AN ASSESSMENT ON THE CONTRIBUTION OF SMALLHOLDER MAIZE IRRIGATION FARMING TO HOUSEHOLD INCOME AND FOOD SECURITY IN SEMI-ARID REGION OF ZIMBABWE: CASE OF TOKWANE NGUNDU IRRIGATION SCHEME, MASVINGO

A dissertation submitted in partial fulfilment of the requirements for the Master of Science Degree in Food Security and Sustainable Agriculture

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DECLARATION

I hereby declare that the research project entitled "**An assessment on the contribution of smallholder maize irrigation farming to household income and food security in semi-arid region of Zimbabwe: Case of Tokwane Ngundu Irrigation scheme, Masvingo**" submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of **Dr L. Musemwa** and this work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agriculture. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree of diploma.

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DEDICATION

I dedicate this thesis to my two sons Jair and Joel.

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ABSTRACT

The study was aimed at assessing the contribution of smallholder maize irrigation farming to household income and food security in Tokwane Ngundu in Masvingo District, Zimbabwe. Some research has been done in irrigation schemes but little is known about maize production in Tokwane Ngundu and how irrigating maize contributes to household income, this research will help the beneficiaries in irrigation schemes to improve maize productivity. Multistage sampling was used to purposively select study area and random sampling was used to choose 70 participants out of 88 households. Structured questionnaires, key informants' interviews and passive observations were used to collect data. To explore challenges, descriptive statistics was used, multiple linear regression was used to determine factors affecting the contribution of maize to household income. Food security was assessed using Household Food Insecurity Access Score (HFIAS) and Household Food Access Prevalence (HFIAP). The higher the HFIAS the more the household is food insecure. Mismanagement of irrigation resources by irrigation scheme management, water unavailability and high-water costs, inputs unavailability and input costs, market availability were discovered to be the main challenges affecting maize production in the irrigation scheme. Area under production and age of household heads significantly affected the contribution of maize to household income at 5% significance level while average maize yield was significant at 10% significance level. The average HFIAS for the interviewees was 9.7 and ranged from 0 to 13. Most of the study participants (48.6%) were severely food insecure, while 42.9% were moderately food insecure, 5.7% were mildly food insecure and only 2.9% were food secure. The results clearly show that the majority of the interviewed maize irrigation farmers are food insecure meaning the irrigation scheme are not meeting the set objectives of producing excess food supplies to the nation. Irrigation farmers should get agricultural extension education, use improved hybrids of maize seeds, optimum fertiliser applications and recommended pesticide dilutions to improve maize yields. The researcher recommends that young farmers should get agriculture training and education to improve maize productivity. There is need for the provision of food aid within the scheme since some households were severely food insecure.

Keywords: smallholder irrigation, irrigation scheme, household income, food security, food access.

LIST OF ACRONYMS AND ABBREVIATIONS

AD	Anno Domini
ARDA	Agricultural and Rural Development Authority
AusAID	Australian Agency for International Development
BC	Before Christ
CAADP	Comprehensive African Agriculture Development Programme
CWR	Crop Water Requirement
DOIRR	Department of Irrigation
D-W	Durbin Watson
EVDSA	Ethopian Valley Development Study Authority
FANTA	Food and Nutrition Technical Assistance project
FAO	Food Agricultural Organization
FAOSTAT	Food Agricultural Organization Statistics
FAW	Fall Armyworm
GDP	Gross Domestic Product
HFIAP	Household Food Insecurity Access Prevalence
HFIAS	Household Food Insecurity Access Score
IMC	Irrigation Management Committee
O level	Ordinary level
SSA	Sub Saharan Africa
UNCSD	United Nations Conference on Sustainable Development
UNDP	United Nations Development Programme
USA	United States of America
VIF	Variance inflation factor
ZimVAC	Zimbabwe Vulnerability Assessment Committee
ZJC	Zimbabwe Junior Certificate

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CHAPTER 1
INTRODUCTION

1.1 Background of the study

Agriculture is considered to be the center of the economy in Zimbabwe and contributes to the Gross Domestic Product (GDP)of this country (Munhande, 2013). It was discovered that about 19.5% of the Gross Domestic Product for Zimbabwe in 2010 was from Agriculture (Mutambara *et al*., 2013). The sector contributes about 40% of the value of the country's exports, about 60% of raw materials to ago industries and sustains livelihoods to at least 70% of the population. Agriculture contributes 66% of the formal labor force CAADP (2010) and thus irrigating crops like maize contributes a certain percentage to household income both in commercial and rural areas.

According to Jones (2003), maize (*Zea mays*) is a major food source for the world and is a high-yield crop. Maize was initially produced in central Mexico in 1500 BC and came to Africa in 1500 AD. It later spread to all parts of Africa in a space of 500 years and it has since become Africa's important grain crop. Maize has become a vital source of starchy food in most developing countries that is Latin America and Sub-Saharan Africa. Ammani (2018) stated that maize has an important role in the energy sector since it serves as forage for the production of biogas. Maize constitutes the most consumed sources of food and is a raw material for animal feed mill, as well as beverage industries. Its sustainable production in different areas promotes supply of food, job opportunities, family income and foreign exchanges. According to FAOSTAT (2012), about 30% of human calorific intake in sub-Saharan Africa is from maize and the second cereal which is wheat accounts for 16%, therefore maize accounts for over 50% of calorific intake (James ,2005).

There are several factors that are contributing to the deterioration of maize yields in Zimbabwe, which include pest invasion and exponential population growth. Fall armyworm and armored crickets were reported as the major pests in the 2016/2017 season according

to ZimVAC (2017). The area under maize only 8% was affected of which 2% was damaged by the fall armyworm in during 2016/2017 season. In Africa, the production of maize is continuously and severely affected by a number of threats which includes weed invasion, insects, bacteria, viruses, nematodes, fungi, low-quality seed, low levels of mechanization, suboptimal post-harvest management, drought, and climate change. Currently, damage caused by stem borers, grain borers, fall armyworms, and Striga has a potential to completely destroy the maize yield not ignoring drought impact on the yield. The erratic rain patterns, inadequate farming systems and drought stress may result in 70-100% crop loss which can be dramatic to farmers and consumers since the whole food chain will be affected (Van Montagu, 2011). These same threats are also affecting maize production in Zimbabwe and the production is limited by diseases that cause grain loss in production (Tagne, 2002).

Due to the exponential increase in population, increase in demand for biofuels and an increase in the demand for livestock feeds, the demand for maize is increasing to an extent that there is a deficit. Exponential growth of population as well as changes in food diet together with rising incomes is continously driving a greater demand for food as well as other agricultural products and yet global food systems are threatened by land degradation, climate change and other stressors (Nelson, 2015). With land of about 30.2 million km^2 while population is approaching one billion, Africa still has potential for both agricultural and economic development. Its population has increased rapidly, population was 120 million in 1900, 221 million in 1950, 796 million in 2000, 867 million in 2010 and is projected to be 1,081 billion in 2020, 1,804 billion in 2050. The issue of food security has been a major concern since the 1970s, the green revolution by passed the resource-poor smallholder farmers of the continent of which Zimbabwe is one of the Sub-Saharan Africa (SSA) countries affected. There were 240 million people who were food insecure in Africa in 2012 while there were 223 million in Sub-Saharan Africa in 2013 and the number is reported to increase by an additional 17 million by 2020 and 2550 billion in 2100 (Rattan, 2015).

Development of irrigation is a special case of agriculture where by technology intervenes and control soil moisture in the crop root zone so as to achieve a high quality of continuous crop production (Rukuni *et al*.,1994). Most smallholder irrigation systems are critical common property that are essential to improve crop water supply and for livelihoods sustainability (FAO, 2015). An improve in agriculture and enhanced production through smallholder irrigation is a key strategy to alleviate poverty and improve the livelihoods in rural communities for which the majority of the poor depend either directly or indirectly on agriculture (Mutiro *et al*.,2015). This is particularly true for Zimbabwe, 80% of agricultural land is found in arid or semi-arid regions (Jacobs *et al*., 2013). In effort to meet food demands by 2020, FAO (2000) the production of food from areas under irrigation increased from 35% in 1995 to 45% of agricultural output in 2020.

Using irrigation, complemented with all the required inputs such as best management practices and correct quantities of fertilizers, (Jacobs *et al*.,2013), explained that maize yields can go up to more than 10 tonnes per hectare. And when farmers can achieve such a yield of 10 tonnes per hectare on potential irrigable area, a total yield of 4.9 million metric tonnes of maize will be produced including the 1.2 metric tonnes from dry land Venot *et al*. (2013) resulting in Zimbabwe producing excess maize hence bouncing back as the Africa's breadbasket. Thus, irrigation development has the potential to improve the maize output in Zimbabwe so as to bridge the gap of moisture stress and fighting against some other certain pests and diseases. Irrigation plays a vital role in agriculture performance which increases income growth. The groownt of income is very essential for economic growth of a country (Hussain *et al*., 2001).

This research explored how irrigating maize in irrigation schemes of Zimbabwe can contribute to household income and tried to examine the challenges and factors surrounding maize irrigation schemes that hindered the contribution such that the irrigation aspect is sidelined to be of less importance.

1.2 Problem statement

Smallholder irrigation systems development was promoted since the pre-independence period as a solution to food deficit problems. According to Mutambara and Munodawafa (2014), over 13 billion dollars have been channeled to the development of irrigation development through Government and different organisations. Most irrigation schemes have sustainability challenges and some of them are in a state of disrepair and some are under operating, despite the critical value for food security, stable agricultural production, job creation and alleviation of poverty in the nation. (Mutambara and Munodawafa, 2014).

According to ZimVAC (2018), almost 2.4 million rural Zimbabwe will require food assistance between the period between October 2018 and March 2019 of which Masvingo has been projected to have the highest population estimated to be almost 470 000 suffering from food insecurity. Due to erratic rains during the 2017/2018 farming season, the number of food insecure population in Zimbabwe has increased from 1.1 million in 2017 to 2 423 528 in 2018 during the peak period of hunger (ZimVAC, 2018). There are farmers who solely depend on maize farming either under dry farming or under irrigation, this means that such farmers look upon maize output for their livelihoods and income generation. The report also indicates that household average incomes are becoming lower than last year, hence there is an increase of households taking poor diets, from 16% to 20%. Erratic rainfall received in most parts of the country resulted in crop yield reduction and the dry spell in January 2018 that lasted for 14 to 26 days resulted in permanent wilting of most crops.

Masvingo had 68% of households being affected with the fall armyworm (*Spodoptera frugiperda*) (Zimbabwean Ministry of Lands, Agriculture and Rural Resettlement, 2018). According to ZimVAC (2018), almost 360 000 tonnes of cereals will be required to alleviate hunger affected population. Maize production in Zimbabwe is estimated a 46% decrease to 1.2 million tonnes in the 2018/19 compared

to 2.2 million tonnes in 2017/2018 season. The report further highlights that the country have to import about 300,000 tons of grain , despite a 15 year high corn carry over stock of about 500,000 tons.

In addition to the above-mentioned challenges, the agricultural sector the Masvingo province is facing on maize production, limited literature on the performance and contribution of irrigation schemes to household income and food security is still very limited thereby prompting the researcher to investigate the contribution of irrigation maize farming to household income and food security.

1.3 Objectives

1.3.1 Main objective

To assess the contribution of smallholder maize irrigation farming to household income and food security in the semi-arid region of Zimbabwe.

