PERFORMANCE ANALYSIS OF MANAGEMENT STRATEGIES IN TSHIOMBO IRRIGATION SCHEME OF SOUTH AFRICA

BY

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As the candidate's supervisor, I agree to the submission of this dissertation.

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Prof. Paramu Mafongoya (Supervisor)

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DEDICATION

To my brothers, Mr K Mwadzingeni and Dr L Mwadzingeni.

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LIST OF ACRONYMS

Acronym	Meaning
ACCI	African Centre of Crop Improvement
BLUE	Best Linear Unbiased Estimators
CSA	Complex Systems Approach
DAFF	Department of Agriculture, Forestry and Fisheries
FAO	Food and Agriculture Organisation
FAOSTAT	Food and Agriculture Organisation Statistics
FDGs	Focus Group Discussions
IAD	Institutional Analysis and Development
ILO	International Labour Organisation
IMC	Irrigation Management Committee
IMT	Irrigation management Transfer
IWMI	International water management Institute
KIIs	Key Informant Interviews
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
M&E	Monitoring and evaluation
MDG	Millennium Development Goal
NPDALE	Northern Province Department of Agriculture, Land, and Environment
PCA	Principal Component Analysis
PCs	Principal Components
PTO	Permission to Occupy
R&D	Research and Development
RCF	Revolving Credit Fund
ROI	Return on Investment
SDG	Sustainable Development Goal
SIS	Smallholder Irrigation Scheme
SSA	Sub Saharan Africa
TLUs	Total Livestock Units
WUAs	Water User Associations

ABSTRACT

The poor performance of most irrigation schemes has undermined their potential of transforming the rural community into economic hubs which will create employment for rural people. Therefore, focusing on the management strategies of smallholder irrigation schemes will create viable alternatives that will improve scheme performance. This study aims to assess the contribution of management strategies on the performance of smallholder irrigation farming in Tshiombo irrigation scheme. The study specifically looks on the performance of scheme farmers, extent to which available incentives impact scheme farmers' performance and the impact of institutional factors on scheme performance.

The study was done in Tshiombo irrigation scheme located in Thulamela Municipality in Limpopo Province of South Africa. Stratified random sampling was used to select 148 from the head, middle and lower section of the scheme. Focus group discussions (FDGs) and Key informant interviews (KIIs) was conducted. Financial performance of the scheme was analysed using gross margin and Ordinary Least Square. Principal Component Analysis and Ordinary Least Square were used to find the relationship between the role of institutions, incentives and scheme performance.

Cabbage has the highest gross margin of R187 324.08, while maize and sweet potatoes have a gross margin of R22 275.95 and R5 873.62 respectively. Age of scheme farmers, labour availability, size of cultivated area pesticide subsidy, market price, and distance of the plot from the main canal significantly affect scheme performance by -0.022, -0.185, -0.30, 0.138, 6.090, and 0.191 respectively. Participation of institutions in Tshiombo irrigation scheme helps to improve scheme farmers' performance. Results show variance on access to institutional services among groups of farmers. Poor combination of institutional factors contributes to the poor performance of irrigation scheme. Smallholder farmers in Tshiombo approach farming as a business and can generate profit from their investment. There is a need for female farmers to prioritise crops with high-profit margins in order to improve scheme performance. The government should change support from subsidy to cash to allow flexibility in access to inputs. Farmers' choice of institutional services should be identified and promoted. Institutions should form some platforms upon which they meet and facilitate resource governance. High yielding combination of institutional services needs to be identified and embraced.

Keywords: incentives, institutional services, investment, livelihood, rural community

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CHAPTER 1: INTRODUCTION

1.1 Background

Smallholder irrigation is a critical investment to the livelihoods of approximately 10% of the world population living in abject poverty of less than $1.90 a day, particularly for millions of rural poor people primarily engaged in agriculture across the globe (World Bank, 2017). According to World Bank (2017), 400 million people in sub-Saharan Africa (SSA), who account for 41% are mostly in rural areas and their livelihoods largely depend on agriculture. High vulnerability to climate variability and change on rainfed agriculture have an outstanding impact on food security in SSA (Gohar and Cashman, 2016). Therefore, the adaptation of smallholder irrigation scheme is a potential alternative to improve the sustainability of rural communities.

In South Africa, 4 million black people from about 2.5 million households account to 92% of poor black people who practice agriculture as their primary source of livelihoods (Cousins, 2013; Pienaar and Traub, 2015). Smallholder farmers who mostly own very small irrigation plots range between 200 000 to 250 000 in South Africa (FAO, 2016). There are in 302 irrigation schemes which cover about 50 000 ha and contribute nearly 3.3% of the total irrigated area in South Africa (Van Averbeke *et al.,* 2011). Consequently, reliance on rainfed agriculture among most of the smallholder farmers in SSA put food security for both household and national levels at risk (Belay *et al.*, 2017), considering the prevalence of drought in recent years. Despite this, irrigation agriculture has a huge potential in South Africa's rural areas.

Irrigation schemes in South Africa were created to increase food production, secure agriculture against drought, establish schemes managed by farmers, and provide rural employment opportunities (Muchara *et al.*, 2016). Unfortunately, many smallholder irrigation schemes have collapsed while most of them are operating below optimum levels. Over one-third of the schemes in Limpopo province are inactive, among them, 69% of large-scale centre pivots were not utilized (van Koppen *et al.*, 2017). Sustainability of smallholder irrigations in South Africa to enhance livelihood security is constrained by poor market access, limited water allocation, land size, operational costs, production levels and institutional incompetence (Mungai *et al.*, 2016; Botlhoko, 2017). Challenges faced by smallholder irrigation schemes need to be explored to improve their performance.

Choice of crops affects the ability of farmers to effectively contribute to the operation and maintenance of irrigation schemes (Pereira and Marques, 2017). Generally, water is allocated to crops which individual farmers consider strategic based on either revenue or food security which impact water value (Wichelns, 2015). Research findings from Msinga Local Municipality of KwaZulu Natal reveal that crops like tomatoes earn a higher average gross margin of 17 249.41R/ha compared to maize with the gross margin of 3 497.57R/ha (Njoko and Mudhara, 2017). Therefore, smallholder farmers can be commercially oriented and approach farming as a business. The collective action of farmers and institutions will ensure farmers to choose profitable crops that will enable sustainability of irrigation schemes through higher scheme performance which enable payment of maintenance fee.

Participatory irrigation management leads to improvement in the quality of irrigation services in terms of farmer perceptions, adequacy, timeliness, and fairness of water distribution (Muchara *et al.*, 2016). Water management decisions and designing of water pricing policies need to be understood by all stakeholders (Muchara *et al.*, 2016). Therefore, improving irrigation management by involving key players like irrigation institutions is of relevant importance to ensure sustainable use of resources in water-scarce areas (Alcon *et al.*, 2017). Institutions and farmers should collectively participate in all scheme activities to improve irrigation schemes performance (Özerol, 2013). A more sustainable way of improving water distribution is implementing water management strategies that meet farmers' interests.

An effort is needed to better understand and define the roles and responsibilities of each institution in order to leverage unique capabilities (Gleick, 2014). However, coordinated management and development of water, land and related resources to maximize economic and social welfare without compromising the sustainability of vital ecosystems need legitimacy and fairness. Technical, institutional and social intervention is required to address the problem associated with increased water demand, water scarcity, and environmental deterioration. Management institutions like Water Users Associations (WUAs) should help farmers to use water wisely, sustainably and equitably (Phalla and Paradis, 2011). To achieve this, there is a need for an inquiry into the management strategies of irrigation schemes in South Africa. Evidence that supports the view that smallholder irrigation schemes are highly productive and that they can reduce rural poverty is very limited (Muchara *et al*., 2016). Hence, examining management strategies will help to unlock, improve and stabilize agricultural productivity such that it can contribute to food security and resilience against climate change and erratic rainfall.

1.2 Problem Statement

Recurring droughts and economic challenges faced by rural households of South Africa who mainly rely on rain-fed agriculture have exposed them to severe and perpetual food insecurity (Nath and Behera, 2011). Therefore, the government has invested in several irrigation schemes to mitigate the problem of drought and worsening climatic change signals (van Koppen *et al.*, 2017). There are limited empirical findings on management strategies across irrigation schemes. Therefore, the study seeks to bridge this gap by exploring the causes and effects of management strategies in irrigation schemes of South Africa, to reveal practices that can improve the performance of most irrigation schemes.

Most smallholder irrigation scheme farmers across the globe lack sufficient incentives to optimize their irrigation deliveries and manage scheme in a way that maximizes its performance (Wichelns and Qadir, 2015). Moreover, higher output price was considered as an incentive that increases profit margin, thereby increasing the willingness to sell products on markets offering higher prices by the rational farmer (Macharia *et al.*, 2014). Incentives gained from irrigated crop types are among the factors considered to determine the performance of the irrigation scheme (Haileslassie *et al.*, 2016). Economic incentives play an important role in the adoption of modern technologies (Ash *et al.*, 2017). The existence of economic incentives makes co-owners to follow institutional arrangements which regulate the operation and maintenance of irrigation schemes (Mosha *et al.*, 2016).

Participation of institutions in scheme management to come up with effective, cost-efficient and legitimate solutions have resulted in rapid access to low cost, swift or social networks to resolve water conflicts (Mosha *et al.*, 2016). Ensuring stakeholder participation through representation in water management decision making is among four key principles on which Integrated Water Resources Management (IWRM) is based. A weak association between people participation in decision making and access to water result in little consensus about other aspects or performance indicators (Loucks and Van Beek, 2017). About 58% of the farmers in semi-improved schemes and 32% in traditional schemes showed strong adherence to the participation and fair say decision making (Mosha *et al.*, 2016). There is no empirical evidence that explores the impact of institutions on performance. Understanding the impact of institutions is essential for policymakers and WUAs to design water policies that would strengthen institutional capacities in water management.

1.3 Research Justification

Smallholder irrigation was supported by the government of South Africa as a means to alleviate poverty, create jobs, boost pro-poor sustainable agriculture and for economic growth (van Koppen *et al.*, 2017). Therefore, promotion of smallholder irrigation is a strategy which paves a way to enhanced income generation, increase food security, and reduce persistent poverty among SSA's poor farmers (Burney and Naylor, 2012). Major areas of concern in South Africa have large-scale inequality, poverty, and household food insecurity which the government wishes to address (Sinyolo *et al.*, 2014). Moreover, Smallholder Irrigation Scheme (SIS) in South Africa has performed dismally by failing to deliver development objectives of improving rural livelihoods through sustainable crop production for food security and poverty reduction (Fanadzo, 2012).

Key issues on agrarian reform in South Africa is the potential of smallholder irrigation to significantly contribute to employment creation, rural development and poverty reduction (Cousins, 2013). NPC, (2011) cited by Cousins, (2013) reveals that the South African government have the potential to create one million new jobs in agriculture and related industries over the next two decades mainly through labor-intensive nature of small-scale farming by expanding area under irrigation by 1.5 – 2 million hectares (Cousins, 2013). Therefore, any untapped potentials to improve food security and employment through smallholder irrigation in South Africa must be explored. There is a need for the government to take a broad range of measures to revitalize irrigation schemes in order to boost broad-based economic growth, create employment and alleviate poverty.

The sensitive nature of the agrarian sector to climatic change has limited the adaption capacity of smallholder farmers in developing nations (Makuvaro *et al.*, 2018). Climate change predictions are that rainfall will be more infrequent but more intense. This will shrink the country's arable land and increase agricultural unpredictability (Ramawa, 2016). High vulnerability to climate variability and change on rainfed agriculture have an outstanding impact on food security (Gohar and Cashman, 2016). Rainfed agriculture is the predominant farming system in sub-Saharan Africa where approximately 90% of cereal is from rainfed agriculture (Makuvaro *et al.*, 2018). Therefore, farmers face challenges to increase productivity to meet the growing demand for food. Failure in planning, management, and decision-making give rise to the inability of the water resource system to ensure adequate, inexpensive and sustainable supplies for both human and natural ecosystems.

1.4 Research Questions

The main question governing the study was; What was the performance of smallholder irrigation farmers in Tshiombo Irrigation Schemes (TIS)?

The specific questions addressed by the study are:

1. What was the financial performance of crops grown in Tshiombo irrigation scheme?
2. What were the available incentives which impact on the performance of farmers in Tshiombo Irrigation Scheme?
3. What was the extent does available incentives impact on the performance of farmers in Tshiombo Irrigation Scheme?
4. What was the impact of institutions on the performance of Tshiombo Irrigation Scheme?

1.5 Research Objectives

The main objective of the study was to assess the performance of smallholder irrigation and identify the role of institutions in Tshiombo Irrigation Scheme.
The study specifically seeks:

1. To assess the financial performance of crops grown in Tshiombo irrigation scheme.
2. To investigate the available incentives and the extent to which they impact scheme performance of farmers in Tshiombo Irrigation Scheme.
3. To assess the role of institutions and their impact on the performance of Tshiombo Irrigation Scheme.

1.6 Specific Hypothesis

H_0 – Management strategies does not affect the performance of farmers in Tshiombo Irrigation Scheme.
H_1 – Incentives affect scheme performance of farmers in Tshiombo Irrigation Scheme more.

H_1 – Institutions impact performance of Tshiombo Irrigation Scheme.

1.7 Conceptual Framework

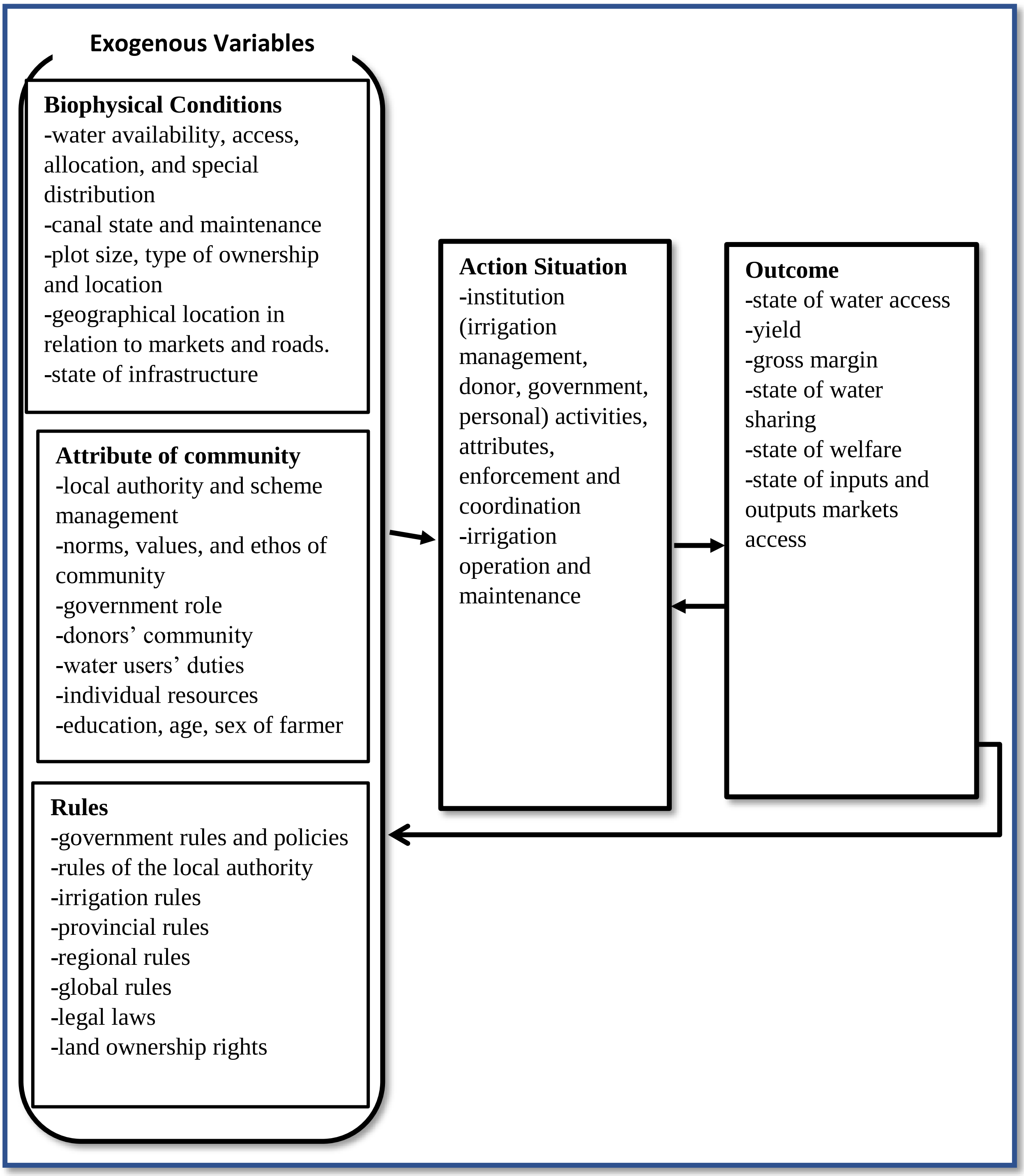

Figure 1. 1 Institutional Analysis and Development Framework showing an arrangement which influence farmer participation in operation and maintenance of Irrigation Scheme

Adopted from Ostrom and Cox, 2010

The Institutional Analysis and Development (IAD) framework define the arrangement of action based on the scope of activities conducted within irrigation schemes (Ostrom and Cox, 2010). It considers the assignment of all relevant explanatory factors and variables to categories and locates them within a foundational structure of the logical relationship (McGinnis and Ostrom, 2014). IAD is suitable for an organization which has multi-sectoral governance which may include public, private, voluntary and community-based (Nigussie *et al.*, 2018). Variables are combined during action situation where management is generally based on assumption that users will take the role formally assigned to them to give output and outcomes.

Agricultural engineers, irrigation management committees, water authorities, farmers as well as stakeholders not normally associated with irrigation schemes are a clear representation of the inclusive nature of stakeholders representing traditional entities (van Rooyen *et al.*, 2017). These stakeholders are part of the larger socio-ecological system within which the irrigation scheme functions and they are multidisciplinary in nature and establishes cognitive diversity of irrigation schemes. Technical problems and systemic capacity challenges are addressed, analyzed and solved (van Rooyen *et al.*, 2017). Individual objectives, requirements, and contributions are influenced by socio-economic characteristics which limit the achievement of overall irrigation scheme goal (Venot *et al.*, 2014).

1.8 Organization of the Dissertation

The dissertation was written using the ‘paper’ format. Chapter 1 introduces the study. Chapter 2 reviews the literature. Chapter 3 is a paper that analyses the performance of smallholder irrigation scheme farmers in Tshiombo irrigation scheme. Chapter 4 is a paper which looks at the roles of institutions on smallholder irrigation scheme performance. Chapter 5 gave the conclusion, recommendations and area of further studies based on the findings from the study.

