfer of ownership and management. Secondly, an interrelated concept of participatory irrigation management was incorporated. This concept particularly referred to increased involvement of water users in irrigation management, along with government involvement. The relationship between the two approaches is that irrigation management transfer intended to replace the role of government but participatory irrigation management strengthens the relationship between water users and government by adding farmer participation to government management (Garces-Restrepo *et al.*, 2007). South Africa cautiously implemented the irrigation management reform for irrigation schemes although most transfer operations were unsure how to design and facilitate the process (Garces-Restrepo *et al.*, 2007; Perret, 2002).

2.5 Summary and conclusions

This chapter has provided background information to the agricultural sector in South Africa. The main conclusions are that South Africa still has huge inequalities in land ownership in a

dual agricultural sector. However, the government is in the process of implementing a land reform programme to address the imbalances in land ownership. The actual number of smallholder farmers in the country is unknown, but they produce crops on 13% of the agricultural land. The Western Cape Province has the largest irrigated area for both commercial and smallholder farming, while Gauteng Province has the smallest. The rest of the provinces each has a share of about 10% in the 1.3 million hectares of irrigated land. Smallholder irrigation farming in South Africa is mainly practised by black people. However, smallholder irrigation farmers are not homogenous. They differ according to control over water supply. Four categories have been identified by different analysts, namely scheme irrigators, independent irrigators, vegetable gardeners and home gardeners. This study focused on scheme irrigators, independent irrigators and home gardeners. Irrigation schemes were developed in former homelands thereby owned by historically disadvantaged populations. When irrigation schemes continued to perform below expectation, management of irrigation schemes was transferred to the farmers with the assumption that such an effort would increase resource use efficiency. Although there has been progress in the implementation of irrigation management reforms, the process is on-going and much is known about the conditions that need to be met if a reasonable degree of success from the interventions is to be expected.

CHAPTER 3

RURAL LIVELIHOODS AND PATHWAYS OUT OF POVERTY

3.1 Introduction

This chapter presents two conceptual frameworks applied in the study. One framework is intended to understand rural livelihoods and the other illustrates how improved household income and food security are pathways out of poverty. The purpose of this chapter is to provide a comprehensive and critical appraisal of literature pertaining to the concepts of rural livelihoods and some asset functions that form the basis for selection of the best strategy to study rural livelihoods and a comparative analysis of the different types of smallholder farmer households in the research site.

3.2 A conceptual framework for understanding rural livelihoods

The concept of 'rural livelihoods' is central to debates on poverty reduction and improved rural household welfare. There are some definitional issues concerning understanding livelihoods. According to Chambers and Conway (1992), a livelihood comprises people, their capabilities and means of living, including food, income and assets (both tangible and intangible assets). Ellis (2000) defines a livelihood as a means to a living. Making a living is largely concerned with income generation. A livelihood is sustainable if it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation, as well as contributing net benefits to other livelihoods at the local and global levels and in the short and long term (Krantz, 2001). A modified definition of sustainable livelihoods was proposed by Ian Scoones of the Institute of Development Studies. The definition excludes the requirement that for livelihoods to be considered sustainable they should also contribute net benefits to other livelihoods (Scoones, 1998). Although there are several definitions of a livelihood, the definition by Chambers and Conway (1992) has been the basis for all the others that researchers have adopted. The Department for International Development (DFID) adopted this definition, with some minor changes. However, researchers have argued that any

definition of livelihood sustainability has to include the ability to avoid or withstand and recover from stresses and shocks (IFAD, 2012).

Given that this study is a livelihood-centred evaluation of the contribution of smallholder irrigation farming to rural livelihoods, the Sustainable Livelihoods Framework (SLF) will be applied extensively[2]. This approach provides an understanding of the livelihoods of poor people. The SLF presents the main factors that affect people's livelihoods and typical relationships between them. The SLF has been used previously, both in planning new development activities and in assessing the contribution of existing activities to livelihood sustainability. The reference scale of such a framework is always influenced by the uses to which it is put. The same framework can be applied at different scales, including livelihoods of individuals, households, villages, communities, districts or nations, assessing sustainable livelihood outcomes at different levels (Scoones, 1998; Ellis, 2000; Mathie & Cunningham, 2005).

Although the framework is not intended to be an exact model of reality, it provides an analytical structure that facilitates a systematic understanding of the various factors that influence livelihood opportunities, and shows how the factors relate to one another (DFID, 1999; Ellis, 2000). The SLF provides an approach that reconciles the contribution made by all the sectors to building up the stocks of assets upon which people draw to sustain their livelihoods (Krantz, 2001). The strengths of the SLF draw from its two key components, which are that it is a systematic view of the factors that cause poverty, and that it is a set of principles that guide action to address and overcome poverty (IFAD, 2012). The rationale of the sustainable livelihoods approach is therefore poverty reduction, although it does not lay down any explicit definition of what exactly constitutes poverty, as poverty is context-specific.

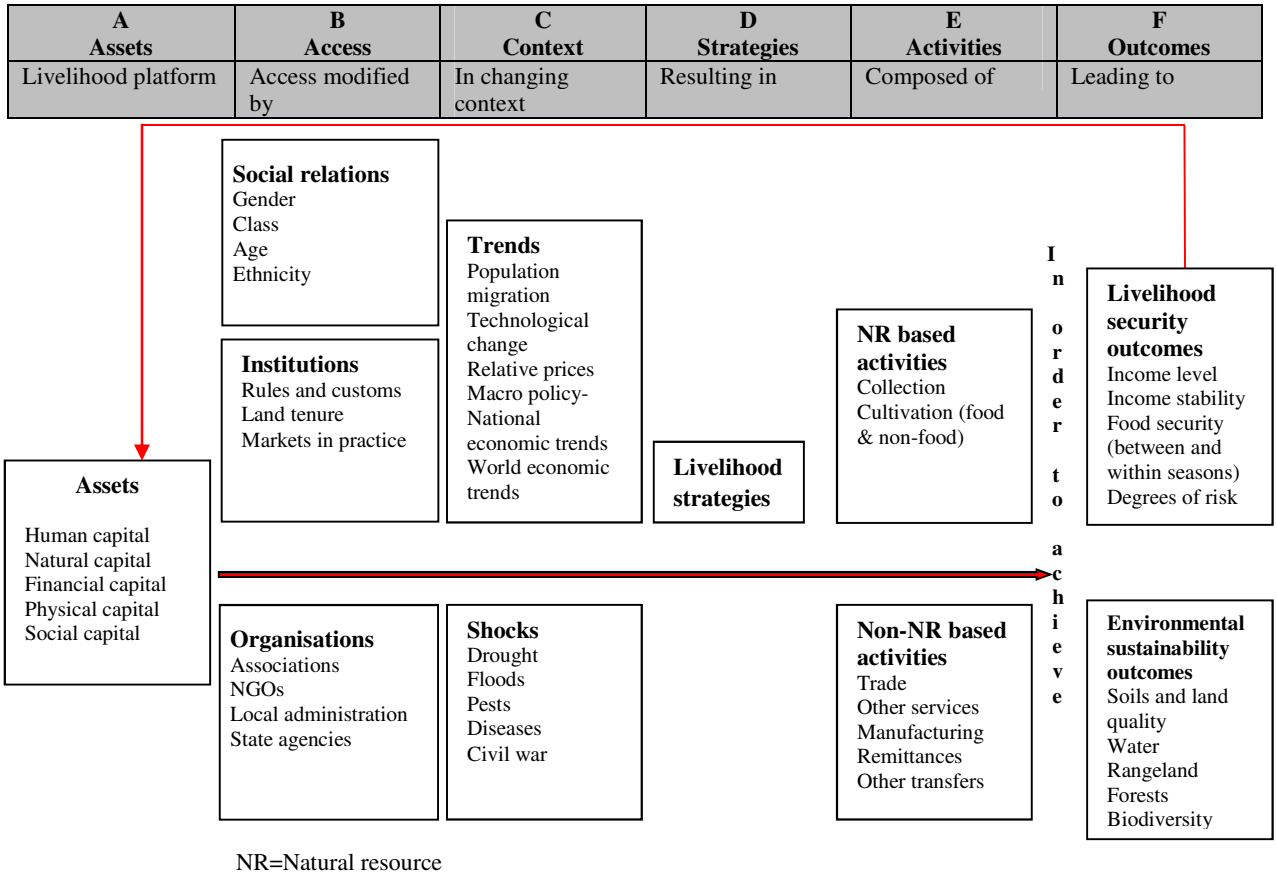
According to Krantz (2001, p.2), "there are three insights into poverty which underpin the SLF approach. The first is the realisation that while economic growth may be essential for

[2]This study adopts the SLF that has been used and promoted by the Department for International Development (DFID) for analysis. DFID adopted the Ian Scoones modified definition of sustainable livelihoods that excludes the requirement that for livelihoods to be considered sustainable they should also contribute net benefits to other livelihoods.

poverty reduction, there is no automatic relationship between the two since it all depends on the capabilities of the poor to take advantage of expanding economic opportunities. Secondly, there is the realisation that poverty, as conceived by the poor themselves, is not just a question of low income, but also includes other dimensions such as poor health, illiteracy, lack of social services, a state of vulnerability and feelings of powerlessness, etc." Furthermore, it is recognised that the poor must be involved in designing projects and policies intended to improve their livelihoods, as they often know their situation and needs best.

The SLF is people-centred and rural poor people, in particular, are central to inter-related influences that affect how they make a living for themselves and their households (Nel, 2015). There are various ways of conceptualising the components of a livelihood and the influences upon it, which has led to numerous, slightly different, schematic representations of these variables and their interconnections. Figure 1 presents a diagrammatic representation adapted from Ellis (2000). The arrows within the framework denote different types of dynamic relationships between the variables listed in columns A to F. Starting from columns D and E, the poor employ a mix of different strategies, given their resources to engage in agricultural, natural resource-based and non-natural resource-based activities. The outcomes of livelihood strategies include effects on livelihood security and on environmental sustainability. Notable is that income in the livelihood security box does not refer only to monetary income but also to income in kind, such as food produced by the farmer for home consumption.

All livelihood strategies depend upon access to assets (column A). The framework is built around five principal categories of assets. Viewed from a livelihood perspective, smallholder irrigation farms are assets. They can be used to increase and diversify the livelihood activity of plant production, resulting in improved livelihood outcomes, either directly in the form of food or income for farming households, or indirectly by providing full or partial livelihoods to people who provide goods and services in support of irrigation farming (Van Averbeke & Mohamed, 2006).



NR=Natural resource

Figure 1: The Sustainable Livelihoods Framework
Source: Ellis (2000)

It is notable that livelihoods depend on a combination of assets of various kinds and not just from one category. The assets, as identified in the SLF, include human, natural, social, financial and physical capital (Scoones, 1998; Ellis, 2000; Luthans *et al.*, 2004; IFAD, 2012). A distinction between different types of assets draws attention to the variety of resources, often used in combination, on which people rely to derive a flow of income or consumption and also invest in so as to increase future flows of income or consumption.

Access to assets (column B) is important, as livelihood strategies may focus on increasing the range of assets to which an individual or household has access in an effort to improve the quality of life. The more assets individuals have, the less vulnerable they are to shocks and trends. The effectiveness of an asset in providing livelihood security depends on contextual factors, such as social relations, institutions and organisations, which affect ways in which people combine and use their assets to achieve their goals. These are their livelihood strategies employed to achieve their livelihood outcomes (Carney, 1998; Winters *et al.*, 2002; IFAD, 2012). It is noteworthy that assets do not deploy themselves but people do so.

Therefore, the effectiveness of an asset will depend on the skills and knowledge possessed by the individual using it, in addition to these contextual factors.

The extent of people's access to these assets is strongly influenced by their vulnerability context, which entails trends (e.g., population, migration, technological change, economic, etc.) and shocks (e.g., epidemics, natural disasters, civil strife). Trends represent gradual change while shocks are sudden changes. Household exposure to trends and shocks can weaken, strengthen or force households into a new direction (Cefims, 2008).

People can be poor at any point in time because they possess few assets. They can also be poor because of financial and other constraints that limit their ability to use the assets they have. Given enough time, people can build up additional assets they need; however, within that time, negative shocks may take place that push people further behind. According to Carter and May (2001), the dynamics of poverty depend on how these dimensions of time interact and on people's strategic choices, given their awareness of time as both opportunity and vulnerability.

3.3 The Pathways Framework

To determine pathways out of poverty through participation in smallholder irrigation farming, the pathways framework is applied. Figure 2 presents a diagrammatic representation of the pathways framework, which illustrates how access to productive and consumptive assets would eventually lead to improved household welfare. The diagram was compiled using various aspects adapted from Ellis (2000), Dorward *et al.* (2001), Hussain *et al.* (2003), Hussain and Hanjra (2004) and Hanjra *et al.* (2009b). The arrows imply certain levels of influence between the variables listed. This framework shows the key interrelated dimensions of the relationship between access to good irrigation water and socio-economic uplifting of the poor in rural communities and improved household welfare.

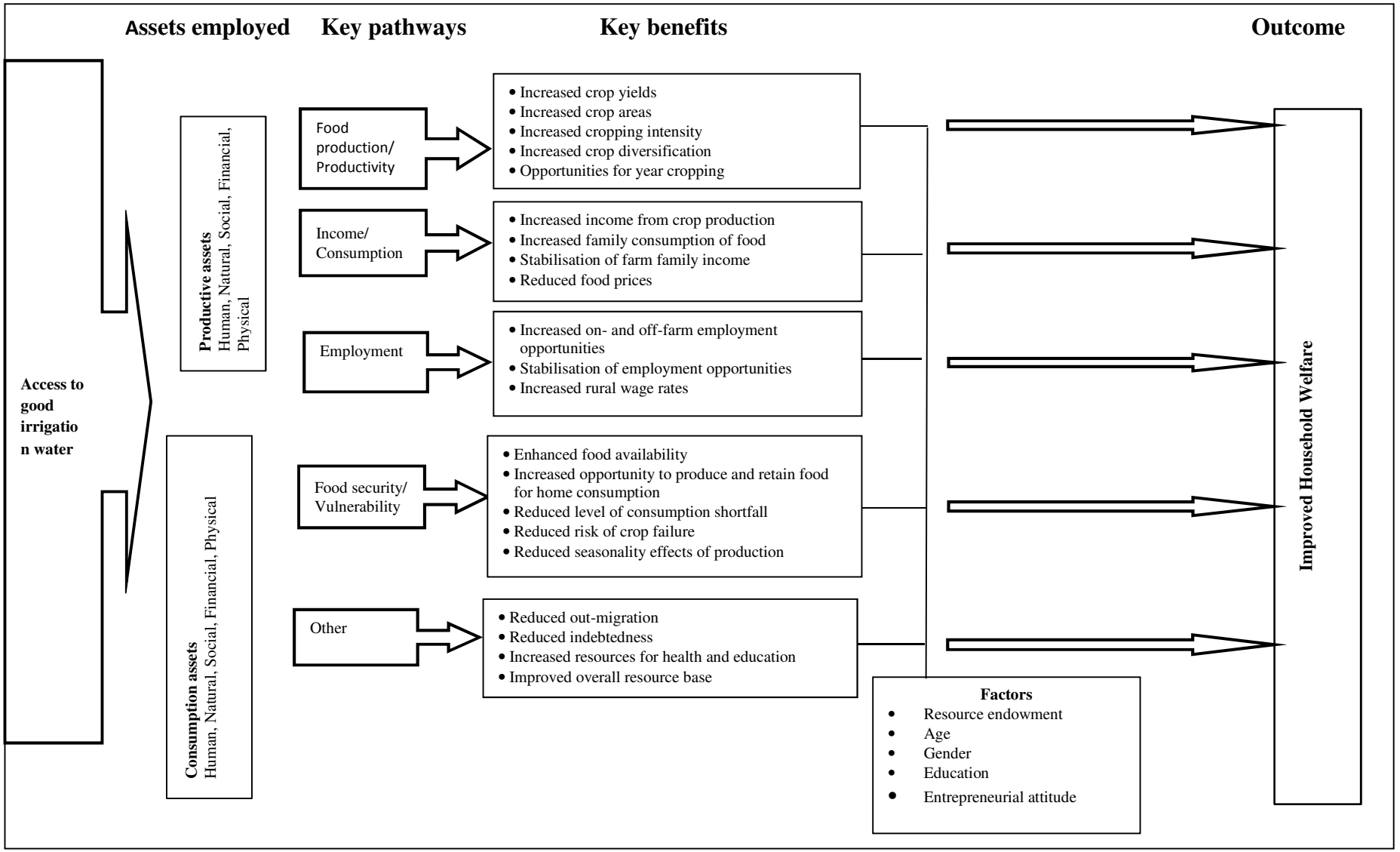


Figure 2: Key pathways through which smallholder irrigation farming contributes to the welfare of rural households
Source: Author compiled with adaptations from Dorward *et al.* (2001); Hussain *et al.* (2003); Hussain & Hanjra (2004); Hanjra *et al.* (2009b)

The framework places emphasis on the importance of assets in realising the key benefits through key pathways and eventually reducing the vulnerability of poor people's livelihoods and improving welfare. The component of assets borrows from the asset function framework by Dorward *et al.* (2001), which illustrates the relationship between the different livelihood functions of assets and the key benefits and pathways to improved household welfare.

The key pathways through which smallholder irrigation farming contributes to improved livelihoods are identified. These comprise food production/productivity, income/consumption, employment, food security and other social impacts contributing directly or indirectly to overall improved household welfare (ADB, 2003; Hussain *et al.*, 2003; Hussain & Hanjra, 2004; Hanjra *et al.*, 2009b). However, the list of pathways is not exhaustive, as Burney and Naylor (2012), concurring with the pathways, put forward an optimistic view that well-designed irrigation technologies can generate income, promote food security, bridge institutional gaps and strengthen local institutions. Households employ productive and consumption assets to generate resources required for production, consumption, employment and food security. The food production/productivity pathway comes about through key direct benefits from irrigation farming such as increased crop yields, increased crop areas, increased cropping intensity, increased crop diversification and opportunities for cropping throughout the year. The income/consumption pathway improves household welfare through increased income from crop production, increased family consumption of food, stabilisation of farm family income and reduced food prices. The employment pathway functions through increased on-farm employment opportunities, increased off-farm employment opportunities, stabilisation of employment opportunities and increased rural wage rates.

Key benefits that bring about the food security/vulnerability pathway include enhanced availability of food, increased opportunity to produce and retain food for home consumption, a reduced level of consumption shortfall, a reduced risk of crop failure and reduced seasonality effects of production. There are other ways in which households benefit from accessing irrigation water, which include reduced out-migration, reduced indebtedness,

increased resources for health and education and an improved overall resource base. Important to note is that water to which the poor have access is also used for other farm and non-farm production activities. According to Meinzen-Dick and Van der Hoek (2001), these activities may include livestock rearing, fish production, brick-making, etc. These small-scale rural enterprises are part of poor people's livelihood strategies and also contribute to improved household welfare.

The fact that irrigation benefits may accrue unevenly across socio-economic groups has been ascertained. Factors that influence the extent of benefiting from smallholder irrigation farming include asset endowment, landholding size, age and gender of the household head, level of education of the household head and the entrepreneurial attitude of the household head (Hussain *et al.*, 2003).

The SLF and the pathways frameworks have been used in a number of livelihood studies before (Hussain & Hanjra, 2004; Hanjra *et al.*, 2009b). However, some studies have also used other methodologies to measure the contribution of irrigation farming to livelihoods. For example, Muchara (2011) used value chain analysis methodologies to profile and map value chains of certain crops and to understand the opportunities that these crops provide for livelihoods of communities participating in irrigation scheme farming in the Eastern Cape Province. Ntsonto (2005) used the sustainable management of irrigated land and environment approach and the SLF to evaluate the diversity of livelihoods and the contribution of farming on a smallholder irrigation scheme in the Eastern Cape Province. Tekana and Oladele (2011) applied multiple regression analysis to assess the impact of irrigation farming on household welfare in the North West Province. Although applying the SLF and the pathways framework, this study uses specific variables that address part of the framework comparing a group of irrigators and non-irrigators to allow for conclusions to be drawn based on two outcome variables, namely: household income and household food security.

3.4 Summary and conclusions

This chapter outlined two conceptual frameworks that were applied in the study. One framework was intended to enable understanding of rural livelihoods and the other illustrated pathways out of poverty through access to irrigation farming. The main conclusions were that livelihood strategies depend upon access to assets, which are, as identified in the SLF, human, natural, financial, physical and social capital. The pathways framework illustrated how access to productive and consumptive assets would eventually lead to improved household welfare through key pathways, which included food production/productivity, income/consumption, employment and food security.

CHAPTER 4

SAMPLING AND DATA COLLECTION

4.1 Introduction

This chapter discusses the sampling methods and data collection procedures employed in carrying out the study. The first part of the chapter describes the study area. The second part of the chapter outlines the sampling procedure used in the study. Subsequent sections of the chapter describe data sources, data collection, entry and management.