1.3.2 Specific objectives

1. To explore the socio-economic, institutional, production and marketing challenges faced by smallholder maize farmers under irrigation in the semi-arid region of Zimbabwe.
2. To determine factors that affect the contribution of smallholder maize irrigation farming to household income in a semi-arid region of Zimbabwe.
3. To assess smallholder maize irrigation farmers' access to food in Tokwane Ngundu Irrigation Scheme, Zimbabwe.

1.4 Research questions

1. What are the socio-economic and institutional challenges faced by smallholder farmers under irrigation in the semi-arid region of Zimbabwe?

2. Are there any factors that affect the contribution of smallholder maize irrigating farmers to household income in semi-arid regions of Zimbabwe?
3. Do smallholder maize irrigation farmers have access to food in Tokwane Ngundu Irrigation Scheme, Zimbabwe?

1.5 Hypothesis

The contribution of irrigation maize farming to household income is significantly affected by age of household head, total household size, average maize yield, price ($/t), plant population and area under irrigation.

1.6 Justification

The research is being carried out during the period when strategies and efforts are desperately needed to efficiently and effectively design programs, policies, and interventions that improve irrigation schemes in Zimbabwe and create high maize production for the sovereignty of the country. Irrigation culminates in what is commonly known as crop diversification and enables the poor and smallholders to spread risk more evenly over the course of a year.

This research will help to explore some institutional, marketing, production and socio-economic challenges that are affecting the maize output which may also have a direct effect on household income and so improving agriculture production contributes to income growth. There are many stakeholders like the Government, the non-governmental organization and other seed houses that are willing to support and boost maize production in Zimbabwe for the sovereignty of this country. Thus, therefore addressing some challenges faced in irrigation schemes will increase maize yields and improve household and national food security, support industrial developmemt and growth, increase agricultural exports and foreign currency earnings and create employment.

The study will assist the government in the development of policies aimed at ensuring high maize yields thereby enhancing the livelihoods and food security status of maize farmers in Zimbabwe. This will in turn stimulate economic growth and reduce rural poverty. The study will also assist the Government and Non-Governmental Organisation involved in aid distribution in determining the extent of hunger in irrigation schemes in arid regions of Zimbabwe. To academics and learners, the study will add to existing board of knowledge on irrigation schemes in Zimbabwe.

1.7 Scope/delimitations and limitations of the study

The study only assessed the socio-economic, production, marketing, and institutional challenges and the contribution of smallholder maize farming to household income and food security in the Tokwane Ngundu irrigation scheme due to limited resources. The study also covered one irrigation scheme in Masvingo province and one crop (maize) making the results of the study difficult to generalise to the whole province.

1.8 Organization of the study

This research report is divided into five chapters, where chapter 1 comprises of a narrative comprehension of the background of the study. It focuses mainly on introducing the whole research and provides the significance of carrying out the research. The problem that has propelled the willingness to want to carry out the research is clearly described in this section and so specifically portrays the aims of the research. The following is chapter two which organizes literature that is relevant to the study of the contribution of maize to household income in irrigation schemes. A conceptual framework which underlines the theme of the research and gives direction to the study is explained in this chapter.

The third chapter of this study will provide an explanation of the materials and methods for data collection and analysis. It is here where the description of the study area and sampling procedure is described. Specifically, this section provides a comprehensive description

of data collection instruments and procedures. Data analytical instruments Finally, the section gives an ethical statement on necessary issues for the successful completion of this study. The fourth chapter explains and analyses the socio-economic, institutional, production and marketing challenges faced by smallholder maize farmers under irrigation in the semi-arid region of Zimbabwe. It is in this chapter again that factors affecting the contribution of smallholder maize irrigation farming to household income in the semi-arid region of Zimbabwe are analysed and data is presented. The findings are discussed according to the results of the analysed data

The fifth chapter is a comparative of food security status whereby food access for maize farmers under irrigation and households of those farming maize under on dry farming are compared. An analysis of data is also done and presented in this chapter; discussions are done according to the findings. The last chapter summarises the whole project research where the conclusion and recommendation of the study are done. The hypothesis of the research is given a conclusion in this chapter and presented before future research directions are suggested.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This is a chapter that will be explaining how other authors view irrigation development in Zimbabwe, major crops irrigated, challenges faced in irrigation schemes. Factors affecting crop production in irrigation schemes and how crop production affect livelihoods were also reviewed. Food security in irrigation schemes is also reviewed in this chapter. Finally, the conceptual framework was reviewed.

2.2. The Development of Irrigation in Zimbabwe

2.2.1 Irrigation in Zimbabwe

In Zimbabwe, irrigation schemes were established by white missionaries during 1930s era and were financially and economically viable. Roder (1965) mentioned that projects of irrigation have been successful since they enabled most farmers to acquire more wealth than dryland farmers, even more than employees of white farmers.

Musemwa *et al*., (2014) described the role of irrigation development in communal areas as a crucial mitigation measure for drought and as a strategy to increase output per unit area. Lower maize yields being experienced by most farmers are a result of erratic, low and unpredictable rainfall. The ability to access sustainable irrigation help farmers to adopt new farming technologies and intensify cultivation which increase productivity, thus higher production and greater returns from farming.

In addition, irrigation development enhances household and national food security and creates employment opportunities both on-farm and off-farm hence improve income, livelihoods and quality of life through reducing vulnerability caused external shocks during season of agricultural production. The population of Zimbabwe demands 2.1 million metric tonnes of maize per annum. Therefore an

investigation of the national food security status of Zimbabwe could then be prompted to check if the government should invest in irrigation development to promote maize crop production (Musemwa *et al*.,2014).

The irrigation schemes reduces tendency of rural to urban migration since it offers rural population source of employment and income generating projects. Roder (1965) further reported that wealth of irrigators was held in farm implements and equipments. Alvord (1933) as cited Zawe *et al*. (2015) mentioned that Mutema irrigation scheme in Manicaland Province alleviated drought effects in the area through sustainable production, the area reduced the need for drought relief grain from the government by approximately 90 to 180 tons per year.

Rukuni (1984) explained that yields on smallholder schemes are higher than rainfed dryland yields in communal areas of Zimbabwe. Meinzen-Dick *et al*. (1993) highlighted that gross margins of farmers under irrigation were greater than those of dryland farmers. Therefore the effect of irrigation on increasing crop production is even more recognized in the dry winter season where dryland crop production is almost impossible because of lack of water.

Ruigu *et al*. (1990) indicated that smallholder schemes are generally financially viable. Agriculture has since developed in Zimbabwe and has covered a total of 206 000 Ha and out of the area that has the potential to be developed there is a total of 1 500 000 Ha, which is irrigable. Agricultural development in this country has been sub sected in the following manner Zawe *et al.* (2015) classifies as Model A2, these are farms larger than 6 Ha and were resettled since the year 2000. Irrigation is almost up to 29.3%, with large private company estates of 30.7%, Agricultural and Rural Development Authority (ARDA) estates with 8.3%. Model A1 these are farms which are smaller than 6 Ha resettled and have settled since 2000 and irrigation schemes and old resettlement areas consist of 14.7% with communal areas which cover 8.3% and wetland cultivation 9.7% (Zawe *et al.*, 2015).

Zimbabwe depends on surface water sources, groundwater resources are very scarce. Irrigation technologies utilized are surface irrigation, overhead irrigation and micro-irrigation. Furrow and border irrigation are dominant for the surface irrigation, and types of sprinkler irrigation systems common are semi-portable, portable and centre pivots (Makombe *et al*.,1993). The drag-hose sprinkler irrigation system is not very commom although small portable and semi-portable systems can be found. There are only three conventional micro-irrigation projects have been put up. Ruigu *et al*. (1990) emphasized that units of drip irrigation systems have been distributed to individual farmers as well as to some community gardens for small garden irrigation.

2.2.2 Defining smallholder irrigation in Zimbabwe

Smallholder irrigation schemes in Zimbabwe have the following characteristics: (i) irrigated plot-holding ranging from 0.1 – 1.5 ha according to commonly agreed classification that include A1 farmers (ii) infrastructure that is shared (iii) self-management, management which is joint between farmers and government, but mostly it is government management (iv) communal land tenure (v) a community committee (Makombe *et al*.,1993).

A smallholder irrigation scheme is defined as a scheme where a group of farmers irrigates together, with a water source that is shared and the same delivery line and some individuals control the irrigation and farming activities. Schemes are communally owned and operated significantly implicates the performance of the sector, opportunities to participate and challenges for the sustainable development of the sector (Makombe *et al*.,1993). However, in the case of wetland cultivation, irrigation schemes are normally individually owned and managed. In these schemes, there is virtually no government support to farmers. As a result, wetland irrigation is sometimes referred to as informal irrigation. It is not surprising, therefore, that these irrigation schemes are sometimes referred to as unofficial, and are often of the government record.

2.2.3 Historical overview of irrigation in the country

Pre-independence and post-independence governments are the key drivers of smallholder irrigation development in Zimbabwe at both strategic planning, financing, implementation and management levels. The government involvement extent was dictated by objectives that were different before and after independence (Kirda, 2000). None of the governments produced a comprehensive irrigation document of policy, considerations that were strategic varied from one government to the next with a significant impact on irrigation development in terms of projects initiation , financing the technologies that were selected and implementation.

Smallholder irrigation development placed smallholder farmers at the epicenter of the strategies, allowing farmers to participate to the extent that was consistent with the strategic development objectives. Zimbabwe did not have an irrigation policy to guide irrigation development, development policies and legal instruments were there and most from other sectors of the economy therefore they shaped the perception of implementation and irrigation management in the country.

2.2.4 Benefits of irrigation

FAO (1997) indicated that there are a number of benefits in irrigation especiall when it is done on small scale. A socio-economic impact assessment of Hama Mavhaire, Hoyuyu 5 and Nyaitenga, as some of the samples of irrigation schemes in Zimbabwe, farmer's incomes from irrigation was significantly higher compared to incomes of dryland farmers. Input levels in terms of quantity and quality were found to be higher in smallholder irrigation schemes than in dryland farming areas. This therefore suggested a more intensive crop production in smallholder irrigation schemes than in dry land agriculture practices. Farmers in irrigation schemes were found to be much better off in terms of access to basics as compared to some workers in urban areas who are facing challenges of rent, water and electricity charges.

FAO (1997) pointed that smallholder irrigation schemes can be more viable when issues such as reducing drought relief handouts, then create employment to reduce rural urban migration should be considered during the economic analysis of irrigation schemes.

Smallholder irrigation can be the basis where rural development evolve resulting in improved standards of living of many Zimbabwe's rural communities.

FAO (1997) emphasized that improving management of irrigation schemes enhances a positive impact in terms of benefits to farmers. However there is need to avail security of land tenure to irrigating farmers and it is important to provide farmers with a decentralized system of managing irrigation schemes. There is a need to assist farmers to maintain minimum acceptable levels of production by individual farmer to justify the investments on irrigation development, A clear policy on the handing-over of irrigation schemes to farmers should be very specific on the timing of hand-over as well as a respective role of farmer and government after the hand-over.

2.2.5 Major crops irrigated in Zimbabwe

Kirda (2000) emphasized that Zimbabwe is one of the countries that have an agro-based economy. Agriculture is practiced both in arid and semi-arid regions and supplementation of water to crops in seasons of dry spells is through irrigation. there are a lot of crops that are produced under irrigation and these include cotton, maize, wheat, sunflower, sugar beet and potato, sugarcane, citrus only to mention a few. These crops are well suitable for irrigation either throughout the growing season or at pre-determined growth stages (Kirda, 2000).

Irrigated crops like wheat and barley can be grown in the colder and drier months (May-September). Rome (2006) explained that adequate soil moisture is a requirement for the normal wheat plant development at all the growth stages. There is little or no rainfall in winter along most Sub Saharan Region therefore irrigation is essentially required to for good wheat crop yield.