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CHAPTER 2: LITERATURE REVIEW

2. 1 Introduction

Management of Smallholder Irrigation Schemes (SIS) has received little attention from researchers and investors who are pushing for crop development, physical infrastructure development and rehabilitation (Loucks and Van Beek, 2017). In addition, there is limited performance data about smallholder agriculture in general and smallholder irrigation in particular (Koppen *et al.,* 2017). Focus on infrastructure has often yielded little and proved to be fruitless due to the incapability of human capital to effectively utilize and manage socio-biophysical entity. SIS has been established in South Africa over the years to increase production in different regions of the country (Fanadzo *et al.*, 2010b). Fanadzo *et al.,* (2010b) further assert that the objectives of SIS in South Africa remain at stake. This chapter attempt to explore previous findings of management constraints that affect SIS in South Africa. The information that is obtained from this chapter will help in defining the research problem, the population, and increase the credibility of the study and for comparative purposes. History, contribution, previous research findings, and constraints of SIS are some of the issues captured in this chapter.

2. 2 Importance of Irrigation for Poverty Reduction and Economic Growth in Africa

People and their economies have both benefited from water resources systems for many centuries (Loucks and Van Beek, 2017). Rapid economic growth and poverty reduction, accompanied by massive changes in agri-food systems and human nutrition have been experienced in the first 15 years of the twenty-first century in many African nations (Mbatha Masuku., 2018). Across the world, 40% of total world food comes from irrigated land which contributes 20% of the total world cultivated land (Nakawuka *et al.*, 2017). Irrigation farming is a critical factor influencing food security, incomes, employment and health, given that over 70% of African countries' population derive their livelihood from agriculture (Nakawuka *et al.*, 2017).

The population of SSA is expected to increase by 250% and demand of cereal to triple the current consumption by 2050 (Van Ittersum *et al.*, 2016). Matching rapidly changing demand for food from large and more affluent population to its supply in an environmentally and socially sustainable way and ensure world's poorest people are no longer hungry is the world's major challenge (Van Ittersum *et al.*, 2016). There is a need for intensification of agriculture production by irrigation farming to ensure food security, economic growth and poverty reduction, particularly on rural areas.

Expansion of irrigation schemes could improve the livelihoods of approximately 40% of the present-day rural population in SSA (Pavelic *et al.*, 2013). In Kenya and Ethiopia, more than 80% of the total population derive their livelihood from agriculture and other agriculture-related activities (Nakawuka *et al.*, 2017). Rural poor in SSA earn their livelihoods mostly from climate-sensitive rainfed agriculture (Houdret *et al.*, 2017). Africa has the potential to boost irrigation cultivated area to 49.5% and 83.2% by 2035 and 2060 respectively (Houdret *et al.*, 2017). Crop production can be increased by 73% in SSA by 2030, mainly through the development and expansion of irrigation area (Valipour, 2015a). Houdret *et al.*, (2017) added that there is the potential of expanding irrigation area by 40 million hectares in SSA countries by 2030. Therefore, this review validates calls to increase the irrigated area in Southern Africa and highlight the need to strengthen the way in which future irrigation schemes will be undertaken.

According to You *et al.*, (2011), there is limited poverty and high growth potential for irrigation farming system, hence considered an important cornerstone for agricultural development given that crop yield are double or more compared to rainfed yields. Rural areas in SSA which manly rely on rainfed production for livelihood have the poorest population given that crop productivity is characteristically low and subjected to weather-driven fluctuations, and production is typically limited to 3 – 6 months rainy season (Houdret *et al.*, 2017). Therefore, there is a need to scale-up investment in smallholder irrigation farming.

The contribution of agriculture to overall economic development and poverty eradication have been recognized by African leaders who consider it for overcoming food security (Juma, 2015). Africa faces the challenge of poverty, hunger, and malnutrition of majority of its populations despite vast fertile soils, favourable climates, vast water basins and potential rivers that could be utilized for irrigation and lead to Green Revolution and mitigation of the adverse effects of climate change (Juma, 2015). Globally, SSA has the lowest percentage of irrigated land of only a total of 4% is irrigated land from its total cultivated land (Nakawuka *et al.*, 2017). Expansion of irrigation farming is essential for achieving one of Sustainable Development Goals (SDGs) which seeks to eradicate extreme poverty and hunger by 2030 (UNFCCC, 2015), especially in

SSA which is fitted with only 6% of technical irrigation in relation to global average of 18% (You *et al.*, 2011).

Agriculture holds a dominant position in terms of employment creation in Africa (Siddik *et al.*, 2015), creating employment for 226 million of African youth who are approximately 20% of the global youth population (Secretariat *et al.*, 2017). An increase of youth population by 42% in 2030 is the enormous challenge Africa face (Secretariat *et al.*, 2017). For Southern Africa, the unemployment rate of 24.6% was observed in 2013 due to a limited growth path in relation to providing jobs (Nattrass and Seekings, 2018). According to Koppen et al (2017), irrigation farming played a role of creating own-entrepreneur among rural communities in Africa. Investing in irrigation in Africa will increase labour-hours for employees in agriculture as it raises farming period from seasonal to farm throughout the whole year. Therefore, embracing irrigation agriculture will ensure employment creation in Africa.

There is reduced access to nutrients and micronutrients via home production or purchase and potential caloric shortages among the rural communities in sub-Saharan Africa during the dry season which makes their family members suffer from diminished nutritional status (Burney and Naylor, 2012). In SSA where over 60% of the population is in rural area and mainly rely on rainfed agriculture, 39.6%, 9.4% and 21.4% of children under five years are stunting, wasting and underweight respectively (Domènech, 2015). Therefore, the full potential of irrigated agriculture cannot be achieved without addressing nutritional security as it is a special entry point to address malnutrition among the rural community. Role of irrigation agriculture to fight malnutrition is related to water availability to fully supply or supplement water across the season to ensure a constant supply of a nutritious diet among the community members.

Food insecurity remains a threat in the African continent where approximately 230 million people who contribute 20% of the continent's population experience chronic hunger (Siddik *et al.*, 2015). The challenge of food insecurity can be intensified given a proposed 2.5% increase in population per year which may double the African population to 2 billion by 2015 (Siddik *et al.*, 2015). Higher production potential of irrigation agriculture makes irrigation the best alternative for intensification and reduce the seasonal variation of production in Africa (Nakawuka *et al.*, 2017). Therefore, there is a need to intensify agricultural production to increase yields to ensure food security and poverty reduction, especially in rural areas.

Investment in agricultural water management can, directly and indirectly, reduce poverty and contribute to economic growth. It can directly increase yields, allow an increase in the intensity of crops, change to higher value crops and increase farm output and incomes following justification of yield-enhancing inputs by irrigation (Unver *et al.,* 2018). Furthermore, technology should pave way for increased consumption, asset accumulation, and reduction of persistent poverty (Burney and Naylor, 2012). Much evidence has been achieved towards Sustainable Development Goal (SDG) of eradicating hunger and poverty, despite this, 842 million people are estimated to experience chronic hunger today (Unver *et al.*, 2018). The previous finding from Zimbabwe, Madagascar, and Tanzania realize that per capita income increase with an average of 226% among smallholder farmers who engage in irrigated rice project (Peacock *et al.*, 2007). Though the findings realize that per capita incomes in most irrigation investments was more than treble, none of the projects achieved anywhere near optimum yields and outputs.

Moderate performing investments in irrigation have significant impacts on farm incomes and result in poverty reduction, hence could have a greater impact on poverty reduction if it performs better. Promotion of irrigation was severally considered as a strategy for reducing poverty and improving nutritional security in the world's poorest communities (Burney and Naylor, 2012). Irrigated agriculture uses some 20% of the total farmland in the world but produces 40% of the food which directly benefit approximately 75% of poor people in developing countries which rely mainly on agriculture for livelihood (Unver *et al.*, 2018). An average labour wage valued at approximately $1/labour-day was found to be increased by 45 days/ha as a result of irrigation development (Peacock *et al.*, 2007). The increase in food output can reduce local food prices and improve real net income among net food purchasers among both rural and urban poor, this reduces poverty and hunger. Therefore, irrigation schemes have a multiplier effect on income and employment within the surrounding non-farming economy.

An investment which reduces poverty need to be enhanced by a number of ways like understanding the socio-economic profile of the communities, how they derive their livelihood, their constraints, their socio-economic interests, and how water management can improve their livelihoods (Burney and Naylor, 2012). Measures to make project more pro-poor that include capacity building and empower them to participate effectively, consider their ideas in participatory planning, land and water allocation decisions as well as optimizing their potential for direct and indirect employment gains (Peacock *et al.*, 2007). However, there is underutilization of smallholder irrigation schemes located in former homeland areas in South Africa which result in failure to meet objectives (Bourblanc *et al.*, 2017). Development of irrigation schemes which will improve the sustainability of rural communities must involve engaging with scheme communities.

The household food security situation is most threatened by the lack of independent access and control over land by most women (Jacobs, 2002). Gender imbalances in irrigator groups/associations or as owners of irrigation equipment among SSA is an indicator of marginalization (Bjornlund *et al.*, 2017). Women are responsible for providing labour force across the globe while in developing countries are valued for providing more than half of the food produce (FAO *et al.*, 2011). Moreover, women contribute 43% of the global agricultural labour force (FAO *et al.*, 2011). Therefore, a widely encountered phenomenon in South Africa is the dominant role played by women, who are contributing 65.15% household head in smallholder irrigation schemes (Sinyolo *et al.*, 2014). Despite this, there is a considerable variation in the contribution of the women on agriculture labour force across regions and within countries.

Women who are a crucial resource in agriculture and rural economy are facing several constraints than the men to access productive resources, this results in the underperformance of most schemes (Fikirie, 2016). Training and support services targeting women to ensure equitable participation that benefits agricultural water investments, improve productivity and enhance poverty reduction (Peacock *et al.*, 2007). In irrigation agriculture, there is an assumption that farm household resources should be predominantly controlled and allocated by man (Fikirie, 2016). Studies find out that gender-equitable agricultural production boosts productivity (Sinyolo *et al.*, 2014). Therefore, the adaptation of irrigation technology and institutions that support the needs of women should be considered.

2. 3 Importance of Irrigation in South Africa

Many African countries consider SIS as the driving force for rural development and poverty alleviation despite failures and problems. Irrigation has already contributed to improving livelihoods, broad-based economic growth, poverty alleviation, food security, and self-employment in the former homeland in South Africa (Koppen *et al*., 2017). South Africa has an exceptionally high level of unemployment of approximately 24.9% and is among countries with a high unemployment rate in Southern Africa as per 2013 data from International Labour Organisation (ILO) (Nattrass and Seekings, 2018). Currently, South Africa has approximately 1.6 million ha of land under irrigation for both commercial and subsistence agriculture and they contribute almost 30% of the total agricultural production (DAFF, 2017). Southern Africa is the second region in the world to be challenged by devastating rainfall shortages following the Middle East and North Africa (DAFF, 2017).

South Africa stands out as one of the most water-scarce countries in the continent (Sinyolo *et al.*, 2014). The country is also characterized by extremely variable rainfall, both geographically and over time. In the 12% of the country that is suitable to produce rain-fed crops, productivity tracks rainfall, making farming a challenging business. Climate change predictions are that rainfall will be more infrequent but more intense (Nattrass and Seekings, 2018). This will shrink the country's arable land and increase agricultural unpredictability. Farmers will find it increasingly difficult to increase productivity in rainfed farming to meet the growing demand for food.

2. 4 Large-Scale and Small-Scale Irrigation Schemes

Smallholder irrigation schemes in SSA can be grouped into two categories: large-scale and small-scale. Small-scale irrigation schemes use technology which can be effectively operated and maintained by farmers who have control over them and have a plot size of less than 0.2 ha (Fonteh, 2017). Large-scale irrigation schemes are formal irrigation schemes, developed and managed formally and usually by the state or agri-business unit (Fonteh, 2017). Both small-scale and large-scale irrigation schemes in SSA are required to change of management systems to enable them to perform better.

There is an expansion of both small-scale and large-scale irrigation schemes owing to international agencies prefer to sponsor the development of large-scale projects (Kay, 2001) and individual small-scale irrigation schemes initiatives (Ward, 2016) respectively. There was a rapid development of large-scale irrigation schemes between 1970 and 1980 due to financial support (Kay, 2001). Small-scale irrigation schemes are expanding in dryland especially where there are ready markets for high-value products due to availability of low-cost pumps capable of drawing water from both groundwater and surface sources (Ward, 2016), Small-scale irrigation schemes are more flexible, tuned easily to the farmer's context, that makes them more adaptable and suitable (Fonteh, 2017). Governments and international financing institutions consider that economic growth can be stimulated by financing and managing large irrigation schemes (Houdret *et al.*, 2017). Large-scale irrigation schemes have low development costs/ha because they achieve significant economies of scale (Fonteh, 2017), although constrain of management challenges which result in their collapse are not considered. Large-scale irrigation schemes are of vital importance for food security in developing countries and are of more relevant in subtropical countries where pressure on water resources is high.

Large-scale irrigation schemes are complex and require higher transaction costs to collaborate around shared water and other collective action among large numbers of farmers (van Koppen *et al.*, 2017). Therefore, constraint of public financial sources and public management of irrigation schemes have increased difficulties and risks for large schemes to tape their vast potentials (Houdret *et al.*, 2017). Therefore, frequent need for rehabilitation of large-scale irrigation schemes results in poor sustainability of irrigation schemes in SSA. Community based small-scale irrigation schemes have the greatest potential to develop 8 million ha of SSA’s drylands (Ward, 2016). Large projects investing in multiple small-scale irrigation schemes have reasonable costs and often achieve high returns on investments (Merrey and Sally, 2017). Small-scale irrigation schemes in Ghana employs 45 times more individuals and covers 25 times more land than large-scale irrigation schemes (Giordano *et al.*, 2012). Small-scale irrigation schemes need to be regulated by the government to ensure equitable access to water resources within the water resources management framework.

There are a number of speculations on failures of publicly developed and managed large-scale irrigation schemes due to; top-down planning, poor investment decision, lack of transparency, accountability in public sector management agencies, inadequate skills to manage schemes, high costs, lack of financial viability and failure to involve farmers in any of the process (Peacock *et al.*, 2007; Kay, 2001). Isolation of small-scale irrigation schemes from the market and other supportive institutions lower prices, reduce their profitability and decrease effort to improve infrastructure leading to the long-run reduction of yields of products (Bjornlund and Pittock, 2017). Efforts to integrate small-scale irrigation schemes into the value chain, capacity building, and critical institutional and governance issues will improve livelihood and food security (van Rooyen *et al.*, 2017). Measures need to be put in place to reduce the failure of large-scale irrigation schemes.

Physical rehabilitation alone without workable institutional reforms has been largely unsuccessful and uneconomic even if technology and cropping pattern promise adequate economic returns. The long-term sustainability of large-scale irrigation schemes mainly in low-income crops like rice is threatened by deficits in management and organizational skills among farmers-beneficiaries, deferred maintenance, lack of resources for major repairs, and renewal (Merrey and Sally, 2017). Large-scale irrigation schemes of average 359 ha have low levels of utilization as larger groups are more difficult to lead (van Koppen *et al.*, 2017). Lack of technical know-how on building and operating such systems at a local level have resulted in the underdevelopment of small-scale irrigation scheme in SSA. Moreover, many rural households are far from reaching an initial investment cost of up to US$6 000 per ha (Ward, 2016). Institutional reforms need to be addressed to improve the success of irrigation schemes

Transparency, accountability, efficient and financially self-sustaining institutions are key for successful improvement of large-scale irrigation schemes. Other large-scale irrigation schemes can be turned around if institutional reforms are introduced gradually allowing time to overcome resistance to change and time for adjustment, adaption and fine-tuning, provided that the project is economically profitable. Factors that include limited competition among contractors, more focus on the construction of new schemes rather than rehabilitation of existing infrastructure, higher mobilization costs due to more remote projects, and higher construction input prices lead to the decline in performance of irrigation schemes (Kadigi *et al.*, 2012). This lead irrigation investment in large-scale irrigation schemes to leave farmers more vulnerable to poverty, as well as the project to be considered as high-cost, and uneconomic.

2. 5 Crops Grown Under Irrigation

Change of cropping pattern over time and space in a region is closely influenced by geo-climatic, socio-economic, historical and political factors (Sinyolo *et al.*, 2014). Importance of irrigation is mainly recognized by 69% irrigated sugarcane, 20% irrigated wheat, 33% irrigated rice, 26% irrigated horticulture, and 11% irrigated cotton across the globe (Peacock *et al.*, 2007). Cereals are the main irrigated crop group followed by high-value horticulture and industrial crops (Odegard and Van der Voet, 2014). Cropping pattern is also depending on terrain, topography, slope, soils, availability of water for irrigation, use of pesticides, fertilizers and mechanization (Odegard and Van der Voet, 2014). Maize which contributes 48.0%, sugar cane which contributes 13.2%, wheat which contributes 9.7% and both soya beans and hay which contribute 7.4% towards gross value are the largest contributors towards the gross value of field crops in South Africa for the past 5 years (DAF, 2017). There is a high likelihood that food supply in the world by 2050 will mostly come from irrigated farms.

Cereals account for over 60 percent of irrigated crop area worldwide, hence they are predominantly irrigated group of crops in SSA (FAO, 2016). Focus on staple food result in 76% of irrigated areas of the developing countries dedicated to cereals (Jensen *et al*, 2014). Irrigated cereals yields achieved by smallholders in the region are generally below global standards despite that some slow improvements have been noted recently (Ward, 2016). In South Africa, around 8% of white maize and 17% of yellow maize produced is grown under irrigation (Wettstein *et al.*, 2017). In the 2015/2016, maize contributes a gross value amounting to R27 556 million, 6% of this was produced under smallholder farming (DAF, 2017). High-value horticulture, roots, and tubers cover irrigated crop area that accounts to 13% in SSA with a predominant share of 344 thousand hectares in Southern Africa (Barrientos and Visser, 2013). Production of vegetables in South Africa account to 2 860 000 tons in 2015/16 season following a steady increase in production since the 2011/12 season (DAF, 2017).

2. 6 Performance of Irrigation Schemes

Problems of technical, financial and social feasibility have constantly arisen as decentralization and participation were incorporated into projects (Ward, 2016). Implementation of monitoring and evaluation (M&E) system is a complete failure as it typically starts too late in the cycle and fails to recognize that it is also required for farmers' enterprise management purposes and that farm-level information system is required to feed into project-level M&E system (Ward, 2016). Farmers were neither awarded a chance to accurately judge the effectiveness of improved technologies nor provided with justification for investments made, hence no realistic assessment of poverty reduction impacts were done (Peacock *et al.*, 2007). Over-estimation of water resource availability, poor design and construction, inadequate attention to institutional arrangements and agriculture support services, and negligence of farmer empowerment and poor profitability are problems that emanate from the weakness of earlier project planning (Svendsen *et al.*, 2009).