4.2 The study area

The study was conducted in Greater Tzaneen Local Municipality in Mopani District Municipality of Limpopo Province of South Africa from August to December 2013. The interests of this study spread across villages that fall under Nkuna Traditional Authority, such as Solani, Nyanyukani, Nkowankowa, Hweetjie, Bordeaux, Ezekhaya, Masoma, Gabaza, Tours, Mokgapeng, Julesburg, Mashilwana and Rhulani. Special focus though was placed on Rhulani village where the Julesburg irrigation scheme is located. Although membership of the scheme is open to all households living in any of the villages of Nkuna tribal area, this study found that most of the scheme members at the time the study was conducted came from Rhulani village.

Julesburg irrigation scheme was established in 1972 and occupies 240 hectares of the land in Rhulani village. It is situated 35km north of Tzaneen. Mopani district municipality is characterised by high poverty levels as it has few economic resources and limited economic activity. The unemployment rate among the economically active population in Greater Tzaneen municipality is 36.7% while youth unemployment is 48.5% (Stats SA, 2011). Agriculture is the fourth largest economic sector after mining, government and community services and wholesale and retail (Limpopo Department of Agriculture, 2009). Rain-fed crop production is challenging because the area is hot and dry with annual temperatures ranging from 5^{o}C in cooler months to

37°C in hot months. The annual rainfall ranges between 400 and 10 000mm with a larger portion of the district, the east-ward side of the Drakensburg escarpment, receiving annual average rainfall of about 400 – 500mm while the area at the foot and on the escarpment receive 600 - 800mm and 800 - 10 000mm, respectively. These climatic conditions enable the district to accommodate a wide range of agricultural commodities, both livestock and crops. The district is traversed by rivers some of which are used for irrigation purposes (Limpopo Department of Agriculture, 2009).

Julesburg irrigation scheme farmers share water supply infrastructure. Water is drawn from Tours dam under gravity and a diesel pump is used to propel the water upon reaching the farm plots. Irrigators take turns in diverting irrigation water to their plots at least once a week. Farmers in the irrigation scheme were each allocated 5 hectare plots. A few farmers later acquired additional plots from neighbours and could access up to 10 hectares. The method of irrigation is a mixture of gravity sprinkler and furrow. The main crops grown are okra, green mealies, green beans and tomatoes. Farm produce is sold in local markets and some is packaged and transported to Pretoria and Johannesburg Fresh Produce markets.

Rhulani village is a product of betterment planning or villagisation that the National Party government pursued in different parts of the former homelands in the mid-20th century. Prior to villagisation, the community comprised dispersed homesteads on a communal landholding regime under Mhlaba chieftaincy. The process of villagisation involved land use planning, which resulted in mechanical separation of land parcels. Residential land was set aside, in which homesteads got 50m x 50m plots exclusively for residence and backyard gardening, while arable and grazing lands were likewise set in different zones. Households were issued with Permission to Occupy (PTO) certificates, which acknowledged rights to occupy residential plots but were silent on rights in arable and grazing lands (Personal communication with local leadership, 2013).

Figure 3 is a map of Rhulani village, showing the position of Julesburg irrigation scheme and some of the surrounding villages that formed part of the study. Individual independent irrigators

were identified in villages around Julesburg irrigation scheme during a census survey of smallholder irrigation schemes in 2010 (WRC, 2012). The independent irrigators irrigated in diverse situations, commonly along river terraces using run-off-river pump-sets, with some accessing underground water through boreholes. Access to water was largely unlawful as independent irrigators abstracted water with no legal water rights allocated to them. The major system of irrigation among independent irrigators was sprinklers. Although irrigation technologies used by independent irrigators in the study area are similar to those used by scheme irrigators, a few independent irrigators used more efficient irrigation systems such as drip irrigation. It is expected that pumping costs are very high for these types of farmers. They, however, cultivate larger farm plots compared to scheme irrigators. There were many independent irrigators operating on plots of variable sizes, i.e. 5-20 ha farms.

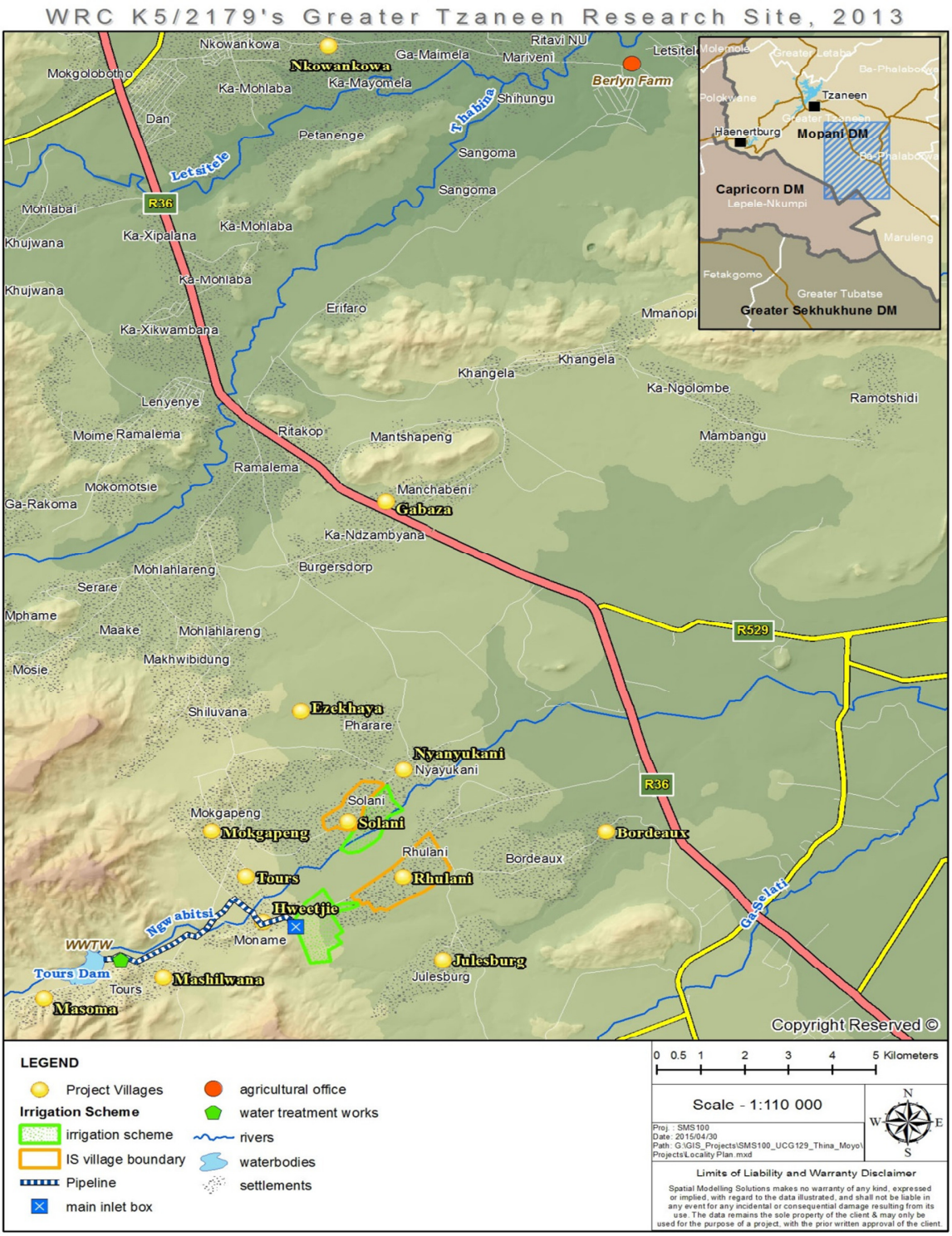


Figure 3: Greater Tzaneen research site showing Julesburg irrigation scheme and specific project villages
Source: Spatial Modelling Solutions (2015)

4.3 Sampling

Sampling was largely guided by certain requirements of a bigger Water Research Commission (WRC) project, K5/2179, of which this study is part. The WRC project aims at exploring water use productivity, associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Limpopo Province (WRC, 2013).

Selection of the research site required that care be taken to ensure that an operational irrigation scheme was chosen, which did not face severe constraints such as a limited water supply, serious social conflict, highly dilapidated infrastructure or any other disabling factors. In addition, the selected research site had to include the three targeted types of smallholder farming households, namely scheme irrigators, independent (non-scheme) irrigators and non-irrigating households (including home gardeners). Therefore, Julesburg irrigation scheme was purposively selected, among 101 operational irrigation schemes in the area, as the anchor of the research site, whose vicinity represented each of the three farmer typologies displaying similar contextual factors, such as agro-ecological factors, access to markets, economic opportunities other than agriculture, farming practices and traditions, language and other cultural attributes. An irrigation scheme with existing agricultural activity and production was purposively chosen based on prior knowledge derived from fieldwork undertaken by the research team members in 2010 covering all schemes in Limpopo Province, where 57% of South African smallholder irrigation schemes are located (Mohamed, 2006; Van Averbeke *et al.*, 2011).

A single research site was used for this study given available resources. Using a single research site, however, allows for a detailed description and analysis of the case, which can bring about deeper understanding of important issues, patterns and processes that define and explain the diversity within and outside the area. It is noteworthy that because rural livelihoods are complex and heterogeneous, multiple sites would have been justified to account for the diversity that exists in the South African rural environment (Leroy *et al.*, 2001).

Sampling at Julesburg irrigation scheme involved a census of all registered plot holders. A list of all farmers that hold plots on the Julesburg irrigation scheme was obtained from the scheme chairperson and based on the small number of farmers it was decided to include all the scheme irrigators in the study. Julesburg irrigation scheme had a total of 48 registered smallholder farmers. However, only active farmers were interviewed, resulting in 27 scheme irrigators being included in the study.

Independent (non-scheme) irrigators were selected from villages around Julesburg irrigation scheme using snowballing and with assistance from the local extension officer located at the Department of Agriculture offices at Berlin Farm. Independent irrigators were difficult to locate, as there was no existing database in the extension office. A census approach was therefore adopted, where all active non-scheme irrigating farmers that were identified were interviewed.

Non-irrigating households were randomly selected in Rhulani village. The home gardeners were regarded as non-irrigators because almost every household cultivated part of the homestead during the rainy season. Home gardeners did not necessarily water their crops, but relied on rainfall. They therefore represented the general population. Since Rhulani village was the focus of the study, it was important to obtain a comparator group of non-irrigators showing similar contextual factors as the irrigators. The assumption was that households in the same locality would have relatively low diversity among them.

The map of Rhulani village was used as a sampling frame for randomly selecting the comparator households. A map was printed from Google Earth, showing all 900 homesteads within the boundaries of the village. In consultation with the field assistants, it was found that some stands that appeared on the map were either vacant or used for purposes other than residential. Such stands that had nobody staying on them had to be identified on the map and excluded from the sampling frame. This resulted in a village population of 800 homesteads, of which 15% were sampled. A 15% sampling fraction was decided upon based on available resources and time for the study. The selection procedure involved assigning numbers to the 800 homesteads on the Google Earth map of Rhulani to allow for selection using random numbers. In total 120 random

numbers were generated, using random number generation statistical methodologies, and the randomly selected households were identified on the map. This random selection ensured that both home gardeners and households that did not practise farming were selected.

The distribution of households by type and village is shown in Table 1. Although irrigators interviewed were distributed across 13 villages around Julesburg irrigation scheme, most of the irrigators were from Rhulani village, the village where the scheme is located. Participation in irrigation farming was voluntary, although evidence also showed that, in some instances, advice from the extension officers and access to water sources influenced farmers' participation.

Table 1: Number of respondents by type and village

	Number of irrigators			Number of non-irrigators					
	Scheme irrigators	**Independent irrigators**	**Total**	**Home gardeners**	**Dryland farmers**	**Livestock farmers**	**Orchard farmers**	**Not farming**	**Total**
Rhulani	16	4	20	53	37	3	7	16	116
Solani	3	1	4	0	0	0	0	0	0
Nyanyukani	3	3	6	0	0	0	0	0	0
Nkowankowa	2	5	7	0	0	0	0	0	0
Hweetjie	1	6	7	0	2	0	0	0	2
Bordeaux	0	5	5	0	0	0	0	0	0
Ezekhaya	0	2	2	0	0	0	0	0	0
Masoma	0	2	2	0	0	0	0	0	0
Gabaza	1	0	1	0	0	0	0	0	0
Tours	0	3	3	0	0	0	0	0	0
Mokgapeng	0	1	1	0	0	0	0	0	0
Julesburg	1	0	1	0	0	0	0	0	0
Mashilwana	0	3	3	0	0	0	0	0	0
Total	**27**	**35**	**62**	**53**	**39**	**3**	**7**	**16**	**118**

Source: Survey data (2013)

The overall sample, therefore, consisted of scheme irrigators, independent irrigators, home gardeners, dryland farmers and non-farming households and was representative of the community in the research area. The actual sample size was 180 households, determined by the sampling procedure used. Table 2 shows the sample size by category of households within the research site.

Table 2: Sample size

Description	Number
Non-irrigators	118
Scheme irrigators	27
Independent irrigators	35
Total number of respondents	**180**

4.4 Data sources

Primary data were collected by using structured questionnaires in two phases. The first phase used a general livelihoods instrument while the second phase used an agricultural and entrepreneurship instrument. One hundred and eighty households were interviewed in the first phase and 97 were followed up in the second phase. The second phase targeted households who had indicated involvement in farming activities during the first phase. Individual household interviews were conducted with representatives of the 180 households across four groupings, namely independent irrigators (19% of the sample), scheme irrigators (15% of the sample, home gardeners (29% of the sample) and other types of households (36% of the sample)[3]. Because of the relatively high illiteracy levels among smallholder farmers and lack of records at farm level, interviewing was seen as the best data collection method, since these farmers' ability to respond to any other type of questionnaire is limited. Both questionnaires took about an hour to administer. The first phase collected detailed information on household composition and characteristics, income-generating activities, household expenditure, household wellbeing, household asset endowment, household savings and loans, and membership of associations.

The second phase gathered additional livelihood data on agriculture and entrepreneurship to augment the general livelihood survey. Data collected included the availability of and access to farm labour, farmers' goals and aspirations for each of the different types of farming practised during the period July 2012 to June 2013, access to land and water, ownership of agricultural assets, farm enterprise income statements, marketing of both livestock and crops, farmer support services, entrepreneurial attitude and attitude to risk.

[3]Other households included households that were dryland farmers, livestock keepers, orchard farmers or households that did not practise farming.

Table 3 shows variables that were captured in the two data collection phases and their expected relationship with the dependent variables. Variables used are characteristic of the components of the sustainable livelihoods framework. In general, given the nature of variables listed, an increase in the explanatory variable will result in an increase in the dependent variable, hence more positive relationships were expected.

4.5 Data collection, entry and management

The data collection team consisted of field officers and postgraduate students from the University of Pretoria. The enumerators were thoroughly trained in data collection, the importance of the study and data quality management prior to commencement of the exercise. Field activities included recruiting three field assistants who spoke the local languages, Sepedi and Xitsonga. This was necessitated by the fact that most of the data collection team members were not competent in the languages spoken in the sampled villages. They, however, had extensive experience of conducting surveys. The field assistants were trained during a day's workshop. Training involved going through all the questions in the questionnaire, establishing common understanding of the type of data required by each question. In addition, all questions were translated into the two local languages and consensus was sought on whether the translations represented the English meaning of the original questions.

Interviewing with the field assistant involved first asking the question in English; the assistant would then ask the same question in the local language with which the respondent was comfortable. The respondent would then respond in his/her language, after which the assistant translated the response to English for the data collector to record on the questionnaire in English. Such a process had to be followed because the researcher was not a native language speaker but had to be involved in all the interviews.

Table 3: Variables and their expected relationship with the dependent variable

Variable	Expected relationship with dependent variable	Rationale
Dependent variables		
Total household income (R)	These were the select livelihood security outcomes measured in the study.	
Household food security (likert scale)		
Independent variables		
Food types consumed	+	These variables capture farm and household characteristics, which are important to understand livelihood strategies.
Total household expenditure (R)	-	
Expenditure on food (R)	-	
Sources of household income	+	
Distance to irrigation scheme (village location)	-	
Participation in irrigation (yes/no)	+	These variables capture natural capital. The more natural capital endowment a household has, a positive effect on household income and food security is expected.
Plot size (ha)	+	
Size of land cultivated (ha)	+	
Crop diversification (types of crops)	+	
Household income by source (R)	+	These variables capture financial capital. A positive relationship is expected between household income and food security and financial capital endowment.
Savings (R)	+	
Loans (R)	+	
Household size (number of members)	-/+	These variables capture human capital. Human capital is expected to have a positive effect on household income and food security because as households accumulate more human capital, this would have a positive effect on household welfare. However, household size would influence household income and food security either negatively or positively depending on the age distribution of additional household members. Household welfare would decline if a household has more of the dependent age group. The opposite is true if a household has more economically active members who also contribute to household labour.
Age of household head (years)	+	
Gender of household head (male/female)	+	
Marital status of household head (single/married)	+	
Level of education of head of household (number of years)	+	
Number of years of farming	+	
Number of years of irrigating	+	
Self-perceptions of innovation, need for achievement, risk-taking (likert scale)	+	
Farmer support services (yes/no)	+	These variables capture social capital. Existing and good social networks are expected to influence household income and food security positively.
Membership of associations (yes/no)	+	
Agricultural assets owned (yes/no)	+	These variables capture physical capital. Assets owned are expected to have a positive effect on household income and food security.
Household assets owned (yes/no)	+	

Source: Survey (2013)

Each day was concluded by checking the questionnaires to minimise measurement errors and using Google Earth to capture the GPS coordinates of the homesteads visited. A data entry template and a coding sheet were developed before commencement of fieldwork. When the data collection exercise ended, responses were coded in preparation for data entry. Coding of the responses was necessary to enable the capturing of numeric values instead of qualitative or string responses, as most statistical software works with numeric variables. Upon completion of the surveys, data were entered in the Excel template. Checking for outliers and wrong entries through running descriptive statistics and physical cross-checking with questionnaires ensured that captured data were clean and ready for analysis.

4.6 Summary and conclusions

This chapter addressed the sampling methods and data collection and data management procedures employed in the study. The chapter also described the study area and presented a map showing the location of Julesburg irrigation scheme and surrounding villages, which provided the context for the study. Primary data was collected through face-to-face interviews using structured questionnaires. To enable testing of hypotheses that the study sought to test, the study approach ensured that data collection was conducted in a way that allowed for comparative analysis across the different types of households.

CHAPTER 5

ANALYTICAL PROCEDURES

5.1 Introduction

This chapter discusses data analysis procedures employed to examine the contribution of smallholder irrigation farming to household income and food security. An empirical model and the estimation strategy are outlined. The chapter provides a detailed explanation of how the four study objectives were addressed and the hypotheses tested. The two economic theories that formed the basis of this study, namely, the sustainable livelihoods framework and the pathways framework, are reflected in econometric models. To recommend suitable strategies for improving rural livelihoods, it is necessary to understand the factors that influence participation in smallholder irrigation farming and the contribution of irrigation farming to rural livelihoods. These factors were identified through literature review and statistical tests were performed to identify the factors that are significantly related to the assessed indicator of being an irrigator. The chapter furthermore highlights other studies that applied similar approaches.

5.2 Data analysis, the empirical model and estimation

As this study is aimed at determining the contribution of smallholder irrigation farming to livelihoods, the need for a representative and inclusive sample that characterises multiple perspectives of the three types of farming households was imperative. In analysis, therefore, the three types of households were accorded equal attention. The study approach ensured that research work was conducted in such a way that comparative analysis was possible across the different types of households.

A combination of SPSS version 22 and STATA version 12.1 software packages was used to perform several analytical procedures to estimate the contribution of smallholder irrigation farming to the rural livelihoods of the different categories of farming households. Firstly, a descriptive analysis of asset endowments for the different types of farming households was

carried out. Secondly, an analysis of means and proportions for the whole sample was undertaken and then a comparison of the characteristics between irrigators and non-irrigators using the *t*-distribution (continuous variables) and chi-square distribution (discrete variables) at $p = 0.1$ level of significance. These characteristics (and other variables) were later used as explanatory variables in the estimation of the propensity score and treatment and outcome models that are presented under the matching and econometric regression models. A combination of smallholder irrigation farming literature, economic theory and the outcome of informal communication with lead farmers was helpful in selecting the explanatory variables used.

Three hypotheses of the study were tested using mathematical methods. Overall, the empirical analysis explores how certain livelihood outcomes are influenced by smallholder irrigation farming. Primary livelihood outcomes of interest are levels of household income and food security. Household income is a continuous variable, while the food security situation is a binary outcome, recorded as one for improvement in the indicator and zero otherwise. The household food security situation was determined through household heads' perceptions of the availability of food in the previous year and not through measurement. The estimation strategy used is a semi-parametric propensity score matching (PSM) method, econometric regression models and analysis of variance (ANOVA), as described in the sections that follow.

5.2.1 Econometric regression models and analysis of variance

The first method of estimation is based on assuming an econometric expression to test hypotheses 1 and 2 of this study. The aim of the analysis was to establish the relationship between smallholder irrigation farming, on the one hand, and household income and food security, on the other, for each type of household.