Basera (2019**)** explained that irrigation is critical provided water is used wisely and recommended that farmers should use irrigation equipment economically. An encouragement to farmers was not to under apply water since this resulted in loss of crop yield affecting

the top line and bottom line stories. Over application of water causes cost structure to grow affecting your bottom line and over application of water promote development of disease and affect the crop yields.

2.2.6 Maize Production

Maize is a warm season crop, not well-adapted to the harsh, hot conditions although it may perform poorly under rain-fed conditions, maize yields of over 10.0 t/ha were achieved under irrigation in some irrigation schemes like Katherine and Kununurra in the 1980s (Muchow 1989; Warren 1982). ZIMVAC, (2018) emphasized that international climate forecasts indicates the December 2018 to March 2019 period, Zimbabwe is likely to receive the below average seasonal rainfall. This forecast has changed since the initial forecast in August, but still maintains the earlier seasonal forecast or normal to below-normal rainfall. The season is also likely to experi nhgr32ence a slow start of rains, with high chances of experiencing mid-season droughts and early cessation of rains. These will likely reduce cropped areas across most parts for the country and impact on yield levels.

Limited access to crop inputs will remain a key production challenge for poor farmers during the 2018-19 production season. Through the Presidential Crop Input Scheme, the government plans to reach approximately 1.63 million small-holder households. However, due to prevailing economic challenges and inadequate resources, the government may face challenges to reach the targeted population and meet the demand of the input packages. As well, price increases of crop inputs such as seed, fertilizers, and chemicals experienced ahead of the production season are likely to continue, or at least prices will remain high. There is a short supply of inputs like fertilizers as manufacturing companies struggle with foreign currency shortages to import raw materials. Prices on the black market are way beyond the reach of poor households.

Recent multiagency coordination meetings reiterated that Fall Armyworm (FAW) will remain a key production hazard for the 2018-19 cropping season despite ongoing awareness and training activities for extension workers and farmers. ZIMVAC (2018). reported that

the proportion of households with maize affected by FAW during the 2017-18 production season increased from 36 to 53 percent. The AGRITEX second-round crop and livestock assessment report (2018) indicated that the pest affected 7 percent of the maize cropped area.

Maize prices are well above average for this time of the year and are expected to remain above average throughout the outlook period. The current economic crisis has resulted in price increases of commodities (including maize) and this is likely to continue in combination with expected seasonal changes in prices.

Maize market supplies are currently low and are expected to further decrease between January and March due to farmers withholding their surplus stocks in response to the poor rainfall season that is expected. As maize demand increases during the peak of the lean season, prices are expected to reach their peak in March. Only marginal decreases are expected in April and May due to the late harvest and anticipated below-average production (based on the factors contributing to the 2018-19 maize production assumption). Maize grain prices for Mbare Market in Harare are expected to increase up to 50 percent above the same time last year and the five-year average during the outlook period. However, potential maize grain price increases may be cushioned by the relative availability and prices of maize meal ZIMVAC (2018). High transport and milling costs may influence shifts in consumer purchases from grain to maize meal purchases in some areas. The GMB prices for maize grain are likely to remain at the current levels.

Maize meal prices have previously been expected to remain stable throughout the outlook period as millers access subsidized grain from the GMB. However, following the October 2018 price hikes and deepening foreign currency shortages, maize meal prices are expected to increase further from the October/November levels as demand increases. Millers cite increases in non-grain and other operational costs like packaging materials, for the increases in maize meal prices. However, in some areas close to the borders some businesses and households may increasingly resort to cheaper imported brands if local brands become relatively costlier ZIMVAC (2018). Even where

maize meal may be cheaper at GMB depots, poor access and high transport costs for most rural households to such depots will reduce effective demand.

2.2.7 Maize water requirement

Maize crop is a C4 plant, which has the capacity to use CO2, sun's radiation, water and Nitrogen in food production as compared to C3 crops. Crop water requirement of the crop maize is calculated to be twice than C3 crops grown at similar places under similar conditions. Maize has different cultivars that has some varying water requirements as well as crop water use efficiencies (Asare *et al*, 2011). Irrigation water requirement of crops varies among all the crop hybrids (Maria, 2009). Growth and development of maize, for its normal development and to achieve it's highest and even yields it is important to keep an optimal soil moisture within the root zone over the growing period.

Water demand increase brought by rapid population growth created the need to increase food productivity by expanding irrigation and industrial production so that the basic human needs are met. The primary mandate of irrigation is to supplement water to maintain crop evapotranspiration when precipitation is not enough. Hess (2005) defined crop water requirements as the water needed for both transpiration and evapotranspiration during the stages of plant growth from planting to harvest of a specific crop in a particular climate regime. When enough soil water is maintained by rainfall or by irrigation it does not limit plant growth as well as crop yield.

Irrigation development, technologies, scheduling may be more effective and of rational uses when there is limited water supplies. Requirement of water by a crop is determined by climatic conditions, crop type and area, soil type, growing seasons and crop production frequencies (FAO, 2009; George *et al*., 2000).

2.2.9 Challenges in smallholder irrigation schemes

The development of smallholder irrigation systems has been promoted since the pre-independence period as the strategic answer to food deficit and a lot of investment has been channeled to the development of irrigation infrastructure through Government and different NGOs (Makadho and Sampath, 2004). However, many of these schemes are facing sustainability challenges which have left some of them in a state of disrepair or operating below their design capacity despite the critical value for food security, stabilisation of agricultural production, employment creation and poverty alleviation (Makombe and Sampath, 2010). A number of researches have been carried out on small scale irrigation schemes but the focus has been mainly on analysis of the design options and water management, financial viability of different crops, identification of appropriate irrigation technologies and the socio- economic impacts of these schemes (Makadho, 2000; Meinzen-Dick, 1993; Makombe and Sullins 1993; Mupawose, 1984; Ruigu and Rukuni, 1990; FAO, 2000; Rukuni, 1984).

2.2.10 Socio-economic challenges

2.2.10.1 Scheme ownership and inheritance

The question of scheme ownership raised a lot of problems because it was not clear to the farmers what scheme ownership means. The confusion was brought about by the fact that an irrigation scheme comprises of land and irrigation infrastructure on it. Some farmers could not understand what could be owned: the land or the irrigation equipment or both (FAO, 2009).

Management of the irrigation schemes is another challenge that most irrigation face. Most schemes have got an Irrigation Management Committee (IMC) and sub-committees under the IMC. On other schemes, there is a poor farmer selection scheme, operation, and maintenance of infrastructure is not adequate which affects the performance of the scheme (Makombe and Sullins 1993)**.**

2.2.10.2 Institutional challenges

The high cost of capital investment in irrigation works when one considers that communal farmers are resource poor. Rural infrastructure to facilitate input procurement and produce marketing is weakly developed in some areas, for example, roads, telecommunications, and electricity. Lack of reasonably priced appropriate irrigation technology for the smallholders. Shortage of human resources at both technician and farmer levels. Poor catchment management, which results in the siltation of some water bodies. Lack of decentralized irrigation service companies to give back-up service in rural areas.

Mupawose (1984) questioned the economic viability of smallholder irrigation schemes in Zimbabwe. The author pointed out that certain smallholder schemes have failed and are under-utilized. He attributed this to poor management, lack of inputs and irrigation experience by farmers. In the same report, Mupawose(1984) advocated for the reduction of subsidies on smallholder irrigation and indicated that irrigation development has become expensive.

2.2.10.3 Production challenges

Malanco et al. (2018) in his study concluded that water shortages currently experienced at the scheme are a result of inefficient water management by over-abstraction from the dam beyond the firm yield, adoption of inefficient irrigation methods and high channel losses in the canal Moyo *et al*. (2014) provided evidence that land utilization is low and the supply dam for Mkoba has siltation problems and cannot meet the irrigation-water requirements of the whole scheme. Irrigation conveyance channels at both schemes are not fully functional; water canals are leaking, and the night storage dam valves are not functional, leading to water losses. Issues such as very small plot sizes, land tenure, and infrastructure ownership, weak input and output markets, poor infrastructure, high transport costs, and poor policies were presented as the main productivity barriers in the schemes by (Moyo *et al*., 2014).

2.2.10.4 Marketing challenges

Lack of transport to the markets seems to be a problem for several schemes According to Dube (2016) irrigation schemes in Gweru are facing very transport costs transporters which depend largely on the condition of the roads which are poor. Some farmers complained that transporters are shunning their scheme because their feeder road is in a bad state and transporters who accept to come to the scheme charge exorbitant prices (Dube, 2016).

2.2.11 Factors affecting the contribution of irrigation to the livelihoods of smallholder farmers.

Dube (2016) discovered that Employment is both direct and indirect through the employment of people to work on the farms and indirectly through the provision of raw materials for other economic sectors. Well, managed irrigation schemes result in community economic development (Dube, 2016). Receipts from crop sales by farmers were channeled towards developmental activities. Funds were in the construction of better houses. The houses were fitted with corrugated iron roofs and cemented floors. The other money was used to drill home boreholes, purchase farming tools and equipment. The remainder was used to acquire livestock such as cattle, goats, and chickens. Most importantly irrigation profits were used for the acquisition of medicine and sending children to school.

Dube, (2016) discovered that irrigators' families live way above the national and provincial poverty datum line. Irrigators' family's average disposable income isUS$458.33 against the poverty household datum line for Midlands Province standing at US$157.48 and the national figure standing at US$161.56. High disposable income irrigators have enabled them to live a better quality of life. Irrigators were able to build better houses and furnish them to match urban housing standards. These houses are well equipped with gadgets such as television, radio, and telephone set being bought from irrigation income proceeds.

Agriculture performance has declined in communal smallholder irrigation schemes due to a plethora of challenges that have impacted negatively on the general performance of irrigation agriculture in the arid regions of the country. The results from the study revealed that membership composition which comprises mainly aged women who sideline youths from active participation by demanding

deterrent joining fees is a recipe for poor performance by most irrigation schemes in the district. It has been established that as women have other chores to perform for the daily upkeep of their families farming always suffers as less time is budgeted for it (Chisango and Maposa, 2016). Period of stay in irrigation schemes particularly by old members brings with it the reluctance by members to adopt new innovations and technologies which boost production as such members have allegiance to their traditional indigenous technologies, which however lack the capacity to match demands of the current trends of climate change and variability.

Failure by stakeholders to avail inputs on time and the porous distributive system which is on partisan lines have also been noted to be a major obstacle crippling operations, productivity and viability of smallholder irrigation agriculture in Zimbabwe's marginalised areas (FAO, 2008). It has been established that as the country continues to experience a sharp decline in agricultural productivity, this is a clear testimony that Zimbabwe will continue to struggle to reposition itself and regain its original status of being the breadbasket of the region (Chisango and Maposa, 2016).

2.3 Food security

The meaning of food security has gone through an evolution throughout the years, moving from a supply-focused concept mostly related to food availability, to a multidimensional notion to consider also food accessibility, food utilization and food stability (Pieters *et al*., 2012). The concept of food security was first originated in the mid-1970s when the World Food Conference (1974) defined food security in terms of food supply - assuring the availability and price stability of basic foodstuffs at the international and national levels. In 1983, the Food and Agriculture Organization of the United Nations analysis focused on food access, leading to a definition based on the balance between the demand and supply side of the food security equation. The definition was revised to include the individual and household level, in addition to the regional and national level of aggregation, in food security analysis. The concept of food security was defined in the World Food Summit (1996) to include food access, availability, food use and stability (FAO, 2006). Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and

food preferences for an active and healthy life (FAO, 2008). From this definition, four main dimensions of food security can be identified and which are physical availability of food, economic and physical access to food, food utilization and stability.