Investment in technology has failed to gain full potential benefits through water efficiency and has incurred high water prices (Levidow *et al.*, 2014). For instance, underperformance due to inefficient main system management, neglected maintenance and farmers remaining peripheral to the management system have yielded to non-impressive economic returns to specific investments on new irrigation in Sri Lanka (Aheeyar and Smith, 2016). Better water management is evident to be implemented by involving relevant farmer participatory activities for management/distribution of the required quantity of water (Ward, 2016). Irrigation management system involving farmer's perspective and assessment of irrigation performance is critical for the successful scheme (Minch, 2016).

Growing competition for water from other sectors has given rise to increased attention on irrigation performance across the world. Performance and a wide range of socio-economic benefits to the plot holder and immediate community vary considerably among different irrigation schemes and countries, some are improving while others are declining (Shah *et al.*, 2002). Smallholder irrigation has the potential to meet the rural development and poverty reduction but has failed to meet these objectives in South Africa (Sinyolo *et al.*, 2014). Limpopo province defies the belief that smallholder farmers are neither commercial nor are primary producers for subsistence and own consumption (Koppen *et al.*, 2017).

One of the considerable driving force towards implementation of IMT was reported the success of privately owned irrigation (Shah *et al.*, 2002). SIS have the potential to reduce government expenditure and operation cost effectively and improve the maintenance of its infrastructure (Shah *et al.*, 2002). In response to this, farmers assume a driving role in improving their water use for agriculture by bringing about changes in knowledge, production, technology, use, investment patterns, and marketing linkages, and the governance of land and water (Woodhouse *et al.*, 2017).

According to Sinyolo *et al.*, (2014), irrigated agricultural output, water supply, and financial returns are the main determining factors of the performance of irrigation schemes. The condition of the irrigation system, operational status, farm income and observations of cropping intensity where used to assess productivity on irrigation schemes in South Africa (Valipour, 2015b). These are some of the major conditions that have led to the low contribution of irrigation schemes to social and economic development (Bembridge and Sebotja, 1992; Fanadzo *et al.*, 2010; Tlou *et al.*, 2006). Nevertheless, contrary to a background of the deprived performance of SIS, studies on management strategies to ensure that all these factors are combined effectively and efficiently among the schemes are very limited. For effective planning and revitalization of existing and new schemes, information on management strategies are the priorities.

Approaches to empower farmers can significantly improve project quality by moving responsibility and capacity for project implementation and services to the local level, increase participation of disadvantaged groups in decision making, improving accountability of service providers and help smallholder to form strong organizations. Performance of irrigation schemes can be ranked according to the utilization of production factors where low input-low output schemes had a significantly low economic rate of returns. This has resulted in extensive dissatisfaction with the performance of irrigation projects in developing countries despite their potential as engines of agricultural growth (Minch, 2016). Irrigation projects have a mixed track record on sustainability, returns on investments can be high while risks can also be high.

2. 7 Institutional Reforms in smallholder irrigation schemes

The ‘public good’ characteristic of water, the ‘common pool resources’ nature of irrigation schemes, and land tenure system of SSA need governments to play a pro-active role in creating security and stability for investments (Houdret *et al.*, 2017). Failure of institutions to meet various users’ demand result in mismanagement of irrigation schemes (Mosha *et al.*, 2016). Projects, where farmers made large capital contributions and managed irrigation systems or share management with government irrigation agencies, keeps costs down and improves performance (Ward *et al.*, 2006). Therefore, effective and legitimate water management institutions involve farmer participation in decision making, collective action and conflict resolution mechanism in governing water allocation and distribution (Mosha *et al.*, 2016). Approaches that empower farmers by taking them in as partners and decision makers from the beginning and support their development as commercial agents equipped to deal in the marketplace from beginning appear to keep costs down and improve performance (Peacock *et al.*, 2007). SSA countries must establish farmer-owned liability companies to run commercial businesses by increasing access to extension services, financial products, input supply, and access stable markets (Houdret *et al.*, 2017). These companies will enter into contracts with private sector companies for irrigation management, service provision and market access.

Decentralized and farmer-driven irrigation projects with high farmer contributions, leads to lower unit costs.

Projects designs in the past where largely top-down managed, new projects are adopting more participatory approaches with more fit of projects to goals, consideration for alternatives, perfect understanding of markets, farming systems, livelihood, and demand drive (Svendsen *et al.*, 2009). Fair representation in water decision making bodies improve the performance of irrigation schemes (Mosha *et al.*, 2016). Newer projects have adopted a less top-down approach by integrating user participation into project planning and implementation in some countries (Ward *et al.*, 2006). Common weaknesses like poor treatment of land and water security, lack of adequate environmental assessment, lack of evaluation of markets and profitability, lack of agricultural support package, over-estimation of institutional capacity, poor technical design, and over-optimistic hydrological analysis have reduced the quality of projects (Svendsen *et al.*, 2009). Successful performance of irrigation schemes differs among regions, countries, large schemes, and small schemes, due to the potential of water governance institutions to keep common pooled resources sustainable (Mosha *et al.*, 2016).

Smallholder irrigation schemes need long-term support such as vocational training along with assistance in designing contracts and acquiring management skills (Houdret *et al.*, 2017). The inadequacy of implementation agencies to the task given have impaired project implementation. Performance of staff and public agencies involved fail to meet the complexity of the organizational structure set up due to lack of skills, resources, and incentives to do the job assigned to them (Peacock *et al.*, 2007).

Characteristics of resource and resource users influence institutions or regimes of water allocation and distribution (Mosha *et al.*, 2016). Institutions work within a set of water users' capacity, experience, and motivation which have consequences on the choice made by several agencies and influence outcome (Goldin, 2010). Meeting the objectives of irrigation development requires going beyond water delivery, hence it is important to evaluate not only the hydrological performance of the irrigation system but also the performance of irrigation agricultural system and agricultural economic system (Sinyolo *et al.*, 2014). Hence, problems may occur if management strategies do not fit the demands and expectations of users (Mosha *et al.*, 2016). Therefore, there is little consensus about performance indicators that predict the presence or absence of a good set of management strategies that should be adopted to achieve productivity and sustainability of irrigation schemes.

2. 8 Water Associations in smallholder irrigation schemes

Irrigation water users associations (IWUA), irrigation cooperatives and water committee are forms of irrigation institutions found in irrigation schemes, in other schemes they are absent while in some they exist in name only as their impact is insignificant (Haileslassie *et al.*, 2016). Members of the water users association are people who are 18 years and above, who own a plot within the irrigation scheme and they are privileged to receive their services and benefits in relation to their compliance to rules and obligations of the scheme (Mosha *et al.*, 2016). Membership in WUA for traditional schemes is 100% compared to 70% for modern to semi-modern schemes (Haileslassie *et al*., 2016). Presence of non-member water users was considered to deter the decision-making processes and the enforcement of rules and regulations for water use, creating an opportunity for free riders (Haileslassie *et al.*, 2016) According to Mosha *et al.,* (2016), adopting membership rights which allow access of water for a use without jeopardizing other user's rights have a positive impact on efficient water management.

Key functions of WUAs are to provide irrigation services and activities in which they are mandated to operate and maintain irrigation infrastructure, make the decision to facilitate operation and maintenance as well as to make the financial decision (Haileslassie *et al.*, 2016). Infrastructural and management interventions are needed to fill performance gaps can be properly planned by a rational approach based on the quantitative and integrated analysis (Haileslassie *et al.*, 2016). There is limited evidence that water users organizations have been successful in reducing poverty and improving equity or productivity in Africa, suggestions from others are that process resulted in low productivity (Bjornlund *et al.*, 2017). This study will identify action to be undertaken to positively influence collective irrigation performance, to increase the level of service provision for more productive and efficient resource use. Moreover, the provision of the minimum institutional framework by indigenous farmer groups for irrigation to be a true poverty-fighting tool will be explored.

2. 9 Decentralisation of irrigation scheme management

Irrigation management transfer was a global trend where irrigation-scheme management was transferred to farmers and this reform dates back to over 50 years (Loucks and Van Beek, 2017). Schemes managed by state agencies and pay farmers as employees, perform poorly and consequently collapsed, most of them were handed to smallholder farmers while others were privatized (van Koppen *et al.,* 2017). Involvement of active participation of interested stakeholders in water planning and management processes and calling for less government oversight, regulation and control were on an increase for the past decades (Loucks and Van Beek, 2017). Policies were done to spearhead the irrigation sector by governments of most countries embrace Irrigation Management Transfer (IMT) (Shah *et al.*, 2002). South Africa restructure the management of irrigation scheme from state to be managed by people involved in irrigation in the late 1990s after they realize sustainability of irrigation systems managed by stakeholders (Loucks and Van Beek, 2017). Government simultaneously withdraw from active farming, restraining its responsibilities to well-defined functions, mainly related to information supply through research and extension, and capital development from a long-standing system of support and management of SIS (Ntsonto, 2005).

Scheme managers have been attempting to manage farmers which result in impoverishment and dependency rather than encourage poor entrepreneurial development, which was the long-term effects of these support systems (Loucks and Van Beek, 2017). Smallholder irrigation development can transform the rural fabric to become productive and sustainable if subsistence smallholders are turned into rural entrepreneurs (Woodhouse *et al.*, 2017). Community uplifting and lucrative agroindustry on existing SIS and in the communities surrounding the schemes was the main vision of IMT and revitalization (Denison and Manona, 2007). Despite this, schemes deteriorate quickly on the wake of IMT, due to lack of technical and management skills by farmers entrusted with responsibilities to operate and maintain schemes (Shah *et al.*, 2002). Therefore, there is a need for a combined effort by all plot holders in planning, human capital development, access to information, repair and re-design of existing infrastructure and ensuring a financially sustainable development strategy.

2. 10 Farmer Management of Irrigation Schemes

Farmers on irrigation schemes should team up and be willing to work collectively towards the routine maintenance of the scheme infrastructure to achieve their individual objectives (Van Averbeke *et al.*, 2011). Farmers should institute the mobilization of resources by payment for energy where pumping is involved. Collective approach guarantees equitable land distribution as well as easy access to inputs and output markets (Letsoalo and Van Averbeke, 2005).

Institution and organization of SIS are challenged by the inability of irrigation voluntary leadership structures to enforce rules for farmers to pursue a collective goal in place of their own (Van Averbeke *et al.*, 2011).

Irrigation committees found it problematic to regularly maintain the water distribution system, this threatens the sustainability of irrigation schemes by reducing water delivery and shortening the life-span of irrigation scheme (Ncube, 2017). Degradation of SIS in South Africa was mainly attributed to insufficient regular maintenance (Letsoalo and Van Averbeke, 2005; Shah *et al.*, 2002). Sustainability of SIS can be ensured by training and development of irrigation committees (Van Averbeke and Mohamed, 2006). Multi-disciplinary stakeholder management forums need empress complex issues that support and constrain smallholder irrigation sector. Much research on management of irrigation schemes need to be done to support irrigation committees by providing best management practices (Denison and Manona, 2007; Mnkeni *et al.*, 2010).

Fanadzo *et al* (2012) pointed out that it is important for a social group to define and enforce rules regulating access and use of the communal resource at a community level. To achieve this, the institutional arrangement must be effective in defining access, exclude non-users and regulate the use of resources (Akudugu, 2013). That's the effectiveness of irrigation schemes management to define access and regulate the use of irrigation schemes determine the sustainability of the scheme (Knox *et al.*, 2013). Akudugu *et al.*, (2013) find out that it is difficult to enforce rules to exclude non-users and can be costly and not feasible. Inability to regulate access and use of a resource expose it to overuse, exploitation, and underutilization. Borrowing vital strategies from those schemes which are successful has a high probability of scaling up their performance.

2. 11 Governance of Water in Smallholder Irrigation Schemes

Water supply issues need to be addressed by the improvement of irrigation technology, field production management practices, and capacity building to ensure economic growth in rural areas (Bjornlund *et al.*, 2017). The main performance indicators of water delivery systems of SIS are adequate water supply, equity of water distribution and dependability of water supply (Van Averbeke, 2013). Majority of schemes fail to maintain a reliable and equitable water distribution system and experience water shortages which result in low production (Van Averbeke, 2013). Some irrigation schemes have major challenges with distributing water to farmers due to the fluctuating levels of water in the reservoir, which force scheme management committees to schedule water among the various sections and some farmers to abandon their allocated plots (Bjornlund *et al.*, 2017). Generally, uneven distribution of water has caused varied problems across the globe which range from conflicts and disputes among farmers, inadequate water supply, leaks and obstructions along the canal (Van Averbeke, 2013; Mutambara and Munodawafa, 2014). Improper irrigation water management practices in most irrigation schemes have resulted in salt build up which affects productivity. Proper irrigation management reduces the adverse effects of waterlogging and salinity in the irrigation system due to pollutants from irrigated lands (Kijne and Vander Velde, 1992).

Establishing the amount and types of irrigation water fees will be an important step to finance water use (Haileslassie *et al.*, 2016). Farmers were obliged to pay a water fee of US$6 per acre per crop in Iringa District, while in Kilombaro District they paid 5% of the total harvest per cropping season (Mosha *et al.*, 2016). Funds collected were partly used to pay water fees and partly used for the renovation of irrigation infrastructure and operational costs (Mosha *et al.*, 2016). Financial management was not common among most of the schemes where irrigation fees exist, this results in a lack of empirical evidence on what to pay and how much to pay.

The household food security situation in most countries is threatened by the lack of independent access and control over land by the most woman (Jacobs, 2002). Poor representation of women in irrigator groups/associations or as owners of irrigation equipment among SSA is an indicator of marginalization (Bjornlund *et al.*, 2017). Women are responsible for many irrigation scheme labour force across the globe while in developing countries are valued for providing more than half of the food produce (FAO *et al.*, 2011). Generally, women contribute 43% of the global agricultural labour force (FAO *et al.*, 2016). A widely encountered phenomenon in South Africa is the dominant role played by woman contributing 65.15% household head in smallholder irrigation schemes (Sinyolo *et al.*, 2014). Majority of female farmers were observed to utilize irrigation land to the same extent as those with male farmers (Koppen *et al.*, 2017). Despite that, the women who are a crucial resource in agriculture and rural economy are facing several constraints than the men to access productive resources, this results in the underperformance of most schemes (Fikirie, 2016).

Government policies such as land reform have allowed farmers in South Africa to gain access to productive land, however, these policies have not made provision for farmer support services and have resulted in the failure of many SIS (Mutambara and Munodawafa, 2014). In addition, government policies like land tenure do not support a conducive environment for the successful operation of smallholder irrigation (Moyo *et al.*, 2017). The productivity of the agriculture sector is the main concern of policymakers among Sub-Saharan countries, to determine the pace and direction of the overall economic growth (Nhamo *et al.*, 2016). Policy and institutional support are essential to permit the irrigators to tap into innovations developed in other sectors (Moyo *et al.*, 2017). Enhanced security of land tenure improve productivity and empowers farmers in view of long-term investment and building permanent production structures. Level of long-term investments is determined by the security of tenure as perceived by farmers and potential investors (Moyo *et al.*, 2017).

2.12 Irrigation Infrastructure, Equipment and Methods Used by Schemes

There is inadequate infrastructure in the majority of smallholder irrigation schemes in South Africa which limit scheme farmers to access markets which are essential in improving rural economies (Mbatha *et al.*, 2018). According to Mbatha, (2018), smallholder farmers in South African rural communities are limited to access market due to the poor transport system. Shortage of storage infrastructure reduces sustainability and food security of farmers during drought due to high fluctuation in farm income and rural livelihoods (Gohar, 2015). Van Averbeke et al (2011) assets that poor maintenance of infrastructure and equipment is associated with poor performance. The limited success of irrigation schemes has resulted in decaying infrastructure among most of them.

Pressurised irrigation systems have the main advantage of lower establishment costs per unit area and reduced labour despite having a shorter lifespan of the systems, higher operating costs and greater maintenance needs (Van Averbeke et al, 2011). Gravity-fed irrigation could match or exceed the irrigation efficiency of other systems when used correctly. Smallholder irrigation schemes might be prevented from the timely access of equipment which affects the timing of operation, lack of adequate good-quality inputs, lack of transport to access best-paying markets, safe crop storage and also by poor access to financial institutes (Bjornlund and Pittock, 2017). Only 6% of technical irrigation was developed in SSA in relation to the global average of 18% (You *et al.*, 2011). Measures to improve access to capital for both scheme types need to be developed to improve their economic returns.

2. 13 Gross Margin

Gross margin is one of the most common types of the ratio used in agriculture and farming analysis when assessing the performance of the organization over a period of time (Muchara *et al.*, 2016; Yokwe, 2009; Cousins, 2013). Gross margin analysis is commonly used to analyse the performance of agricultural enterprises across the globe and has proved to be one of the greatest tools to precisely measure the viability of the farming system (Adeyemo *et al.*, 2017;). Cousins (2013) used the gross margin analysis to calculate financial returns among smallholder irrigation schemes in South Africa.

2. 14 Ordinary Least Square

OLS model is a plausible strategy across many disciplines like agriculture which fit lines through data (Kilmer and Rodriguez, 2017). Values of unknown parameters are chosen such that the residual sum of square become as small as possible (Gujarati, 2009). Moreover, it has been demonstrated as an effective means for estimating independent factors that affect a dependent factor. OLS model is the best linear unbiased estimator under the full set of Gauss-Markov assumptions (Gujarati, 2009). OLS have strong statistical properties, particularly that the population regression model is linear in parameters, where E(y/x) is a linear function of x, the data obtained constitute a random sample from a distinct sample, absence of perfect multicollinearity, error mean with an expected value of zero, homoskedasticity and unlikelihood of large outliners (Gujarati, 2009).

OLS is the oldest and frequently used data analysis technique in the field of agriculture that best fit a set of data points. Ordinary least square was used to assess the influence of community-level characteristics on smallholder adaptation (Gujarati, 2009). A positive influence on agricultural income by adaptation of small-scale irrigation farming as a climate-smart agriculture practice was shown by OLS (Mango *et al.*, 2018). Moreover, the significance of 12 explanatory variables on annual gross farm income was also revealed using the OLS model (Gujarati, 2009). Therefore, outstanding evidence of high usage of the OLS model to assess gross income have proven fruitful in evaluating the performance of smallholder irrigation farming.

A reweighted iterative regression procedure is proposed to produce a constant estimate as transfer function models are not necessarily consistent (Gujarati, 2009). Choice of the conditional mean and conditional variance function is typically made to ensure that predictions fitted-values from the specified model are admissible. An iterative method has regularly used a technique where a search in a stepwise fashion for the best value of estimate is done (Kilmer and Rodriguez, 2017). Kilmer and Rodriguez, 92017) added that the technique uses a linear approximation of the function and refine the approximation by successive corrections.

Reciprocal of tolerance, Variance Inflation Factor (VIF) was used to show how much the variance of the coefficient estimate is being inflated by multicollinearity. F-test was used to check if the model is better suited for analysing the data (Kilmer and Rodriguez, 2017). Durbin Watson statistics was used to detect the presence of autocorrelation in the estimated model. Kilmer and Rodriguez, (2017) used Durbin Watson to analyse autocorrelation in the model. The chi-square test, goodness of fit test find out how the observed value of given phenomena is significantly different from the expected value.