1) *The contribution of smallholder irrigation farming to household income and food security varies between types of farmers and these benefits are unequally distributed among households.*

2) *The distribution of benefits from smallholder irrigation across rural households is dependent on resource endowment and socio-economic characteristics of the household head.*

The two hypotheses were tested through running descriptive statistics and econometric models. To assess the relationship between irrigation farming, benefits from irrigation farming and factors that influence distribution of the benefits (asset endowments, gender and other factors), a natural logarithm of the welfare ratio was used. In this case, household consumption is regarded as a better proxy for welfare than income, as described in detail by Skoufias and Quisumbing (2005). It is generally argued that, for developing countries, consumption data collected at a given point in time are more likely to accurately represent a household's welfare compared to income data (Ravallion, 1994; Deaton, 1997). Based on the seasonality of agriculture and the fact that rural livelihood strategies often result in seasonal fluctuations in income, households insure themselves against being vulnerable to poverty through consumption smoothing. Hence, vulnerability to poverty is typically measured by the probability that the consumption of a household will fall below a predetermined poverty line within a fixed time interval.

Households face risks that affect their welfare. Generally, households respond to the risks by taking various actions in order to ensure they will be able to consume at previously acceptable levels in the future. Such a process is referred to as consumption smoothing (Sugiyanto *et al.*, 2012). Consumption smoothing is the economic concept used to express the desire of people to have a stable path of consumption. Haughton and Khandker (2009) state that while household income can fluctuate significantly overtime, consumption will be smoothed as households save and borrow to buffer their standard of living. According to Skoufias and Quisumbing (2005), households smooth their consumption through coping strategies, which could be selling off assets when there are shortfalls in income. Morduch (1995) stages that households take steps to protect themselves from income shocks and this can be done at two stages. First, households can smooth their income by making conservative production or employment choices and diversifying economic activities. Such a smoothing mechanism protects the household from shocks before they occur.

Another smoothing mechanism, as described by Morduch, involves borrowing and saving, depleting and accumulating non-financial assets, adjusting labour supply and employing formal and informal insurance arrangements. Such mechanisms follow after the occurrence of shocks to mitigate effects of income variability on consumption patterns. Therefore, the degree of consumption insurance focuses on the extent to which households are successful at insulating their consumption from changes in their income opportunities and other shocks. The amount of money households are willing to pay to completely eliminate income variability is an indicator of welfare costs associated with a perceived risk. The ability of households to effectively smooth consumption overtime reflects an important dimension of well-being as it indicates households' capacity to satisfy their present and future basic needs, despite the existence of risks and the occurrence of shocks (Sugiyanto *et al.*, 2012). However, markets play an important role in influencing household decision-making to evade risks. Risk aversion can affect the way households decide both the composition and nature of income generating activities when full markets for consumption smoothing do not exist (Morduch, 1995; Kazianga & Udry, 2006). Well-functioning markets will facilitate income and consumption smoothing activities (Kazianga & Udry, 2006).

Given these conditions, estimation involved log nominal consumption expenditure per adult equivalent, deflated by a poverty line to give a welfare ratio (equation 1 and 2) (Hanjra *et al.*, 2009b). The poverty line used in this analysis is the lower bound national poverty line of R433 per month per person (in 2011 prices), according to the 2013 Millennium Development Goals country report (Stats SA, 2013b)[4]. The assets included in the model emphasised human resources, which have been recognised as a source of sustained competitive advantage for most poor communities (Luthans *et al.*, 2004; Loayaza & Raddatz, 2010). The DFID (1999) asserts that accumulation of human resources can be an end in itself. Ellis (1999) concurs that human resources are widely substantiated as a key to successful livelihood diversification. The model will, therefore, embrace human capital and assess how this has influenced the livelihoods of the poor. The rest of the assets were handled in descriptive statistics.

[4] The national poverty line is derived based on the cost of adequate food and non-food items (clothing, housing, and transport, among others). The sign 'R' stands for the South African currency, the rand.

$$\text{In}\left(\frac{\hat{C}_i}{Z}\right) = \beta_0 + D_i\beta_1 + H_i\beta_2 + F_i\beta_3 + E_i\beta_4 + A_i\beta_5 + v_i \quad (1)$$

where C_i = consumption expenditure of household i,
D_i = household demographic characteristics,
H_i = human capital variables,
F_i = farm characteristics,
E_i = entrepreneurial attitude variables,
A_i = matrix of technology-related variables, like irrigation,
Z = poverty line, and
v_i = error term.

The above equation, when presented in a more compact form, can be presented as follows:

$$\text{In}\left(\frac{\hat{C}_i}{Z}\right) = X_i\beta + v_i \quad (2)$$

where X_i is a matrix of explanatory variables indicated above.

The estimated regression coefficients measure the percentage change in real consumption for a unit change in the explanatory variables. If the sign of an estimated coefficient is positive and significant, that variable contributes significantly to household consumption and consequently to improved household welfare. The determinants of household consumption were modelled separately for each of the household types.

In addition, an ANOVA was run to investigate differences in weekly diets among the different types of households. The ANOVA significance value enables a conclusion that there is a statistically significant difference between the frequency of meals of the various food groups eaten by a household. However, this significance value does not indicate which condition means are different. To remedy this limitation, post-hoc tests were carried out. These tests are used when a statistical significance between conditions has been found but it is not known where the

statistical differences are. It is noteworthy that when the results of a one-way between subjects ANOVA are not statistically significant, post-hoc tests are necessary. The Tukey post-hoc test is popular for comparing groups, to find out which of the groups were significantly different from the others in the consumption of certain food types.

5.2.2 Propensity score matching

Hypothesis 3 of this study was tested through PSM methods.

3) *Smallholder irrigation farming affects rural livelihoods largely through increased household income and improved household food security.*

5.2.2.1 Model specification

The PSM technique considers the possibility that (a) irrigators and non-irrigators might exhibit systematic differences in characteristics, which might make them less comparable; and (b) selection into an irrigating or non-irrigating group has largely been non-random, based on certain unobservable criteria. Given the non-random selection of scheme and independent irrigators, a simple comparison of household income between irrigators and non-irrigators would yield biased estimates of irrigation farming impact. The challenge is, therefore, to identify a suitable comparison group of non-irrigators whose outcomes, on average, provide an unbiased estimate of the outcomes that irrigators would have had in the absence of irrigation.

Accordingly, the PSM method was used to deal with this challenge by sampling from the potential control group a smaller control group whose distribution of covariates was similar to the distribution in the treated group (Rosenbaum & Rubin 1983; Smith & Todd, 2005). PSM gives an average treatment effect on the treated (ATT), which is considered a better indicator of whether to continue promoting programmes that target specific groups of interest, such as poor farmers, than population-wide average treatment effects (ATE) given by probit models (Rosenbaum & Rubin, 1983; Heckman *et al.*, 1998; Rosenbaum, 2002). Irrigation farming is the

treatment and PSM is based on the assumption that it is not possible for each farming household to be both an irrigator and a non-irrigator. This then necessitates the creation of a counterfactual of what can be observed by matching irrigators (treatment) and non-irrigators (control) groups. PSM, therefore, matches irrigators to non-irrigators with similar values of p(x), giving equation 3 to estimate:

$$E(y_1 - y_0|p(x))=E(y|w = 1, p(x))- E(y|w = 0, p(x)). \quad (3)$$

y_0 and y_1 are household income levels without and with irrigation farming, respectively. w is a binary indicator of involvement in irrigation farming (participation =1, 0 = otherwise). p(x) is the propensity score, which is defined as the conditional probability of being in the group of irrigators conditional on x**.** The vector x contains a set of covariates considered to influence the decision to participate in smallholder irrigation farming. Averaging over the distribution of propensity scores in the treated population gives the average treatment effect on the treated (ATT) conditional on probability propensity scores (PPS), as shown in equation 4:

$$ATE_1^{PSM} =E[E(y|w = 1, p(x)) - E(y|w = 0, p(x))|w = 1]. \quad (4)$$

The principal econometric concern that arises in estimating treatment effects is that of sample selection bias. This problem arises from the fact that treated households are different from the non-treated for reasons apart from being treated per se. The challenge is therefore to identify a suitable comparison group of non-irrigators whose outcomes, on average, provide an unbiased estimate of the outcomes that irrigators would have had in the absence of irrigation. Given the non-random selection of the irrigation research site and farmer self-selection, a simple comparison of household income between irrigators and non-irrigators would yield biased estimates of irrigation farming impact.

Based on the selection of the research area, there are two potential sources of bias in measuring the impact of irrigation farming on household income. The first source of bias would come from the selection of observables, meaning that irrigators are likely to differ from non-irrigators in the

distribution of their observed characteristics. A bias of this nature would arise because the criteria used to select irrigation schemes and farmer selection can also be expected to have a direct effect on income levels in the absence of irrigation farming. To eliminate part of the sample selection bias would entail selecting non-irrigators to be similar to the irrigators in terms of observed characteristics, such as distance to the market, agro-climatic conditions, language and other cultural attributes, economic opportunities other than agriculture, farming practices and traditions, etc.

Propensity score matching was used to control for differences in observed characteristics between irrigators and non-irrigators using survey data. This approach provides an unbiased measure of irrigation impact under the assumption of conditional mean independence, whereby pre-programme outcomes are independent of participation in irrigation, given the variables used as controls for matching (Godtland *et al.*, 2003).

Secondly, irrigators may differ from non-irrigators in the distribution of unobserved characteristics (e.g., in the entrepreneurial attitude, which affect farming ability and affect both the decision to irrigate and the desire to seek new knowledge), resulting in "selection on unobservables". In the absence of a suitable instrument for programme participation, it is impossible to control explicitly for selection on unobservables. However, following work by Altonji *et al.* (2005), an informal way of assessing the potential bias that could result from unobservables was adopted.

Two assumptions underlie the above discussion. The first assumption is that of stable unit treatment value in the retained sample. The assumption is that the treatment only affects the outcomes of those who irrigate; that is, there is no spill-over effect between irrigators and non-irrigators. The second assumption is that of the ignorability of treatment (irrigation): Conditional on the area observed and individual household characteristics x_v, x_i, outcomes (y_0, y_1) and being an irrigator *w* are independent. The second assumption implies weaker conditional mean independence:

$$\mathrm{E}\,(y_0|x_v, x_i, w) = \mathrm{E}\,(y_0|x_v, x_i) \text{ and } \mathrm{E}\,(y_1|x_v, x_i, w) = \mathrm{E}\,(y_1|x_v, x_i). \quad (5)$$

y_0 and y_1 are the household income levels without and with irrigation farming, respectively. w is a binary indicator (participation =1 and 0 otherwise) of involvement in irrigation farming and x_v, $u_{v,}$ x_i, u_i denote observed and unobserved area and individual characteristics, respectively.

The above two conditions allow for building a statistical comparison group for irrigators with similar households from the non-irrigators, and to estimate the impact of irrigation by comparing the observed outcome y_1 of irrigators with the outcome y_0 of households in the comparison group.

Estimation by matching on probability propensity scores requires an index to be constructed out of the observed variables to allow for matching of individuals via a single variable, given that households will differ in many respects. The most commonly used technique to do this is the PSM. This method, developed by Rosenbaum and Rubin (1983), is based on modelling the probability of treatment given the explanatory variables, called the PPS:

$$\mathrm{p(x)} \equiv \mathrm{P(w = 1|x)}. \quad (6)$$

Suppose that two households from the population have identical PPS. Then under the ignorability condition, the ATE, conditional on the PPS, is equal to the expected difference in the observed outcomes between irrigators and matched non-irrigators:

$$\mathrm{E(y_1 - y_0|p(x))=E(y|w = 1, p(x))- E(y|w = 0, p(x))} \quad (7)$$

Averaging over the distribution of propensity scores in the treated population gives the ATT:

$$ATE_1^{PSM} = \mathrm{E}[E(y|w = 1, p(x)) - E(y|w = 0, p(x))|w = 1]. \quad (8)$$

Implementation of this method relies on having an estimator for the PPS. To predict the PPS for the population (the probability of being in the treatment group), a flexible probit model of

participation, where independent variables and various functions of these independent variables are introduced, will be estimated. The estimated model can be used to predict $p(\dot{x})$ for the population {P(irrigators) + non-irrigators} used for the estimation of the ATE.

As the non-irrigators are not included in the estimation of the propensity score, this constitutes an out-of-sample prediction. Its validity relies on the existence of sufficient overlap of the independent variables, and on the assumption that the same participation model would apply in both samples if irrigation facilities were offered to the non-irrigators. The latter is an assumption of the ignorability of the choice of farmers for irrigation.

A third assumption is the ignorability of the selection of irrigators: Conditional on observed area and individual characteristics x_v, x_i, the choice of areas for the placement of an irrigation facility and participation *w* are independent.

This assumption implies conditional mean independence:

$$P(w = 1|x_v, x_i, irrigation) = P(w = 1|x_v, x_i). \quad (9)$$

5.2.2.2 Model estimation

A probit model was estimated to predict propensity scores (p(x)), using covariates (x) (namely age of household head, age of household head squared, gender of household head, distance to the irrigation scheme, education of household head, water source, membership of a farmer association, membership of a farmer cooperative, membership of a village committee and membership of a political party). Covariates were first selected based on previous research focussing on determinants of household welfare (Mendola, 2007; Irajpoor & Latif, 2011; Tekana & Oladele, 2011; Sinyolo *et al.*, 2014), followed by a statistical stepwise procedure to get the best region of common support. Results of the probit model are used to predict the PPS, which is then used to match irrigating households with observationally similar non-irrigators. A number of matching methods can be used at this stage, each using a different function to conduct the

matching, although the result of each is an ATT value that indicates the impact of irrigation farming on the selected livelihood indicators.

In this study, to construct the comparison group, kernel-based matching was used. This method matches a treated unit to all control units weighted in proportion to the closeness between the treated and the control unit; that is, control units receive weights based on the distance between their propensity score and the propensity score of the treated unit to which they are being matched. To check the robustness of the results from kernel matching, another matching algorithm in the calculation of the ATT, the nearest neighbour matching method, was used. This method involves choosing a unit from the control or comparison group as a matching partner for a treated individual that is closest in terms of the propensity score. To check that the propensity score is balanced across treatment and comparison groups, the common support or overlap condition was imposed on the estimation by matching in the region of common support. The common support condition requires balancing of covariate distribution between treated and untreated observations to ensure that treated observations have comparable untreated observations nearby in the PS distribution (Caliendo & Kopeinig, 2008). If the common support condition is satisfied, there should be significant overlap in the distribution of the propensity scores of both treated and untreated groups. Furthermore, the reliability of the PSM results is explored by assessing the quality of the matching process. A two-sample *t*-test is run to investigate the significance of the post-matching differences in the covariate means for the two groups. After matching, none of the variables used should portray any statistically significant difference between irrigators and non-irrigators.

5.3 Summary and conclusions

This chapter outlined analytical procedures employed in the study. The chapter described the analytical techniques used for data analysis. The empirical model and the estimation strategies used to estimate the relationship between smallholder irrigation farming on the one hand and household income and food security on the other were described. A semi-parametric PSM method and econometric regression models were used to test the hypotheses that the study

sought to test. The main conclusion was that through these estimation procedures, the different types of households were accorded equal analytical attention and the study approach ensured that research work was conducted in such a way that comparative analysis was possible across the different types of households.

CHAPTER 6

SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLED HOUSEHOLDS

6.1 Introduction

This chapter describes the socio-economic characteristics of the sampled households to provide an understanding of the type of community studied. Household characteristics are important determinants of economic activities, livelihood strategies and decisions taken by households. Socio-economic characteristics are also important in assessing the vulnerability of different households to economic, political and socio-psycho-cultural shocks. This chapter also presents an exploration of household capabilities and assets. An understanding of household characteristics and asset endowments will be useful in crafting appropriate disaggregated policy recommendations for the different household typologies studied. In addition, this chapter presents an analysis of the different reasons why households in the study area engaged in smallholder farming, allowing for comparison with the national general household surveys conducted by Statistics South Africa. The last part of the chapter presents a description of the different household typologies found in the study area and a description of their income portfolios.

6.2 Household capabilities and assets

Household capabilities have to do with the capacity of the household to secure a livelihood (De Satge *et al.*, 2002). Household capabilities are closely linked with the different types of household assets owned or accessed. All livelihood strategies depend upon access to assets. Assets are the tangible and intangible building blocks of livelihoods. Nel (2015) describes assets as what gives people the capacity to act and thus are a source of meaningful engagement with the world. Tangible assets are resources (such as land, tools and livestock) and stores (e.g. food and savings, often in the form of consumer durables). Intangible assets are the human capacity, values and access people have to tangible assets.

Assets owned are key in implementing livelihood strategies such as crop and livestock husbandry, which are necessary for the realisation of desired livelihood outcomes (LaFlamme & Davies, 2007; Nkala *et al.*, 2011). The SLF, as presented in Chapter 3, is built around five principal categories of assets. These assets include: human, natural, social, financial and physical capital (Scoones, 1998; Ellis, 2000; Luthans *et al.*, 2004; IFAD, 2012). Livelihoods depend on a combination of assets of various kinds and not just from one category. A distinction between different types of assets draws attention to the variety of resources, often used in combination, which people rely on to derive a flow of income or consumption and also invest in so as to increase future flows of income or consumption. This section gives a descriptive analysis of the asset endowment of respondents in Julesburg research site.

6.2.1 Human capital

Human capital comprises the skills, knowledge, amount and quality of labour and good health important for the successful pursuit of different livelihood strategies. Human capital varies according to household size, skill levels, leadership potential and health status (Scoones, 1998; DFID, 1999; Krantz, 2001; Haidar, 2009). Table 4 shows human characteristics of the different types of households in the study area. In terms of gender and age of household heads interviewed, the average age distribution of the household heads ranged from 56 years for home gardeners to 63 years for scheme irrigators. Scheme irrigator households had the greatest proportion of male heads (96.3%). The oldest household head was a female aged 104 years, while the youngest was a 29-year-old male, both of which were among the home gardeners.

In terms of household size and the highest education level attained by the heads of households, Table 4 shows that the average household size is 5.7 for all the households interviewed. Although household sizes did not differ significantly among household types, 'other' households had the largest household size (6.2 members), compared to independent irrigator households (5.8 members), home gardeners (5.5 members), and scheme irrigator households (4.9 members). Household size determines the size of the labour pool in a household (Bhacha *et al.*, 2011; Badisa, 2011). If most resident household members worked full-time on the farm, households would not have a serious problem of farm labour and would be likely to adopt labour-intensive

technologies when only labour resources are considered. The opposite can also apply when members of a household refuse to work on the farm, but still participate in consumption of the household resources (Dlova *et al.*, 2004). However, this would only be applicable if all family members were old enough to perform farm work and were willing to provide labour.

Table 4: Demographics of different households

Characteristic	Scheme irrigators (n=27)	Independent irrigators (n=35)	Home gardeners (n=53)	Other (n=65)	Total (n=180)
Mean age of household head (years)	63	60	56	62	**60**
Gender of household head (%)					
• Male	96.3	82.9	41.5	50.8	**61.1**
• Female	3.7	17.1	58.5	49.2	**38.9**
Household size (number)	4.9	5.8	5.5	6.2	**5.7**
Number of economically active adults	3.2	3.5	3.4	3.7	**3.5**
Number of aged adults	0.6	0.6	0.3	0.5	**0.5**
Number of children	1.1	1.7	1.7	2.0	**1.7**
Number of adult equivalents	3.7	4.2	3.9	4.3	**4.1**
Labour force ratio	0.65	0.64	0.65	0.59	**0.63**
Household members who completed secondary education (%)	74.1	77.1	64.2	64.6	**68.3**
Household members who completed tertiary education (%)	22.2	28.6	15.1	20	**20.6**
Education level of household head (%)					
0-7 years of schooling (%)	55.6	40.0	62.3	61.5	**56.7**
More than 7 years of schooling (%)	44.4	60.0	37.7	38.5	**43.3**

Source: Survey data (2013)

Education level is important in as far as it affects assessment and adoption of new technologies and marketing decision-making by smallholder farmers. Literate farmers are likely to be more receptive to new ideas. Skills and knowledge are closely linked with education, which can be obtained formally or informally (Winters, 2011). Access to formal education enables people to gain skills and knowledge in ways that provide official recognition for their educational achievements in the form of qualifications, which typically improve their opportunity to make a living (Ellis, 2000; Kyei & Gyekye, 2011). Literature has indicated the role of informal education in the transfer of traditional knowledge, which may include knowledge of farming (Mango, 2002). Mohamed (2006) reported that smallholder irrigators at Dzindi learnt to farm in

informal ways, i.e. from their parents and from one another. Table 4 shows that the group of independent irrigators has the highest proportion of household heads who spent more than seven years at school (60%), while home gardeners had the lowest proportion (37.7%). Therefore, independent irrigators are more likely to adopt new technologies and ideas when only education level is considered.

The number of economically active, aged adults and children did not show much variation among the different types of households, hence, similar values were found for the adult equivalents and labour force ratio. These indicators also determine the size of the labour pool in a household.

Selected personality traits of the household heads, which are associated with entrepreneurship, are shown in Table 5, which also provides information on the perception of household heads of the extent to which their farm enterprises were innovative. Personality traits linked to entrepreneurship were grouped into three categories, namely need for achievement, locus of control and risk-taking propensity. Need for achievement involved questions regarding always looking for new ways of making money and improving the farming business. Locus of control included questions on reaching the goals set for the farm enterprise and the ability to solve all the problems encountered on the farm. Risk-taking propensity involved the belief that problems on the farm could be solved in many ways and hope that the farm enterprise would always recover after setbacks.