2.3.1 Food security and livelihoods

The link between livelihoods and food security is influenced by a variety of factors that differs in importance across contexts and over time there are pathways through which they influence household livelihood and food security as shown in Figure 1, that will serve a number of purposes (Woller, 2012). Therefore, the definition of food security may apply to the individual and rarely do definitions of food security refer to the household whether as an aggregation of individuals whose food needs must be met or as a unit.

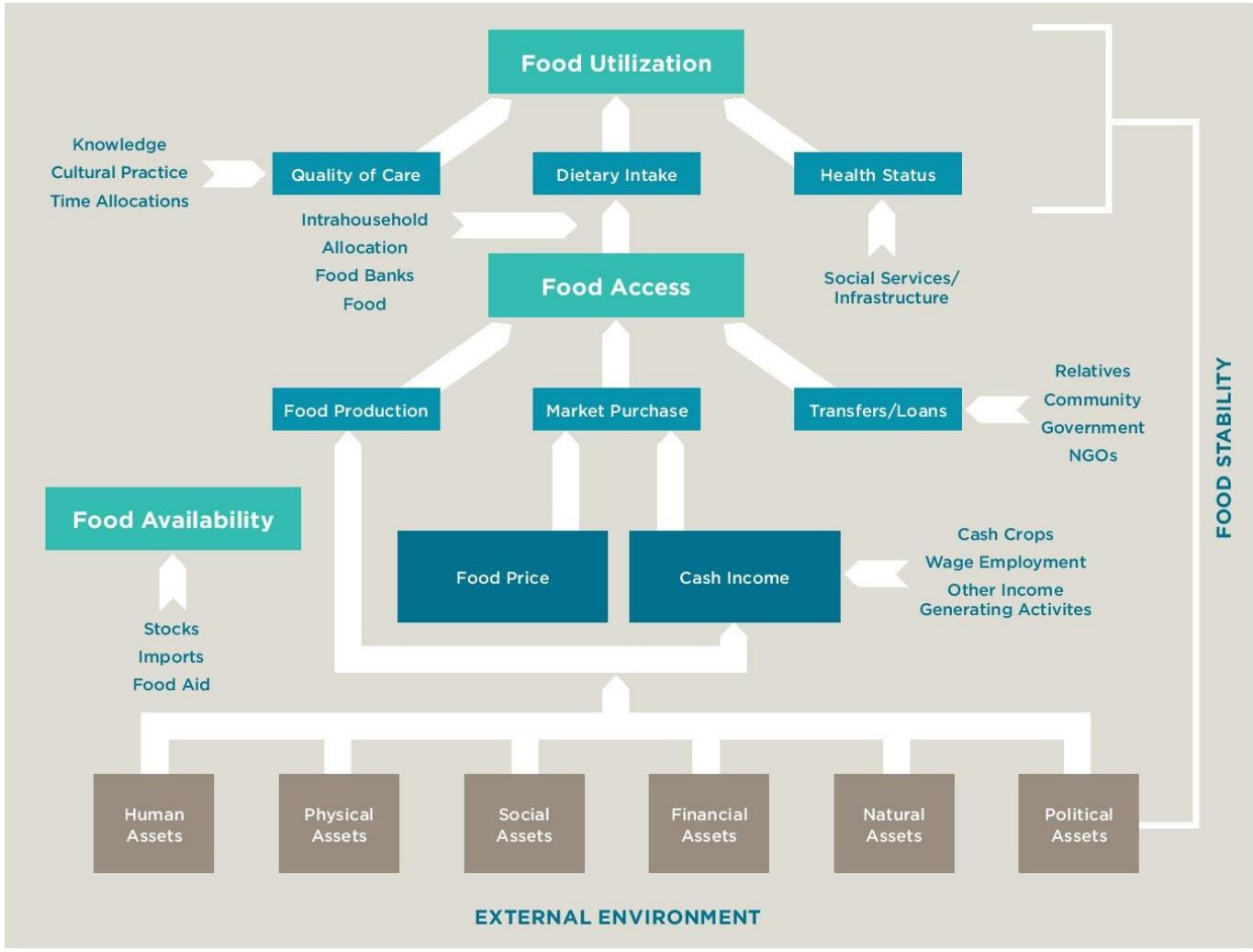

Figure 1: Food Security Framework

[Source: Woller (2012)]

Food security at the national level refers to the condition whereby the nation is able to manufacture, import, retain and sustain food needed to support its population with minimum per capita nutritional standards (Toit *et al*., 2011). At the community level, food security is defined as the condition whereby the residents in a community can obtain safe, culturally accepted, nutritionally adequate diets through a sustainable system that maximizes community self-reliance. At the household level, food security refers to the availability of food in one's home which one has access to. In this case, a household is regarded as food secure when the members of the family do not live in hunger or fear of starvation (Toit *et al*., 2011).

In many parts of the world and especially in developing countries, agriculture is key to food security (Toit *et al*., 2011). Hence, investing in agriculture is essential to improve food security for the majority of the world's poor, who rely directly on agriculture for subsistence (AusAID, 2011). Maize, wheat, and rice are the three major cereal crops that not only produced but also feed the world (Karim *et al*., 2015).

2.3.2 Food Access

Access refers to the resource individuals have at hand to obtain appropriate foods for a nutritious diet and was defined by USAID (1992) as when individuals have adequate assets or incomes to produce, purchase, or barter to obtain levels of appropriate foods needed to maintain consumption of an adequate diet and nutrition level. Individuals obtain food through, own food production and consumption (including wild food gathering), purchases in the market place and in-kind transfers or loans from relatives, members of the community, the government or foreign donors private citizens. An individual's ability to access food from these sources is in turn determined by their asset endowment and by the social, economic, policy, physical, and natural environments, which define the set of productive activities they can pursue in meeting their income and food security objectives. Opara (2013) explained that food access is influenced by the aggregate availability of food through the latter impact on supply and prices in the market.

Food accessibility is the physical access of food in the market and economic access at the household level (Opara, 2013; FAO, 2008). A household can access food if it has the opportunity to obtain the food of sufficient quantity and quality for a safe and nutritious diet (Pieters *et al*., 2013). The level of household income is a key determinant of a household's ability to spend on food which also measures household's food accessibility (Opara, 2013). Food access for urban dwellers, hinges primarily on the household's ability to purchase food whereas, for rural dwellers, food access rely highly on household's food production though in some instances may depend on the household's ability to purchase food (Muhihi *et al*., 2012). Household has a limited amount of resources at its disposal, including assets, labour, human capital, and natural resources and Muhihi *et al*. (2012) emphasised that the allocation of these resources to food production, wage labour or other business activities allows the household to access food, either directly or indirectly.

Household food accessibility is influenced by both the level of income available at a household, the quantity of livestock products and the quantity of maize produced. Moreover, the level of household income depends on the sales of livestock products, cash crops produced, maize produced and off-farm income.

2.3.3 Measuring Household Food Access in socio-economic evaluation

Accurate measurement of food access is not only important for targeting interventions but also facilitates the effectiveness and efficiency of evaluation as well as accurate provision of information to interested stakeholders, both national and international (Jones *et al*., 2013). Food access can be determined using four ways as they will be explained by the authors below.

2.3.3.1 Household Food Insecurity Access-related Conditions

These indicators provide disaggregated information on the behaviors and perceptions of the surveyed households. If a program is providing assistance in growing staple crops and improved storage facilities, it might be useful to understand what percent of households had run out of food (Castell *et al*., 2015). The indicators present the percent of households that responded affirmatively to each question,

regardless of the frequency of the experience and can measure the percentage of households experiencing the condition at any level of severity. Each indicator can be further disaggregated to examine the frequency of experience of the condition across the surveyed households (Coates *et al*., 2007).

Households experiencing the condition at a given frequency = Percent of households that responded often to a specific frequency-of-occurrence question.

$$= \frac{\text{Number of households with response 3 to Q7a}}{\text{Total number of households responding to Q7}} \times 100$$

2.3.3.2 Household Food Insecurity Access-related Domains

These indicators provide summary information on the prevalence of households experiencing one or more behaviors in each of the three domains reflected in the HFIAS which are anxiety, uncertainty, insufficient quality, and insufficient food intake and its physical consequences.

Household Food Insecurity Access-related Domains =

Households experiencing any of the conditions at any level of severity in each domain=Percent of households that responded yes to any of the conditions in a specific domain.

$$\frac{\text{Number of households with response = 1 to Q2 OR 1 to Q3 OR 1 to Q4}}{\text{Total number of households responding to Q2 OR Q3 OR Q4}} \times 100$$

2.3.3.3 Household Food Insecurity Access Scale (HFIAS)

The household food insecurity access scale is a 9-item food insecurity experiential measure that was developed by the USAID Food and Nutrition Technical Assistance Project (FANTA) in an increasing need to have a universally comparable and cost-effective measure of food security (Coates *et al*., 2007). It consists of a self-administered questionnaire with occurrence and frequency question progression; from anxiety, quality and quantity up to outcome questions. The validated scale ranges from 0 to 27, and this scale produces a prevalence measure of four food security categories, viz; food secure, mildly food insecure, moderately food insecure and severely food insecure (Castell *et al*., 2015).

The use of HFIAS in several countries shows its ability to capture different food security situations in different settings at a cheaper cost. The information generated by this tool can be of valuable use to assess the prevalence of household access food insecurity which is vital for geographical targeting (Coates *et al*., 2007). HFIAS studies in developing countries show that it is a reliable and valid tool in capturing access components of food security (Gebreyesus *et al*., 2015; Castell *et al*., 2015; Knueppel *et al*., 2010).

The HFIAS is a tool that assesses food insecurity. It measures the severity of food insecurity in the past 30 days, as reported by households themselves. It also detects changes in the household food insecurity situation over time. The questions can be added to a standard baseline and final evaluation survey (Coates *et al*., 2007) . The HFIAS provides a simple and user-friendly approach for measuring impacts of development food aid programs on the access component of household food insecurity. It allows the extent and severity of food insecurity at the household level to be assessed is a useful measure for comparing food access across different population groups. It can be used for monitoring and also for evaluation of the impact of policies or programs. It can be integrated into a food security information system to monitor trends on a long-term basis (Coates *et al*., 2007). The use of the tool at the global level for cross-country comparisons is theoretically possible as the questions it asks are based on universal behaviors. The guide includes a standardized questionnaire and data collection and analysis instructions. The tool is composed of nine questions that ask about food consumption

patterns due to limited resources to acquire food. The questions should be directed to the person in the household who is most involved with the food preparation and meals to respond on behalf of the entire household, (Jennifer C, *et al*, 2007).

HFIAS is calculated as:
HFIAS Score (0-27) = Sum of the frequency-of-occurrence during the past four weeks for the 9-food insecurity-related conditions.

$= \sum (Q1a + Q2a + Q3a + Q4a + Q5a + Q6a + Q7a + Q8a + Q9a)$

2.3.3.4 Household Food Insecurity Access Prevalence

The Household Food Insecurity Access Prevalence (HFIAP) status indicator is used to report household food insecurity (access) prevalence or instance. The HFIAP indicator can be reported in addition to the average HFIAS Score for program monitoring and evaluation (Jones *et al*., 2013). The HFIAP indicator categorizes households into four levels of household food insecurity (access) which are food secure, mild, moderately and severely food insecure and households are categorized as increasingly food insecure as they respond affirmatively to more severe conditions and/or experience those conditions more frequently as shown in Figure 2.