2. 15 Conclusion

Smallholder irrigation schemes prove to be of considerable importance to the livelihood of rural poor across the globe, in Africa and in rural communities of South Africa. Smallholder irrigation has directly and indirectly impacted food security, poverty reduction, income generation, and employment creation in sub-Saharan Africa for several decades. However, the performance of the irrigation system has never yielded to the optimal level despite the high potential for irrigation development. Various crops are grown in irrigation schemes without proper guidance and advice from scheme management, compromising irrigation for profitability which has direct and indirect influence on operation and maintenance of the irrigation scheme. Therefore, the management of irrigation schemes was considered of critical importance in determining the performance of irrigation schemes. Failure to consider the management of irrigation schemes as a critical component will give rise to poor operation and maintenance and deterioration of the system in the long run. This chapter has explored previous findings on importance, performance, and management of irrigation schemes.

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CHAPTER 3: SMALLHOLDER IRRIGATION SCHEME FARMERS' PERFORMANCE IN TSHIOMBO IRRIGATION SCHEME LIMPOPO PROVINCE, SOUTH AFRICA

Abstract

Smallholder irrigation farming has received international recognition for playing a pivotal role in reducing hunger; ensure food and nutrition security, improving the welfare of rural communities, and generating employment. In South Africa, smallholder irrigation farming is the scope for rural communities. Reports on smallholder irrigation schemes across the globe highlighted their low performance. Focusing on the performance of scheme farmers will ensure economic and financial sustainability of scheme for better welfare of the current and future generation. This study focused on the performance of farmers in Tshiombo irrigation scheme, located in the Limpopo province of South Africa. This study encompasses administering structured questionnaires, focus group discussions (FGDs) and key informant interviews (KIIs). A representative sample of 148 farmers was selected randomly and interviewed. Categorical data and numerical data were collected from the sample population. Gross margin of crops grown in the scheme was employed as a performance indicator in relation to this study. Ordinary Least Square (OLS) with gross margin for sweet potato, which is the main crop grown in the scheme was used to estimate factors that affect the financial performance of scheme farmers. The study identified cabbage as a potential crop with higher gross margin compared to maize and sweet potatoes which are main crops grown the scheme. Age of farmers, labour availability, size of cultivated land, pesticide subsidy, market price and distance of the plot from the main canal significantly impacted gross margin with a margin of -0.022, 0.185, -0.13, 0.138, 6.09 and 0.191 respectively. Focusing on encouraging young farmers to join scheme farming by increasing economic incentives like high market prices for produce and providing them with irrigation plots will improve scheme performance and sustainability. Moreover, government subsidies that are provided to scheme farmers should relate to farmer's production needs like pesticide by enquiring from them.

Key Words: economic incentives, financial performance gross margin, institutions,

3.1 Introduction

Agriculture faces a challenge of achieving the aim of 2030 Agenda for Sustainable Development Goal (Agenda 2030) of ending hunger, achieving food security, improve nutrition and promote sustainable agriculture in the world by 2030 (Food and Nations, 2017). The number of undernourished people signal an upward trend by increasing from 777 million in 2015 to 815 million in 2016 and deterioration of food security situation worsening in parts of SSA (FAO *et al*, 2017; Fanadzo and Ncube, 2018). Smallholder irrigation scheme can improve the livelihood of over 400 million people in SSA who are living in extreme poverty of less than $1.90 a day among nearly one billion raised out of abject poverty (Mundial, 2017). Approximately 92% of poor black people practice agriculture in South Africa (Pienaar and Traub, 2015). High variability of climatic conditions has limited crop yield in rain-fed crop production (Van Averbeke *et al.*, 2011). In response to this Africa aspire to modernise agriculture and improve productivity through the use of science, technology, innovation and indigenous knowledge by 2063 to eliminate hunger and food insecurity and reduce food imports (A. U., 2015).

In South Africa, 4 million black individuals from about 2.5 million households account for 92% of poor black people who practice agriculture as their primary source of livelihoods (Cousins, 2013; Pienaar and Traub, 2015). Very small irrigation plots are owned by smallholder farmers who range between 200 000 to 250 000 across South Africa (FAO, 2016). Approximately 302 smallholder irrigation schemes which cover 47 667 ha and contribute Approximately 3.3% of the total irrigated area in South Africa are of great importance due to their location in the former homeland (Van Averbeke *et al.*, 2011; Fanadzo and Ncube, 2018). Consequently, reliance on rainfed agriculture among most of the smallholder farmers in Sub-Saharan Africa put food security for both household and national levels at risk (Belay *et al.*, 2017), considering the prevalence of drought in recent years. Despite this, irrigation agriculture has a huge potential in South Africa's rural areas as in Asia where it has reduced poverty, support industry and develop economy (You *et al.*, 2011; Turral *et al.*, 2010).

Irrigation schemes in South Africa were created to increase food production, secure agriculture against drought, establish new owner-operators in the farming sector, and provide rural employment opportunities, where over 60% of the country receive less than 500 mm of rainfall which is far below minimum requirement for effective dryland farming (Muchara *et al.*, 2016; Fanadzo and Ncube, 2018). Unfortunately, many smallholder irrigation schemes have collapsed while majority are operating below optimum levels over one-third of the schemes in Limpopo province are inactive, among them, 69% of large-scale center-pivots were not utilized (Van Koppen *et al.*, 2017). Sustainability of smallholder irrigation in South Africa to enhance livelihood security is constrained by market access, limited water allocation, land size, operational costs, production levels and institutional incompetence (Mungai *et al.*, 2016; Botlhoko, 2017).

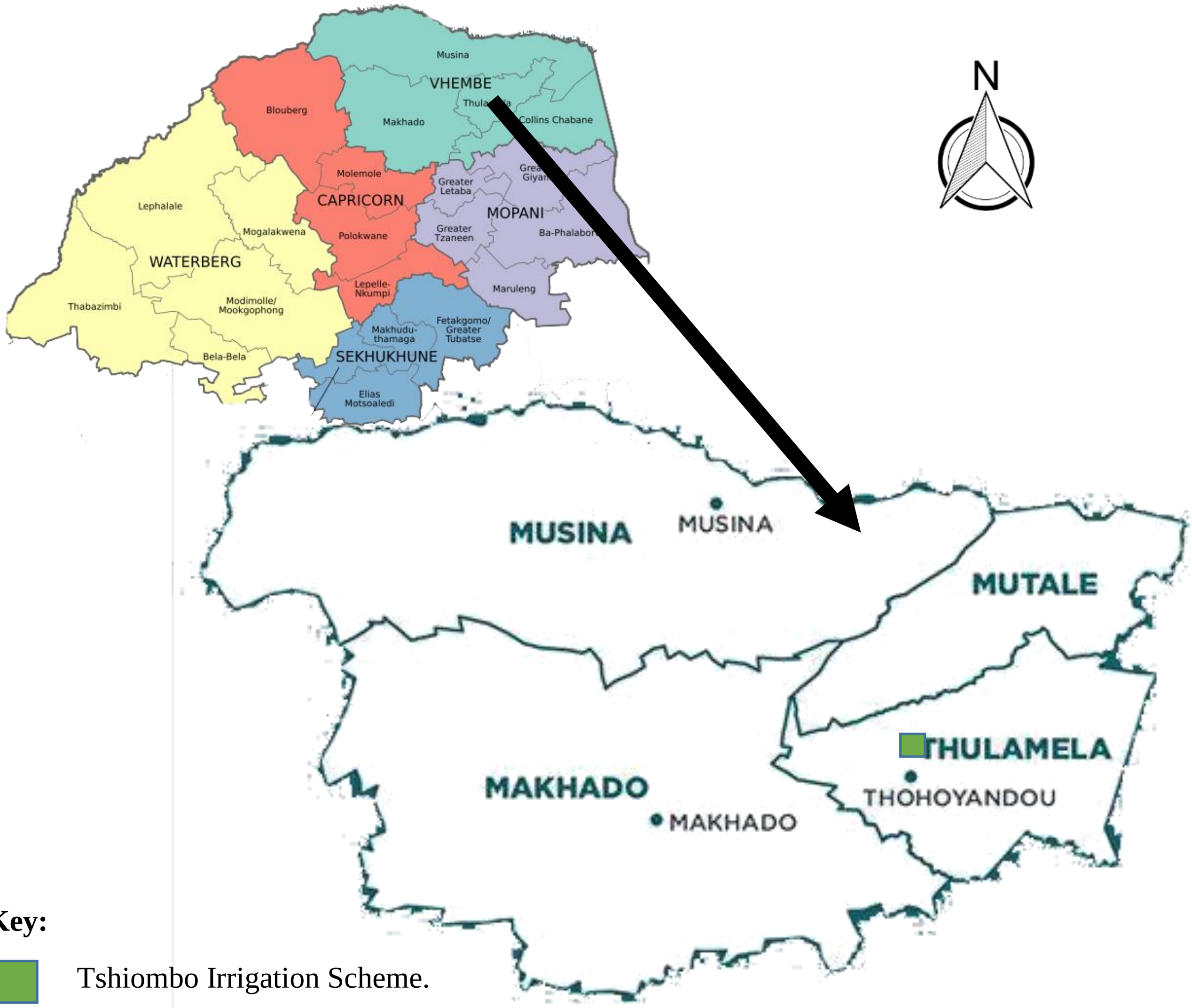
Investment decisions on water resources need to be understood by all stakeholders (Muchara *et al.*, 2016). Smallholder irrigation farmers in South Africa cannot carry out agricultural plans due to inadequate funding on account that total budget allocated to agriculture decline from 2.08% in 2012 to 1.81% in 2016 (Fanadzo and Ncube, 2018). Therefore, the government have neglected training, management and institutional development in favour of infrastructural rehabilitation (Denison and Manona, 2007). Several agricultural policies and support programmes like Compensative Agricultural Support Programme (CASP) which identify the need of advisory and regulatory services, market development, information and training, capacity building and financial services introduced after 1994 faces collapse. Therefore, the collective participation of institutions and farmers is an incentive to scheme performance (Özerol, 2013).

3.2 Methodology

3. 2.1 Study Area Description

The study was conducted in Tshiombo Irrigation Scheme (TIS) which is situated 40 km from Thohoyandou in Thulamela Municipality of Vhembe District in Limpopo Province of South Africa (Figure 3.1). Vhembe district has a total of 2 076 390.38 ha of agricultural land and is the second-best district after Waterberg in Limpopo province (LDA, 2017). TIS is among the biggest irrigation project in Limpopo Province, covering an area of 1 196 ha in the western end of Tshiombo valley (Thagwana, 2010; Lahiff, 1997). Limpopo is one of the best three provinces in relation to the proportion of the total number of smallholder irrigation schemes with KwaZulu Natal and Eastern Cape (Denison and Manona, 2007).

There is fruit and vegetable production in Limpopo Province, as a result, its abundant agricultural resources which make it the prime agricultural region in South Africa (Cai *et al.*, 2017). According to executive summary of agricultural industry of Limpopo Province, the province dominates in production of avocados (63%), citrus (25%), litchis (25%), macadamia (54%), mangoes (75%) and pawpaw (65%) across the whole nation in 2016/17 season (LDA, 2017). Limpopo province has 303 000 black small-scale farmers operating on 30% of agricultural land and predominantly produce field crops particularly maize, grain sorghum, millet, beans, and groundnuts on a smaller scale (LDA,2017) Mixed crop and livestock farming is the common agricultural practice among the inhabitants.



Key:

Tshiombo Irrigation Scheme.

Figure 3. 1 Location of Tshiombo Irrigation Scheme in Vhembe District of Limpopo Province

Vhembe district is on the northernmost part of Limpopo province, partly sharing international boundaries with Botswana, Zimbabwe, and Mozambique. The agroecology of the area is characterized by an arid and semi-arid climatic environment which is a major challenge of rainfed crop production. The average rainfall is ±500mm annually with most rainfall during the summer (October to March), whilst the other three seasons are generally dry (Cai *et al.*, 2017). The distribution of rains is uneven and erratic. The average temperature in summer is around 27 °C, though it can be very hot reaching between 45 and 50 °C in Limpopo province (Cai *et al.*, 2017). This climatic condition gives rise to frequent drought hence irrigation is a possible opportunity for food security in such societies. Tshiombo offers the local community an opportunity to increase income and participate in the local economy. TIS was developed by the Department of Native Affairs, South African authorities between 1959 and 1964 on the land provided by the local chief, Tshivhase (Lahiff, 1997). TIS is divided into four blocks (1, 2, 3 and 4), block 1 and 2 are subdivided into 3 and 2 blocks respectively. Water is diverted from a roughly 15.2km long weir constructed along Mutale river into the canal which diverts water into gravity fed farrows in TIS (Lahiff, 1997). Irrigators take turns to divert irrigation water to their plots. TIS has approximately 930 plots, with an average plot size of 1.5 Ha in size.

Maize, cabbages, potatoes, tomatoes, onions, beans, spinach and butternut are among the crops grown in the scheme. Block committees are responsible for water distribution among other duties on TIS who are supervised and monitored by the Irrigation Management Committee (IMC) (Muchara *et al.*, 2015). Tasks of IMC are equitable water distribution among blocks, inspection of irrigation infrastructures, sourcing funds for maintenance and conflicts management.

3. 2.2 Sampling Procedure

The study was conducted on households in TIS. Data and information were collected on current agronomic practices employed by farmers in the study area. Proportionate stratified random sampling was used to select 148 scheme farmers from the head, middle and tail section of irrigation scheme at 95% confidence level using statistical software (Raosoft). TIS was stratified into the head, middle and tail sections. On average 49 scheme farmers were randomly selected and interviewed from the head, middle and tail section of the irrigation scheme. Questionnaires which was validated by a pilot test was administered by trained interviewers.

3.2.3 Data Collection

Face to face interviews was conducted using a structured questionnaire as the main data collection tool. Trained enumerators were enrolled to assist in data collection. The questionnaire composed of both open and closed-end questions. Open-ended questions allow respondents to include more information, anticipated feeling, permit creativity, cut down on response error and can be used for primary data collection. While close-ended questions are easier and quicker for respondents to answer, fewer relevant answers of different respondents are easier to compare, code and statistically analyze. Variables which were captured include household name, education level, size of land under irrigation, and varieties are grown, among others. Secondary data sources were used for trend analysis, to supplement, for reference and for comparative purposes. Focus Group Discussions (FDGs) enable the researcher to obtain detailed information about personal and group feelings, perceptions, and opinions while saving time and money. FDGs was categorized in relationship to gender and Physical location (head, middle and tail section) of irrigation schemes. Key Informant Interviews (KIIs) were done to collect information from extension workers, chiefs, committee members and old farmers who have first-hand knowledge about the community and can provide insight on the nature of problems and may suggest recommendations for solutions.

3. 2.4 Model Specification

SPSS version 25.0 was used to analyze the data collected from the study. Data from the study was coded, captured and cleaned before being analyzed. Return on Investment (ROI) was used to calculate efficiency of investing in each crop production in Tsiombo irrigation scheme. ROI was calculated by dividing Gross Income by Total Variable Costs. It measures the amount of profit gained by investing a rand into crop production. Gross margin analysis was done to assess the performance of crops grown in Tshiombo Irrigation Scheme. The relationship between incentives and scheme performance was analyzed by Ordinary Least Square. Gross margin per hectare will be calculated as total sales revenue less direct production, marketing, and transport costs, estimates for a collection of household production, each horticultural and cereal crop in the study area. Individual crop gross margins will be computed based on related crop revenue and variable costs. Variable costs that include the cost of seeds, agrochemicals (fertilizers), land preparation, water subscription fee, and labour cost. In the case where household labour, subsidies and other non-paid goods and services were used, no variable cost was computed in relation to their values.

3.2.4.1 Gross Margin Analysis

The gross margin model is established as follows:

$$Gross\ Margin(GM)\left(\frac{R}{ha}\right) = Gross\ Income(GI)\ \left(\frac{R}{ha}\right) - Total\ Variable\ Cost)TVC)\left(\frac{R}{ha}\right) \quad (1)$$

where:

$$GM = \sum_{i=1}^{n} P_i\, Q_i - \sum_{i=1}^{n} P_i X_i \quad (2)$$

$$GI = Quantity\ of\ Output\ (Qi) \times Price\ of\ Output(Pi) \quad (3)$$

$$TVC = \sum_{i=1}^{n} P_i\, X_i = Quantity\ of\ input(Qi) \times Price\ of\ Input(Pi) \quad (4)$$

Where:

i – number of respondents (i = 1,2, 3, … n)

Q_i – quantity in KGs

P_i – price in Rands

X_i – ith farmer

n – number of farmers

GM – Gross Margin

GI – Gross Income

R – revenue produced

Ha – hectare

3.2.4.1 Ordinary least square (OLS)

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon \quad (5)$$

Where:

Y – response variable

α – the value of Y when all values of explanatory variables are zero

β – the average change in Y that is associated with a unit change in X

X – is the explanatory variable

ε – error term

Chi-square test was used to test if the model fits well for analysis of the data. Chi-square was used to test the significance of dependent factors at the P values of 5% and 1% (D'Agostino, 2017). The Durbin Watson test statistics were used to test the presence of autocorrelation if it is closer to 2 this shows the absence of correlation. The VIF which ranges from 1.5 to 2.5 has proven the absence of multicollinearity among factors in the regression model (Wooldridge, 2014). R squared greater than 30% show that OLS closely fit the regression line enough to explain the variability of response data around its mean.

3.2.4.2 Definition of regression analysis variables

Table 3.1 below shows variable definition used for regression analysis.

Table 3: 1 Definition of regression analysis variables

Variables	Description
Gender	Gender of household head, a dummy variable where the male is 1 and female is 0.
Age	Age of household head in years
Formal Education	Number of years in formal education of the household head
Household Size	Number of members of the household
Market price	Sales price of produce
Years in irrigation farming	The number of years in irrigation farming.
Extension contact	Number of time farmer meet extension officers per season in days
Plot fee	Fee paid for plot ownership in Rands
Agric Training	Whether the farmers took formal agricultural training or not where those who take is 1 while those who didn't is 0. Dummy variable which
Area cultivated	Size of land cultivated in 2017 to 2018 season
Fertilizer subsidy	The quantity of fertilizer subsidy obtained by farmers in 2017 to 2018 farming season in Kgs
Pesticide subsidy	Quantity pesticide subsidy obtained by farmers in 2017 to 2018 farming season in litres.
Land preparation subsidy	Size of land preparation done by government in 2017 to 2018 farming season in hectares
Social grant	Amount of social grant earned by the farmer per year in Rands
Hawking	Total income from hawking in Rands
Plot distance from the main canal	The distance of the plot from the main canal in Kms
Irrigation days per week	Number of days of irrigating per week
Period in cooperatives	Number of years being a member of a cooperative
Maintenance fee	Money paid for scheme maintenance in Rands
Years in market participation	The number of years participating in a produce market.
Total Livestock units	Value of livestock owned by farmers in TLUs

3.3 Results Presentation

3.3.1 Gender of Household Head

Results from the study show that 76.4% of the plots are owned by female household heads. Results obtained from this research further shows that 46.9% of the female household head were either widowed, single or divorced. The scheme mainly constituted by ageing farmers (average of 59 years), Table 3.2 shows that there is a significant difference in the marital status of male and female household head at 1% level of significance.