The need for achievement was generally high compared to the other two entrepreneurial traits. The proportion of household heads with a need for achievement was lowest among home gardeners, compared to independent irrigators and scheme irrigators. Locus of control was similar for all household types, with an average of 67%. Risk-taking propensity was highest among independent irrigators and lowest among home gardeners.

Table 5: Indicators of entrepreneurship among household heads

Entrepreneurship indicator	Scheme irrigators (n=21)	Independent irrigators (n=29)	Home gardeners (n=47)	Total (n=97)
Entrepreneurial trait				
Need for achievement (%)	82.1	86.8	56.4	71.1
Locus of control (%)	64.6	65.7	68.9	67.0
Risk-taking propensity (%)	69.4	74.6	65.7	69.1
Degree of innovation				
Object of farming (%)	25.2	38.9	3.5	18.8
Farming practices (%)	23.8	41.2	12.7	23.6
Farming inputs (%)	23.7	34.3	33.9	31.8
Farming equipment (%)	19.0	19.4	8.5	14.0
Produce markets (%)	25.2	49.2	5.0	22.6

Source: Survey data (2013)

Independent and scheme irrigators showed a greater need for achievement than home gardeners. The mean score for locus of control of the farmer was similar among the three household types. Independent irrigator households scored higher on risk-taking propensity than scheme irrigator households and especially home gardener households in the study site. The perceptions household heads had of the degree of innovation in their farm enterprises were much higher for independent irrigators across the different aspects of the farm enterprise. The highest score for independent irrigators was for the aspect of produce markets.

6.2.2 Natural capital

Natural capital constitutes the natural resource stocks (soil, water, air, genetic resources, etc.) and environmental services (hydrological cycle, pollution sinks, etc.) from which resource flows and services useful for livelihoods are derived (DFID, 1999). For this study, an assessment of natural capital was limited to the land and water that were used for agricultural purposes. Natural capital, therefore, referred to the natural resource stocks that households owned or had access to for irrigation farming purposes.

Table 6 shows natural capital owned by the different types of households in the study area during the 2012/13 season. Home gardeners cultivated relatively small parcels of land, about 0.4 ha on

average. Both scheme and independent irrigators cultivated land parcels in the order of 3 ha. Inadequate access to water was a primary constraint to cultivation in home gardens.

Table 6: Natural capital of the different types of households

	Scheme irrigators (n=21)	Independent irrigators (n=29)	Home gardeners (n=47)	Total (n=97)
Total land area owned/accessed (m^2)	67066 (38011)	67221 (90592)	6618 (17672)	37789 (61386)
Area cultivated (m^2)	37247 (28908)	31399 (25242)	4434 (11252)	19588 (25346)
Adequacy of land holding (%)	100	74.7	85.1	86.3
Adequacy of water source (%)	66.7	66.4		
Source of irrigation water for residential plots				
Tap	0.0	100.0	0.0	12.5
Canal	33.3	0.0	0.0	12.5
Ground by means of borehole	0.0	0.0	25.0	12.5
Dam	66.7	0.0	75.0	62.5
Source of irrigation water for scheme plots				
River by direct extraction	40.0	88.9	14.3	52.4
Canal	0.0	0.0	28.6	9.5
Dam	60.0	11.1	57.1	38.1
Source of irrigation water for independently irrigated plots				
River by direct extraction	30.0	57.1	33.3	43.8
Canal	10.0	14.3	11.1	12.5
Ground by means of borehole	20.0	28.6	22.2	12.5
Dam	40.0	0.0	33.3	31.3

Note: Figures in parenthesis are standard deviations
Source: Survey data (2013)

The household head's perception about the adequacy of land and water for the purpose of farming indicates more than 60% satisfaction with water adequacy for scheme and independent irrigators. On land adequacy, contrary to expectations, 'land hunger' appeared limited. This is indicated by the overall means of the adequacy of land holding scores of 86.3%. This score was

designed to range between 33.3% (all households in the group consider their land holding as much too small) and 167% (all households in the group consider their land holding as much too large). For all types of households, this score ranged between 75 and 100%, suggesting the absence of a desire for more land among households. The independent irrigators scored lowest (74.7%), indicating that as a group they had the greatest desire for more land. Adequacy of land holding could be influenced by siting, where independent irrigators located close to a river would have a desire for expansion as opposed to irrigators on a scheme where plot sizes are fixed.

Sources of water for irrigation were diverse. Scheme irrigators relied on the dam for irrigation water while independent irrigators extracted water from rivers. Home gardeners used water from various sources (dam, river or borehole) depending on their location and the water source that they can easily access.

6.2.3 Financial capital

Financial capital is the capital base (cash, credit/debt, savings and other economic assets, including basic infrastructure and production equipment and technologies) that is essential for the pursuit of any livelihood strategy. Indicators of the financial capital of households are presented in Table 7. Home gardener households had the lowest regular flows of income of the three household types and scheme irrigators the highest. The value of 'other flows of income', which were derived from various forms of self-employment excluding agriculture, was much lower than that of the regular flows. Scheme and independent irrigators had higher 'other flows of income' than home gardeners, both at household level and on a 'per person' basis. Income from farming was highest among independent irrigators. The pattern for money saved mirrored that of income flows.

Money invested in insurance, almost invariably in the form of funeral policies taken out with formal and informal (community-based) institutions, tended to be more evenly distributed among the different types of households than savings, particularly because the great majority of households of all types held at least one funeral policy. This result suggests that insuring against

death in the family takes priority over saving money. The value of loan repayments by households was a fraction of their savings, suggesting that on the whole, households were 'building' financial capital thereby engaging in a consumption smoothing mechanism (Sugiyanto *et al.*, 2012).

Table 7: Financial capital indicators of the different types of households

Financial capital indicator	Scheme irrigators (n=27)	Independent irrigators (n=35)	Home gardeners (n=53)	Other (n=65)	Total (n=180)
Regular flows of income (R)	78103	58005	52857	53398	57840
Regular flows of income per person (R)	21200	13906	13044	11775	13977
Other flows of income excluding farming total (R)	7651	7711	3997	4803	5558
Other flows of income excluding farming per person (R)	2313	1830	1206	946	1400
Income from farming (R)	31944	64928	1555	22	17425
Income from farming per person (R)	6843	14554	259	7	3859
Savings total (R)	7710	8342	4112	2482	4886
Savings per person (R)	2138	2298	1288	566	1351
Insurance total (R)	2181	2289	1852	1839	1982
Insurance per person (R)	638	608	569	409	529
Loans total (R)	735	9425	403	765	2338
Loans per person (R)	240	1876	114	176	498

Source: Survey data (2013)

Figure 4 shows the proportion of households that borrowed money by source of loan. About 30% of the households reported having borrowed some money. Although, overall, the difference between the proportion of households that borrowed money from formal sources and from informal sources was minimal, formal sources seemed more popular among scheme and independent irrigator households compared to the rest of the households. Home gardeners and other households, however, seemed to borrow more from informal sources. The main reasons expressed for borrowing money were to buy food, to extend farming operations, to buy farm inputs, to pay for education and to purchase a car/*bakkie*. Households indicated a desire to invest in improving their household welfare.

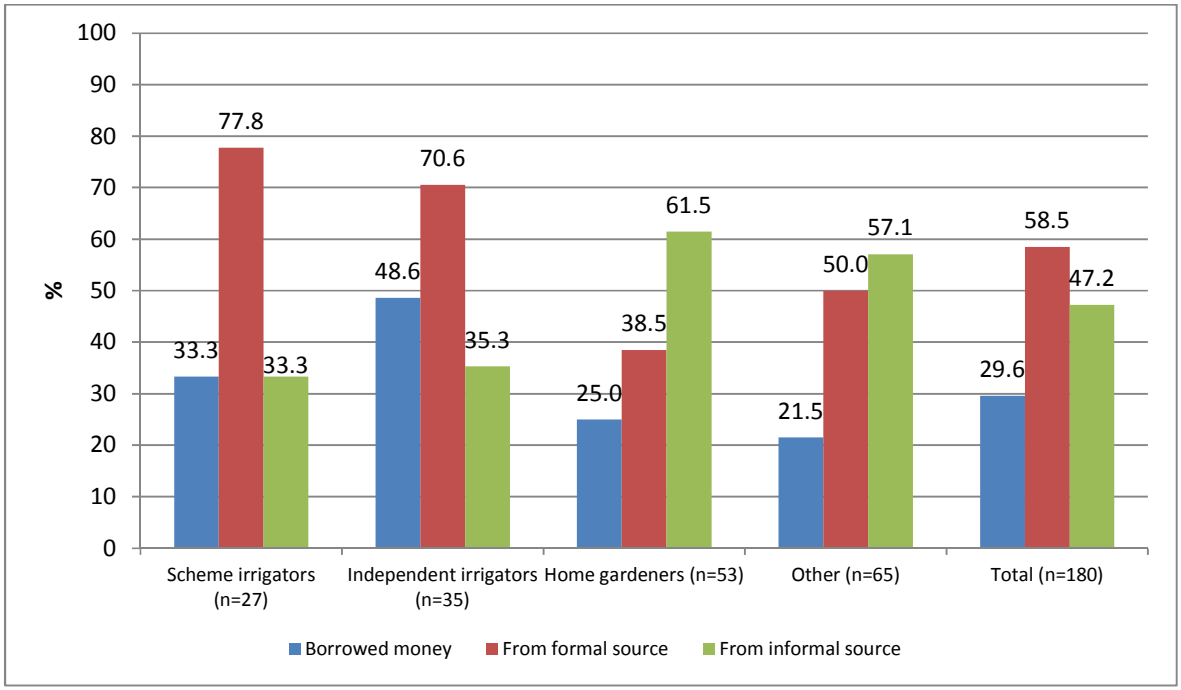


Figure 4: Proportion of households that borrowed money by type of household and source of loan
Source: Survey data (2013)

6.2.4 Physical capital

Physical capital comprises the basic infrastructure (changes in the physical environment that help people meet their basic needs and to be more productive) and tools and equipment needed to support livelihoods. Table 8 shows ownership of physical assets by interviewed households. The scope of this study was limited to 'production goods and privately owned infrastructure' used in agriculture, and excluded public infrastructure and producer goods used in livelihood activities that are part of other economic sectors, such as construction.

Physical assets owned by the majority of households across type were limited to basic hand tools, particularly hand hoes and spades. These results indicate that agricultural activities in rural areas are not mechanised. Ownership of knapsack sprayers was very common among scheme and independent irrigators but rare among home gardeners. Ownership of wheelbarrows, on the other hand, was widespread among home gardeners. Ownership of physical assets is directly related to the major agricultural activities of each household type, for example, home gardeners

used wheelbarrows to fetch water from public taps while irrigators cultivated cash crops which predominantly required regular chemical spraying for pest and disease control hence they owned knapsack sprayers.

Ownership of the means to cultivate land using draught power, be it animals or tractors, was limited. Of significance was that ownership of cattle, which can be used to provide draught power, was considerably more widespread than ownership of animal-drawn cultivation implements. This suggests that only a fraction of the households that owned cattle used these animals to provide draught power for cultivation.

The proportion of households that owned a tractor was 10.3%, but ownership was limited to households in the scheme irrigator group only. None of the home gardener households owned a tractor. This is not necessarily a constraint to cultivation, because the small size of the home gardens makes it feasible to cultivate by hand. This does not apply to the irrigated holdings of scheme and independent irrigators. Limited ownership of the means to cultivate and the use of draught power among households in these two groups suggest that the majority among them hired the services of land preparation companies (e.g. contractors & tractor owners) operating in their communities, which probably included other farming households who owned the means to provide these services.

Ownership of mechanised transportation such as *bakkies* and trucks was common, particularly among independent irrigators. Ownership of irrigation equipment was unevenly spread among household types. Privately owned infrastructure for use in agriculture, which included poultry production facilities, farm sheds, grain storage facilities and grain mills, was found most commonly in independent irrigator households, while scheme irrigators had the highest levels of farm shed and grain mill ownership.

Table 8: Proportion of ownership of implements and other physical assets used in farming by type of household

Asset/Implement	Scheme irrigators (n=21)	Independent irrigators (n=29)	Home gardeners (n=47)	Total (n=97)
Basic hand tools used in farming				
Hand hoe (%)	100.0	100.0	95.7	97.9
Spade (%)	95.2	86.2	85.1	87.6
Rake (%)	47.6	58.6	63.8	58.8
Knapsack sprayer (%)	90.5	75.9	2.1	43.3
Wheelbarrow (%)	33.3	55.2	89.4	67.0
Draught animals and animal-drawn cultivation implements				
Cattle (%)	28.6	37.9	10.6	22.7
Horses (%)	0.0	0.0	0.0	0.0
Donkeys (%)	4.8	10.3	0.0	4.1
Animal-drawn plough (%)	4.8	6.9	2.1	4.1
Animal-drawn harrow (%)	0.0	3.4	2.1	2.1
Animal-drawn ridger (%)	0.0	0.0	2.1	1.0
Animal-drawn planter (%)	0.0	0.0	0.0	0.0
Animal-drawn cultivator (%)	0.0	0.0	2.1	1.0
Mechanised draught and tractor-drawn cultivation implements				
Tractor (%)	14.3	24.1	0.0	10.3
Tractor-drawn plough (%)	9.5	20.7	0.0	8.2
Tractor-drawn disk (%)	4.8	6.9	0.0	3.1
Tractor-drawn ridger (%)	0.0	10.3	0.0	3.1
Tractor-drawn planter (%)	0.0	0.0	0.0	0.0
Tractor-drawn cultivator (%)	0.0	0.0	0.0	0.0
Physical assets for transportation				
Tractor-drawn trailer (%)	14.3	10.3	0.0	6.2
Animal-drawn cart (%)	4.8	3.4	0.0	2.1
Bakkie/truck (%)	23.8	27.6	6.4	16.5
Physical assets for irrigation				
Irrigation pump (%)	28.6	37.9	0.0	17.5
Irrigation pipes (%)	61.9	69.0	8.5	38.1
Water storage facility (%)	4.8	10.3	10.6	9.3
Immovable fixed assets used in farming				
Poultry production facility (%)	0.0	13.8	2.1	5.2
Farm shed (%)	23.8	20.7	0.0	11.3
Grain storage facility (%)	4.8	13.8	4.3	7.2
Grain mill (%)	9.5	3.4	2.1	4.1

Source: Survey data (2013)

6.2.5 Social capital

Social capital represents the social resources (networks, social claims, social relations, affiliations, associations) upon which people draw when pursuing different livelihood strategies requiring co-ordinated action (Dacosta & Turner, 2007; Adhikari & Goldey, 2010). Social capital has also been defined as referring to the quantity and quality of social resources upon which people draw in pursuit of livelihoods and as safety net mechanisms to meet shortfalls in consumption needs (Frankenberger *et al.,* 2000). The different definitions emphasise that social

capital is built through networks and connectedness, including kinship, joining formalised groups and building relationships of trust, reciprocity and exchange. For rural households social capital is important for two main reasons, namely to claim against in times of crisis (Van der Geerst, 2004; Bell, 2012) and to count on when pursuing livelihood activities or strategies that require co-ordinated action (Scoones, 1998; Krantz, 2001). Woolcock and Narayan (2000) pointed out that the basic idea of social capital is that one's family, friends and associates constitute an important asset that can be called upon in a crisis, enjoyed for its own sake and/or leveraged for material gain. Social capital provides access to other assets and access is the most critical resource of all (Mathie & Cunningham, 2005).

For this study, social capital was captured in terms of the associations and networks of which households were members at the time of the interview. Table 9 provides information on household membership of different types of organisations that could be found at the local level at the study site. Membership of religious organisations (churches) and burial societies was most predominant, exceeding 70% across household types. While this is of great significance from a livelihood perspective, because it indicates that these two types of organisations connect people and bring them together on a frequent basis, these two types of organisations have little to do with farming.

Membership of farmers' associations and cooperatives was considerably lower than membership of religious organisations and burial societies. This was partly due to the low membership of agriculture-related organisations among the home gardener group. The difference in membership of agriculture-related organisations between home gardeners on the one hand and scheme and independent irrigators on the other could be seen as a reflection of the relative importance of farming in the livelihoods of these households.

Membership of political parties and village committees is important for empowerment and political action. Membership of village committees link households to governance at the local level, where in many cases decisions or recommendations on natural capital allocations are

made. A significant finding was that independent irrigator households were more likely to be members of political parties and village committees than households in the other two groups.

Table 9: Proportion of households that were members of associations

	Scheme irrigators (n=27)	Independent irrigators (n=35)	Home gardeners (n=53)	Other (n=65)	Total (n=180)
Farmers' association	63.0	31.4	0	3.1	16.7
Farmers' cooperative	3.7	14.3	1.9	0	3.9
Farmer-related groups	7.4	2.9	0	0	1.7
Water user association	25.9	8.6	0	0	5.6
Professional organisation	11.1	5.7	1.9	1.5	3.9
Trade or labour union	7.4	8.6	7.5	9.2	8.3
Village committee	18.5	22.9	11.3	4.6	12.2
Religious group	85.2	85.7	83	78.5	82.2
Political party	33.3	45.7	28.3	24.6	31.1
Cultural association	7.4	17.1	5.7	4.6	7.8
Burial society	85.2	74.3	83	83.1	81.7
Credit or savings group	33.3	28.6	34	36.9	33.9
NGO or civic group	3.7	5.7	7.5	4.6	5.6
Any other group	0	0	1.9	1.5	1.1

Source: Survey data (2013)

Information on the perceived likelihood of households being able to claim livelihood resources from others is presented in Table 10. The results indicated that a substantial proportion of households were likely to claim livelihood resources against others successfully in times of need. When in unforeseen need of money, households were most likely to claim successfully against friends or neighbours (68.3% and 60.3%, respectively). The same pattern applied to claims for food and to a lesser extent labour.

Table 10: Perceived likelihood of success when claiming selected livelihood resources against selected networks among households

Likelihood of claiming successfully	Scheme irrigators (n=27)	Independent irrigators (n=35)	Home gardeners (n=53)	Other (n=65)	Total (n=180)
Assistance with money in case of emergency					
• Family (%)	26.9	45.0	32.7	36.2	35.5
• Friends (%)	78.7	60.7	68.3	68.1	68.3
• Neighbours (%)	61.1	60.7	57.7	61.9	60.3
• Organisation (%)	33.3	45.7	35.1	38.9	38.3
Assistance with food in case of emergency					
• Family (%)	22.2	22.9	25.0	26.9	24.9
• Friends (%)	72.2	52.9	63.5	91.5	72.9
• Neighbours (%)	46.3	56.4	50.0	53.9	52.1
• Organisation (%)	45.4	45.7	47.1	48.5	47.1
Assistance with labour in case of emergency					
• Family (%)	10.2	11.4	17.8	16.5	14.9
• Friends (%)	38.9	27.1	26.9	35.8	32.0
• Neighbours (%)	23.2	30.0	22.1	27.7	25.8
• Organisation (%)	20.4	28.6	21.6	32.7	26.8

Source: Survey data (2013)

6.3 Reasons for household involvement in agricultural activities

Households practised farming for varied reasons and these were explored in this study. According to a 2014 general household survey (Stats SA, 2015), in South Africa, the majority of households that participated in agricultural activities did so to obtain an extra source of food (77.5%). A small proportion of households (9.6%) engaged in farming to meet most of their food requirements. Other reasons for farming were to earn extra income (5.1%), as a hobby (5.9 %) and as a main source of income (1.9%). In the more rural provinces, the principal reason for farming for nearly 90% of households remained an extra source of food (i.e. Limpopo=91.1%, Eastern Cape=85.6% and Mpumalanga=85.9%) (Stats SA, 2015).

For comparison of the study area with the national statistics, Table 11 shows the purpose of farming for households that indicated that they engaged in farming activities. Of the 165 households (92% of the sample) that indicated that they were involved in farming, 40% farmed

as an extra source of food, 30% farmed as a main source of food, 21% farmed as a main source of monetary income and 6.7% got extra income from farming, while about 1% of the households were farming as a leisure activity.

Most of scheme and independent irrigators regarded farming as their main source of income (48.1% and 57.1%, respectively), while 66% of the home gardeners engaged in farming as an extra source of food. Forty-eight percent of the other types of households regarded farming as a main source of food. It is noteworthy that the goal of food production dominates among home gardeners, while making money was the predominant goal for scheme and independent irrigators. A pearson chi-square test revealed that there were statistically significant differences in the purpose of farming among different types of households at 0.01 level of significance (p=0.000).

Table 11: Number and proportion of households indicating their purpose of farming by type of household

		Scheme irrigators	Independent irrigators	Home gardeners	Other	Total
Extra source of food	n	4	6	35	21	66
	%	14.8	17.1	66.0	42.0	40.0
Main source of food	n	4	5	17	24	50
	%	14.8	14.3	32.1	48.0	30.0
Main source of monetary income	n	13	20	0	2	35
	%	48.1	57.1	0	4.0	21.0
Extra source of monetary income	n	6	4	1	1	12
	%	22.2	11.4	1.9	2.0	6.7
Leisure activity	n	0	0	0	2	2
	%	0	0	0	4.0	1.2
Total	n	27	35	53	50	165
	%	100	100	100	100	100

Source: Survey data (2013)

When different production systems for all household types were analysed, results indicated that the goal of the majority of households (71%) who reared livestock on their residential site was to produce food for home consumption. Detailed results of the production system analysis can be found in deliverable 14 of the WRC report (WRC, 2015).