A food secure household experiences none of the food insecurity (access) conditions or just experiences worry but rarely. A mildly food insecure (access) household worries about not having enough food sometimes or often and is unable to eat preferred foods or eats a more monotonous diet than desired or some foods considered undesirable (Coates *et al*., 2007) . But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating). A moderately food insecure household sacrifices quality more frequently by eating a monotonous diet or undesirable foods sometimes or often or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions (Coates *et al*., 2007). A severely food insecure household has graduated to cutting back on meal size or number of meals often and experiences any of the three most severe conditions (running out of food, going

to bed hungry, going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered severely food insecure.

Question	Frequency		
	Rarely 1	Sometimes 2	Often 3
1a			
2a			
3a			
4a			
5a			
6a			
7a			
8a			
9a			

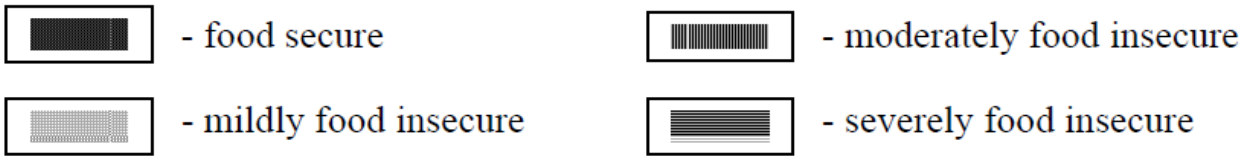

Figure 2: HFIAP [source :Coates et al., 2007]

2.4 Conceptual framework

2.4.1 The Household Livelihood Approach

The household livelihood model is a framework that describes an approach for understanding the context in which a household pursues a sustainable livelihood. Livelihood term is often used in place of economic strengthening which refers to economic production, employment, and household income. Woller (2012) explained that a more holistic understanding of livelihood incorporates a general definition within a broader context of economic development, reduced vulnerability, and environmental sustainability. The focus of the sustainable livelihood approach is on household ways in which it uses its assets to undertake a range of livelihood activities and to ensure its livelihood security which can be defined as the adequate and access to income and other needs (Chambers *et al*,1991).

The household livelihood approach can be incomplete when there is no incorporation of the sustainable livelihood approach, which was be defined as Livelihood comprises the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living as shown in Figure 3. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels in the short and long term (Chambers *et al*,1991).

Food security is one of many household needs and is, therefore, one of a range of factors households consider in determining how they balance competing interests so as to subsist in both the short and longer terms (Coates et al., 2007). Household needs differ from household to household but some basics cover a spectrum of food, education, health, and personal needs.

This concept emphasizes that food still constitutes a critical basic need and looms large in any conceptualization of household livelihood. In fact, the close relationship between food security and livelihood is a consistent theme (explicit or implied) in definitions of food

security, Maxwell (1991) food security will be achieved when equitable growth ensures that the poor and vulnerable have sustainable livelihoods.

Food production constitutes one of the most basic livelihood activities and can be a critical source of food access, particularly for rural households. The household's ability to purchase food in the marketplace is another critical determinant of food access, which in turn depends on the household's ability to generate income. Food insecurity in developing countries, even among so-called subsistence farming groups, are net purchasers of food, reinforcing the critical role of income generation in determining food access (Maxwell, 1991).

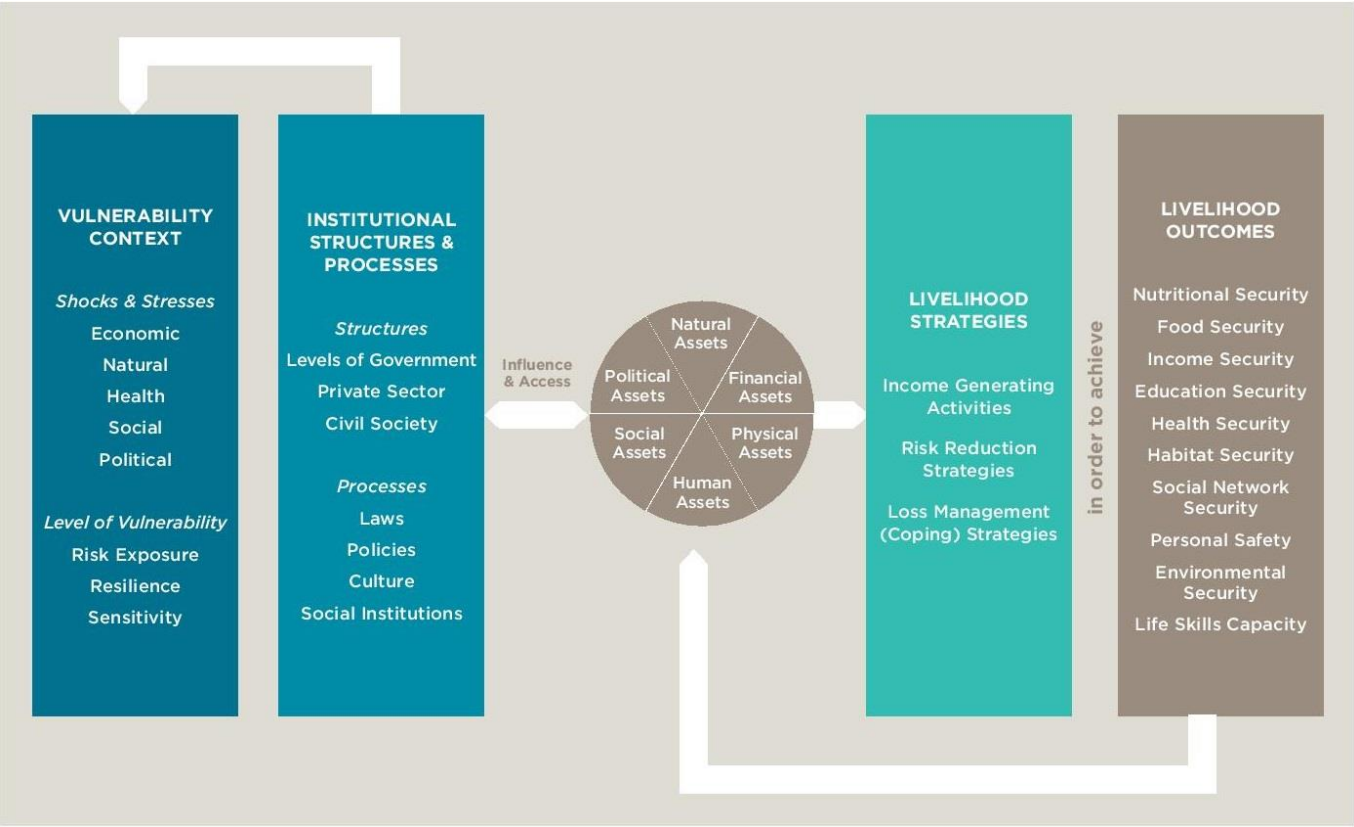

Figure 3: The Household Livelihood Framework

[Source: Woller (2012)]

It is thus not surprising that research further indicates that the quantity and quality of food consumed is positively associated with household income and food production. As USAID (1995) has noted, the primary cause of food insecurity is the continued lack of economic opportunity to produce adequate amounts of food or to obtain sufficient income to purchase adequate amounts of food. As incomes rise, poor households spend more on food (although proportionately less than the increase in income), purchase a more diverse

variety of foods, and shift to higher quality foods with greater nutritional value (Behrman, 1995; Diskin, 1995; Kennedy, 1989). A household's livelihood activities, moreover, enable it to manage risks, cope with stresses and shocks, and build or replenish assets, all important determinants of household food security.

2.5 Summary of literature review.

Views by other authors about irrigation crop production, challenges faced in irrigation schemes had been explored in this chapter. Livelihoods that rely on irrigation had been discussed and how crop production promotes sustainable life in irrigation schemes. The status of food security in farmers was viewed, food access in particular and how this food security pillar is determined in communities. Finally, the conceptual framework was discussed which all the issues of irrigation schemes, crop production, and food security hinged on.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter outlines the framework for the analysis of the contribution of irrigating maize, in irrigation schemes by smallholder farmers to the household income and food security in Zimbabwe, case of Tokwane Ngundu irrigation scheme in Masvingo District, Zimbabwe. Various techniques and methods were used in analyzing data. The Chapter looks at research design, population, sampling procedures, sample, research instruments and the methods used for data analysis. The aim of the Chapter is therefore to provide techniques on how to collect the data that tries to achieve objectives set during this research, with proper justification of the variables included.

3.2 Study area

Tokwane Ngundu is an irrigation scheme in Masvingo province which is located in the lowveld of Zimbabwe, the map location of the scheme is shown in Figure 4. It has minimal rainfall patterns of about 600mm per annum and the average annual temperature is about 20 degrees Celsius. A large part of the province is drought prone for example Region 5 such that most parts are unfit for agriculture, apart from cattle ranching. The scheme was established in 2003 when a canal that connects from the Tokwe Mkosi dam to Triangle Estates was completed. There were dryland farmers who had been settled in this area and so farmers for village 8 of Ward 30 of Masvingo were awarded the privilege of harnessing the water from the great canal to irrigate their crops.

Ward 30 has a total area of 1076 households of which 88 of them are in village 8 where they irrigate their crops. The irrigation scheme covers about 258ha, which is divided into 4 sections: section A with 59ha, section B with 66ha, section C with 72.2 and section D with 61.5ha. according to the records provided by Agriculture Officers of DOIRR working within the scheme. The height above sea level of this ranges from 450m to 1240m (Victoria East) above sea level. Generally, the soils in the region are fersiallitic type, the terrain in

the district ranges from moderate to steep slope and in areas where slopes are high, soils are shallow and are of poor texture, the potential for erosion hazards exist.