Table 3: 2 Marital status of household heads

		Not Married	Married	Total	Significant level
Gender	**Female**	53	60	113	
		46.9%	53.1%		
	Male	3	32	35	
		8.6%	91.4%		***
Total		56	92	148	
		37.8%	62.2%		

3.3.3 Average Age of Household Head and years in irrigation farming

Household heads in Tshiombo irrigation scheme are old with an average age of 58.66 years (Figure 3.2). Female farmers are as old as their male counterparts. Moreover, scheme farmers have been owning an irrigation scheme for an average of 29 years (Figure 3.2). The average household size for farmers in Tshiombo irrigation scheme is 6 members and an average of 2 individuals work in the scheme.

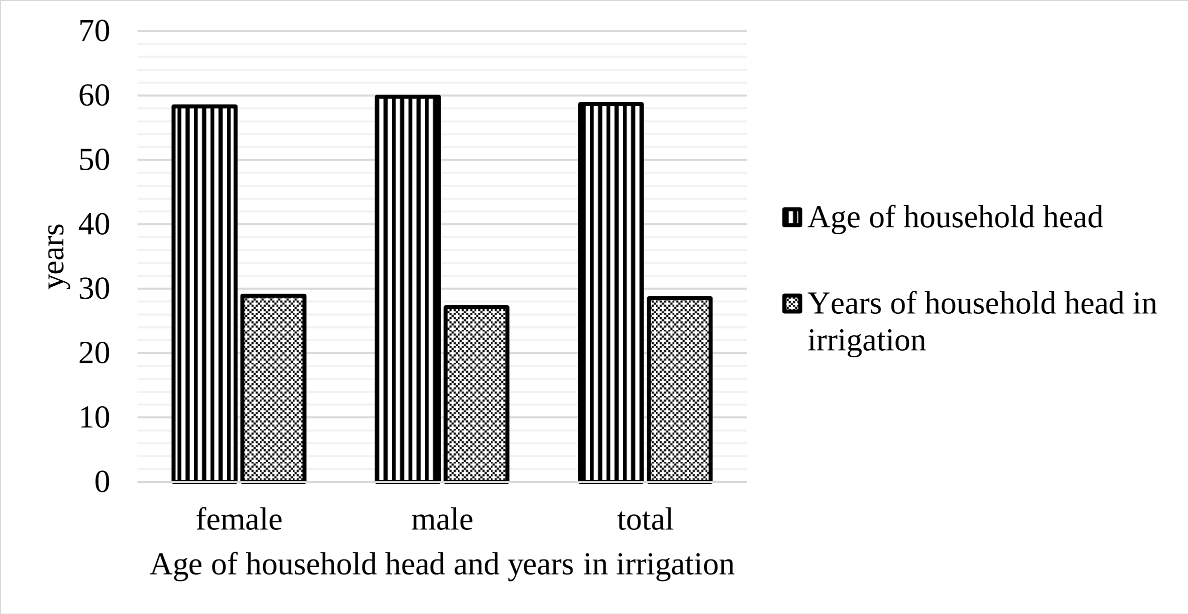


Figure 3. 2 Average age of household head and years in the irrigation scheme

3.3.5 Educational Level of Household Heads

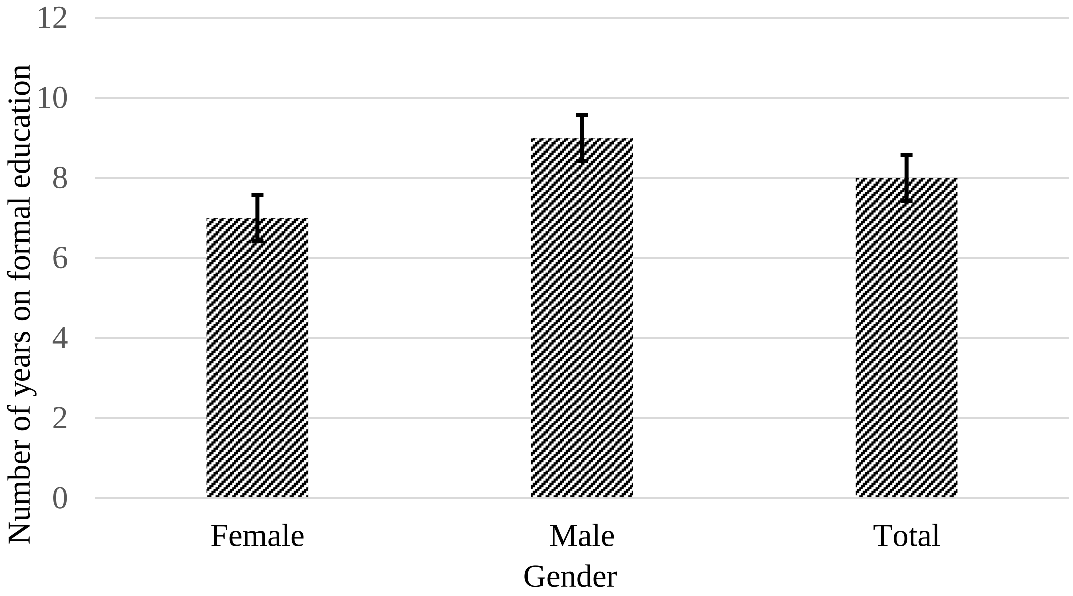


Figure 3. 3 Number of years in formal education of household head

Farmers in the scheme are literate since they have attained formal education for an average of 8 years (Figure 3.3). Female household head attains formal education for an average of 7 years while male farmers attain formal education for an average of 9 years.

3.3.6 Crops grown in the Tshiombo irrigation scheme

A variety of crops are grown in Tshiombo irrigation scheme which includes sweet potatoes, maize, groundnuts, beans (dry and green), cabbage, and spinach. Sweet potatoes which were grown by 89.2% of scheme farmers is the main crop grown in the scheme (Table 3.3). Maize is grown by 71.4% of farmers. Groundnuts are significantly grown by more female farmers than male farmers in Tshiombo irrigation scheme at 1% level of significance. Beans are produced by 26.4% of scheme farmers. Cabbage is grown by 6.8% of scheme farmers. Cabbage is dominantly grown by male farmers in the scheme at 5% significant level.

Table 3: 3 Percentage of crops grown in the Tshiombo irrigation scheme

Crop	Female%	Male%	Total%	P-Value
Sweet potatoes	87.6	94.3	89.2	
Maize	71.7	71.4	71.6	
Groundnuts	37.2	8.6	30.4	***
Bean	25.7	28.6	26.4	
Cabbage	4.4	14.3	6.8	**
Spinach	8.8	5.7	8.1	
Green leaf	1.8	2.9	2.0	
Pepper	0.9	00	0.7	

*NB: ***, ** - Statistically significant at 1% and 5% respectively*

The mean area under sweet potato production was 0.43 ha per year with some farmers reaching a maximum of 1.6 ha per year. Maize which is the second main crop grown in the scheme and is mainly grown for green mealies was grown on an area of an average of 0.46 ha which is slightly higher than that of sweet potato. Groundnuts, sugar beans, cabbage, and spinach have a mean area of 0.26 ha, 0.33 ha, 0.18 ha, and 0,19 ha respectively (Table 3.4). Potential crops like onion, calabash, green leaf, and tomatoes occupy an average area which ranges from 0.1 ha to 0.3 ha.

Table 3: 4 Average areas for crops grown in the scheme

	N	Minimum	Maximum	Mean	Std. Deviation
Sweet potatoes	132	0.10	1.60	0.43	0.27
Maize	106	0.10	2.00	0.46	0.29
Groundnuts	44	0.10	0.70	0.26	0.14
Beans	39	0.10	1.50	0.33	0.29
Cabbage	29	0.10	0.30	0.18	0.08
Spinach	12	0.10	1.00	0.19	0.26
Green leaf	3	0.20	0.30	0.23	0.06
Onion	1	0.10	0.10	0.10	
Calabash	3	0.10	0.30	0.20	0.10
Tomato	3	0.10	0.10	0.10	0.00

Where*: N = Number of farmers*

3.3.7 Average Plot size and average irrigated area

Figure 3.4 below show average plot size and average area cultivated in the 2017-2018 season. Households have an average of 1.27 ha of irrigation land which is subdivided into 0.1 ha plots.

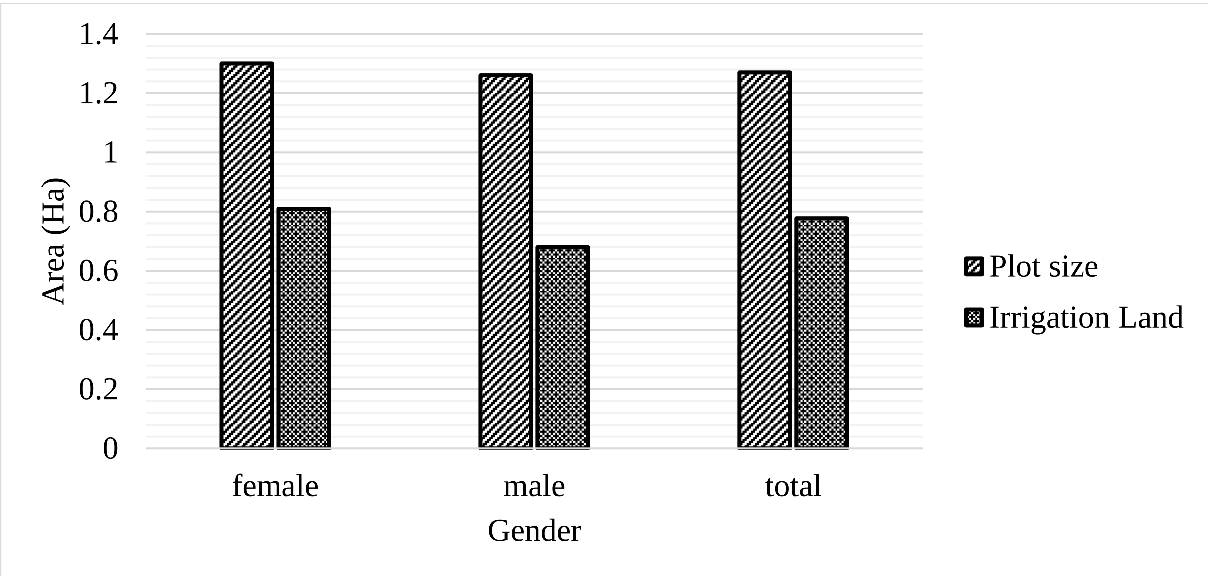


Figure 3. 4 Average areas under irrigation and the average cultivated area in relation to gender

3.3.8 Main income sources among scheme farmers.

Income from irrigation farming contributes 63% of total household income, while income from social grant contributes 34% of household income in the scheme (Figure 3.5). Other sources of household income contribute only 3% of the average income for scheme farmers. Livestock production does not yield much among farmers in TIS since they only contribute 2% of household income.

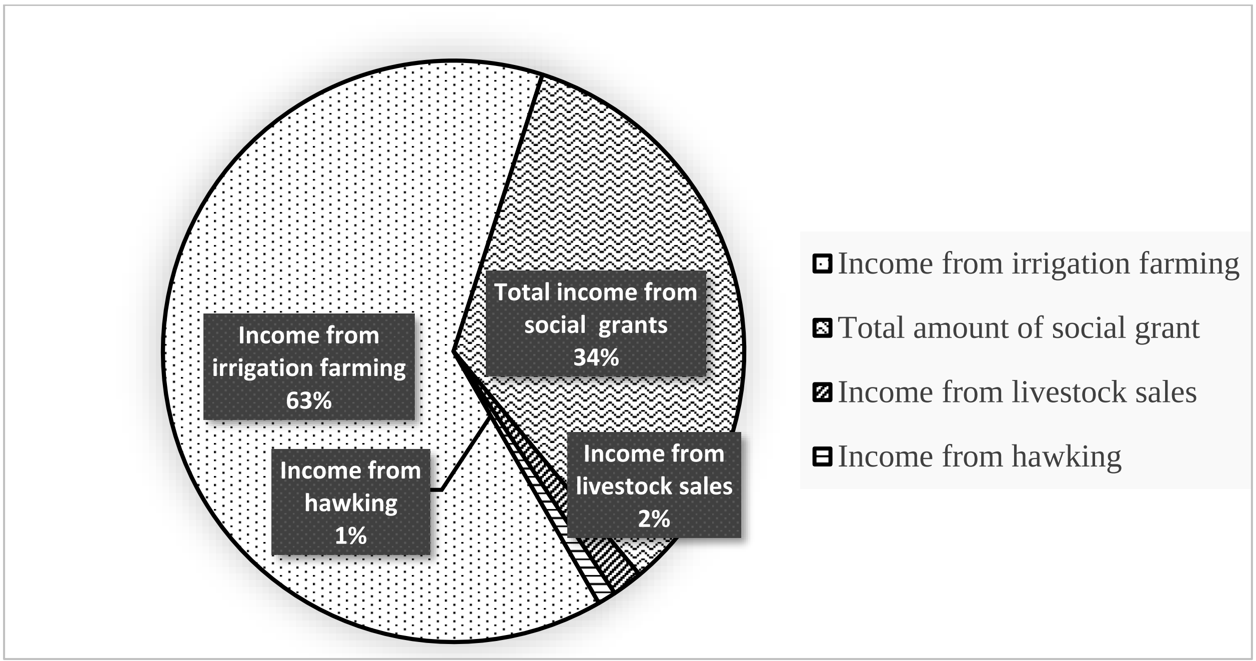


Figure 3. 5 Sources of income among smallholder farmers in the scheme.

3.3.9 Access to extension services

According to Table 3.5 below, more farmers receive extension services. Results show that extension services are received by 67.6% of irrigation scheme farmers. There are no significant differences on accessing extension services between female and male farmers, therefore extension services are accessed alike among all scheme farmers.

Table 3: 5 Percentage access to agricultural extension services

Access to extension services		No	Yes	Total	Significant level
Gender	Female	36	77	113	
		31.9%	68.1%	100.0%	
	Male	12	23	35	n.s
		34.3%	65.7%	100.0%	
Total		48	100	148	
		32.4%	67.6%	100.0%	

3.3.10 Access to credit by scheme farmers

There is no significant difference in access to financial credit between male and female farmers. Table 3.6 below shows that 7.4% of all the smallholder irrigation farmers in the scheme were able to access credit. Few farmers can access credit from formal credit institutions like banks.

Table 3: 6 Farmers who access credit in 2017

Access to credit		No	Yes	Significant level
Gender	**Female**	104	9	
		92.0%	8.0%	
	Male	33	2	n.s
		94.3%	5.7%	
Total		137	11	
		92.6%	7.4%	

3.3.11 Members of the scheme who participate in cooperatives

Table 3.7 below show the percentage of farmers in scheme cooperatives in relationship to gender. There were cooperatives in the scheme. Majority of smallholder farmers in irrigation scheme are members of scheme cooperatives. There is no significant difference in the cooperative membership of farmers among female and male household head. Among all the household heads in the scheme, 53.4% are members of cooperatives.

Table 3: 7 Percentage scheme cooperative membership

Member of cooperative		No	Yes	Total	Significant level
Gender	**Female**	56	57	113	
		49.6%	50.4%		
	Male	13	22	35	n.s
		37.1%	62.9%		
Total		69	79	148	
		46.6%	53.4%		

3.3.12 Return on investment

Cabbage has a Return on Investment (ROI) of 8.42 Rands per Rand invested which exceed ROI of sweet potato of 1.28, maize of o.4, groundnuts of 1.02, beans of 2.1 and spinach of 2.10 (Table 3.8). Sweet potatoes, maize, groundnuts, and dry beans have ROI of 1.28, 0.40, 1.02, 2.10, and 2.10 respectively.

Table 3: 8 Return on Investment (ROI)

Variable	Sweet Potatoes	Maize	Ground Nuts	Dry Beans	Cabbage	Spinach
Total Variable Costs	17463.1	14652.3	11505.2	14117.9	22231.5	15985.4
Net Profit	22276	5873.62	11752.1	29650.9	187324	33535.4
Return on Investment	**1.28**	**0.41**	**1.03**	**2.10**	**8.43**	**2.10**

3.3.13 Gross margin analysis

Gross margin analysis of crops grown in TIS during the 2017 to 2018 farming season shown in Table 3.9 was performed to investigate the profitability of crops grown during the season. Sweet potato which was the main crop in the scheme has a gross margin of R29 169.61. Table 3.9 shows that cabbages have the highest gross margin of R187 324.94 while maize has the least gross margin of R5 873.62. Groundnuts and beans yield a gross margin of R11 752.08 and R29 650.94 respectively. Transport for maize was cheaper than that of sweet potatoes given that maize was mainly sold on the farm while sweet potatoes were mainly transported to distance markets. Farmers carry more land preparation operations in maize than in sweet potatoes which contribute to higher cost of land preparation for maize.

Table 3: 9 Gross margins of crops grown in Tshiombo Irrigation Scheme

Variable		**Sweet Potatoes (**Rands)	**Maize (**Rands)	**Ground Nuts (**Rands)	**Dry Beans (**Rands)	**Cabbage (**Rands)	**Spinach (**Rands)
Gross income		**39739.06**	**20525.96**	**23257.29**	**43768.80**	**209555.56**	**49520.83**
Transport cost		268.47	61.66	1122.91	98.97	444.44	208.33
Inputs	Seed	4012.12	1115.94	1502.27	1758.12	3779.63	1037.50
	Fertilizer	4533.55	4233.80	1442.05	3906.41	8009.26	5206.25
	Pesticide	299.57	818.31	204.07	508.21	2466.67	1350.00
Land preparation		3165.10	3303.21	3218.18	2921.79	2438.89	3158.33
Labour	Planting	1305.44	1282.63	1205.49	1167.95	1203.70	1291.67
	Weeding	1195.94	1200.94	1266.10	1190.17	1111.11	1208.33
	Irrigating	1025.25	1018.28	1064.96	1012.82	1000.00	1000.00
	Spraying	533.03	569.83	509.66	508.55	500.00	508.33
	Harvesting	1124.64	1047.74	1035.61	1044.87	1277.78	1016.67
Total Variable Costs		**17463.11**	**14652.34**	**11505.21**	**14117.86**	**22231.48**	**15985.41**
Gross Margin		**22275.95**	**5873.62**	**11752.08**	**29650.94**	**187324.08**	**33535.42**

3.3.14 Factor Affecting Performance of Scheme Farmers

Chi-square test was statistically significant at 1% level of significance. The Durbin Watson test statistics shows the absence of correlation since it is closer to 2. The VIF ranges from 1.5 to 2.5 has proven the absence of multicollinearity. Ordinary Least Square was found to be significant at 1% level of significance, hence the OLS model was fitting well for this analysis. The data analysed by the OLS closely fit the regression line given the R squared of 33.8%.