The different types of households were grouped into two categories, irrigators and non-irrigators, to allow for comparison of means of key variables. Table 12 shows a summary of statistics and a description of the variables for irrigators and non-irrigators separately (columns 3 and 4, respectively) and for the full sample (column 5). The *p*-values for the *t*-test for equality of means are reported (column 6) to determine whether differences in means of these variables are significantly different between irrigators and non-irrigators at 0.1, 0.05 and 0.01 levels of statistical significance.

The statistics reveal that irrigators constituted 34% of the sample size of irrigators and non-irrigators. Overall, the *t*-tests reveal considerable, significant differences in the characteristics between the two groups of irrigators and non-irrigators. The food security situation was assessed by asking household heads to indicate whether they had had enough food most of the time or not in the previous year[5]. Of the pooled famers, 66% reported being food-secure; they had enough food most of the time. There was a statistically significant difference in the food security situation of irrigators compared to non-irrigators. Household income was statistically different between irrigators and non-irrigators at an average of R125 006.65 and R57 607.98 for irrigators and non-irrigators, respectively.

Insignificant differences existed with regard to the age of the household head, household size, membership of trade/labour unions, membership of religious groups, membership of credit/savings groups, membership of any other group, borrowing money from informal sources, ownership of assets (both household assets and means of transport) and in the value of food consumed from own farm production.

[5] The study's approach to assessing a household's food security situation was based on the household head's perception and self-reported experience of access to food over the 12 months prior to the interview. Given the open-ended nature of the food security definition, this study only covered an aspect of food security without specifically considering all the pillars of food security i.e. food availability, access to food, food utilisation and stability (Vink, 2012).

Table 12: Descriptive statistics (means) of variables used in the analysis

Variable	Description	Irrigators	Non-irrigators	Full sample	*t*-test (*p*-values)
Dependent variables					
Food security situation (dummy)	1=Food-secure; 0=Otherwise	0.77	0.61	0.66	0.02**
Household income (R)	Annual household income	125 006.65	57 607.98	81 731.20	0.00***
Independent variables					
Irrigator	1=Household irrigates; 0=Otherwise			0.34	
Age (years)	Age of household head	61.50	59.15	59.96	0.20
Gender	1=Male household head; 0=Female	0.89	0.47	0.61	0.00***
Marital status	1=Single household head; 0=Otherwise	0.23	0.53	0.42	0.00***
Household size	Total household members	5.37	5.85	5.68	0.25
Education	Highest level of education for household head 1= More than 7 years of schooling; 0=0-7 years of schooling	0.53	0.38	0.43	0.06*
Entrepreneurial attitude	Entrepreneur 1=Yes; 0=Otherwise	0.74	0.64	0.69	0.00***
Membership of associations	Member of a farmer association 1= Member; 0=Otherwise	0.45	0.02	0.17	0.00***
	Member of cooperative 1= Member; 0=Otherwise	0.10	0.01	0.04	0.00***
	Member of other farmer-related group 1= Member; 0=Otherwise	0.05	0.00	0.02	0.08*
	Member of a water user association 1= Member; 0=Otherwise	0.16	0.00	0.06	0.00***
	Member of a trade/labour union 1= Member; 0=Otherwise	0.08	0.08	0.08	0.93
	Member of a village committee 1= Member; 0=Otherwise	0.21	0.08	0.12	0.01***
	Member of a religious group 1= Member; 0=Otherwise	0.85	0.81	0.82	0.39
	Member of a political party 1= Member; 0=Otherwise	0.40	0.26	0.31	0.06*
	Member of a credit/savings group 1= Member; 0=Otherwise	0.31	0.36	0.34	0.50
	Member of any other group 1= Member; 0=Otherwise	0.00	0.02	0.01	0.16
Borrowed money	Household borrowed money from formal source 1=Borrowed money; 0=Otherwise	0.31	0.11	0.18	0.00***
	Household borrowed money from informal source 1=Borrowed money; 0=Otherwise	0.15	0.14	0.14	0.98
Means of transport	1=Owned means of transport; 0=Otherwise	0.77	0.74	0.75	0.58
Household assets	1=Owned assets; 0=Otherwise	1.00	0.99	0.99	0.32
Land size	Total land area owned or accessed 2012/13 season (ha)	6.7	0.7	3.8	0.00***
Area cultivated	Area cultivated 2012/13 season (ha)	3.4	0.4	2.0	0.00***
Value of consumption (R)	Monetary value of consumption	2315.50	1499.45	1920.10	0.18
Expenditure on food (R)	Monetary value of monthly expenditure on food	965.40	649.58	758.36	0.01***
Household expenditure (R)	Monetary value of total monthly expenditure	5050.44	2684.12	3499.18	0.02**
Years operating farm business	Number of years operating farm	14.6	21.0	17.7	0.03**
Training	Received agricultural training 1=Yes; 0=Otherwise	0.7	0.1	0.37	0.00***

Note:*, **, *** = significant at 0.1, 0.05 and 0.01 level of significance, respectively.
Source: Survey data (2013)

Sixty-one percent of the households were male headed, with an average age of 60 years. The irrigator group was dominated by male household heads compared to non-irrigators. Male dominance among irrigators may be explained by apartheid plot allocation policies in schemes that excluded women (Lahiff, 2000; Maimela, 2002; Van Koppen & Hussain. 2007; Thagwana, 2009). In addition, the household head was not always the farmer but the person bearing legal responsibility for the land farmed. In general, literature states that scheme plots were open to all households except for cases where schemes were specifically targeting rural women (Chancellor, 1996; Thagwana, 2009). About 43% of the household heads completed more than seven years of schooling, with irrigators being more educated. Entrepreneurial attitude was statistically significantly different between irrigators and non-irrigators. Membership of associations was statistically significantly different between irrigators and non-irrigators, particularly with regard to farmer associations, cooperatives, water user associations, village committees, political parties and other farmer-related groups. Since the mean values for the irrigators were consistently higher than the means for the non-irrigators, it can be concluded that irrigators joined groups or associations significantly more often than non-irrigators did.

The average farm size or land accessed in 2012/13 season was 3.8 ha and the average cultivated area was 2 ha for the full sample. The irrigators had significantly larger farm sizes and cultivated larger plots compared to non-irrigators. However, non-irrigators had been operating their farm businesses for significantly longer that the irrigators, at 21 years and 14.6 years, respectively. Household expenditure averaged R3 499.18 for the full sample, with irrigators spending significantly more than the non-irrigators per month. Expenditure on food followed the same pattern, with a monthly average of R758.36. Access to agricultural training was more inclined towards the irrigators compared to non- irrigators.

6.4 Household typologies

Household typologies offer a useful tool for stratifying into homogenous units with minimal internal differences, which provide an opportunity for developing disaggregated domains for policy recommendations. Variables used for developing the typologies were based on the

knowledge of characteristics that caused heterogeneity between households. In order to assess the effects of differences in asset endowments and socio-economic characteristics in the sampled households, household typologies based on sources of income for the different household types were analysed (Table 13). Members of about 37% of the households interviewed were salary earners. The majority of these salary earners were home gardeners (43%). The other types of households that emerged from this analysis included pensioner households (22%), households dependent on social grants (14%), farming households (12%), households with diversified sources of income (9%) and households active in the informal sector (5%).

Table 13: Household typologies by source of income and household type

		Scheme irrigators	Independent irrigators	Home gardeners	Other	Total
Salary earner households	n	10	7	23	26	66
	%	37	20	43.4	40	36.7
Pensioner households	n	5	7	12	16	40
	%	18.5	20	22.6	24.6	22.2
Households dependent on social grants	n	1	8	7	9	25
	%	3.7	22.9	13.2	13.8	13.9
Farming households	n	9	12	0	0	21
	%	33.3	34.3	0	0	11.7
Households with diversified sources of income	n	2	1	4	10	17
	%	7.4	2.9	7.5	15.4	9.4
Households active in the informal sector	n	0	0	6	3	9
	%	0	0	11.3	4.6	5
Missing values	n	0	0	1	1	2
	%	0	0	1.9	1.5	1.1
Total	n	27	35	53	65	180
	%	100	100	100	100	100

Source: Survey data (2013)

In addition, household typologies or clusters were created, including those aspects that will increase understanding of issues pertaining to crop production, income and consumption, employment, food security, vulnerability and other social impacts contributing to overall improved welfare (Carney, 1998). The variables included sources of household income,

household expenditure, assets owned, farm size (ha), total land area owned or accessed in the 2012/13 season (ha), area cultivated in the 2012/13 season (ha), and household sizes.

The typologies were created using a clustering method. Clustering was done separately for irrigators and non-irrigators to allow for differences in livelihood outcomes that may arise from participation in irrigation farming. Using the agglomerative hierarchical clustering technique, three distinct clusters were developed for both irrigators (the treated group) and non-irrigators (the counterfactual group). Results of the clustering process are shown in Table 14. It is noteworthy that clusters 1 and 3 among irrigators owned bigger pieces of land, cultivated bigger areas and had received agricultural training, in contrast to cluster 2. Among non-irrigators, although most of the variables considered had similar outcomes, cluster 1 received income from making goods and selling farm produce, while the other two clusters did not. Clusters 1 and 3 of the non-irrigators had received agricultural training. For a detailed analysis of the significance of differences between mean values of the variables used for clustering, refer to Table 12.

Table 14: Summary of cluster solution for irrigating and non-irrigating households

Variables	Cluster 1		Cluster 2		Cluster 3	
	Irrigators	Non-irrigators	Irrigators	Non-irrigators	Irrigators	Non-irrigators
Income from salaries (R)	41923	13241	130000	115762	156000	285000
Income from remittances (R)	1620	3823	0	3528	13200	21000
Income from social grants (R)	18334	16349	14400	12040	30240	10920
Income from making goods (R)	929	393	0	0	0	0
Income from farming (R)	34410	15	482800	0	139200	0
Income from service provision (R)	4842	1920	5000	432	36000	0
Monthly expenditure (R)	4670	2066	6855	5762	23883	5258
Household size	5	6	6	6	4	9
Owned household assets (%)	100	99	100	100	100	100
Received agricultural training (%)	54	2	0	0	100	50
Land owned or accessed (ha)	4.98	0.31	0	0.02	4.20	0.05
Area cultivated (ha)	2.79	0.21	0	0.02	4.50	0.05

Source: Survey data (2013)

There was greater heterogeneity among households that participated in irrigation farming than those who did not irrigate. The typologies provide a basis for an in-depth analysis of differences between irrigators and non-irrigators in the study area.

6.5 Summary and conclusions

This chapter provided a descriptive analysis of the socio-economic characteristics of the sampled households. Household capabilities and assets owned or accessed by the different types of households were explored. The chapter also addressed the typologies that emerge among households based on identified household characteristics. The main conclusions were that there were statistically significant differences in characteristics between the two groups of irrigators and non-irrigators. These characteristics included household income, household food security, education level of the household head, entrepreneurial attitude, membership of associations, farm sizes and access to agricultural training. Substantial differences existed in the capital base of irrigators and non-irrigators. Irrigators had a stronger capital base. The identified household typologies were significantly different with regard to ownership of land, size of land cultivated, sources of income and access to agricultural training. There was more heterogeneity among irrigators compared to non-irrigators. The differences in typologies provided a basis for further analysis of differences between irrigators and non-irrigators.

CHAPTER 7

THE NATURE OF BENEFITS FROM SMALLHOLDER IRRIGATION FARMING

7.1 Introduction

This chapter presents results of a descriptive analysis of the different types of benefits derived from participating in smallholder irrigation farming. There are a number of direct and indirect benefits from irrigation farming. A brief review of evidence from literature has revealed that these benefits accrue unevenly across household types. This chapter tests the hypothesis that the nature of benefits from smallholder irrigation farming varies between different types of households and that these benefits are unequally distributed among households.

7.2 The nature of benefits from smallholder irrigation farming

It is important to note that views on the importance of irrigation farming in developing countries have tended to be polarised. On the one hand, irrigation is viewed as a costly diversion of resources from rain-fed agriculture. It is further viewed as an activity that is equity-reducing and competes with other sectors for scarce water resources, as well as having negative consequences for women and other disadvantaged groups and the environment. Another view held by advocates of irrigation farming recognises the contribution of irrigation farming to eliminating national food insecurity and reducing food prices in light of rising populations and urbanisation. Both viewpoints, however, acknowledge the contribution of smallholder irrigation to poverty reduction (Strzepek *et al.*, 2001). Irrigation is typically seen as a 'necessary evil'. Irrigation farming's potential for poverty reduction has received inadequate attention. Contrary to the recognition of irrigation farming's role is the declining trend in irrigation infrastructure investment since the peak in the late 1970s (Jones, 1995), coupled with a more concerning decline in investment in agriculture and rural development (Rosegrant *et al.*, 2002).

Studies done elsewhere reveal that access to irrigation infrastructure enables farmers to adopt new technologies and intensify cultivation, leading to increased crop productivity, increased production levels, greater returns from farming, employment opportunities, enhanced linkages in the rural economy and a realisation of the multiple uses of water supplied by irrigation infrastructure (Hussain *et al.*, 2004; Smith, 2004; Tesfaye *et al.*, 2008; Ghosh *et al.*, 2012). An improvement in the levels and security of productivity was identified by Smith (2004) as one way in which smallholder irrigation farming benefits farmers. Evenson *et al.* (1999), Smith (2004) and Ghosh *et al.* (2012) identified, in particular, increased employment opportunities and household incomes, increased opportunities for rural livelihood diversification and multiple uses of water supplied by irrigation infrastructure as major benefits from irrigation farming. However, in this study, given available data, benefits that will be explored include household income, crop diversification, improved household food security, access to financial services and employment creation.

7.2.1 Household income

Smallholder irrigation farming has enabled irrigating households to realise higher average incomes compared to their non-irrigating counterparts. Table 15 presents the mean, minimum and maximum household incomes by type of household[6]. The average annual total household income for all households was R81 731.20. It is clear that the mean annual income for irrigators was more than double that of non-irrigators. Independent irrigators had the highest mean annual income (R130 644.63), followed by scheme irrigators (R117 698.15). The maximum annual income realised was R696 400 by an independent irrigator. The minimum household income of R4 800 was realised in a home-gardening household.

[6] The number of households included in this computation is 178 instead of the whole sample of 180 households. This is because two households refused to give figures on their incomes but were willing to provide expenditure information. They were, therefore, excluded from the household income analysis.

Table 15: Mean annual household income (R) by type of household

	Scheme irrigators (n=27)	Independent irrigators (n=35)	Home gardeners (n=52)	Other (n=64)	Total (n=178)
Mean	117 698.15 (92 207.10)	130 644.63 (156 022.19)	57 947.69 (64 301.98)	59 132.22 (46 159.17)	81 731.20 (94 318.41)
Minimum	20 160.00	14 400.00	4 800.00	8 520.00	4 800.00
Maximum	384 000.00	696 400.00	333 840.00	178 320.00	696 400.00

Note: Figures in parenthesis are standard deviations
Source: Survey data (2013)

7.2.2 Crop diversification

Smallholder irrigation farming allows farmers to diversify their crop mix. As evidenced in Tesfaye *et al.* (2008), Bacha *et al.* (2011), Oxfam (2011) and Benson (2015), access to smallholder irrigation enables farmers to grow crops more than once a year. Table 16 shows the types of crops that each type of household grew. There is a clear distinction between the crop mixes of irrigators compared to those of non-irrigators.

Results indicate that households who irrigated grew a wider variety of crops compared to non-irrigators. Scheme and independent irrigators grew on average 16 different crops during the 2012/13 season while home gardeners grew 13 crops. The *p*-values of the ANOVA indicate that there were statistically significant differences between the growing of most types of crops by irrigators and non-irrigators. There were, however, no statistically significant differences in growing onions, mustard, peas, bambara nuts, spinach, beetroot and sweet potatoes. Because of limitations in data, differences in the productivity of these crops by type of household could not be computed.

Table 16: Proportion of households cultivating different crops by type of household in 2012/13

Type of crop	Scheme irrigators (%) (n=21)	Independent irrigators (%) (n=29)	Home gardeners (%) (n=46)	ANOVA (*p*-values)
Tomatoes	9.5	37.9	2.2	0.00***
Onions	9.5	6.9	2.2	0.62
Sugar cane	4.8	20.7	0	0.01**
Soya beans	9.5	0	0	0.06*
Green beans	71.4	41.4	2.2	0.00***
Sugar beans	9.5	20.7	52.2	0.00***
Maize	52.4	58.6	17.4	0.01**
Okra	90.5	10.3	2.2	0.00***
Mustard	5.0	6.9	0	0.38
Green pepper	25.0	20.7	0	0.01**
Butternuts	0	27.6	0	0.00***
Cabbage	0	17.2	2.2	0.03**
Peas	5.0	0	0	0.29
Chillies	38.1	20.7	0	0.00***
Bambara nuts	5.3	4.2	2.4	0.95
Spinach	0	10.3	4.3	0.43
Paprika	9.5	0	0	0.06*
Pumpkin	0	0	30.4	0.00***
Beetroot	4.8	3.4	2.2	0.95
Peanuts	23.8	10.3	45.7	0.00***
Cowpeas	0	0	15.2	0.04**
Sweet potatoes	0	3.4	2.2	0.87

Note:*, **, *** = significant at 0.1, 0.05 and 0.01 level of significance, respectively.
Source: Survey data (2013)

7.2.3 Food security

With regard to the food security situation of households, Figure 5 shows that, in general, more irrigating households reported being food-secure than their non-irrigating counterparts. Independent irrigators had the highest proportion of households that reported being food-secure (82.9%), followed by scheme irrigators (70.4%). Overall, irrigators had higher proportions of households reporting being food-secure compared to non-irrigators. These results confirm findings of other studies in Ethiopia, Kenya, South Africa and Zimbabwe, which show that households participating in irrigation farming never run out of food and their hungry months are reduced substantially, unlike their non-irrigating counterparts (Mudima, 2002; Ngigi, 2002; IFAD, 2005; Benson, 2015; Dube & Sigauke, 2015).

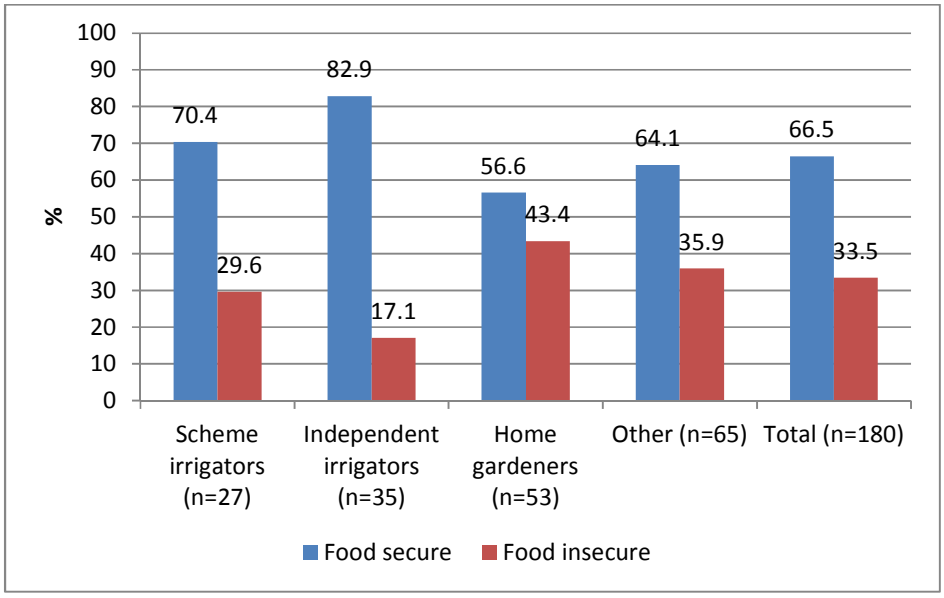


Figure 5: The food security situation of irrigators and non-irrigators
Source: Survey data (2013)

7.2.4 Access to financial services

Access to financial services has emerged as a benefit to participation in irrigation farming in that households that irrigated accessed formal financial sources better than non-irrigating households. As discussed in section 6.2.3, formal financial services were more popular among scheme and independent irrigators compared to home gardeners and other households. Home gardeners and other households accessed financial support from informal sources. Although the relationship between participation in irrigation farming and access to formal financial services was not statistically tested, the positive correlation implies that irrigators used their farm plots as a form of collateral to access formal finance sources. This assertion is confirmed by the range of reasons that farmers gave for borrowing money, i.e. for extension of farming operations, for purchasing farm inputs and to acquire means of transport.