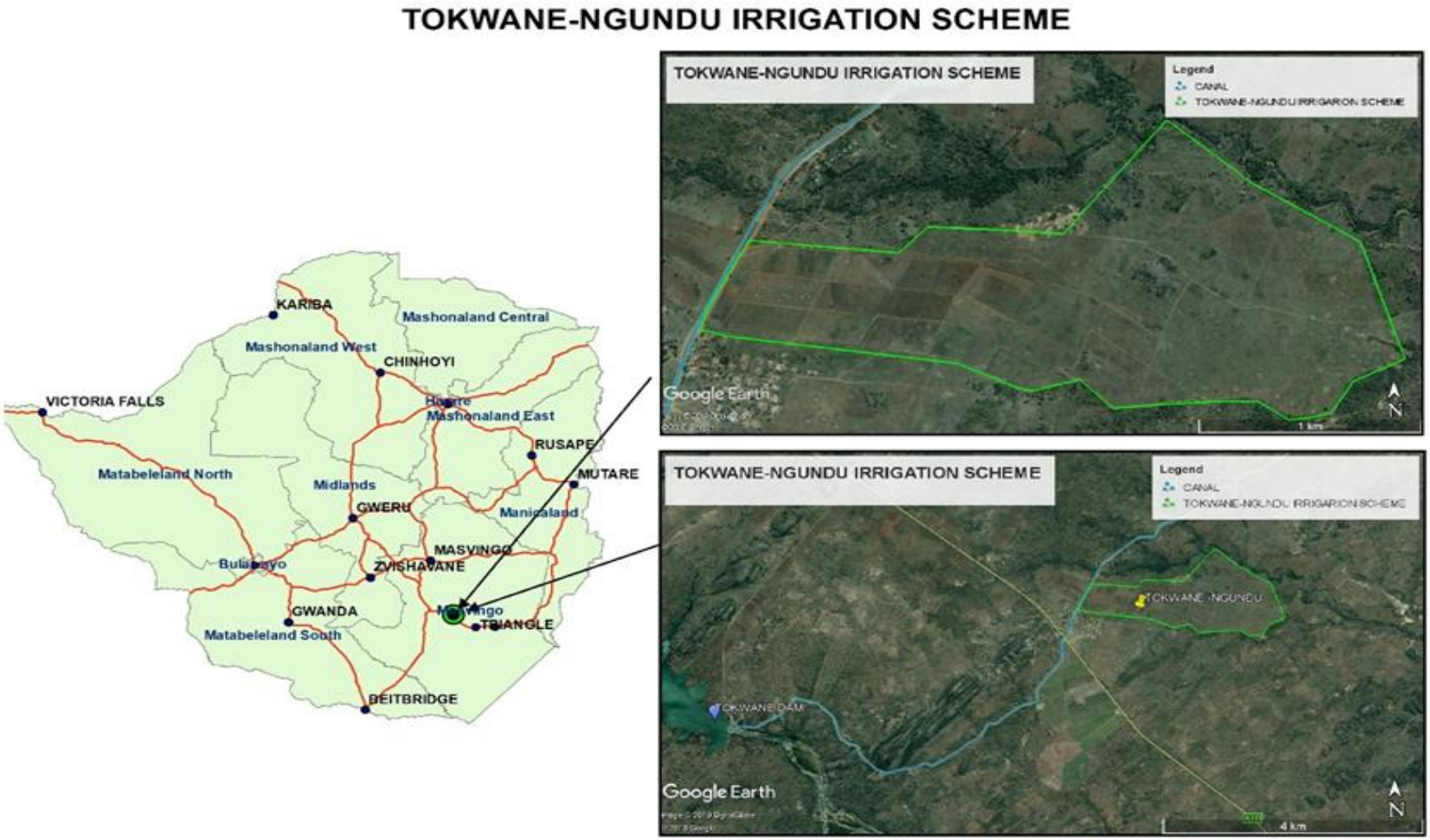

Figure 4: Tokwane Ngundu Irrigation Scheme

[Source: Google Earth]

3.3 Research design

A survey was conducted to collect data using structured questionnaires and interviews with both households and agricultural extension officers within the irrigation scheme. They are particularly useful for nonexperimental descriptive designs that seek to describe reality (Nigel *et al*.,2009). A survey is based on some form of random sampling technique, Nigel and his colleagues (2009) explained that the sample produced will represent the particular population under study and will produce findings which may be generalised to the wider population.

3.4 Sampling procedure

Masvingo province is one of the semi-arid areas of Zimbabwe and has been divided into seven districts namely Bikita, Gutu, Masvingo, Zaka, Mwenezi, Chiredzi, and Chivi. There are a total of 66 irrigation schemes in the province as highlighted by the Department of Irrigation (2018) report. A multistage sampling method was employed during the research. The researcher purposively selected Masvingo District with 17 irrigation schemes. Purposive sampling method provides researchers with the justification to make generalisations from the sample that is being studied, whether such generalisations are theoretical, analytic and logical in nature (Gaganpreet, 2019). Using Purposive sampling method again Tokwane Ngundu irrigation scheme was selected in ward 30, which has got 12 villages. However, village 8 which has a total population of 88 farmers was purposively selected due to its attributes of producing maize under irrigation.

Then random sampling method gives each possible sample combination an equal probability of being picked up and each item in the entire population has an equal chance of being included in the sample (Kothari, 2004). A sample was determined using the formula below:

$$\boldsymbol{n = \frac{N}{1+N(e)^2}}$$ where,

- *n* refers to sample size
- *N* refers to the population size,
- *e* refers to the level of significance.

Out of the population of 88 households, 70 households were randomly sampled. The question of how big the sample should be unfortunately has no obvious answer (Juselius, 2006). Whether the sample is small or big is a function not only of the number of observations but also of the amount of information in the data (Nyangara, 2013). The optimum sample size is one that fulfills the requirements of efficiency, representativeness, reliability, and flexibility (Kothari, 2004).

All agriculture extension officers in the selected ward were interviewed as key informants, where 3 of them were supervising maize production under irrigation and 2 of them were supervising production under dry farming but both of them had knowledge of maize production and household standard of living.

3.5 Data collection methods

Targeted households were interviewed in their local languages, which is Shona and the researchers recorded the responses on the questionnaire and the interview guide. The questionnaire included sections on household demographics, socioeconomic characteristics, Household Food Insecurity Access Score. Close-ended and open-ended questions were used to complement each other due to the need for direct answers and in-depth explanations. Close-ended questions require less time to complete and the answers are easy to code and analyze statistically which eliminates interpretation bias by the researcher Sanders *et al.* (2003) but they do not leave room for spontaneity and expressiveness (Rosenthal *et al*., 2008). While open-ended questionnaires were flexibility as they provided the respondents to let their thoughts roam freely and spontaneously although most respondents find them difficult and time-consuming to respond to in writing (Rosenthal *et al*., 2008).

Observation was done to assess the standard of living within the community, and the state of crops in the fields under irrigation. Appearance (dressing and skin status), assets, the general status of the household as well as building conditions were observed by the research so as to give a general observed comment on the financial status of the household. Walshe *et al*. (2011) explained that data collection using observation span research paradigms and qualitative approaches contribute to allowing the explanation of social processes and phenomena and can facilitate understanding of

what people do and how these can alter in response to situations and over time, especially where people find their own practice difficult to articulate.

Key informants guide was used to interview the agricultural officers, to get information about the farming standards that the farmers are supposed to meet, the current production status and some general challenges that the irrigation scheme is facing according to their observation since they work with farmers every day. Key informant interviews often provide data and insight that cannot be obtained with other methods and they may tell of incidents, local happenings or conditions that explain implementation problems (Kumar, 1989). Table 1 shows the data collected and tools used for each objective.

Table 1: Summary of data collection

Objective	**Data to be collected**	**Data gathering tool**	**respondents**
To explore the socioeconomic, institutional, production and marketing challenges faced by smallholder maize farmers under irrigation semi-arid region of Zimbabwe	Landownership, boundaries, irrigation system maintenance, rainfall, inputs prices, pests and diseases, selling price, markets availability, transport	Questionnaire and Interview, Key informant guide	Heads of the household.
To determine factors that affect the contribution of smallholder maize irrigation farming to household income in the semi-arid region of Zimbabwe	Age of household head, irrigated area, maize yields, other income, green cod, dry grain income, total maize income,	Questionnaires. Interviews, Key informant guide	Heads of households.
To assess smallholder maize irrigation farmers' access to food in Tokwane Ngundu Irrigation Scheme, Zimbabwe.	Number of meals, reserved grain(t), a period of food shortage, frequency of occurrence 9 questions	Questionnaires. Interviews, Key informant guide	The person responsible for preparing food within the household.

[Source: survey data, 2019]

3.6 Data analysis

To explore challenges, descriptive statistics was used, multiple linear regression was used to determine factors affecting the contribution of maize to household income. Food security was assessed using Household Food Insecurity Access Score (HFIAS) and Household Food Access Prevalence (HFIAP). The higher the HFIAS the more the household is food insecure. Table 2 shows the analytical framework that was used in the study. Details of the data analysis methods used are in Chapters 4 and 5.

Table 2: Data Analysis

Objective	**Data collected**	**Data analysis methods**
To explore the socioeconomic, institutional, production and marketing challenges faced by smallholder maize farmers under irrigation semi-arid region of Zimbabwe	Landownership, boundaries, irrigation system maintenance, rainfall, inputs prices, pests and diseases, selling price, markets availability, transport	Descriptive statistics: descriptives and frequencies
To determine factors that affect the contribution of smallholder maize irrigation farming to household income in the semi-arid region of Zimbabwe.	Age of household head, irrigated area, maize yields, other income, green cod, dry grain income, total maize income,	Multi-Linear Regression
To assess smallholder maize irrigation farmers' access to food in Tokwane Ngundu Irrigation Scheme, Zimbabwe.	Number of meals, reserved grain(t), the period of food shortage, frequency of occurrence 9 questions	Descriptive statistics: descriptives and frequencies

[Source: Survey Data, 2019]

3.7 Ethical considerations

The approval letter was sort from college, the Faculty of Agricultural Economics and Environmental Science and was granted. The approval letter from college was used to request for authority from the Department of Irrigation to collect data in Tokwane Ngundu irrigation scheme and permission was granted as shown in Appendix 6.

Chief Nyajena was notified and Headman Maregere was visited to solicit for permission. This is in sync with the consideration of the norms and cultures of a community whenever carrying out research. The chairperson of the irrigation scheme and the whole committee were consulted and all villagers were notified and were aware of the research, which made the data collection easier. The questionnaire had an introductory section at the beginning as shown in Appendix 1 such that the participant was notified of why he was giving out that information. Moreover, there was a consent form that was signed in duplicate by both the researcher and the participant as shown in Appendix 3. Openness was therefore considered whereby clarity on how data provided, remained confidential.

3.8 Summary

This Chapter presented an overview of the research methods that were used to carry out the research. The research used a quantitative descriptive research method. The chapter looked at the research design used by the researcher in carrying out the study. The target population and sampling procedure were also defined in the chapter together with the sampling techniques employed. The Chapter looked at data collection methods and instruments used. Table, figures and graphical presentations as appropriate were used to present the data collected for ease of understanding and analysis. The following chapter presents the research findings gathered from data analysis.

CHAPTER 4

RESULTS

CHALLENGES AND FACTORS THAT INFLUENCE THE CONTRIBUTION OF SMALLHOLDER MAIZE IRRIGATION FARMING TO HOUSEHOLD INCOME IN SEMI-ARID REGION OF ZIMBABWE

ABSTRACT

This research seeks to explore challenges that are faced in Tokwane Ngundu irrigation schemes and to determine factors that influence the contribution of smallholder maize farming to household income. Maize is the major crop being produced in this irrigation scheme. Some researches in irrigation schemes but little is known about maize production in Tokwane Ngundu and how it contributes to household income, hence this research will help the beneficiaries in irrigation schemes in improving the contribution of maize production to their household income and food security. Multistage sampling was used to purposively select study area and random sampling was used to choose participants. Structured questionnaires and key informants' interviews, as well as observations, were used to collect data. To explore challenges, descriptive statistics were used and multiple linear regression was used to determine factors affecting the contribution of maize to household income. Mismanagement of irrigation resources by irrigation scheme management, water unavailability and high-water costs, inputs unavailability and input costs, market availability were discovered to be the challenges affecting maize production in the irrigation scheme. The area under production and age of household heads were tested at a 95% significance level and the average maize yield was tested at a 90% significance level, all of them proved to statistically affect the contribution of maize to household income. In conclusion, there are challenges that are reducing the full capacity of maize production in the irrigation scheme and some factors have been discovered that influence the contribution of irrigation maize farming to household income. Recommendations were made that irrigation farmers should get agricultural extension education, use improved hybrids of maize seeds, use optimum fertilizer applications and use recommended pesticide dilutions to improve maize yields. Young farmers in the irrigation scheme should receive agriculture training and education to acquire more experience from expertise to improve maize yields since age has been found to have an effect on the contribution of maize on household income

Key Words: Income, smallholder irrigation farming, maize, irrigation scheme.

4.1 Introduction

Agriculture contributes a substantial share to the GDP of many developing countries and it is often the leading sector of the economy as a source of income, employment and foreign exchange Tsehaye (2014). Agriculture is the source of most food basics which includes growing crops, rearing livestock and fish farming. Most crops that are produced under irrigation in Zimbabwe include wheat, maize, rapoko, beans, and horticultural crops. Maize is one of the major crops produced under irrigation in most Southern African countries. In Zimbabwe, maize as a staple crop is being produced under irrigation and Tokwane Ngundu irrigation is one example of irrigation schemes that is producing maize as a major crop.