Age of household head, labour per household, size of land cultivated, price, the distance of plot from the main canal, and pesticide subsidy significantly influence the productivity of sweet potatoes in Tshiombo irrigation scheme (Table 3.9). Among factors which are statistically significant, the age of household head, labour force per household, size of cultivated land impacted the productivity of potatoes negatively while pesticide subsidy, the market price of sweet potatoes and distance from the main canal to the plot impact income from sweet potatoes positively.

OLS regression shows that age of household head, household size and size of irrigation land cultivated negatively impact yield of sweet potatoes, while pesticide subsidy, market price and distance from the main canal positively impact yield of sweet potatoes. An increase of age by a year lead to a decrease in gross margin of sweet potatoes by 0.02% at a statistically significant level ($P<0.01$) (Table 3.10). As the age of scheme farmers increase their gross margin decreases. Results from OLS show that there is a 0.19% decrease in sweet potato profit in every 1% increase in the household labour force ($P<0.01$). The increase in the cultivated area by a hectare result in a decrease of gross margin by a margin of 0.13 per unit land increase ($P<0.05$). Table 3.10 shows that access to a unit of pesticide subsidy results in an increase of gross margin by a margin of 0.14 at a statistically significant level of 1%. An increase in market price of sweet potato by a Rand leads to 6 Rand increase in sweet potato income. ($P<0.5$). It is statistically found that a percentage increase in distance from the main canal to the plot lead to 0.19 percentage increase in sweet potatoes production at 5% level of significance.

Table 3: 10 OLS results on the factors which affect the gross margin of sweet potatoes

Variable Name	B
Gender	**0.111***
Age	**-0.022*****
Formal education	-0.026
Household size	**-0.185*****
Years in irrigation farming	0.003
Extension contact	0.072
Plot fee	0.008
Area cultivated	**-0.130****
Fertilizer subsidy	0.000
Pesticide Subsidy	**0.138*****
Subsidized Land preparation	0.064
Social Grants	2.169
Hawking	-2.756
Market price	**6.090****
Distance from the main canal	**0.191****
irrigation days per week	-0.091
Period in cooperative	0.019
Maintenance fee	0.001
Years in market participation	-0.003
Total Livestock Units	9.208
R	**0.58**
R Square	**0.34**
significant	**0.00**
Durbin Watson	**1.66**
F-Test	**2.53**

Note: ***, **, *- *Statistically significant at 1%, 5% and10% confidence interval respectively*

3.4 Discussions

3.4.1 Household socio-economic characteristics

In relation to the results shown in Table 3.2, there is distinctive plot ownership by female farmers in Tshiombo irrigation scheme as in Mogalatsane and Setlaboswane irrigation schemes in Limpopo province which have an average of 64% of irrigation plots owned by female farmers (Mapedza *et al.*, 2016). Results obtained from this research further show that 46.9% of the female household head were either widowed, single or divorced (Table 3.2). Marital status show stability among most households (Mdlozini, 2017), therefore, there is high likelihood of instability among most female-headed households in Tshiombo irrigation scheme. Findings from KIIs show that female farmers face challenges in accessing production resources which are most likely to result in the low performance of the scheme. Results in Table 3.4 where male farmers dominate in the production of cabbages which have high financial return support those findings.

There might be little interest in smallholder irrigation farming by youth farmers in Tshiombo irrigation scheme as the scheme is dominated by ageing farmers (Figure 3.3). Ageing affects the technical efficiency of the agricultural system in South Africa as farmers are unwilling to change their practices and they are slow to adopt technology (Senyolo *et al.*, 2018). Therefore, most of the scheme farmers are most likely unable to carry out their farming activities due to ageing. Increased household head's age is among factors that have a negative impact on an adaptation of irrigation farming decisions (Mango *et al.*, 2018). Though farmer accumulates experience as they get older, they face difficulties in the adaptation of dynamic irrigation practices as they tend to lose energy, have shorter planning horizons, fail to meet rapid technological changes, and become more risk-averse (Mango *et al.*, 2018). Old age is also a barrier of proper management of irrigated crops which include access to required storage, transport facilities, market, and technology. The future of irrigation farming in Tshiombo is highly compromised by little training and participation of youth farmers in the scheme as land is primarily owned by the adults.

Table 3.3 shows an average of 1.6 household members works in the plot, with female-headed families leading on the average number of household members involved in agriculture. Despite this, an average of 2 people works in the plots as most of the family members are not involved in any farming activities, hence they have very insignificant help to the farming operations taking place in the plots. Majority of household members opt to engage in other economic activities which are more lucrative due to lack of motivation in farming, leaving the household head responsible for all farming activities (Njoko and Mudhara, 2017).

Majority of the household head are mainly into irrigation farming; therefore, farmers are satisfied with participating in irrigation farming and value irrigation farming as a vital business. These findings concur with the survey research findings which found that more than 70% of the household heads in smallholder irrigation schemes are predominantly irrigation farmers and are into crop production (Kergna and Dembele, 2018). Farmers in the scheme are literate hence they have the capacity to adapt to technological change which is key to improve scheme performance and there is the ability for sustainable development (Figure 3.3).

Findings from Figure 3.4 support the previous findings that the scheme size in TIS averages 1.29 ha per household (Van Averbeke, 2012). A review of the literature state that plot holder has a plot less than 5 ha which is a setback for them to meet food security and income needs at the household level as well as generating sufficient income for household and investment need (Ncube, 2018). FGDs discussions and KIIs interview show that the land was not enough for the plot holder since it cannot provide farmers with enough for their sustainability and cannot generate enough income to incentivise them to participate in scheme farming. One of the major factors which lead to reduced area cultivated was that majority of farmers are ageing, as most farmers are not fit to meet the needs of irrigation work.

Figure 3.5 shows that people in the scheme mainly rely on the farming for their livelihood, income from irrigation farming contributes nearly two-thirds of household income among scheme farmers (Figure 3.5). Most farmers in the scheme are aging, therefore they benefit from unearned income in form of the social grant. Extension service was mainly received from the government through agriculture extension officers stationed in the scheme. Agriculture extension workers in Tshiombo irrigation scheme also distribute input subsidies from the government among farmers in the scheme. Therefore, conflicts that arise as a result of poor satisfaction with input subsidy distribution were most likely to hinder access to extension services from extension officers. Results from the study show that among scheme farmers who participate in the study, 84.6% of them indicate that they receive subsidies from DAFF through extension workers.

Poor access to credit mainly due to the absence of collateral security is a key barrier to the performance of smallholder farmers in Tshiombo irrigation scheme. Limited support from inputs suppliers and output markets was noted. Lack of collateral security, high-interest rate, lack of credit information, and being risk-averse are some of the barriers which prevent farmers from accessing loan from banks (Sinyolo and Mudhara, 2018).Most farmers sell their produce mainly via informal markets, limiting them from accessing loan facilities from lucrative markets. Farmers in the scheme were offered Permission to Occupy (PTO) documents for their irrigation land which doesn’t renter them any form of collateral security to access credit. This relates to findings that major contributing factor towards the collapse of smallholder irrigation farming in South Africa is the lack of credit facilities (Chauke and Anim, 2013). Poor access to credit leads into several bottlenecks to performance and sustainability of smallholder irrigation sector.

3.4.2 Performance of Scheme Farmers

Several researchers previously indicated the importance of gross margin analysis as a way to cut off the cost of production, justify smallholder irrigation farming, sustainability of management system and identifying crop choices that are economically viable, among others (Dube, 2016; Sinyolo *et al.*, 2014; Mutambara *et al.*, 2016). Gross margin is the difference between gross income and variable costs (Gujarati, 2009). A comparative analysis of the gross margin of some crops grown in TIS scheme which comprises of sweet potatoes, maize, groundnuts, beans, cabbage and potential crops like tomatoes was done to identify best alternatives to enhance farmer's profit level. Therefore, the most viable and profitable crops were identified, and recommendations were drawn. Farmers’ preference on the selection of crops to grow in an irrigation system is an important factor to drive revitalization process when farmers have great flexibility of choice among enterprises (DAFF, 2012).

Gross margin analysis shows that cabbage is the crop with the highest profit margin well above that of sweet potatoes and maize which are the main crops grown in the scheme. The results on gross margin (Table 3.9) results which support that of ROI (Table 3.9) which shows that cabbage is more profitable than all crops grown in the scheme. Cabbage was a crop which was significantly grown by male farmers at 5% level of significant (Table 3.4), therefore, male farmers have a comparative advantage to productive resources than female farmers. In TIS, men produce commercial crops while ladies are limited to household food security since crops like groundnuts which are mainly used for household consumption which are significantly grown by female farmers at 1% level of significance (Table 3.4). These findings are in support of the research findings that crops produced by men are more commercialized (Domènech, 2015). Gender imbalances on ownership of essential productive resources are most likely to affect the performance of smallholder irrigation scheme which is mainly characterized by the dominance of female farmers and farm workers. On the other hand, lack of access to formal markets for cabbages keeps its production being a venture for fewer farmers particularly males, thereby risking scheme for possible collapse since farmers will not be capable to cover the growing cost of maintaining the ageing scheme.

Sweet potatoes have an average yield of 5.29 t/h which is far below the mean marketable yield which ranges from 13.1 to 19.0 t/ha (Laurie *et al.*, 2017). Low cost of production, readily available local market and high resistance to water stress where the main factors considered by farmers on choosing sweet potatoes as their main crop. Low yields of sweet potatoes have resulted in a low gross income of R20 525.96 per hectare. Reliance of smallholder farmers on marketing of sweet potatoes on domestic markets with less than 2% world exports diverted farmer's perception on sweet potato production since they also struggle to sell their products after production (DAFF, 2011). Farmers sell their sweet potatoes on their own on fresh produce markets mainly along the roads which is not reliable.

3.4.3 Factors Affecting Scheme Performance

Age of farmers negatively affect performance of the scheme. Majority of scheme farmers have an average age of 58.66 years, therefore further increase on age lead to a decrease in their performance. In relation to Table 3.10 ageing has a diminishing effect on the performance of scheme farmers (Dube *et al.*, 2018). Despite that, performance of aged farmers is less than that of young farmers, smallholder farming is not a lucrative business as a result it fails to attract young farmers.

Labour per household was found be high in Tshiombo irrigation scheme. According to Table 3.10 an increase in household labour does not contribute to participation in sweet potato production. Increase in the labour force is attributed due to the increase in the number of members owing to the increase in food needs of the households, hence farmers divert to staple food crops mainly maize. With an average of 6 household members per scheme farmer, most farmers hire extra labour to work in the plots because most young members shun participating in schemes due to unattractive income from scheme farming in relation to nature of work done in scheme farming. The prospects for raising labour productivity are constrained by the limited opportunity to boost scheme performance (Sender, 2016).

Irrigation farming in Tshiombo irrigation scheme is partly subsidized by the government and private organizations. Farmers access subsidies in form of land preparation, the seeds of selected crops, fertilizers and pesticides from the government of South Africa. Although some factors are not statistically significant, findings relate to literature which find out that input subsidies are associated with increased efficiency among farmers, hence providing incentives for farmers to produce more (Michael *et al.*, 2018). As per the study, there is the high and effective use of pesticide subsidies among the scheme farmers. Fertilizer subsidy is not valued to produce sweet potatoes owing that farmers consider fertilizer as a source of income, hence they sale it. Subsidy of land preparation fails to convince farmers enough to increase production of sweet potatoes in the scheme. Use of pesticide subsidies helps to control the outbreak of pest and diseases. There is variation in value of different kinds of subsidy to scheme performance. Therefore, there is need for the government to identify and supply subsidies that relates to farmers' production needs.

The market price of sweet potatoes has an autonomous impact on production decision of sweet potatoes in the scheme. Farmers increase production of sweet potatoes if sweet potato sales price increase. Higher price of sweet potatoes is an incentive for sweet potato production. Absence of formal markets for sweet potatoes makes markets prices to be very difficult to estimate since farmers mostly rely on the informal markets which are mainly characterized by volatile market price. Performance of smallholder farmers is affected by market price since most farmers do not enjoy full price due to lack of formal markets.

Distance from the main canal determine the crops grown as farmers who are away from the main canal perceive that they have poor water access. Farmers with plots closer to the main canal opt to produce other crops while those away from the irrigation plot consider sweet potato production as the best choice. Farmer argues that the higher the distance from the main canal reduce access to water, hence growing of sweet potato in plots which are far away from the main irrigation canal is more viable since it strives well when water is minimal than other crops grown in the scheme.

3.5 Conclusion

This study was conducted in 148 scheme farmers in Tshiombo irrigation scheme in Limpopo province of South Africa. The study assesses the financial performance of scheme farmers in relation to crops they grow. Scheme farmers diversify the crops they grow in their plots. There are several incentives and disincentives to scheme farming. This chapter establishes that scheme farmers are profitable on all crops they produce. There is a variation on the performance of crops grown in the scheme. To assess the performance of scheme farmers to meet objectives' demand, on-farm irrigation system analysis was done.

The results of the gross margin analysis show that cabbages have a higher gross margin than that of other crops. In relation to descriptive statistical analysis, sweet potato is the most preferred crop in the scheme grown by 89.2% of the scheme farmers due to perceived irrigation water inadequacy for more profitable crops. Positive gross margins among all crops produced show that scheme farmers are generally benefiting from irrigation farming, hence irrigation farming has positive economic benefits to rural communities. Sweet potato is mostly rotated with other crops like maize. Results from the Ordinary Least Square (OLS) regression model show that pesticide subsidy, market price and distance from the main canal are the incentives to scheme performance. While ageing, labour access and size of land cultivated significantly reduce the performance of scheme farmers. Ageing farmers mostly benefit from unearned income in form of social grants, hence their participation was limited due to access to adequate income to meet their daily needs. The future of Tshiombo irrigation scheme is more likely to be characterised by poor performance and sustainability due to limited participation of young farmers. There is underutilisation of most of the irrigation land which might also be related to the dominance of scheme ownership by ageing scheme farmers.

Integrating research and development will enable scheme farmers to acquire knowledge which helps them to venture into production of more profitable crops which will help them to maximize their profit margins. The policy should focus on incorporating young farmers into irrigation farming. Farmer support system should integrate scheme farmers into value chain so that they can maximize their profit and engagement with lucrative markets. Subsidy must target crops which farmers produce.

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CHAPTER 4: THE ROLE OF INSTITUTIONS ON SMALLHOLDER IRRIGATION SCHEME PERFORMANCE IN TSHIOMBO IRRIGATION IN LIMPOPO PROVINCE OF SOUTH AFRICA

Abstract

Smallholder irrigation schemes is an interdependent system of biophysical environment, on-farm, and scheme management and institutions. According to literature, institutions have impacted the performance of irrigation schemes, but their impact remains unnoticed as a potential entry point to address the sustainability of smallholder irrigation scheme through their ability to enhance production. Poor performance which is famous in most smallholder irrigation schemes in South Africa can only occur when the services offered by institutions fail to be recognized and combined fairly to meet the needs of farmer managed irrigation schemes. While several institutions play a pivotal role in irrigation schemes in South Africa, the level of appreciation by farmers on the importance and possible benefits of their participation has not been explored. This study sought to assess the impacts of participation of institution on scheme performance. The services of institutions and their relevancy to scheme farmers in Tshiombo Irrigation Scheme were examined. Structured questionnaires, Key Informant Interviews and Focus Group Discussions were used for data collection. The ordinary least square regression model was used to assess the relationship between the institution and scheme performance following reduction of the services of institutions by Principal Component Analysis into 8 principal components. Results reveal that the performance of smallholder irrigation schemes is affected by a distinctively combined institutional service. According to the research results, smallholder irrigation schemes is a complex system comprising of multiple endogenous and exogenous factors, therefore, a complex systems approach needs to be employed to investigate the collective behaviour of institutions participating in irrigation schemes and address the interaction and forms of relationships within each niche to develop linkages that will ensure sustainability of irrigation schemes. Out scaling of research on the impact of the institution on irrigation scheme performance to enhance scheme productivity is recommended.

Keywords: Institutions, scheme management, complex system, Principal Component Analysis, sustainability

4.1 Introduction

Smallholder irrigation schemes are an alternative for transforming rural farming system in South Africa which is at a point of collapse on the wake of erratic rainfed farming (Rockström and Falkenmark, 2015). Van Averberke et al (2011) define irrigation as a way of enhancing production of plants by artificial water application. The increasing demand for smallholder irrigation schemes among rural communities is being perpetuated by the climatic change which gave rise to persistent drought, food insecurity, unemployment, and underprivileged rural livelihood among most rural communities in sab-Saharan Africa (Rockström and Falkenmark, 2015; Cheeseman, 2016). Therefore, putting more thrust on smallholder irrigation farming has an outstanding potential to transform the lives of rural farmers owing to the role of agriculture as a key industry in rural communities. However, previous studies have noted that among the smallholder irrigation schemes which were established by the government of South Africa in former homeland, majority of them are non-functional while others are operating below average (Sinyolo *et al.*, 2014; Muchara *et al.*, 2016).

Previous studies reveal that research and investment in irrigation infrastructure have not contributed much towards improving irrigation performance among most schemes in South Africa (Fanadzo, 2012; Mapedza *et al.,* 2016). The overall performance of irrigation schemes did not improve given that little has been done to address the quality of services provided by irrigation agencies (Malano and van Hofwegen, 2018). However, this reflect that smallholder irrigation scheme is a complex system which is challenged by governance styles along with management strategies (van Rooyen *et al.*, 2017; Mapani *et al.*, 2018), this result in considering institutions is an alternative that could provide the best ways to improve performance of smallholder irrigation schemes in the region (Sharaunga and Mudhara, 2016; Fanadzo, 2012; Mapani *et al.*, 2018). Failure to include institutions in irrigation schemes have devastating impacts of poor performance (Van Averbeke *et al.*, 2011). Moreover, this have emanated to extensive challenges of farmer participation in maintenance of irrigation infrastructure among most schemes which threaten the collapse of irrigation schemes (Sharaunga and Mudhara, 2016; Mapani *et al.*, 2018). Institutions which can either be formal or non-formal formulate the rules that govern human interaction, thereby reducing uncertainty and provide insight which helps to link diverse stakeholders (van Rooyen *et al.*, 2017).

Van Averberke (2011) recommend the need for a thorough investigation on how to make institutions effective in smallholder irrigation schemes by paying considerable attention to social capital in irrigation schemes. Moreover, the African Union Summit recommend the creation and enhancement of necessary institutional conditions to end hunger in the African continent by 2025 (Union, 2015). Services offered by institutions in smallholder irrigation schemes need to be identified through an aggressive assessment to improve scheme performance. Effective institutions will transform farmers from observing landowners to be entrepreneurs who perceive irrigation as a business (Fanadzo, 2012; Senyolo *et al.*, 2018). Expectations that Water User Associations alone will yield development have not yielded much among most smallholder irrigation schemes as the majority of farmers default payment for water and participation in Water User Association's activities are very low (Fanadzo, 2012). Support services in most SIS are weak which deprive farmers of critical networks that help them to develop the necessary capacity to manage scheme and their plots (Sinyolo and Mudhara, 2018). Therefore, the decline in institutions has reduced the performance of smallholder irrigation schemes in South Africa and pause a threat to sustainability of rural livelihood.