7.2.5 Employment opportunities

Chambers (1994) confirms that access to reliable and adequate irrigation facilities increases employment. Employment includes landless labourers as well as the smallholder farmers

themselves, who will have more work on more days of the year. In this study, employment was explored in terms of the number of jobs that were created in the 2012/13 season when both casual and permanent labourers were employed on plots of households who were interviewed. A total of 244 jobs were created. The greatest proportion of jobs were created by independent irrigators (94 jobs=38.5%), followed by scheme irrigators (78 jobs=32%) and lastly home gardeners (72 jobs=29.5%). There was a statistically significant difference in the number of jobs created by the different types of households at 1% level of significance (p=0.002).

7.3 Summary and conclusions

This chapter addressed the different types of benefits derived from participating in smallholder irrigation farming. The main conclusions were that irrigation farming offers a number of direct and indirect benefits, but that these benefits are unequally distributed among different types of households. Smallholder irrigation farming allows poor households to realise higher household income, diversify income sources, diversify their crop mix, improve household food security, improve access to financial services and improve employment opportunities for both farmers and the community.

The mean annual income for irrigators was found to be significantly higher than that of non-irrigators. Independent irrigators had the highest mean annual income, followed by scheme irrigators. Households who irrigated their crops grew a wider variety of crops compared to non-irrigators. Irrigators reported being more food-secure compared to their non-irrigating counterparts. Irrigators also accessed formal financial services more easily than non-irrigating households. Regarding employment creation, irrigators created significantly more jobs than non-irrigators during the reference period. The conclusion is that benefits from smallholder irrigation farming accrue more to independent irrigators compared to scheme irrigators.

CHAPTER 8

THE CONTRIBUTION OF SMALLHOLDER IRRIGATION FARMING TO HOUSEHOLD INCOME AND FOOD SECURITY

8.1 Introduction

This chapter presents and discusses results on the contribution of smallholder irrigation farming to household income and household food security. A review of literature has shown that smallholder farmers in sub-Saharan Africa are involved in many activities for survival. Rural livelihood strategies are determined by several factors. The purpose of this chapter is to indicate the important role that farming has played in determining livelihood strategies of rural communities, particularly for smallholder irrigation farmers. This chapter contributes to testing the hypothesis that smallholder irrigation farming affects rural livelihoods, largely through increased household income and improved household food security.

8.2 Contribution of smallholder irrigation farming to household income

Identification of livelihood categories based on sources of household income is important. A determination of the contribution of farm produce sales to household income in comparison with the contribution of other income sources showed that there were different possible income sources for the different groups of households interviewed (salaries/wages, remittances, social grants, trading, making goods for sale, service provision and farm produce sales). Table 17 presents the actual amount of money that households derived from the different income sources by type of household, while Figure 6 shows the proportional contribution of each income source to household income for irrigators and non-irrigators. Overall, salaries and wages, farm produce and social grants were the main contributors to household income[7].

[7]Salaries and wages were derived from employment during 2012-13 and employment-related pension earned during the same period.

For independent irrigators, the bulk of the household income came from farm produce sales (R64 928 or 49.7%), followed by salaries and wages (R38 651 or 29.6%) and social grants (R17 840 or 13.7%). Home gardeners derived about 63.3% (R36 696) of their household income from salaries and wages and 24.3% (R14 054) from social grants. Other households were also more dependent on salaries and wages for their livelihood, as reflected by 54% (R31 924) of the household income. Social grants contributed 29.3% (R17 343) of the household income for other households.

Among irrigators, income from smallholder farming contributed an annual average income of R96 872 (39% of total household income). This was second to salaries and wages, which contributed an annual average income of R95 564, constituting 38.5% of total household income. Social grants were the third most important source of income, contributing R36 963 per annum (14.9% of total household income).

Table 17: Annual household income and the proportion of annual household income by source and type of household

Source of income	Scheme irrigators (n=27)		Independent irrigators (n=35)		Home gardeners (n=52)		Other (n=64)		Total (n=178)	
	Mean	% of total annual household income	Mean	% of total annual household income	Mean	% of total annual household income	Mean	% of total annual household income	Mean	% of total annual household income
Salaries and wages	56912.59	48.4	38651.43	29.6	36696.15	61.7	31923.97	54	38004.3	47
Remittances and child maintenance	2066.67	1.8	1514.29	1.2	3123.08	5.2	4965.63	8.4	3272.22	4
Social grants	19123.7	16.2	17839.77	13.7	14054.23	23.6	17342.5	29.3	16563.73	20.5
Trading	2755.56	2.3	445.71	0.3	1369.23	2.3	3409.5	5.8	2107.82	2.6
Making goods for sale	740.74	0.6	994.29	0.8	288.46	0.5	369.38	0.6	519.11	0.6
Service provision	4154.45	3.5	6270.85	4.8	2416.54	4.1	1098.74	1.9	2931.28	3.6
Farm produce	31944.44	27.1	64928.29	49.7	1555	2.6	22.5	0.04	17424.61	21.6
Total	**117698.15**	**100**	**130644.63**	**100**	**59502.69**	**100**	**59132.22**	**100**	**81 731.20**	**100**

Source: Survey data (2013)

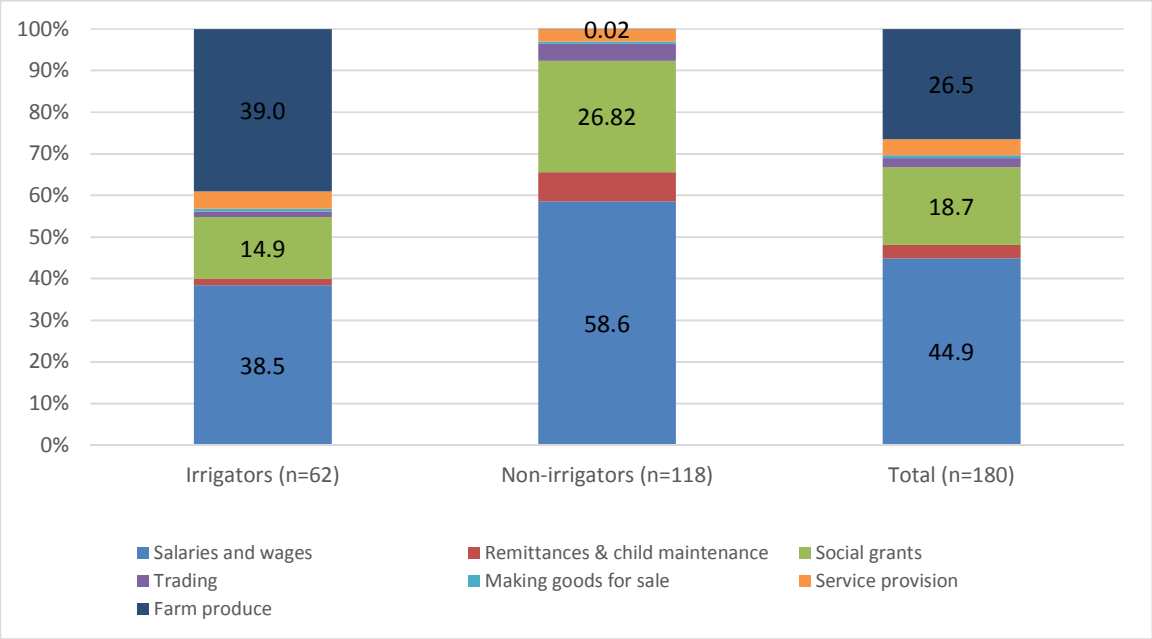


Figure 6: Proportional contribution of each source of income to household income for irrigators and non-irrigators
Source: Survey data (2013)

Non-irrigators did not rely on farming for household income. Instead, they derived 58.6% of their household income from salaries and wages and 26.8% from social grants (annual average of R68 620 and R31 397, respectively). The figures suggest that farming was the main source of income for irrigators, while non-irrigators derived their income mainly from non-farm sources.

The above confirms findings of previous studies that social grants and social networks, in particular, are critical to many poor households in South Africa, with over 15 million people, up from 2.5 million in 1998, receiving social welfare grants from the government (Tapela, 2008; Department of Social Development, 2010; AfDB *et al.*, 2012). South Africa's rural livelihoods have always been characterised by a combination of land-based and non-farm activities (Cousins, 2013), with significant reliance on the country's comparatively well-developed system of state cash transfers (Neves & Du Toit, 2013). The diversity of rural livelihood strategies in South Africa has been documented in literature as relying heavily on remittances from relatives. Other households rely on membership of burial societies and church organisations as a livelihood coping strategy (Tapela, 2008).

8.3 The contribution of smallholder irrigation farming to food security

Smallholder irrigation farming contributes to household food security. Food security consists of hierarchical pillars, namely availability of food, access to food, effective utilisation of food and stability (Barrett, 2010). Food security exists when a number of dimensions of the four pillars are realised simultaneously. This section presents certain aspects that contribute to the dimensions of food security. If data allowed, all pillars of food security would have been addressed.

8.3.1 Understanding food security

According to the World Food Summit of 1996, food security exists "when all people at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996a). This definition was a refinement of the 1974 World Food Summit version that emphasised the production of food to ensure adequate world food supplies (United Nations, 1974). Food security has been defined and understood in various ways by different authors. Therefore, food security is a subject that requires comprehensive treatment. Although this is true of most important socio-economic issues, food security is arguably an extreme case, because it involves questions of agricultural production systems, market dynamics, nutrition, people's habits and preferences, social security systems, etc. These dimensions of food security make achieving food security such a challenge.

Numerous studies have been undertaken on the impact of irrigation farming on food security and poverty reduction, particularly in South Asia and a few African countries (Smith, 2004; Hanjra *et al.*, 2009b; Irajpoor and Latif, 2011; Ghosh *et al.*, 2012). Generally, access to good irrigation allows poor people to intensify food production. Irrigation farming, which is much more productive than rain-fed agriculture, contributes nearly 40% of world food production on 17% of cultivated land (FAO, 1996b). Improved access to food by the poor through their own increased production or enhanced purchasing power and economic ability to buy food has been found to be the most effective way to move poor people out of poverty, particularly in low productivity areas. As documented in Hussain and Hanjra (2004), Asia's cereal production more than

doubled, between 1970 and 1995, from 300 million tons to 650 million tons. This remarkable growth in food production was largely attributed to the growth in irrigated agriculture, coupled with the use of high-yielding varieties and fertilizers. At present, about 40% of the cropland in Asia is irrigated and accounts for about 70% of total cereal production. Irrigation is believed to have benefited the population by providing more food at reduced prices.

In South Africa, although the nation is relatively well-off, with adequate domestic food production, food security remains high on the country's list of priorities. Food security issues have always been prioritised in the policies of the country since the 17th century (Tshuma, 2012; Vink, 2012; Hendriks, 2013). Over time, South African food security determinants have been interpreted differently by different authorities, but central to the context were the composition and contribution of the agricultural sector, which shaped consumption patterns and determined rural livelihoods. Evidence has shown that while farming has played an important role in providing food for low-income households, household food security in South Africa depends primarily on total household income (however derived) required to afford bought-in food, and much less on household food production (Hendriks, 2003; HSRC, 2004; Hendriks *et al.*, 2006; Van Averbeke & Khosa, 2007; World Bank, 2008; Shisana & Hendriks, 2011). Although there is adequate food at national level, more than 50% of the population has insufficient food, or is exposed to inadequate nutrition as a result of low incomes (Backeberg & Sanewe, 2010; Shisana *et al.*, 2013; HSRC, 2014). It has been argued that there is enough food in the country to feed everyone adequately; the problem is distribution (D'Haese *et al.*, 2013). According to Stats SA (2012), although there has been a significant decline in the vulnerability to hunger of South African households over the past decade, a large proportion of households continue to experience difficulties in accessing food.

Consequently, the South African National Health and Nutrition Examination Survey (SANHANES) reported that too many people in the country were underfed, overfed, or both[8].

[8] The South African National Health and Nutrition Examination Survey (SANHANES) was established by the Human Sciences Research Council (HSRC) to provide a broad and comprehensive platform to study the health and nutritional status of South Africa.

According to the 2012 SANHANES-1 survey, 45.6% of the population were food-secure, 28.3% were at risk of hunger and 26.0% were experiencing hunger (Shisana *et al.*, 2013). In an effort to address the food security challenge, a unique Centre of Excellence (CoE) in Food Security was established, jointly hosted by the University of the Western Cape and the University of Pretoria, to spearhead interventions that will change people's lives positively and combat food insecurity in the country. South Africa has viewed the CoE approach as particularly appropriate in addressing food distribution, in particular as an important aspect of food security. Food distribution concerns markets, livelihoods and value chains (Meyer, 2014) and forms part of the CoE's thematic areas.

8.3.2 The food security situation of interviewed households

Grouping the households into irrigators and non-irrigators indicated that, in general, irrigating households were food-secure compared to their non-irrigating counterparts (Figure 7). Overall, about 77% of the irrigators reported being food-secure compared to 61% of the non-irrigators. These results confirm reports by the Food Security Initiative (FSI) that food production increases in smallholder agriculture is seen as a possible solution to the food insecurity challenges in the rural areas of Limpopo Province, based on a study conducted on two farms in the rural areas of Giyani during the period 2012 to 2013 (Harper, 2014). The study concluded that significant increases in yield would lead to improved livelihoods for rural smallholder farmers in the Giyani area.

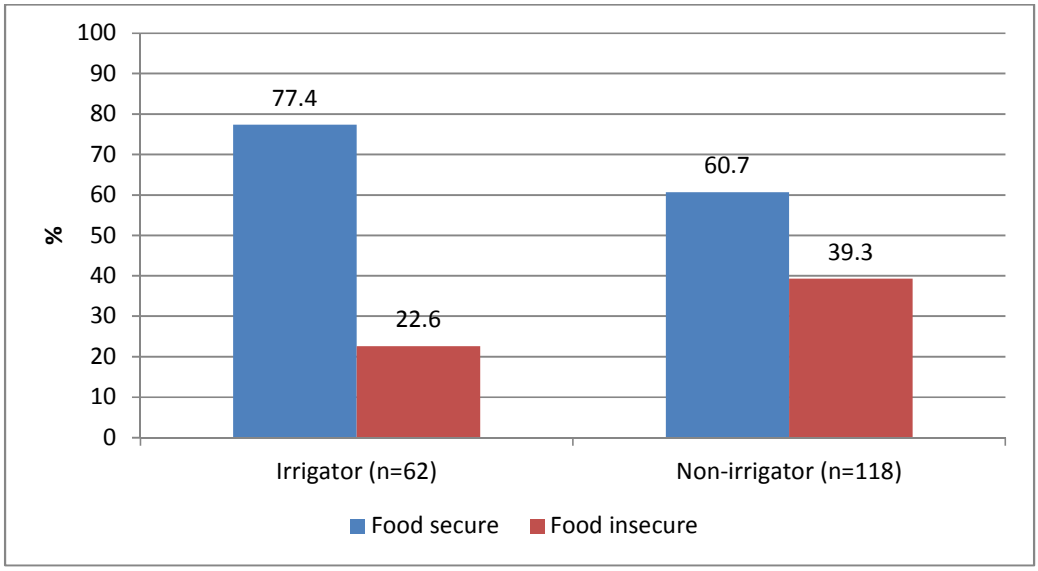


Figure 7: The food security situation of irrigators and non-irrigators
Source: Survey data (2013)

Table 18 shows the diversity of diets among the different household types and the average number of times specific food types were consumed in a week. An indication of differences between groups of households in the consumption of different types of food is also presented in this table. There was a statistically significant difference between the frequency of consuming legumes and vegetables among the different types of households at a 5% level of significance. Scheme and independent irrigators consumed legumes twice a week, while home gardeners and other households consumed legumes once a week. Vegetable consumption was more frequent than legume consumption overall at five times per week. Independent irrigators consumed vegetables six times a week, while scheme irrigators and other households consumed vegetables five times a week. Home gardeners consumed vegetables less frequently, four times a week. For the rest of the food types, fruit, meat, eggs and dairy products, there were no statistically significant differences in the frequency of consumption per week.

Table 18: Diversity of food types consumed in a week

Food types consumed per week	Group	Mean	ANOVA (p-values)
Legumes	Scheme irrigators	2 (2.23)	0.00***
	Independent irrigators	2 (2.08)	
	Home gardeners	1(0.89)	
	Other	1(1.49)	
	Total	2 (1.67)	
Vegetables	Scheme irrigators	5 (2.67)	0.03**
	Independent irrigators	6(2.08)	
	Home gardeners	4(2.55)	
	Other	5(2.46)	
	Total	5(2.49)	
Fruits	Scheme irrigators	3(2.66)	0.32
	Independent irrigators	4(2.46)	
	Home gardeners	3(2.46)	
	Other	3(2.75)	
	Total	3(2.60)	
Meat	Scheme irrigators	4(2.52)	0.43
	Independent irrigators	3(2.03)	
	Home gardeners	3(1.98)	
	Other	4(2.20)	
	Total	3(2.16)	
Eggs	Scheme irrigators	3(2.56)	0.21
	Independent irrigators	2(2.20)	
	Home gardeners	3(2.61)	
	Other	2(2.53)	
	Total	2(2.51)	
Dairy	Scheme irrigators	4(2.94)	0.37
	Independent irrigators	3(2.88)	
	Home gardeners	3(2.95)	
	Other	3(2.74)	
	Total	3(2.86)	

Note: Figures in parenthesis are standard deviations
Note:*, **, *** = significant at 0.1, 0.05 and 0.01 level of significance, respectively.
Source: Survey data (2013)

Table 19 shows results of the Tukey post-hoc tests for legume and vegetable consumption. The results show multiple comparisons of the consumption of legumes and vegetables (the two food types whose consumption was significantly different among different household types). The number of times a particular household type consumed legumes or vegetables is compared with the consumption of the same type of food by another household type and a *p*-value determines whether there were significant differences in the consumption patterns between the households. The number of times legumes were consumed by home gardeners in a week was statistically

significantly lower than that for scheme irrigators (p = 0.07) and for independent irrigators (p = 0.01). Consumption of legumes by other households was also statistically significantly lower than that for independent irrigators (p = 0.06). The number of times vegetables were consumed by home gardeners was statistically significantly lower than that for independent irrigators (p = 0.02).

Table 19: Tukey post-hoc test results for legume and vegetable consumption by type of household

Comparison between two groups		Consumption of legumes (p-values)	Consumption of vegetables (p-values)
Scheme irrigators	Independent irrigators	0.94	0.70
	Home gardeners	0.07*	0.40
	Other	0.33	0.91
Independent irrigators	Scheme irrigators	0.94	0.70
	Home gardeners	0.01***	0.02**
	Other	0.06*	0.18
Home gardeners	Scheme irrigators	0.07*	0.40
	Independent irrigators	0.01***	0.02**
	Other	0.71	0.63
Other	Scheme irrigators	0.33	0.91
	Independent irrigators	0.06*	0.18
	Home gardeners	0.71	0.63

Note: Fruit, meat, eggs and dairy produce were excluded from this table, as the post-hoc tests' p-values indicated no statistically significant differences in the frequency of consumption between the different types of households
Note:*, **, *** = significant at 0.1, 0.05 and 0.01 level of significance, respectively.
Source: Survey data (2013)

8.3.3 Household food production

An analysis of the contribution that own farm production makes to household consumption forms part of testing the hypothesis that smallholder irrigation farming affects rural livelihoods through increased household income and improved household food security. Irrigation farming increases a household's consumption from own production and reduces expenditure on bought-in food. Irrigation farming also makes food available and affordable for the poor, who are largely net buyers of food and spend a major part of their monthly expenditure on basic food. Better and affordable food is expected to improve nutrition and health, which in turn could have a

favourable effect on the learning capabilities and skills of the poor. Higher incomes enhance improvements in productivity and returns to human capital and physical endowment (ADB, 2003; Hussain & Hanjra, 2004).

Table 20 shows that the type of crops grown by the different types of households during the 2012/13 season. The main crops grown by irrigating households in the sample were green beans, okra, green peppers, maize, chillies, tomatoes and sugar beans. Of the households that cultivated a crop, 90.5% of the scheme irrigators grew okra and 71.4% grew green beans. Among independent irrigators, most households (48.3%) grew maize and 41.1% grew green beans. About 98% of the home gardeners grew maize on their home gardens followed by 44.7% who grew sugar beans.

Table 20: Crops grown by scheme irrigators, independent irrigators and home gardeners in the 2012/13 season

Crops grown	% of scheme irrigators (n=21)	% of independent irrigators (n=29)	% of home gardeners (n=47)	% of sample (n=97)
Green beans	71.4	41.4	0.0	54.0
Okra	90.5	10.3	0.0	44.0
Maize	14.3	48.3	97.9	60.8
Chillies	38.1	20.7	0.0	28.0
Tomatoes	9.5	34.5	2.1	24.0
Green pepper	25.0	20.7	0.0	22.4
Sugar beans	4.8	20.7	44.7	22.7

Source: Survey data (2013)

The types of crops grown indicate that, in general, irrigating households tended to produce cash crops and vegetables for the market. A portion of the production was consumed at home, while the bulk of production was sent to the market. Non-irrigators tended to produce staple food crops, consistent with the purpose of farming presented in Chapter 6. These results confirm findings by De Cock *et al.* (2013) that households produce for both home consumption and the market. These findings endorse statements that agriculture plays a major role in the livelihoods

of rural people. It was, however, difficult to assess the true contribution of own food production, as households did not keep records. They could not recall the quantities that were taken for home consumption and crop production in their home gardens.