Irrigation development is a special case of agricultural development in which technology intervenes to provide control for the soil moisture regimes in the crop root zone to achieve a high standard of continuous cropping (Rukuni *et al*., 1994). Irrigated agriculture is the most viable means of reducing crop failure, hunger, and malnutrition in Africa, and an effective means for improving the competitiveness of smallholder farming in most parts of Africa (World Bank, 2008).

A number of studies have claimed that earlier irrigation schemes, established by missionaries in the 1930s, performed well in terms of agricultural performance, financial and economic viability (Zawe *et al*, 2014). Roder (1965) indicated that irrigation projects have been successful in enabling farmers to obtain a certain amount of wealth, substantially more than dryland farmers, probably more than employees of white farmers. Irrigation plays a key role in the performance of agriculture, which increases income growth. Income growth is essential for economic growth (Hussain *et al*., 2001). Irrigation is a key driver behind the growth in agricultural productivity and increasing household income which highlights the various ways that irrigation could have an impact on poverty. Lipton *et al*.(2004) as cited by Haile (2008) explained that there are four interrelated mechanisms by which irrigated agriculture can reduce poverty which is (i) increasing production, household income and reduction of food prices, that help very poor households meet the basic needs and associated with improvements in household overall economic welfare, (ii) protecting against risks of crop loss due to erratic, unreliable or insufficient rainwater supplies, (iii) promoting greater use of yield-enhancing farm inputs and (iv) creation of additional employment, which together enables people to move out of the poverty cycle.

However, some of the irrigation schemes in Zimbabwe are facing sustainability challenges which have left some of them in a state of disrepair or operating below their design capacity despite the critical value for food security, stabilisation of agricultural production, employment creation and poverty alleviation (Makadho *et al*., 2004). Moreover, significant droughts were recorded in Zimbabwe, in the 1980s, early 1990s and 2000 which then makes irrigation agriculture a cushion of crop failure under such conditions (Perry, 1997; Svendsen *et al*, 2009). In the same way, Zhou *et al*. (2008) mentioned that irrigation contributes to agricultural production in two ways that are increasing crop yields and enabling farmers to increase cropping intensity and switch to high-value crops. Therefore, irrigation can be an indispensable technological intervention to increase household income.

There is the number of constraints, which are hampering smallholder irrigation development in Zimbabwe which include high cost of capital investment in irrigation works when one considers that communal farmers are resource-poor, rural infrastructure to facilitate input procurement and produce marketing is weakly developed in some areas, for example, roads, telecommunications, and electricity. Lack of reasonably priced appropriate irrigation technology for the smallholders and shortage of human resources at both technician and farmer levels has been explained as other challenges (Mutambara *et al*.,2014). Poor irrigation catchment management, which results in the siltation of some water bodies as well as lack of decentralized irrigation service companies to give back-up service in rural areas has been discovered to affect negatively production in irrigation schemes.

Mupawose (1984) questioned the economic viability of smallholder irrigation schemes in Zimbabwe. The author pointed out that certain smallholder schemes have failed and are under-utilized due to poor management, lack of inputs and irrigation experienced by farmers. In the same report, Mupawose (1984) advocated for the reduction of subsidies on smallholder irrigation and indicated that irrigation development has become expensive. He suggested that some form of cost recovery should be employed in these schemes.

A number of researches have been carried out on small scale irrigation schemes but the focus has been mainly on analysis of the design options and water management, financial viability of

different crops, identification of appropriate irrigation technologies and the socio-economic impacts of these schemes (Mupawose (1984); Mutambara *et al*.,2014; Zhou *et al*. (2008); Makadho *et al*., 2004); (Zawe *et al*, 2014). Roder (1965) Tsehaye (2014) (Hussain *et al*., 2001)). Little has been researched concerning the contribution of irrigating maize to household income in Tokwane Ngundu, Zimbabwe.

Therefore, this research seeks to explore challenges that are faced in Tokwane Ngundu irrigation schemes and the factors that influence the contribution of smallholder maize irrigation farming to household income. This will help the beneficiaries in irrigation schemes in improving the contribution of maize production to their household income and food security.

4.2 Material and methods

4.2.1 Study area

Tokwane Ngundu is an irrigation scheme in Masvingo District under Masvingo Province, which is found in the semi-arid region of Zimbabwe. It has minimal rainfall patterns of about 600mm per annum and the average annual temperature is about 20 degrees Celsius. A large part of the province is drought-prone for example Region 5 such that most parts are unfit for agriculture, apart from cattle ranching. More details for the study area refer to Chapter 3, section 3.2.

4.2.2 Research design

A crossectional survey was done to collect data from households. More details research designs are explained in Chapter 3, section 3.3

4.2.3 Sampling procedure

Using a multistage sampling method purposive sampling method was first used to select the irrigation scheme in the district, to select the village to carry out the research. Random sampling method was then used to select households to participate in the study. More details of the sampling procedure are explained in Chapter 3, section 3.4

4.2.4 Data collection procedure

The researcher used structured questionnaires and key informants interview guides to collect data. A structured questionnaire was used to collect demography information, challenges, and factors affecting participants in the scheme, area of household's field, sources of income and maize selling price. Key informants were interviewed to information about when the scheme was established, area of the scheme, crops planted, maize production challenges, market status, and socio-economic activities. Details of data collection methods are in Chapter 3, section 3.5

4.2.5 Data analysis

Descriptive statistics which includes means and frequencies were used to analyse institutional, socio economic, production and marketing challenges in the irrigation scheme. To determine factors influencing the contribution of smallholder maize irrigation farming to household income, the multiple linear regression was used. According to Greene (2008), the prime objective of regression analysis is to determine the factors that affect the dependent variable. Therefore, linear regression analysis was used in this study to determine the factors influencing the contribution of smallholder maize irrigation farming to household income in Tokwane Ngundu Irrigation scheme, since the dependent variable was numeric and normally distributed. The variables used in the regression model are shown in Table 3.

Model specification:

The model was specified as follows;

$$Y = \beta_0 + \beta_1 \mathbf{age} + \beta_2 \mathbf{hhsize} + \beta_3 \mathbf{yld} + \beta_4 \mathbf{price/t} + \beta_5 \mathbf{pltpop} + \beta_6 \mathbf{ha} + \mathbf{e}$$

Where;

Y= the dependent variable, is the contribution of irrigation maize farming to household income,

$$Y = \text{maize contribution} = \frac{\text{total maize income}}{\text{total household income}} \times 100$$

where,

Total maize income = ∑ green cob income + total dry gain sale

total household income = ∑ total maize income + other income

β_0 = constant variable

β_1----β_4 = Coefficients of factors affecting the contribution of irrigation maize farming to household income,

Age = Age of household head

hhsize = *total* household size

yld = total maize yields

price/t = maize price per tonne

pltpop = total plant population per hectare

ha = area under irrigation

e = is the stochastic error term which captures all other factors neglected but affecting the contribution of irrigation maize farming to household income

4.2.6 Challenges encountered during data collection

There were very limited challenges met since the agricultural extension officers were available waiting to help me through my data collection in the irrigation scheme. However, most household heads failed to give total amounts of income they got from maize production since they did not have records. The interviewer had to probe so as to get better estimates.

4.3 Results and discussions

4.3.1 Demographic profile of participants

The majority (62%) of the households which participated in the survey were headed by men. Muparange (2002) discovered that in smallholder irrigation schemes, most of the farmers were females and youths who generally are not interested in agricultural production, which is a contrasting scenario in Tokwane Ngundu irrigation schemes which have more male-headed households participating in maize production by irrigation. Girma *et al*. (2012) explained that there is a relationship between gender and participation in agriculture activities. Of the study sample that participated in the survey, 71% of households were headed by married men, 9% were widowed, 6% were divorced and 14% were single as displayed in Table 3. The mean household

size of the study participants was 7 against the national average of 5 (ZimVac, 2012). A household with the smallest number of family members had 3 while the biggest family had 16 members

The youngest interviewed farmer was 31 years old while the oldest was 80. The mean age of the participants was 50 years. Regnard (2006) urges that in total the accumulation of wealth is highly dependent on the age of an individual, whereby a direct relationship is experienced. Most (46%) of the participants had O level, 36% had tertiary education, 14% had primary education and 11% had secondary education up to ZJC. The level of education is a factor of both economic growth and productivity (Mwikila, 1992). The implication of this is that the majority of household heads in the study sample had basic education enough for them to seek or receive better agricultural production and marketing technologies available from different sources such as extension agent, publications and mass media. In Sub Saharan Africa, a low level of education has been blamed for limiting access to information and understanding of commercial farming concepts which are critical to sustaining high production levels in irrigation schemes (Shah *et al*., 2002). Studies by Dube, (2016) in irrigation schemes in Gweru that education enhanced farm productivity directly by improving the quality of labor and is critical to crop production, especially in a rapidly changing technological or economic environment.

Table 3: Demographic profile of participants

Marital status	
Married	71%
Single	14%
Divorced	6%
Widowed	9%
Education of head of household	
No formal education	26%
Grade 7	14%
ZJC	11%
O-level	46%
Cert. or Diploma	3%

[Source: survey data 2019]

4.3.2 Agricultural activities practiced in Tokwane Ngundu irrigation Scheme

Tokwane Ngundu irrigation scheme has a total area of 258ha where the largest individual owned plot is 5ha and the least is 1ha. On average each household owns 3.214ha. All plots were self-owned and the participants had title deeds. Maize is the major crop being produced in the irrigation scheme, however, crops like sugar beans, cowpeas, and horticultural vegetables are also grown in the scheme. The irrigation scheme used the canal system to draw water from source and flooding for irrigating individual plots.

4.3.3 Maize production in Tokwane Ngundu Irrigation Scheme

A sample study area of 223ha which all was under irrigation maize production and occupied by 70 out of 88 farmers. A participant with the smallest plot had 1ha while the biggest plot was 4.5ha. The minimum maize yield per hectare was 0.80 tonnes while the maximum maize yield was 4.7 tonnes. Average maize yield per hectare was discovered to be 1.73tonnes. The participant who sold dry maize grain with the lowest price was $330 per tonne and the highest maize market fetched $730 per tonne. On average maize was sold at $635 per tonne. Makombe and Sampath (2010) emphasized that irrigation is employment creation and poverty alleviation, however with Tokwane Ngundu, the level of their average maize output per hectare, which is as low as 0.80 t/ha can sustain the livelihood of a household per season. This level of maize production may be due to a lack of proper resources such as improved seed varieties, right quantities of fertilisers and lack of production skills.

4.4 Challenges of participants

4.4.1 Socio-Economic challenges

Mismanagement of resources by irrigation scheme committee members was the major socio-economic challenge in Tokwane Ngundu irrigation scheme highlighted by 77% of the study participants. The least socio-economic challenge were conflicts that arose in plot boundaries expressed by 14,3% of the interviewees as shown in Figure 5. Other socio-economic challenges that were faced in this scheme were ownership conflicts with 28.6% of respondents and inheritance disputes with 34,3 respondents. Mupawose (1984) attributed his findings of the irrigation of

scheme underutilization to mismanagement of irrigation resources like equipment by the management committee.