The way institutions contribute to management of land and water resources has a profound impact on the functionality of these systems in the provision of goods and services. Furthermore, irrigation management policies among many initiatives implemented by governments and international funding institutions in irrigation schemes in many developing countries in Asia, Africa, and Latin America lack systematic impact assessment and evaluation to provide insight into policies and practices of institutions that take part in irrigation schemes (Senanayake *et al.*, 2015). There is an inadequate investigation of management strategies which limit the ability of schemes to improve productivity, come up with initiatives to maximize profitability and ensure effective operation and maintenance. These finding on management strategies prompt the need to improve operation and management among irrigation schemes. Therefore, more research is needed on scheme institutions to correct several challenges among most smallholder irrigation schemes across the country to improve their performance.

4.2. Methodology

4.2.1 Study Area

The study area was used for this chapter is the same as described and explained in Chapter 3.2.1

4.2.2 Sampling procedure

The sampling procedure used in this chapter is the same as described and explained in Chapter 3.2.2.

4.2.3 Data Collection

The data collection procedure used in this chapter is the same as the one described and explained in Chapter 3.2.3.

4.2.4 Model Specification

The standardized yield of sweet potatoes was estimated using OLS with robust standard errors. The yield of sweet potatoes was standardized by logging it to normalize it since there was presence of outliers (Marino and Li, 2017). The yield of sweet potato was logged to normalize it (Marino and Li, 2017). Breusch-Pagan / Cook-Weisberg test for heteroskedasticity was used to detect any linear form of heteroskedasticity (Baum *et al.*, 2003). The F-test was used to analyse statistical significance of the model. The yield of sweet potato was logged to normalize it (Marino and Li, 2017). The OLS model which was derived from the iteration of socio-economic and institutional variables fail to meet the assumption of the least regression, hence OLS poorly perform.

Two steps were taken to analyse the impact of irrigation institutional typological delineation on the performance of irrigation schemes. Firstly, the dimension of institutional factors was reduced from a large data set which deteriorates the quality of analysis into a new set of a dataset using principal component analysis (PCA) (Chatfield, 2018). Relevant principal components (PCs) from the institutional factors were selected from a large group of institutional factors. And finally, an Ordinary Least Square (OLS) regression was conducted from the projections of PCs and socio-economic factors to draw the influence of institutional factors on scheme performance. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity was used to detect any linear form of heteroskedasticity of OLS. The minor problems about normality, heteroscedasticity and some observations that exhibit large residuals which result in failure to meet the assumption of OLS was dealt with by using robust standard errors. OLS which is a widely adopted for analysis of a wide range of scientific research, especially into agricultural sciences where it was used for analysis of a substantial amount of data, was used (Sinyolo and Mudhara, 2018; Blignaut *et al.*, 2009; Kurukulasuriya and Mendelsohn, 2007).

Cumulative percentage of variance is a popular and intuitive index of the goodness of fit in multivariate data analysis, where a higher percentage of variance explained by a proposed model, the more valid the model is (Lorenzo-Seva, 2013). The Kaiser's criteria (eigenvalue of greater than 1) and the cumulative percent where used to extract principal components out of many approaches which include Scree plot, parallel analysis, Kaiser's criteria, and cumulative percent. The varimax rotation was used to maximize the variance of the factors, therefore the eight extraction factors have a well-distributed total amount of variance accounted. Composite variables were created by contributing institutional factors with loading greater than 0.5 under each component. Higher factor loading greater than 0.5 indicates that principal components are greatly influenced by those factors (Zhang *et al.*, 2017). That's where two or more factors with a higher factor loading (greater than 0.5), the one with the highest loading were considered to determine the composite variable through the other factors were not neglected.

PCA is a widely used analysis for dimensionality reduction and denoising in the field of agriculture (Lukac and Zhang, 2016; Goswami *et al.*, 2018). An orthogonal linear transformation that reduces a set of variables into a smaller number of variables (Danso *et al.*, 2017). Sinyolo et al (2014), used indices generated from PCA as the dependent variable for OLS during his study of water and rural household food security in South Africa. More evidence reveals that PCA was successfully used in combination with other data analysis techniques to condense all the information from the original interrelated variables to a smaller set of factors (Sinyolo and Mudhara, 2018; Goswami *et al.*, 2018)

Suppose $X^T = [X_1, \ldots, X_P]$ is a p-dimensional random variable

With mean - $\boldsymbol{\mu}$

To find a new set of variables $\boldsymbol{Y_1}, \boldsymbol{Y_2}, \dots, \boldsymbol{Y_p}$ (whose variance decrease from first to last, each $\boldsymbol{Y_i}$ (principal component) is taken to be a linear combination of the $\boldsymbol{X_j}$ (institutional factors)

$$\boldsymbol{Y_j = a_{1j}X_1 + a_{2j}X_2 + \cdots + a_{pj}X_p} \tag{6}$$

Where:

$$\boldsymbol{a_j^T = [a_{1j}, \dots, a_{pj}}$$

OLS regression with dependent variable Y being yield per hectare with scores from PCA where eigenvalue is equal or greater than one and socioeconomic factors as independent variables were done. There is a present of multicollinearity on running OLS with large volumes of the institutional variable which result in parameter estimation errors to be incorrectly interpreted (Soares dos Santos *et al.*, 2016). Therefore PCA reduces the number of variables through orthogonal transformations and removes multicollinearity of the independent variables (Soares dos Santos *et al.*, 2016). A new set of variables, PCs, with uncorrelated same information as original was produced.

$$Y_i = a + b_1X_1 + b_2X_2 + \cdots + b_mX_m + C \tag{7}$$

Where:

Y_i - is the dependent variable.

$X_1, X_2, \dots, X_m$ are the independent variables.

a - independent variables

$b_1, b_2, \dots, b_m$ are the multiple regression coefficients.

4.2.5 Livestock Unit

An inventory of livestock was taken in relation to animal species which are kept at household level among scheme farmers. Some farmers in Tshiombo Irrigation Scheme keep animal species which includes cattle, sheep, goats, pigs, chicken and other poultry. Livestock units are simply ‘exchange ratio’ among livestock species representing total body weight and potential market value (Chilonda and Otte, 2006; Mosites *et al.*, 2015). South Africa livestock unit coefficients based on weights from FAOSTAT, the global statistical database compiled by FAO (FAO 2005a) cited by Chilonda and Otte (2006) was used during this study.

4.2.6 Asset index

PCA was used to used to define asset index A_i for individual *i* as follows

$$A_i = \sum_k f_k \left[\frac{(a_{ik} - \bar{a}_k}{s_k}\right]$$

Where a_{ik} is the value of asset where a_{ik} is the value of asset k for household a_k ,is the sample mean, and s_k is the sample standard deviation.

4.2.7 Variable definition for regression analysis

Table 4.1 shows variable definition for regression analysis

Table 4: 1 Definition of regression analysis variables

Variables	Description
Gender	Gender of household head, a dummy variable where the male is 1 and female is 0.
Age	Age of household head in years
Education	Number of years in formal education of the household head
Household Size	Number of members of the household
Agric Training	farmers took formal agricultural training or not where those who take is 1 while those who didn't is 0. Dummy variable
Plot Distance	The distance of the plot from the main canal
Community credit support	Farmers access loan from community and cooperatives, participate in cooperative scheme maintenance, access to the market for their products through cooperatives and sell their produce to the local community
Academic extension support	Farmers dominantly access extension services from academic institutions, extension officers and private organizations. They are also privileged to access traditional leaders and cooperatives for conflict management.
Private organization input support	Consist of farmers who mainly access inputs from private organizations rely on traditional leaders for conflict resolution. They as well rely on irrigation committee to access the market.
Cooperative inputs support	Farmers are provided with input subsidy from cooperatives and market from private institutions.
Cooperative extension support	Farmers access extension services from cooperatives and subsidized inputs by the government.
Academic institution market and input support	Farmers access input subsidies from academic institutions, but they do not access the market from them.
Community maintenance support	Farmers participate in community scheme maintenance.
Community input support	Farmers access inputs from the community but are less likely to rely on the local community for the market of their produce.
Livestock Unit	Livestock units per household
Asset index	Asset index per household

4.3 Results

4. 3.1 Demographic Data

Table 4.1 shows that scheme farmers were benefiting from institutions considering that over 40% of farmers access to support from them. Female farmers significantly benefit from the government than males ($P \leq 0.01$), 79.6% of the female farmers benefit from government services in relation to 57.1% of male farmers (Table 4.2).

Table 4: 2 Percentage of scheme farmers who benefit from institutions

Institutions	Percentage			Sig
	Female	Male	Total	
Government Agencies	79.6	57.1	74.3	***
Traditional Leaders	40.7	45.7	41.9	n.s.
Cooperatives	53.1	37.1	49.3	*
Private Organisations	52.2	40.0	49.3	n.s.
Academics Institutions	52.2	40.0	49.3	n.s.
Irrigation Committees	72.6	71.4	72.3	n.s.
Farming Community	71.7	60.0	68.9	n.s.

4.3.2 Livestock Unit

According to Table 4.3, farmers have an average of 1.17 LU in Tshiombo irrigation scheme.

Table 4: 3 Average Livestock Unit

gender of the Household Head	Mean	Std. Deviation	Sig
Female	1.16	4.15	
Male	1.20	2.94	n.s.
Total	1.17	3.89	

4.3.3 Standard Asset index

According to Table 4.4 the mean standardized asset index value of 0.9493 was obtained from the study sample.

Table 4: 4 Descriptive statistics for asset index

gender of the Household Head	Mean	Std. Deviation	Std. Error Mean
Female	0.93	0.25	
Male	1.02	0.30	n.s.
Total	0.95	0.26	

4.3.4 Interpretation of principal components (PCs) in relation to institutional factors

Appropriateness of the respondent data for analysis was assessed by numerous tests prior to factor extraction. Kaiser-Meyer-Olkin Measure of Sampling Adequacy value of 0.538 which is greater than 0.5 reflect that PCA is a successful model suitable for this analysis. Therefore, responses given by the sample are adequate. Bartlett’s test indicates the strength of the relationship among variables (Garrison and Akyol, 2015). The significance of Bartlett's Test of Sphericity at 1% determine that there is a significant difference in the correlation matrix of the factors used in the PCA, hence factor analysis is suitable for the data. The Bartlett’s test of Sphericity rejects the hypothesis that the correlation matrix is the identity matrix, therefore it validates PCA for the dataset.

Table 4: 5 Rotation Sums of Squared Loadings

Component	Eigenvalue	% of Variance	Cumulative %
1 Community credit support	2.34	11.15	11.15
2 Academic extension support	2.28	10.86	22.01
3 Private organization input support	1.87	8.92	30.93
4 Cooperative inputs support	1.81	8.61	39.54
5 Cooperative extension support	1.74	8.29	47.83
6 Academic institution market and input support	1.54	7.33	55.17
7 Community maintenance support	1.45	6.89	62.06
8 Community input support	1.34	6.39	68.45

Conferring from Table 4.5 above, eight principal components are explained by approximately 68.45% of the data. Moreover, there is an adequate representation of all PCs since their percentage variance have a close range between 6.392% and 11.151% (Table 4.5). The presence of at least two institutional factors with a loading greater than 0.5 in each PC gives a meaningful interpretation (Zhang *et al.*, 2017; Aharonov-Nadborny *et al.*, 2017). Therefore, it was feasible to include all the eight components in the OLS regression model to draw the effects of the various combination of institutional factors to assess scheme performance.

Table 4.5 below shows the PCA results on institutional factors that are accessed by scheme farmers from institutions. Eight PCs with the eigenvalue greater than one which allows meaningful interpretation was produced. A total jointed variation of institutional factors was explained by 68.45% of scheme farmers (Table 4.5). Results from the PCA show that the principal component (PC) labelled "COMMUNITY CREDIT SUPPORT" have a high loading of 0.761 on access of loan from the community. Despite this, factors which include access to loan from cooperatives, participating in cooperative scheme maintenance, access to market through cooperatives, and sale of produce to the local community through the farm gate and roadside/kiosk markets have factor loading higher than 0.5. highest factor loading of 0.761 (Table 4.5). PC, "COMMUNITY CREDIT SUPPORT" explained 11.15% of the variance of institutional factor dimension (Table 4.5).

Table 4: 6 PCA results on the proportion of institutional factors on principal components

Rotated Component Matrix[a]								
Institutional factor	**Component**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Community provide loan	**0.761**	0.028	0.142	-0.040	-0.081	-0.005	0.162	0.007
Cooperatives provide maintenance	**0.671**	-0.037	0.038	0.056	0.033	-0.155	-0.225	0.027
Cooperatives provide loan	**0.554**	-0.031	0.221	0.115	0.097	0.114	**0.378**	0.209
Cooperatives provide market	**0.529**	0.078	-0.051	0.032	**0.326**	**0.357**	0.119	0.240
Academic institutions provide extension	0.006	**0.839**	0.045	-0.080	0.020	-0.042	-0.122	0.144
Cooperatives conflict management	-0.130	**0.645**	0.215	-0.261	-0.040	0.185	0.024	**-0.387**
Private organisations provide extension	0.115	**0.628**	-0.228	0.105	-0.179	-0.037	**0.347**	0.102
Extension officers provide extension	**0.320**	**0.527**	**0.469**	0.254	0.023	0.156	-0.083	0.048
Private organisations provide inputs	0.188	0.024	**0.807**	-0.286	0.135	0.069	-0.040	0.096
Irrigation committees provide market	0.204	-0.014	**0.560**	0.179	-0.212	-0.149	0.221	0.003
Tradition leaders conflict management	-0.170	**0.458**	**0.518**	0.295	**0.329**	-0.205	-0.032	0.002
Cooperatives provide inputs	0.077	-0.003	0.143	**0.834**	-0.125	0.144	0.015	0.167
Private organisations provide market	0.018	-0.044	-0.246	**0.740**	**0.374**	-0.081	0.028	-0.184
Cooperatives provide extension	-0.067	-0.087	0.086	0.022	**0.806**	-0.057	-0.099	0.217
Government provide input subsidy	**0.357**	-0.061	0.078	0.264	**0.522**	0.141	**0.437**	-0.089
Community provide extension	0.139	0.083	-0.155	-0.033	**0.496**	-0.267	**0.426**	-0.101
Academic institutions provide market	0.081	-0.268	0.189	0.141	0.251	**-0.740**	0.061	-0.147
Academic institutions provide inputs	0.087	-0.244	0.119	**0.310**	0.078	**0.733**	0.235	-0.119
Community provide maintenance	-0.039	-0.006	0.063	-0.009	-0.005	0.092	**0.730**	0.061
Community provide inputs	0.207	0.191	0.179	0.034	0.114	0.106	0.022	**0.778**
Community provide market	**0.520**	0.283	0.204	0.080	-0.082	0.132	-0.208	**-0.525**

Table 4: 7 Composite variables from the principal component analysis (PCA)

Component	Description of factor combination
1: Community credit support	Farmers mainly access loan from the community, despite this, they also access loan from cooperatives, participate in cooperative scheme maintenance. Moreover, they access to the market for their products through cooperatives and sell their produce to the local community through the farm gate and roadside/ kiosk market.
2: Academic institution extension support	Farmers dominantly access extension services from academic institutions. Despite this, extension officers and private organizations also offer them with extension support. They are also privileged to access traditional leaders and cooperatives for conflict resolution.
3: Private organization input support	Consist of farmers who mainly access inputs from private organizations they also rely on traditional leaders for conflict resolution. They as well rely on irrigation committee to access the market.
4: Cooperative inputs support	Farmers are provided with input subsidy from cooperatives. Despite this, they access the market from private institutions.
5: Cooperative extension support	Farmers access extension services from cooperatives and subsidized inputs by the government.
6: Academic institution market and input support	Farmers access input subsidies from academic institutions, but they lack access market from institutions.
7: Community maintenance support	Farmers participate in community scheme maintenance.
8: Community input support	Farmers access inputs from the community. They do not rely on the local community for the market of their produce.

The second PC was labelled “ACADEMIC INSTITUTION EXTENSION SUPPORT” is a component where access to extension services from academic institutions has an outstanding factor loading of 0.839. Access to extension services from extension officers, access to extension services from private organizations and resolving conflicts through traditional leaders and cooperatives are other factors of this PC which have higher factor loading of 0.527, 0.628 and 0.645 respectively on the component, “ACADEMIC INSTITUTE SUPPORT” (Table 4.6). This PC explained 10.86% of the variance of institutional factor dimension (Table 4.6). The third PC was labelled “PRIVATE ORGANIZATION INPUT SUPPORT” given that access to inputs from the private organization has the highest factor loading of 0.807 while other factors like access to conflict resolution from traditional leaders and access to market through irrigation committee also contributed significantly with a factor loading higher than 0.5 (Table 4.6). The PC, “PRIVATE ORGANIZATION INPUT SUPPORT” explained 8.92% of the variance of institutional factors (Table 4.5).

For PC, “COOPERATIVE INPUT SUPPORT” which is labelled following a high factor loading of 0.834 on access to inputs from cooperatives, which exceed the factor loadings for access to market from private institutes which have 0.740 (Table 4.6). “COOPERATIVE INPUT SUPPORT” explain 8.61% of the variance of institutional factors (Table 4.6). Higher access to extension services through cooperatives with an index of 0.806 is the main characteristic to PC labelled “COOPERATIVE EXTENSION SUPPORT” (Table 4.6). PC component “COOPERATIVE EXTENSION SUPPORT” also have high loadings of access to input subsidy from the government of 0.740. This PC explain 8.29% of the variance of institution factors (Table 4.6).

Lack of access to market from the academic institutions and access to input support from subsidies from academic institution makes academic institution an outstanding institution in this PC which make it to be labelled as “ACADEMIC INSTITUTION MARKET AND INPUT SUPPORT”. PC, “ACADEMIC INSTITUTION MARKET AND INPUT SUPPORT” explain 7.33% of the variation of institutional factors (Table 4.5). The PC which is labelled “COMMUNITY MAINTENANCE SUPPORT” have a higher factor loading of 0.730 on participation in community scheme maintenance (Table 4.6). “COMMUNITY MAINTENANCE SUPPORT” explain 6.89% of the variation of institutional factors (Table 4.5). The last PC named “COMMUNITY INPUT SUPPORT” have a positive factor loading of 0.778 on access to inputs from the community and a negative factor loading of -0.525 on access of market from the community (Table 4.6). This PC explain 6.39% of the variance of the institutional factors (Table 4.5).