The survey also confirmed that besides crops, some households kept livestock (Table 21). Livestock is as important as crops in value share of production in rural areas, though with strong variations across households and locations. Livestock diversifies and hedges risks; for example, cattle can move from one grazing area to another to escape drought (in these areas cattle are moved to communal grazing areas during drier seasons). Livestock has been viewed as a strategic investment when cash is available, and a cash source in times of financial distress (hence sometimes referred to as 'walking wealth') (International Crops Research Institute for the Semi-Arid Tropics [ICRISAT], 2009). Given the on-going strategies of the International Livestock Research Institute that encourage exploiting crop-livestock synergies, smallholder farmers who keep livestock can benefit through generating ecological synergies with crops. For example, when farmers allow animals to graze on crop residue, subsequent crops benefit from soil-enriching manure deposits. With such strategies, crop-livestock integration is encouraged, as it offers an opportunity for smallholder farming households to increase their incomes, as well as capture the farming benefits highlighted above.

Results from this study show that cattle were the most prevalent type of livestock kept by all households in the sample (21.6%) followed by chickens (14.1%). The scheme irrigator households kept only cattle (23.8%). Independent irrigators and home gardeners kept all four types of livestock, with the greatest proportion of cattle keepers among independent irrigators (41.4%). Independent irrigators had the greatest proportion of households that kept chickens (24.1%), goats (6.9%) and pigs (6.9%). The results indicate that independent irrigator households diversified their sources of livelihood and hedged against risks through strategic investment in livestock more than other types of households.

Table 21: Livestock kept by scheme irrigators, independent irrigators and home gardeners in 2012/13

Livestock owned by households	% of scheme irrigators (n=21)	% of independent irrigators (n=29)	% of home gardeners (n=47)	% of sample (n=97)
Cattle	23.8	41.4	8.5	21.6
Chickens	0	24.1	14.9	14.1
Goats	0	6.9	2.1	3.1
Pigs	0	6.9	2.1	3.1

Source: Survey data (2013)

To determine the level of expenditure on own produced food, an analysis of the monetary value of own food production consumed at home was done. Food items produced and consumed by the household were converted to their monetary values using average local prices. Figure 8 shows the mean, minimum and maximum monetary value of food produced and consumed at home by type of household. Data included in this analysis were only for those households that reported consuming from their own production (79% of sample). The rest of the households (21% of sample), particularly among scheme irrigators and independent irrigators, took all their produce to the market and their consumption was financed by the income derived from farm produce sales. Results show that households who registered the highest monetary value of household consumption from own production were among scheme irrigators (R21 020). The lowest value was among home gardeners (R10 297).

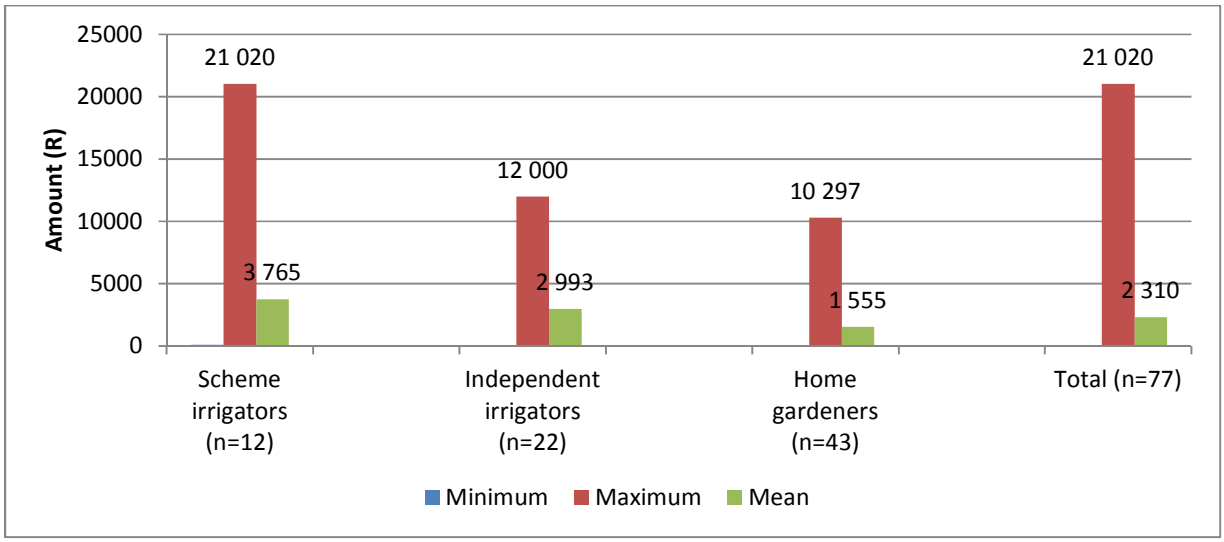


Figure 8: Monetary value of household consumption from own production
Source: Survey data (2013)

8.3.4 Proportion of total household expenditure allocated to food purchases

The proportion of food expenditure to total household expenditure is an indicator of the expenditure capacity of a household, which depends on household income or resources (Mhlongo & Daniels, 2013). This indicator reveals the extent to which the livelihoods of rural households are under strain. While it is not a direct measure of food insecurity, a relative high share of income spent on food is often linked to poor households (Engel's law) (Leroy *et al.*, 2001). It is noteworthy that expenditure on food will depend on other parameters including change in food prices and proximity to shops (De Cock *et al.*, 2013). As documented by Baiphethi and Jacobs (2009), rural households produced most of their own food, whereas urban households purchased most of their food in the past. However, recent studies have shown an increase in dependence on market purchases by both urban and rural households, in some cases reaching 90% of the food supplies. Consequently, food expenditures can be as much as 60-80% of the total household income for low-income households in some parts of sub-Saharan Africa. Previous studies that evaluated household expenditure have shown that expenditure on food is an integral part of every household and is evaluated because of its importance in household welfare (Van Averbeke & Khosa, 2007; Anker, 2011; Mhlongo & Daniels, 2013; Stats SA, 2014). Poor households tend to spend higher proportions of income on food, while for richer households expenditure on food comes second after housing (Mhlongo & Daniels, 2013). The proportion of food in the total household expenditure for the different types of households was computed.

Table 22 shows the total monthly household expenditure, expenditure on food and the ratio of food expenditure to household expenditure by type of household. It is evident that a significant proportion of total household expenditure goes towards food purchases. Overall, interviewed households spent 30.9% of their income on food. This figure compares well to the 37% average food expenditure by households in South Africa (Baiphethi & Jacobs, 2009). Home gardeners emerged as the group that spent a greater proportion of their income on food (32.9%). Independent irrigators had the least proportion of household income spent on food (26.3%). Other households had 31.4% of household income taken up by food purchases, compared to scheme irrigators (31.7%). Therefore, independent irrigators are deemed the wealthier

households, as their proportion of expenditure on food was least compared to other households in the sample.

Table 22: Total household expenditure, expenditure on food and proportion of food expenditure by type of household

		Total household expenditure (R)	Expenditure on food (R)	Proportion of food expenditure (%)
Scheme irrigators (n=27)	**Mean**	5166.46 (10318.85)	933.33 (795.17)	31.7
	Min	662	300	
	Max	53550	3500	
Independent irrigators (n=35)	**Mean**	4960.94 (4739.45)	990.14 (912.96)	26.3
	Min	750	100	
	Max	23883	5000	
Home gardeners (n=53)	**Mean**	2667.39 (2346.62)	670.75 (371.54)	32.9
	Min	370	160	
	Max	10950	2000	
Other (n=65)	**Mean**	2697.76 (2472.97)	632.31 (366.36)	31.4
	Min	463	0	
	Max	12262	2000	
Total (n=180)	**Mean**	3499.18 (4979.38)	758.36 (601.18)	30.9
	Min	370	0	
	Max	53550	5000	

Note: Figures in parenthesis are standard deviations
Source: Survey data (2013)

8.4 Summary and conclusions

This chapter quantified the contribution of smallholder irrigation farming to household income and household food security. The main conclusions were that the mean annual income for irrigators was more than double that of non-irrigators. The income disparity demonstrates the important contribution of irrigation farming to household income. Irrigators were more food-secure than non-irrigators and this can be explained by consumption from own production and substantial actual expenditure on bought-in food. Household food security does not depend only on own produced food, but also on household income.

CHAPTER 9

FACTORS DETERMINING THE DISTRIBUTION OF BENEFITS FROM SMALLHOLDER IRRIGATION FARMING AND THE EFFECT OF IRRIGATION FARMING ON HOUSEHOLD INCOME AND FOOD SECURITY

9.1 Introduction

This chapter presents and discusses empirical evidence on factors that determine the distribution of benefits from smallholder irrigation farming. Literature has shown that smallholder irrigation farmers do not benefit equally from irrigation farming. The chapter also presents results of the effect of smallholder irrigation farming on select household welfare outcomes, i.e. household income and household food security using a semi-parametric PSM analysis method. PSM enables comparison of similar households in the absence of randomisation, within the treated and non-treated groups (Rosenbaum & Rubin, 1983; Mendola, 2007, Khandker *et al.*, 2010). Results of an assessment of the quality of the matching process are presented in this chapter. The chapter contributes to testing the hypothesis that the distribution of benefits from smallholder irrigation across rural households is dependent on resource endowment and socio-economic characteristics of the household head.

9.2 Factors determining accrual of benefits from participating in smallholder irrigation farming and how the benefits are distributed

Benefits from smallholder irrigation accrue unevenly to different households. Hussain *et al.* (2003) and Smith (2004) assert the common perception that benefits from irrigation farming accrue primarily to large landholders. Water rights and potent benefits are virtually tied to land ownership. Hence, in settings with a high degree of inequality in land distribution, irrigation would have a lower impact on poverty (Hussain *et al.*, 2003). Hussain *et al.* (2003) further highlight the importance of understanding the nature of rural households, as they normally comprise four groups: the landless, dependent on the non-agricultural sector; the landless, dependent on agriculture (e.g. agricultural workers); smallholders and large holders.

Other factors recorded in literature include age, gender and marital status of the farmer, level of education of the farmer, household income, access to assets, access to support services and infrastructure (Mendola, 2007; Bacha *et al.*, 2011; Irajpoor & Latif, 2011; Tekana & Oladele, 2011; Sinyolo *et al.*, 2014). Generally, conclusions are that the higher the socio-economic status of the household and the inclusion of males in irrigation, the higher the household welfare improvements. Access to good irrigation infrastructure and farmer support services has led to successful irrigation farming.

Table 23 shows the determinants of household welfare benefits from smallholder irrigation farming for each of the household types. The R squared $(R)^2$ value indicates how much of the total variation in the dependent variable, household welfare, can be explained by the independent variables. Selection of independent variables was influenced by determinants of household welfare, as documented in literature (Mendola, 2007; Irajpoor & Latif, 2011; Tekana & Oladele, 2011; Sinyolo *et al.*, 2014). In the case of scheme irrigators, 91.9% of the dependent variable can be explained. In the case of independent irrigators, 61.8% of the dependent variable can be explained. In the case of home gardeners, only 45.2% of the dependent variable can be explained.

An ANOVA analysis, which reports how well the regression equation fits the data (i.e. predicts the dependent variable) revealed that for scheme irrigators and home gardeners, the regression model statistically significantly predicts the outcome variable, household welfare, at a 10% level of significance. The models are a good fit for the data, with *p*-values of 0.075 and 0.093 for the scheme irrigators and home gardeners, respectively. The model, however, is not a good fit for the data in the case of independent irrigators and with *p*-values of 0.273.

Table 23: Factors determining the distribution of household welfare benefits from participation in smallholder irrigation farming

Variable	Scheme irrigators		Independent irrigators		Home gardeners	
	Co-efficient	*p*-value	Co-efficient	*p*-value	Co-efficient	*p*-value
Constant	2.29	0.49	2.63	0.07	-1.01	0.22
Adequacy of size of land	-0.05	0.96	-0.25	0.50	0.02	0.93
Adequacy of water source	0.79*	0.09	0.18	0.63	-0.15	0.57
Total household size	0.03	0.63	-0.05	0.55	0.01	0.51
Marital status of the household head	-0.29	0.64	-0.96	0.28	1.09***	0.01
Household head's gender	-0.57	0.73	-0.62	0.55	1.15***	0.01
Education for household head	1.09	0.12	0.11	0.79	0.33	0.24
Age of household head	0.00	0.91	0.01	0.72	0.01	0.15
Positive entrepreneurial attitude	-1.28	0.13	-0.75	0.32	-0.15	0.61
Borrowed money	0.59	0.36	-0.32	0.47	-0.45*	0.08
Ownership of means of transport	0.09	0.91	0.72	0.11	0.72***	0.01
Ownership of farm implements	0.05	0.45	0.00	0.99	0.13	0.20
Total land area owned/accessed	-8.1E-06	0.24	3.6E-06	0.16	1.3E-05	0.15
R squared	91.9		61.8		45.2	
ANOVA (*p*-value)	0.075		0.273		0.093	

Note:*, **, *** = significant at 0.1, 0.05 and 0.01 level of significance, respectively.
Source: Survey data (2013)

The adequacy of sources of water for farming significantly influences the distribution of household welfare benefits for scheme irrigator households at a 10% level of significance. There was no significant determinant of benefit distribution among independent irrigators. For home gardeners, gender and marital status of the household head and ownership of means of transport were significant for influencing the distribution of welfare benefits at a 1% level of significance, while the ability to borrow money was significant at a 10% level of significance in determining benefit distribution. Noteworthy is that non-significance of factors that determine benefit distribution, particularly among independent irrigators, could have been because of relatively small sample sizes. If the samples were bigger, the factors could have been significant.

Table 24 presents results from the first stage probit estimation of smallholder irrigation farming, as part of the PSM approach. These results give an indication of the socio-economic determinants of households' decisions to practise irrigation farming.

Table 24: Probit estimates for participation in irrigation farming

Variable	Coefficient	Std. error
Age	0.075	0.097
Age squared	-0.0006	0.0008
Gender	1.738 ***	0.594
Distance to irrigation scheme	0.736***	0.157
Education	-0.579	0.415
Water source	0.031	0.129
Member of farmer association	2.658***	0.533
Member of farmer cooperative	3.477***	1.143
Member of village committee	0.844*	0.468
Member of political party	-0.028	0.399
Constant	-5.866	2.955
Log likelihood	-34.71	
Likelihood ratio test:$\chi^2(10)$	160.27	
Correct predictions (%)	70	
Observations	179	

Note:*, **, *** = significant at 0.1, 0.05 and 0.01 level of significance, respectively.
Source: Survey data (2013)

The gender of the household head was a significant determinant of smallholder irrigation farming at a 1% level of significance. Male headed households were more likely to irrigate compared to their female counterparts. The distance to the irrigation scheme as determined by the village in which a household is located had a positive relationship with irrigation farming and was significant at a 1% level of significance in explaining participation in irrigation farming. Participation in smallholder irrigation farming tended to be for those who were members of a farmer association, farmer cooperatives or village committee. This suggests that smallholder farmers who joined farmer associations and farmer cooperatives were more likely to participate in irrigation farming, at a 1% level of significance. This relationship could be the other way round where membership to these associations was a result of participation in irrigation farming. Membership of a village committee is significant at a 10% level of significance in explaining

participation in irrigation farming. The highest level of education attained by the household head had a negative relationship with irrigation farming and was not significant in explaining participation in smallholder irrigation farming.

Various specifications of the probit model were attempted until the most complete and robust specification that satisfied the balancing tests and establishment of the common support region was obtained. As a result, as shown in Table 24, water source was included in the probit model although there were no statistically significant differences between irrigators and non-irrigators in terms of their sources of water for household use. In addition, although entrepreneurial attitude was a significant factor in explaining participation in irrigation farming, because of the matching balancing property condition, this variable was dropped, as it yielded a smaller overlap in the region of common support.

9.3 Treatment effects from the propensity score matching methods

The hypothesis that smallholder irrigation farming affects rural livelihoods largely through increased household income and an improved household food security situation was tested by using the PSM method. The method enables an investigation of how irrigation farming has contributed to livelihood outcomes. The method uses estimated propensity scores from the first stage results presented in Table 24 to generate samples of matched irrigators and non-irrigators, using the kernel and nearest neighbour matching methods. The common support condition was imposed on the estimation by matching in the region of common support. Figure 9 shows the distribution of propensity scores and the region of common support. The bottom half of the figure shows the propensity scores distribution for the untreated group, while the upper half refers to the treated group. The densities of the scores are on the y-axis.

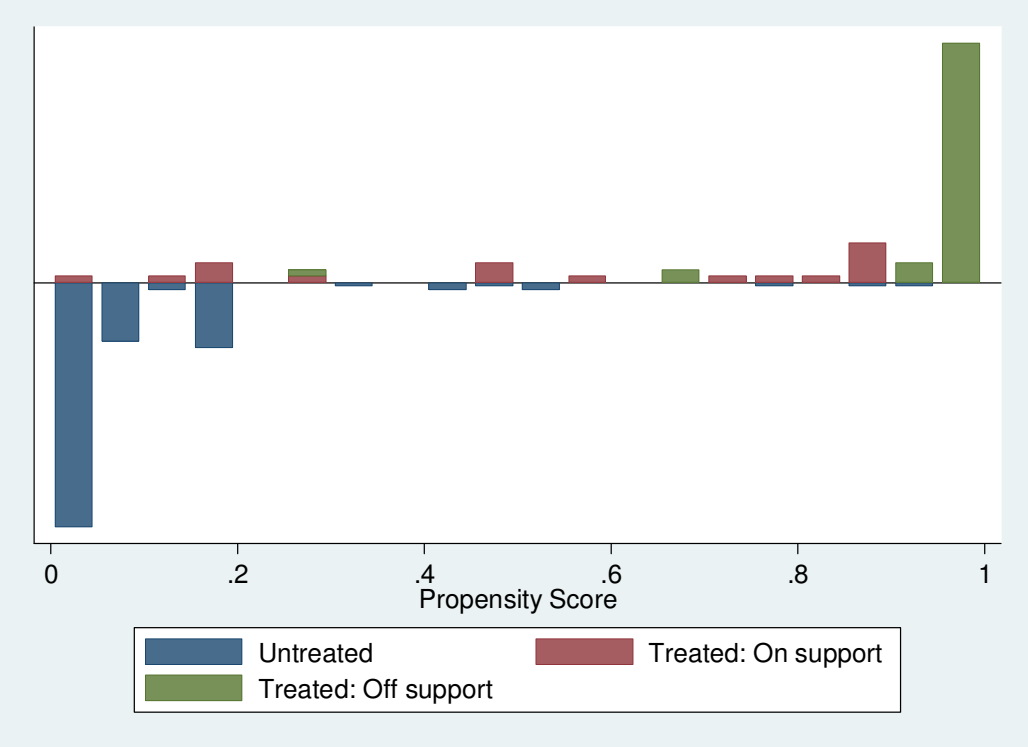


Figure 9: Propensity score distribution and the common support condition
Source: Survey data (2013)

The figure indicates that the common support condition is satisfied, as there is significant overlap in the distribution of the propensity scores of both treated and untreated groups. PSM results are presented in Table 25. Only observations within common support are used, that is, observations for which matches were found (61 irrigators as indicated in Table 25). Since ATT is the average treatment effect on the treated, the standard errors for the ATT were calculated using bootstrapping with 100 replications.

Table 25: Average treatment effects of the outcome variables

Outcome variable	ATT	Standard error	t-value
	Using nearest neighbour method		
Household income (R)	85804.46	43088.19	1.99
Food security situation (dummy)	0.631	0.340	1.86
Number of treated units used = 61 and number of control units used = 13			
	Using kernel-matching method		
Household income (R)	69503.66	30611.07	2.27
Food security situation (dummy)	0.571	0.223	2.55
Number of treated units used = 61 and number of control units used = 57			

Source: Survey data (2013)

Using the nearest neighbour matching strategy, smallholder irrigation farming showed a positive effect on both the household income and household food security situation, shown by the significant *t*-values (1.99 and 1.86, respectively). Confirming results of the nearest neighbour approach, the kernel matching strategy results indicate that smallholder irrigation farming had a significant positive effect on both household income and household food security situation (*t*-values of 2.27 and 2.55, respectively).

The nearest neighbour matching method matched 61 treatment units with 13 control households, and concluded that irrigation access results in an increase of about R85 804.46 in annual household income over that of non-irrigators. Irrigators were 63% more likely to be food-secure compared to non-irrigators. The Kernel matching method, on the other hand, identified 57 matching control households against 61 treatment households in calculating the impact estimate. The Kernel matching method concluded that irrigation access results in a gain of R69 503.66 in household income for irrigators. According to the Kernel method, irrigators were 57% more likely to be food-secure than non-irrigators.

9.4 Assessing the quality of the matching process

Since the PSM method conditions only on the propensity score, an assessment of the quality of the matching process was done by performing balancing tests that examined the standardised

bias for all covariates used in the matching process. This checks whether the matching procedure is able to balance the distribution of the covariates in both the irrigators and non-irrigators. In the case of a successful matching process, differences should not exist after matching. For this study, the balancing property was satisfied, as shown in Table 26. After matching, none of the variables used portrayed a statistically significant difference between irrigators and non-irrigators. The balancing test was satisfied, hence there were no statistically significant differences between the matched treatment and the control units.