4.3.5 Factors determining the yield of sweet potatoes

The yield of sweet potatoes was used in this study as a dependent variable considering that sweet potato production is the main enterprise in the scheme with 87.6% of scheme farmers who are into its production (Table 3.4). The variance of the error term was constant and do not have a constant variance at 1% level of significance. Study shows that 59.39% of the variance is explained by this model. In relation to the F-test, the model is statistically significant to the data it is analysing.

According to Table 4.8, “COMMUNITY CREDIT SUPPORT” and “COMMUNITY MAINTENANCE SUPPORT” were significant at (P<0.01). “COOPERATIVE EXTENSION SUPPORT” and “ACADEMIC INSTITUTION MARKET AND INPUT SUPPORT” impact yield of sweet potatoes at (P>0.05). Moreover, “COMMUNITY INPUT SUPPORT” was significant at (P<0.1) (Table 4.8). The OLS results show that the coefficient of “COMMUNITY CREDIT SUPPORT” has a positive impact yield of sweet potatoes.

Table 4: 8 OLS results on the relationship between the yield of sweet potatoes and institutional factors, social factors and managerial factors

The standardized yield of sweet potatoes	Coef.	Robust Std. Err.	P>|t|
Age	-0.01	0.01	n.s.
Gender	-0.06	0.13	n.s.
Marital Status	0.10	0.13	n.s.
Formal Education	-0.01	0.01	n.s.
Number of household members	-0.00	0.02	n.s.
Years farming in irrigation	0.00	0.00	n.s.
Formal Agricultural Training	-0.12	0.14	n.s.
Distance to the Markets	-0.12	0.07	n.s.
Fertiliser Subsidies	-0.00	0.00	n.s.
Pesticide subsidies	0.04	0.04	n.s.
Hawking	-0.00	0.00	n.s.

Community credit support	0.49	0.06	***
Academic extension support	0.08	0.05	n.s.
Private organization input support	0.03	0.05	n.s.
Cooperative inputs support	0.08	0.06	n.s.
Cooperative extension support	0.12	0.06	**
Academic institution market and input support	0.1	0.05	**
Community maintenance support	0.36	0.06	***
Community input support	0.10	0.06	*
Livestock Unit	-0.01	0.01	n.s.
Asset indices	-0.08	0.22	n.s.
Constant	0.54	0.54	n.s.

A unit increase in farmers who access services in PC labelled "COMMUNITY CREDIT SUPPORT" leads to 0.49 increase in yield at a high statistically significant value of P=0.000 (Table 4.5). A relationship which is statistically significant (P<0.01) was observed between the yield of sweet potatoes and "COMMUNITY MAINTENANCE SUPPORT". An increase in component "COMMUNITY MAINTENANCE SUPPORT" results in a high magnitude impact of 0.362 on the yield of sweet potatoes. "ACADEMIC INSTITUTION MARKET AND INPUT SUPPORT" result in an increase in yield of sweet potatoes by a 0.116 at a statistically significant level of P<0.5.

4.4 Discussions

The benefits obtained by farmers from institutions that participate in the irrigation scheme contribute to the performance of Tshiombo irrigation scheme. Survey results show that farmers benefit from the institutions participating in the irrigation scheme. Institutions which include the government, cooperatives, private organization, academic institutions, traditional leaders, and the general community were identified for taking a supportive role to scheme farmers. This may show that the government play a positive role to address gender imbalances by supporting the initiative of women in irrigation schemes who are socially and economically disadvantaged compared to their male counterparts (Mamary *et al.*, 2018). Female farmers constitute majority of the scheme farmers; therefore, their support will improve performance and ensure sustainability of the scheme. Female farmers significantly benefit from cooperatives compared to male farmers at a statistically significant level of 10%. Study reveals that woman participate in scheme cooperatives than males, therefore more female farmers benefit from cooperatives than male farmers.

4.4.1 Institutional Dimension

Scheme farmers in this PC "COMMUNITY CREDIT SUPPORT" category benefit by accessing soft loan from each other (Table 4.6). Knowledge acquired through access to extension services from extension workers might have encouraged farmers to create cooperatives. Cooperatives created enable farmers to access a loan through a cooperative loan scheme, access market through it and bargaining for competitive market price which assure farmers in cooperative easy and timely marketing of their produce. Competence of extension services, education and training were recognised as for the formation of cooperatives in farming communities (Aerni *et al.,* 2015). Knowledge obtained through participating in cooperatives prompt farmers to alternatively rely apon each other for soft loan. Marketing skills acquired through participating in cooperatives enable farmers in "COMMUNITY CREDIT SUPPORT" to easily access market from the community. Knowledge acquired from extension officers and skills developed by cooperatives equip farmers in this PC to be emerging entrepreneurs, hence they were able to treat smallholder farming as a business.

Scheme farmers in "ACADEMIC INSTITUTION EXTENSION SUPPORT" PC category access extension and conflict management from a combination of institutions that participate in the scheme like traditional leaders, extension officers, the private organisations, cooperatives and academic institutions (Table 4.6). Agricultural extension services link farmers with authorities, resources, information, and develop their capacity to improve scheme performance (Ncube, 2017). Extension services offered by the private organisations, academic institutions and extension officers emphasise scheme farmers who constitute this PC to prioritise conflict resolution strategies to problems that arise following accessing services from other institutions and personal interaction. Therefore, farmers in this PC prioritise to resolve conflicts through cooperatives and traditional leaders. These findings may suggest that farmers in this PC face a myriad of conflicts which interfere with their participation in scheme farming activities.

Farmers that constitute PC, "PRIVATE ORGANISATION INPUT SUPPORT" might have been facing conflict from accessing inputs from private organisation and marketing through irrigation committees which are settled by traditional leaders. Farmers may have been educated through extension officers to use traditional leaders to settle conflicts. The PC, "COOPERATIVE INPUT SUPPORT" consist of farmers who access inputs through cooperatives and academic institutions, as well as the markets are accessed through the private organisation at an individual level. This PC consist of farmers with poor access to extension services from any scheme institution and they also least prioritise accessing loan from all alternative credit sources.

Among farmers that make up "COOPERATIVE EXTENSION SUPPORT", traditional leaders address conflicts that might have been caused by access to inputs from a private organisation and access to the market. Access to extension services from cooperatives and community help farmers with marketing skills which enable them to market their products to private organisations and through cooperatives. Conflicts that might relate to access to inputs from the government and markets were settled by traditional leaders. Extension services are among the technical assistance provided by cooperatives to smallholder irrigation in Mpumalanga (Ncube, 2017). Access to services from cooperatives varies with individual farmer's choices.

In PC "ACADEMIC INSTITUTION MARKET AND INPUT SUPPORT", farmers access inputs academic institutions but does not access market which they alternatively access through cooperatives. Farmers who make up "COMMUNITY MAINTENANCE SUPPORT" mainly participate in scheme maintenance. Farmers access extension services from community and private organisation which encourage them to participate in community scheme maintenance as well as acquiring the loan from cooperatives. Poor access to conflict management from scheme cooperatives among these farmers who constitute "COMMUNITY INPUT SUPPORT" result in poor access to markets despite good access to inputs from fellow scheme farmers.

Successful development of agricultural innovation adaption and up-scaling need adequate capacity from all institutions, in low-income countries there is limited development of innovation systems due to lack of resources (Aerni *et al.*, 2015). Pervasive poverty widens the capacity gap among irrigation schemes in most tropical regions. Platforms with multiple dynamic institutions facilitate coherence and effectiveness of capacity development on their interventions which can lead to improved performance and sustainable development.

4.4.2 Role of institutions on scheme performance

Roles of institutional have a relationship to the performance of smallholder irrigation. Table 4.8 presents that PCs of roles of institutional positively affect scheme performance at a statistically significant level in analysis were socioeconomic factors. PCs of roles of institutions were used as the independent variable to yield of sweet potatoes.

"COMMUNITY CREDIT SUPPORT" and yield of sweet potatoes are positively correlated. That is access to services that make up this PC result in an increase of yield of sweet potatoes with a margin of 0.49. It is characterized by a factor loading of 0.761 being access to credit from community members. Accessing credit from community members was an alternative solution to financial challenges in the scheme. Findings from the study relate to the finding that smallholder communal farmers are challenges to access credit from formal financial institutions like the bank (Senyolo *et al.*, 2018). This is consistent with findings which alluded that traditional savings in form of credit cooperatives are effective access to credit in irrigation schemes (Mdemu *et al.*, 2017; Kwai and Urassa, 2015). Lack of collateral security, lack credit information, fear of the penalty defaulting payment, high interest and distance of financial institutions from the scheme are among other factors suggested by scheme farmers which impact access of loan from banks Sinyolo and Mudhara (2018). Moreover, farmers in the scheme were offered with Permission to Occupy which cannot be used as a security to access money from banks. Empirical findings show that 53.4% of scheme farmers are members of cooperatives. Farmers in the same village or irrigation block who share similar challenges where most likely to collectively meet and negotiate among each other based on the nature of the relationship that exists between them. Research findings from FGDs show that farmers in the same location face the same problems and they are more likely to create cooperatives to address their challenges.

Considering that access to maintenance is the institutional factor with the highest loading of 0.730 compared to other factors which have a loading below 0.5 show that mobilizing the community to maintain will help to improve the performance of the scheme. Performance of irrigation scheme is mainly anchored on reliable access to irrigation water, therefore, maintenance of irrigation canal infrastructure may ensure a constant flow of water and reduce water loses through leakages. Interviews with KIIs and FGDs reveal that the community regularly engages to contribute money for scheme maintenance as well as participating on the canal maintenance. Furthermore, farmers modify and formulate collective rules that emphasize all members of the scheme to participate in scheme maintenance. Despite this, lack of written rules and formal laws binding participation of scheme members in the maintenance of irrigation infrastructure result in the problem of defaulting of payment and non-participation by some scheme farmers. These findings concur with findings by Mdemu *et al.*, (2017), that scheme farmers participate in scheme maintenance is challenges of low payment of maintenance fee and poor participation in infrastructure maintenance which deteriorate reliability and timely water access by farmers at the tail-end. Therefore, the use of traditional chiefs to settle related conflicts have proven to be the best alternative solution in Tshiombo irrigation scheme.

Access to inputs from academic institutions may facilitate farmers to access improved seed varieties which meet the demand of the local and international markets as they might have gone thorough market-led research. Access to market from an institution may have little impact on scheme performance. Though academic institutions do not provide market, KIIs and FGDs meetings factor out that they play a pivotal role in providing market information which enables farmers to make informed decisions on accessing the market.

"COOPERATIVE EXTENSION SUPPORT" has resulted in an increase in yield of sweet potatoes by 0.12. Cooperatives in the scheme may not have been established with a mandate to offer extension services but are accessed through platforms and networking with organizations which support cooperative. KIIs interviews reveal that farmers in cooperatives are loyal to the rules of the cooperatives, therefore easy to offer extension services. Given that cooperatives are significantly dominated by female farmers, female farmers are benefiting from extension through cooperatives.

Apparently, access to extension services from community and access to subsidies from the government have a higher loading greater than 0.3 in "COMMUNITY MAINTENANCE SUPPORT" and "COOPERATIVE EXTENSION SUPPORT" which have impacted yield of sweet potato positively at statistically significant levels. These findings show their importance to scheme performance since they have yielded positive effects on yield of sweet potatoes. Access to extension services from the community may suggest that indigenous knowledge is essential to improve scheme performance. Moreover, agricultural input subsidy is targeted to smallholder resource-poor farmers in conjunction with extension services in South Africa (Kassie *et al.*, 2015). Though subsidies where acquired in the scheme, most subsidies target to crops of economic value to the government in contrast to crop choices of scheme farmers, as a result, most subsidies accessed by farmers remain idle or farmers may end up selling them out because they will be inappropriate for farmer’s use.

Access to credit was observed as a factor that dominates the PC that has the highest impact on sweet potato yield. Given that, on community credit support, access to credit from the community has a loading of 0.761 and access to credit from cooperatives have a loading of 0.554, access to credit impacted yield of sweet potatoes. There is limited access to financial credit from registered financial institutions like banks by farmers in the scheme given that only 7.8% can access credit from banks. Lack of information on accessing credit, lack of collateral security, high-interest rates and high risk-averse are some of the challenges farmers face on accessing credit from banks. Limited access to credit from banks makes farmers come up with alternatives to acquire money from scheme farmers and cooperatives.

4.5 Conclusion

The main aim of conducting this study was to identify institutional services that impact the performance of Tshiombo irrigation schemes. Results have highlighted that institutional factors significantly impacted the performance of smallholder irrigation schemes. OLS was used to analyse data after factor reduction of institutional factors by the PCA. PCA generates eight PCs which were assessed and returned for this study.

A combination of institutional services, with most of them having positive factor loading higher than 0.3 on PCs determine the yield of sweet potatoes in the scheme. Farmers access institutional services which include loan, scheme maintenance, produce markets, extension, conflict management, and inputs subsidies from institutions which include the community, cooperatives, private organisations, academic institutions and traditional leaders. The results from the OLS regression model indicate that institutions play a positive role in the management and support of smallholder irrigation schemes. Results from this study show that scheme performance was positively impacted by the combined services offered by various institutions.

Institutional services accessed by farmers may reflect farmers' institutional needs in the scheme and determine its performance. Several institutions participate in the management of Tshiombo irrigation scheme. PCA revealed that challenges emanating from service offered by one institution are corrected by services offered by other institutions. Failure to properly incorporate institutions in small-scale irrigation schemes will scale up irrigation management challenges among numerous farmer managed irrigation schemes thereby depreciating scheme performance.

Results show that small-holder irrigation farmers are made up of heterogeneous groups that differ in their features, have diverse responses to incentives, have unequal opportunities, and vary in constraints they face among others which affect their decision on the choice of services they acquire from institutions. Understanding the complex nature of smallholder irrigation schemes will help to provide a combination of institutional services that will address the needs of each farmer typology to improve scheme performance and sustainability. There is a need for organizing and grouping of farmers with similar circumstances to enable them to benefit from interaction and for easy training and sharing of information. Therefore, scheme institutions must consider the diversity of scheme farmer typology when they are offering their services to achieve a common goal. The decision on services offered by the institution to scheme farmers should address the heterogeneity of smallholder farmers since their choice of the institutional services they opt to access is influenced by the heterogeneous nature of farming groups. The impact of institutions on scheme performance is determined by the quality of services and the nature of relation build between the institution and scheme farmers.

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CHAPTER 5: CONCLUSIONS, RECOMMENDATIONS AND AREAS FOR FURTHER RESEARCH

5.1. Introduction

This study aims to assess performance of Tshiombo Irrigation scheme. This study starts by looking at the gross margin of smallholder irrigation scheme in Tshiombo irrigation scheme. Further investigations on available incentives on smallholder scheme farmer's performance were done inferring further into the extent to which the influence have on scheme farmer's performance. Moreover, more assessment was done to understand the impact of the role of institutions on performance in Tshiombo irrigation.

Data was collected from a randomly selected sample of 148 scheme farmers, cleaned and analyzed. KIIs and FGDs were concurrently contacted with interviews. Demographic data from the scheme farmers was analyzed by descriptive statistics. The performance of the scheme was analyzed by gross margin, OLS and a data reduction model, PCA. Findings from the study were presented and discussed. This chapter will present the conclusion and recommendations to improve scheme performance.

Empirical findings produced from gross margin show that all crops grown in Tshiombo irrigation scheme have a positive profit margin. Cabbages have a higher gross margin than other crops. Production of crops with low gross margins by female farmers may threaten the irrigation scheme from possible collapse as they will not meet the financial needs of maintaining the scheme infrastructures. Results show that female farmers yield negative impact on gross margin, therefore there is a need for initiatives that support female farmers to improve scheme performance.

Incentives significantly affect the performance of TIS. Market price is an incentive to scheme performance. Poor access to formal market was recognized which result in most farmers selling their produce at a roadside market where market pricing is uncertain. Farmers in Tshiombo irrigation scheme need to be integrated into value chain which enables them to sell their products at competitive prices and they will be incentivized to improve scheme performance. The impact of subsidies offered by the government on the performance of scheme farmers varies with the type of subsidy. This study reveals that some subsidy offered by the government to improve irrigation scheme performance have resulted in significant positive impact while others did not have a significant impact. Farmers with plots far away from the main canal were more likely to grow sweet potato than those who are closer to the main canal. Ageing of scheme farmers in Tshiombo irrigation scheme makes them incapable of efficiently utilize large pieces of land, therefore farmers with large pieces of land were most likely to leave more land unutilized.

Institutional factors significantly affect the performance of Thiombo irrigation scheme. A hypothesis that institutions impact performance of TIS is accepted. Access to a range of institutional factors create challenges that are solved through accessing services from other institutions. A good combination of institutional factors can help to improve scheme performance. Therefore, there is a need for institutions to create platforms where they will interact with each to come up with the best alternative institutional combination that will help to improve scheme performance. Institutions need further identify groups of farmers in relation to their choice of services for them to improve their performance. Based on the findings from the study that there is higher variability of institutional needed among blocks which share different socioeconomic and physical characteristics, there is a need for the establishment of small-scale irrigation schemes which are likely to have similar groups characteristics.

5.2 Policy recommendation

Effective policy plan will enable farmers to maximize irrigation land utilization, increase productivity and profit margin. Findings reveal that the performance of smallholder irrigation schemes could be economically sustainable if measures to address constraints associated with scheme farming are identified and addressed.

- The government must offer permits that enable farmers to have exclusive rights to transfer land when they no longer need to use the land for production purposes.
- Facilitating youth farmers to access irrigation land and help them to acquire knowledge on scheme management as well as addressing the land ownership gap between the youth farmers and ageing farmers.
- A behavioral approach which will help unlearn youth farmers from the negative attitude towards scheme farming and impart them with confidence that they will benefit from scheme farming.

- Market training and integrating farmers into value chain is desired to produce marketing needs in Tshiombo irrigation scheme. Development of a sustainable marketing system will make smallholder irrigation farming a venture for young and educated farmers.
- Promoting institutional platform among all institutions will help institutions to explore and focus on specific institutional factors which will help to improve scheme performance.
- The government should focus on providing working capital in form of revolving credit fund (RCF) with competitive interest rates that will be accessed by farmers through easily accessible channels, for example, input supplier or producer markets.

5.3 Areas of further study

- Performance of smallholder irrigation schemes may require to be addressed by a complex systems approach (CSA) to ensure that it is achieved in a sustainable way. Employing CSA will help improve scheme performance by identifying key roles of key enabling institutions and will help to understand dynamic interrelationship among a wide range of component by comprehending the functioning of the whole system
- Systematic impact of innovation in smallholder irrigation schemes is achieved by scaling out social invention research to several irrigation schemes. Scaling out the study of social behavioral innovation will help to unlock an appropriate initiative, platform or strategy that will positively impact the performance of irrigation schemes.
- There is a need for time series analysis of impacts of institutional factors on scheme performance, to enable setting up a suitable fiscal, legal and social institution framework among smallholder irrigation schemes to improve their performance. This will prop up institutions to aim at enhancing the welfare of scheme farmers by keeping them sustainable through improving their performance.