Table 26: Balancing tests for all matching covariates

Variable	Mean		Standardised bias		*t*-test
	Irrigators	Non-irrigators	% bias	% reduction in bias	*p*-values
Age	59.29	58.48	6.7	65.7	0.85
Age squared	3603.3	3582.2	1.4	90.4	0.97
Gender	0.857	0.883	-6.1	93.9	0.85
Distance to irrigation scheme	2.095	1.545	21.6	83.0	0.34
Education	0.524	0.457	13.4	55.8	0.74
Water source	2.905	3.187	-21.3	21.4	0.65
Member of farmer association	0.190	0.1586	8.7	92.7	0.84
Member of farmer cooperative	0.048	0.048	-0.3	99.2	0.99
Member of village committee	0.238	0.205	9.6	75.0	0.84
Member of political party	0.286	0.317	-6.6	77.9	0.86

Source: Survey data (2013)

9.5 Summary and conclusions

This chapter addressed the factors that determine the distribution of benefits from smallholder irrigation farming. The chapter also addressed the effect of smallholder irrigation farming on household income and household food security, using a semi-parametric PSM analysis method. The main conclusions were that adequacy of a water source was important in influencing accrual of smallholder irrigation benefits among scheme irrigators. For home gardeners, the gender and marital status of the household head, ownership of means of transport and ability to borrow money were significant determinants. None of the factors analysed for independent irrigators were significant in influencing the distribution of smallholder irrigation farming benefits.

The PSM approach confirmed the positive effect that smallholder irrigation farming had on both household income and household food security. The results were affirmed by using both the nearest neighbour approach and the kernel-matching strategy.

CHAPTER 10

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of the thesis. Relevant conclusions are drawn and recommendations are made. Limitations of the study are identified and areas for continued research are suggested.

10.1 Summary of the study

10.1.1 Background and problem statement

Improving rural livelihoods is an important goal in South Africa, as reflected in the strategy of the NDP of reviving the rural economy through expanding irrigation farming. Irrigation is seen as a crucial input into smallholder farming and, therefore, a potentially important poverty reduction strategy. Smallholder irrigation farming is an important factor in improving the lives of poor households and in determining opportunities of escaping poverty. Although polarised views exist about irrigation farming, both schools of thought acknowledge the contribution of irrigation farming to improved household welfare. Generally, access to irrigation water makes the adoption of modern farming technologies possible, which subsequently contributes to increased production, incomes and diversification of income opportunities, resulting in improved household welfare. Evidence has shown that regions with the largest proportion of irrigated land experienced greater improvement in livelihoods than those depending on rainfall.

Since most smallholder irrigation schemes are found in the former homelands of South Africa, where the incidence of poverty peaks, this has made smallholder irrigation farming important. Although irrigation is seen as a crucial input into smallholder farming in the country, it is estimated that about 1.3 million ha of arable land is under irrigation. A number of factors, such as water scarcity due to unevenly distributed low rainfall and large tracks of semi-arid land, necessitate the provision of irrigation farming facilities. For that reason, smallholder irrigation schemes nationally continue to attract huge amounts of government investment annually.

A few studies have established a positive relationship between participation in smallholder irrigation farming and improved livelihoods in South Africa. However, quantified evidence of the contribution of smallholder irrigation farming to livelihoods is limited. Studies conducted on this topic have concentrated on irrigation schemes with little or no documentation on independent (non-scheme) smallholder irrigators, who have been shown to be an important group of irrigators in the country. Little was previously known about independent irrigators in South Africa.

10.1.2 Purpose of the study

The purpose of this study was to examine the contribution of smallholder irrigation farming, both scheme and independent irrigation, to improved rural livelihoods in the Limpopo Province of South Africa. In particular, the study identifies benefits from smallholder irrigation farming and factors that determine the distribution of benefits. The primary focus is on quantifying the contribution of smallholder irrigation farming to rural livelihoods of scheme and independent irrigators. The contribution of smallholder irrigation farming to poverty reduction is largely assumed to flow from this primary goal. This study explores relationships between participation in smallholder irrigation farming, on the one hand, and household income and food security of households, on the other.

To understand the contribution of smallholder irrigation farming to the livelihoods of the rural poor better, it is important to be cognisant of how agriculture fits into rural livelihoods and income strategies of the different types of smallholder irrigation farming households. These households have different social and economic statuses, engage in a wide range of livelihood strategies and operate under different conditions of vulnerability and within different environments. This study contributes to understanding of these issues.

10.1.3 Methods and procedures

The study is based on primary data collected from 180 households in the Mopani district of the Greater Tzaneen municipality in the Limpopo Province of South Africa. This study was part of a WRC project aimed at evaluating water use productivity of crop production and improved livelihoods on selected smallholder irrigation schemes in South Africa. The research site was specifically selected to include an operational irrigation scheme whose vicinity represented the three targeted types of households, namely scheme irrigator households, independent irrigator households and non-irrigating households. Therefore, Julesburg irrigation scheme was chosen as the anchor site because of the presence of both independent irrigators and non-irrigators in surrounding villages.

Data were collected through the use of two structured questionnaires in two phases. Phase one focused on general livelihood data while phase two focused on agricultural and entrepreneurship data. The second phase targeted households who had indicated involvement in farming activities during the first phase. Questionnaires were administered through individual face-to-face interviews.

In the analysis, the three types of households were accorded equal attention and the study approach ensured that a comparative analysis was possible across the different types of households. A combination of analytical methods, including a semi-parametric PSM method, econometric regression models and ANOVA, was used. The focus was on exploring how household income and household food security are influenced by smallholder irrigation farming. PSM allowed for a comparison of these two livelihood outcomes between irrigators and non-irrigators through identification of a suitable comparison group of non-irrigators whose outcomes, on average, provided an unbiased estimate of the outcomes that irrigators would have had in the absence of irrigation. Econometric regression models and ANOVA were run to identify determinants of benefit distribution among the different households.

10.2 Major findings of the study

10.2.1 Benefits from smallholder irrigation farming

Although smallholder irrigation farming has been reported as a failed intervention in South Africa, particularly due to collapsed irrigation schemes, operational irrigation schemes play an important role in rural livelihoods. Smallholder irrigation farming has enabled irrigating households to realise higher incomes compared to their non-irrigating counterparts. The mean annual income for irrigators was significantly higher than that of non-irrigators; it was more than double that of non-irrigators (R125 007 vs R57 608). Independent irrigators had the highest mean annual income (R130 644), followed by scheme irrigators (R117 698). The maximum annual income recorded in the survey was by an independent irrigator household (R696 400). The lowest income was in a home-gardening household (R4 800). This disparity demonstrates the contribution of irrigation farming to household income.

Irrigators were more food-secure than non-irrigators. Results indicate that irrigators were at least 57% more likely to be food-secure than non-irrigators. Households that participated in irrigation farming had higher consumption from own production. Although food security depends not only on own produced food, but also on household income, rural households that produce their own food tend to be more food-secure than those that do not. Results also indicate that irrigating households cultivated a wider variety of crops than non-irrigators. Cultivation of most types of crops by irrigators and non-irrigators was statistically significantly different. This result confirms evidence from other studies that access to irrigation farming allows farmers to grow crops more than once a year, thereby diversifying their crop mix.

One of the benefits of participating in irrigation farming is improved access to financial services. The study found that irrigators had better access to formal financial services than non-irrigating households. Non-irrigator households borrowed money predominantly from informal sources. This trend could be explained by the better asset endowment among irrigators, which provides some form of collateral, enabling irrigators to access formal financial services.

Smallholder irrigation farming creates employment opportunities for both the farmers themselves and the community. The study results indicate that independent irrigators created the greatest proportion of jobs for the community in the 2012/13 season, followed by scheme irrigators and lastly home gardeners. The number of jobs created by the different household types was significantly different. Community members had an opportunity to find jobs either as casual or full-time farm workers.

10.2.2 The contribution of smallholder irrigation farming to household income and food security

The study found that smallholder irrigation farming contributed positively to household income and food security. The study findings support the two hypotheses that (a) the contribution of smallholder irrigation farming to household income and food security varies between types of farmers and these benefits are unequally distributed among households; (b) smallholder irrigation farming affects rural livelihoods largely through increased household income and improved household food security. For simplicity of presentation, the contribution of irrigation farming to each of the livelihood outcomes is presented separately below.

10.2.2.1 The contribution of smallholder irrigation farming to household income

Major sources of household income were salaries and wages, farming and social grants. Income from smallholder irrigation farming contributed substantially to household income of scheme and independent irrigators. For scheme irrigators, irrigation farming contributed about 27% to household income. For independent irrigators, about 50% of their household income came from irrigation farming. Home gardeners, on the other hand, had negligible income from farming but relied on salaries and wages for more than 60% of their household income. PSM revealed that household income for irrigators was at least 54% higher than for non-irrigators.

10.2.2.2 The contribution of smallholder irrigation farming to household food security

Analysis of different dimensions of food security revealed that smallholder irrigation farming had a positive effect on household food security. However, different types of households reported varying household food security situations. Independent irrigators had the greatest proportion of households that reported being food-secure while home gardener households reported not having enough food most of the time. PSM results indicated that irrigators were at least 57% more likely to be food-secure than non-irrigators.

Regarding the frequency of consumption of different types of food, the frequency of consumption of legumes and vegetables was significantly higher for scheme and independent irrigators than for home gardeners. However, consumption of fruit, meat, eggs and dairy produce was not statistically significantly different across the different types of households. The reasons for this are not known. Legumes and vegetables were some of the crops that households cultivated. Irrigation farming, therefore, allowed households to consume different types of food more frequently. It is noteworthy that a portion of the production from irrigation farming was consumed at home, while the bulk of production was sent to the market.

Since a few studies ascertained that household income is an important determinant of household food security, an analysis of the ratio of food expenditure to total household expenditure indicates the expenditure capacity of a household. Irrigators generated more income than non-irrigators, hence they could spend more on food. Results showed that although the proportion of expenditure on food for scheme and independent irrigators was lower compared to the rest of the households interviewed, the actual amount spent on food was higher. In general, however, among all households, a significant proportion of total household expenditure went towards food purchases, with home gardeners spending the greatest proportion of their income on food, compared to irrigating households. Such significant proportions of food expenditure show that food is the most important expenditure item for most households, both irrigating and non-irrigating, therefore implying that rural households have not escaped poverty completely.

Another aspect of food security that the study revealed was the crop-livestock integration for food security purposes. Although the focus of the study was crop cultivation, an analysis of livelihood strategies revealed that some households kept livestock, predominantly cattle and chickens, to supplement their cropping activities for enhanced food security. Linked to this finding was that the goal of food production was dominant across home gardeners' production systems, while the goal of making money dominated across the production systems of scheme and independent irrigators.

10.2.3 Factors determining participation in irrigation farming and the distribution of benefits from smallholder irrigation farming

10.2.3.1 Factors influencing the decision to participate in irrigation farming

Factors deemed to influence the decision to participate in irrigation farming included the gender of the household head, the distance of the household to Julesburg irrigation scheme in terms of the village the household was located, membership of farmer associations, farmer cooperatives and village committees. Participation in smallholder irrigation farming was more inclined towards male-headed households. The distance to the irrigation scheme influenced participation in irrigation farming, more so for scheme irrigators, most of whom were from Rhulani village where the scheme is located. Membership of associations was statistically significantly different between irrigators and non-irrigators. Results indicated that irrigators joined associations significantly more often than non-irrigators. Membership of associations is important for rural households because they provide the much needed social networks that can be called upon in times of need. These results confirm some findings from previous research.

10.2.3.2 Factors influencing benefit distribution

The study found that none of the factors (adequacy of size of land, adequacy of water source, total household size, marital status of the household head, household head's gender, education of household head, age of household head, positive entrepreneurial attitude, borrowed money,

ownership of means of transport, ownership of farm implements, total land area owned/accessed) was significant in influencing the distribution of welfare benefits among independent irrigator households. However, the adequacy of source of water for farming significantly influenced distribution of welfare benefits among scheme irrigator households. Although irrigators are not homogenous, such a result might mean that independent irrigators from the same locality have a lot in common (in terms of production systems, market access, access to land and water, etc) and are therefore bound to benefit in a similar way from irrigation farming. For scheme irrigators, distribution of water within the scheme was a major factor influencing production. For home gardeners, the gender and marital status of the household head, ownership of means of transport and ability to borrow money were significant determinants of welfare benefits.

10.2.4 Additional differences between irrigators and non-irrigators

The study found other differences in the characteristics of irrigators and non-irrigators that could have a bearing on the differences in outcomes measured. Irrigators were more educated compared to their non-irrigating counterparts. However, it is not clear what came first, education or smallholder irrigation farming, because determining causality was out of the scope of this study. Irrigators and non-irrigators differed significantly in terms of entrepreneurial attitude. Irrigators had a higher level of entrepreneurial skill than non-irrigators. Access to agricultural training was more inclined towards the irrigators compared to non- irrigators.

Irrigators owned and cultivated significantly larger farm plots compared to non-irrigators. However, non-irrigators had been operating their farms for significantly longer than the irrigators. These results are plausible, since non-irrigators cultivate part of the homestead grounds and they have been living in those homesteads long before the scheme was functional.

In addition, results showed substantial differences in the capital base among home gardener, scheme and independent irrigator households. Households involved in irrigated cropping had a stronger capital base, not only in terms of natural capital but also physical and financial capital.

This suggests that irrigation farming affects the livelihoods of households in ways that extend beyond the boundaries of agricultural production activities.

10.3 Recommendations

The findings of the study allow for some recommendations to be drawn that could influence policy. Although the study only covered one district in the Limpopo Province, results can be generalised to contextually similar rural communities with access to irrigation facilities, given that analysis of the data took care of biases that could have been introduced through sampling.

10.3.1 Irrigation farming as a source of livelihood

The significant differences in characteristics of irrigators and non-irrigators indicate the potential for smallholder irrigation farming to transform households. There is sufficient evidence that smallholder irrigation farming makes a significant contribution to rural livelihoods through its effect on household income and food security. The most important implication of the study findings is that households should be encouraged to participate in irrigation farming for improved household welfare. However, given the limited capacity of existing irrigation schemes, government intervention should include equipping households with entrepreneurial skills and improving access to resources that would enable more households to irrigate independently, without relying on irrigation schemes. Therefore, government intervention through extension and agricultural training would go a long way in making households rely on farming as a way of life.

10.3.2 Enhanced female participation in irrigation farming

Although most irrigating households were male-headed, it is generally accepted that empowering a woman is empowering a nation. Also, in rural development literature, female-headed households are considered poorer than male-headed households. Therefore, the contribution of smallholder irrigation to rural livelihoods can be enhanced by focussing on policies that encourage female participation in irrigation farming. Government interventions that allocate land

and water to particularly identified poor female-headed households should be implemented. Targeted government support to ensure sustainability should be coupled with this.

10.3.3 The role of associations

Collective action is key for access to inputs and output markets and also offers organised bargaining power. Farmers can enhance their collective action through membership of associations. Results have shown that more irrigators were members of associations. Although it is not clear whether membership of associations led to participation in irrigation or the other way round, the positive relationship between the two is crucial. An important implication of the study is that households should be encouraged to join associations for collective action. In addition, the effectiveness of the associations should be enhanced to allow more households to participate in irrigation farming.

10.3.4 Improving access to water

Access to adequate water for farming is important for households to realise most benefits from irrigation farming. As the results indicated, home gardeners did not irrigate owing to inadequate access to water. Improving access to irrigation water forms part of the current strategy of enhancing access to irrigation farming in the NDP of South Africa. However, practical implementation of these strategies in smallholder environments should be able to outweigh continuous known challenges. Investments in agricultural water will allow households and home gardeners, in particular, to intensify and diversify crop production and hence increase farm output and household incomes. Such an intervention would permit households to transition from home gardening to independent irrigation, consequently contributing to reduced local food prices, increased wage employment and improved household food security. However, pertinent questions will still remain, such as: Is there enough irrigable land for irrigation farming expansion? Is there enough water?

10.3.5 Improving farmer market access

If generating income from farming is the goal of households, which was the case for irrigators in this study, then access to both input and product markets becomes a key issue. Although access to markets is well recognised, improved access still requires further attention. In the study area, access to markets was the domain of individual farming households. However, limited initiatives were aimed at collectively accessing urban fresh produce markets, for example, the Johannesburg Fresh Produce Market. These initiatives involved middlemen, leading to farmers incurring high transaction costs and not having full information on the marketing process. Government interventions through institutional and organisational innovations aimed at establishing effective, collective marketing could reduce transaction costs for individuals. This way, irrigation farming would be successful and would lead to efficient use of scarce resources.

In addition to improving farmers' access to markets, there is a need to address other constraints that, if not dealt with, could render efforts to enhance market access fruitless. Such areas of intervention include investment in rural roads, storage facilities, access to market information and dedicated government support to smallholder farmers.

10.3.6 An integrated rural development strategy

Diversity in livelihood strategies of different household typologies was identified and this is characteristic of rural communities. Although smallholder irrigation farming was not the most important source of household income across households, evidence presented in this study has provided strong motivation for continued investment in smallholder irrigation farming in South Africa. However, it is apparent that irrigation farming is not a panacea to all poverty and food security challenges found in rural areas. As a way of supporting the identified diversity in livelihood typologies, policy needs to provide as much room as possible for farming households to pursue the different livelihood trajectories that are open to them. Therefore, an integrated development approach as part of an overall strategy to improve rural livelihoods and to grow the rural economy is recommended. Given that rural households are vulnerable to trends and shocks,

the role of smallholder farming in the livelihoods of farming households is bound to be dynamic and in some cases could change forcibly. Policy, therefore, should support the dynamic processes by enhancing the flexibility with which individual households can make use of their resources, with specific reference to natural and physical assets.

10.4 Areas for future research

This study was certainly not exhaustive and had limitations emanating from the data, time and methodological approaches and constraints. In the absence of such constraints, the value of the research could be enhanced by allowing a more comprehensive research process, as suggested below.

10.4.1 Benefits of smallholder irrigation farming

The current study did not capture all benefits of irrigation farming as identified in literature. Studies elsewhere show that access to irrigation infrastructure enables farmers to adopt new technologies and intensify cultivation, leading to increased crop productivity, overall higher production, greater returns from farming, linkages in the rural economy and multiple uses of water supplied by the irrigation infrastructure. The current researcher's study findings confirm some of these claims. Future research could comprehensively explore the benefits derived from participation in smallholder irrigation farming. Such an effort would provide complete evidence of the extent to which smallholder irrigation farming benefits smallholder farmers in South Africa and provide some direction on whether investments in smallholder irrigation farming are a sure way to a complete transformation of rural households.

In addition, as independent irrigators benefit more from smallholder irrigation farming, future research could explore why independent irrigators are doing better than everybody else. If there are factors that promote accrual of a wider range of benefits for independent irrigators, then independent irrigation should be promoted as an option for expanding smallholder irrigation farming.

10.4.2 Factors influencing the decision to participate in irrigation farming

Factors deemed to influence the decision to participate in irrigation farming were identified. However, a number of predictors of irrigation participation reported in previous research (for example, land size, perceived soil fertility, household size and access to support services) could not be tested because of data limitations. Future research should be more comprehensive to provide a complete picture of what determines a household's participation in irrigation farming.

10.4.3 The role of positive psychological capital

Regarding assets, this study was limited in the analysis of asset endowment and the contribution of the assets to improved livelihoods. As such, the role of positive psychological capital was not explored because of data limitations. Positive psychological capital entails the four psychological capacities of confidence, hope, optimism and resilience (Luthans *et al.*, 2004)[9]. Going beyond human and social capital, this type of asset consists of who one is rather than what or who one knows, focussing on personal strengths and good qualities for improved performance (Luthans, 2002). This type of asset links to an individual's entrepreneurial attitude, an aspect which was important for this study. Although important, positive psychological capital has not received adequate research attention. Therefore, future research should include examining the role of positive psychological capital at the rural household level.

10.4.4 Conversion of farmers' units of measurement into standard measures

During data collection, data on inputs and production was provided in units that the farmers could understand or remember. Enumerators had to convert the units to standard measures, such as kilograms or tons, after the interview. Measurements given by farmers included number of cups, boxes or buckets for the different types of crops and number of wheelbarrows, etc. Since different crop produce would have a different weight for the same size bucket or box, it was

[9]The four positive psychological states are described in detail by Luthans *et al.* (2004).

difficult for the enumerators to do these conversions and there may have been inconsistencies in the process. However, the challenge was reduced by a series of training sessions before, during and after fieldwork. Enumerators were also encouraged to record the unit of measurement as given by the farmer, and then follow-up conversions were done during data analysis. To eliminate such a challenge in future research, hand-held electronic devices that perform unit conversions should be integrated into the data collection process to eliminate potential errors.

10.4.5 Data used for income statements

Income statements and gross margin computations require the use of extensive amounts of data for each enterprise. The study sought this data during an interview that lasted an hour, on average. Since the smallholder farming households did not keep records of production costs and income but relied on recall for most of the data, chances of incorrect information were high. Future research could explore ways of collecting such data in a systematic way from the households of interest over time.

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