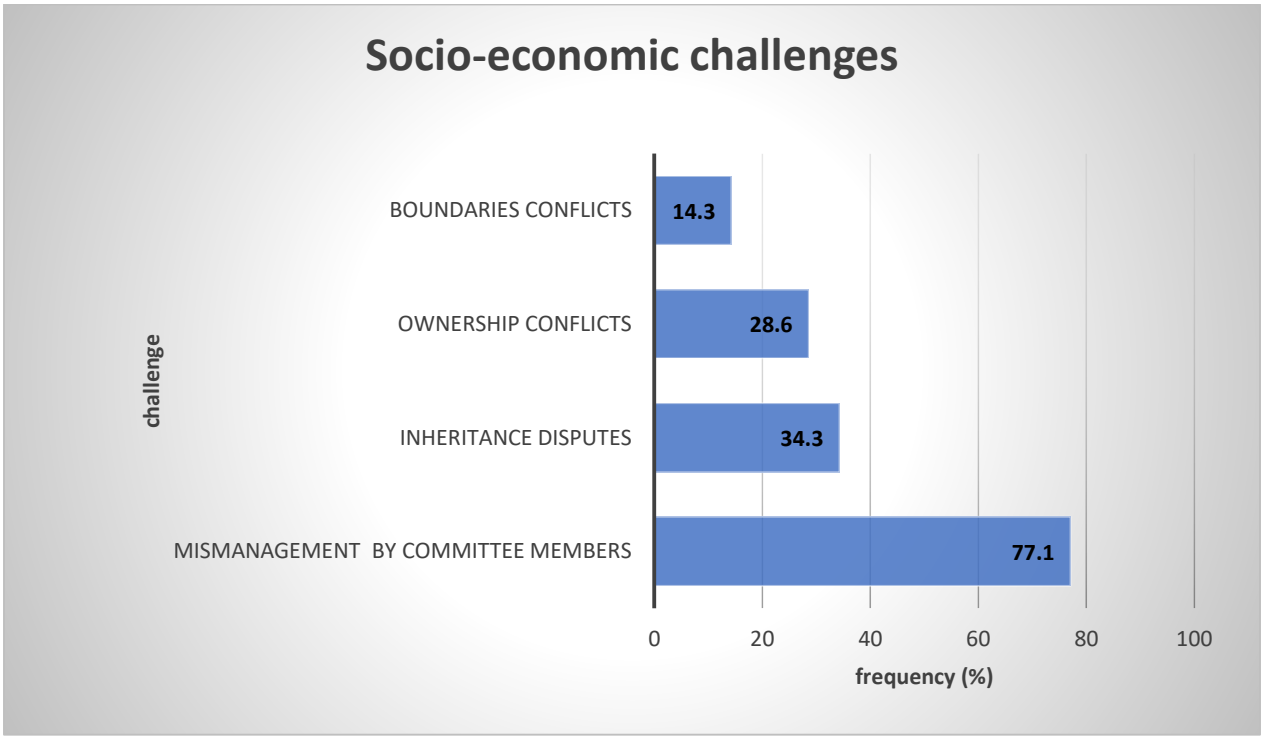

Figure 5: Socio economic challenge [source: survey data 2019]

4.4.2 Institutional Challenges

Water unavailability with 100% of participants was found to be the challenge in the scheme that affected all farmers. The inadequacy of training hours of extension services was the least institutional challenge with 2.9% of the participants being affected with this challenge. Chidenga (2003), explained that lack of knowledge and understanding of operation and maintenance of irrigation infrastructure imposes limitations to irrigation development. Figure 6 shows other institutional challenges which include high water costs, training services unavailability and electricity unavailability.

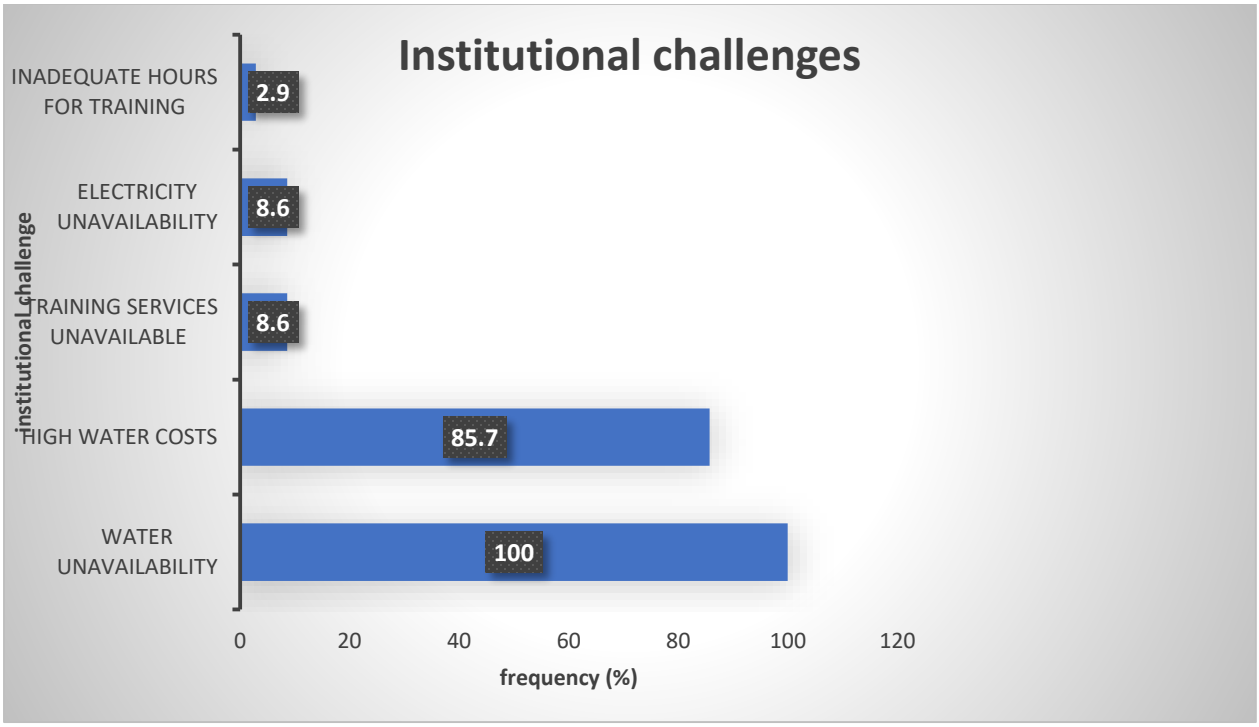

Figure 6: Institutional Challenges [source: Survey data 2019]

4.4.3 Production challenges

Input unavailability was the major (91%) production challenge being faced in the scheme while rainfall reliability was the least challenge with only 8.6% of the participants being affected. Other production challenges are shown in Figure 7, where poor irrigation system management (80%) was the other challenge that affected maize production in the scheme. Research in Northern Ghana by Webb (1991) showed that many schemes severely deteriorated or broke down completely due to insufficient maintenance and poor system management. Mutambara and Munodawafa (2014) discovered that hindrances that affect production sustainability in agricultural schemes include limited access to basic inputs like fertilizers because of the poor supply chain. A report by FAO (2002) concluded that cost recovery from poor farmers for the operation and maintenance of irrigation systems hence water will be unavailable to meet crop water requirements.

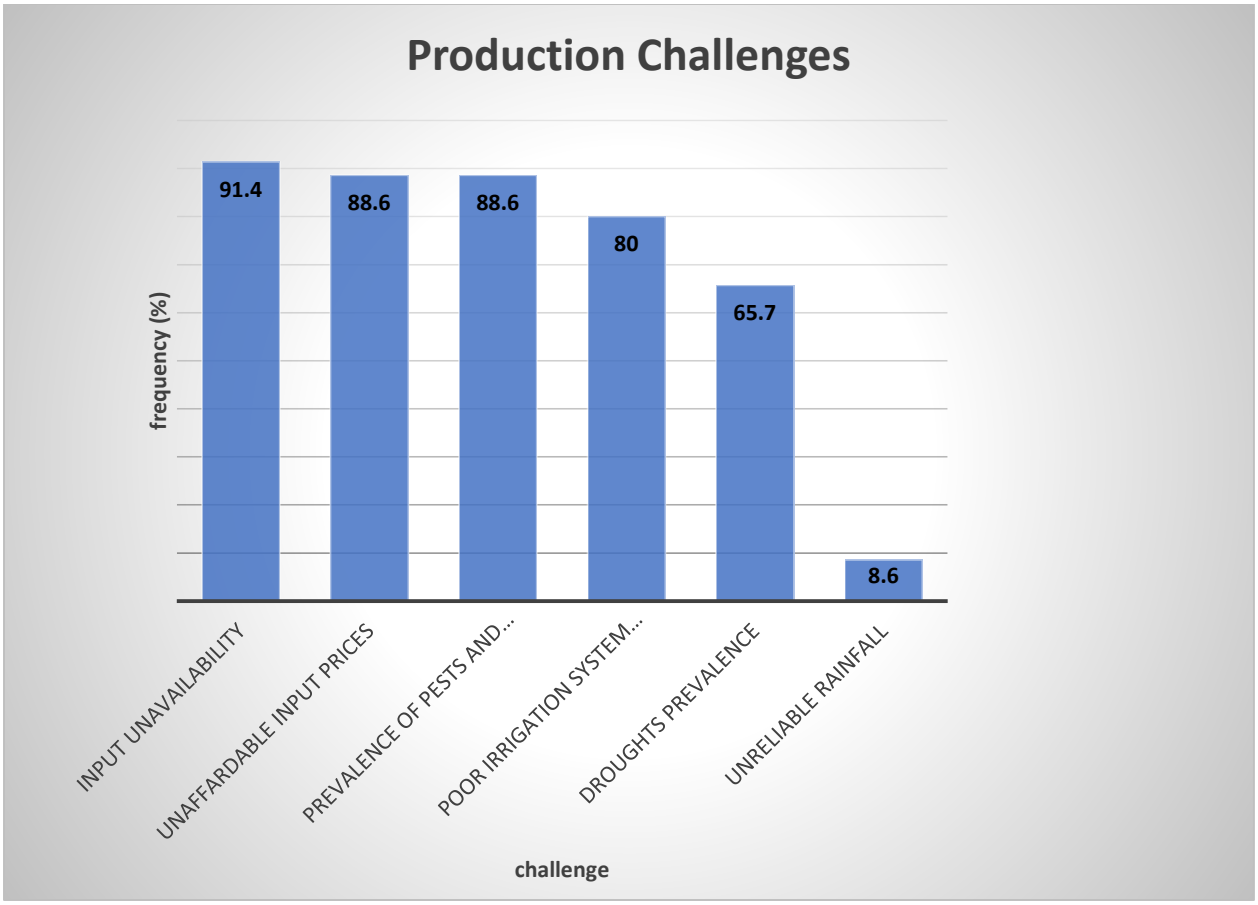

Figure 7: Irrigated maize production challenges

[source: survey data 2019]

4.4.4 Marketing challenges

The majority of participants (71.4%) are faced with challenges on market availability. Approximately 25.7% are facing both selling price and transportation challenges. According to Dube (2016) irrigation schemes in Gweru are facing very transport costs transporters which depend largely on the condition of the roads which are poor. Poor transport brought a challenge to reach out for the markets with fresh and quality products, hence markets became unavailability for 71% of farmers in Tokwane Ngundu irrigation scheme and hence fetch low producer prices.

4.5 Contribution of maize to household income

On average irrigated maize contributed 68.6% to the interviewed household income, while the minimum contribution was 24.4% and maximum was 92.7%. This entails that maize contributes significantly to the household's income in the irrigation scheme as alluded by Roder (1965) who indicated that irrigation projects enable farmers to obtain certain amount of wealth to sustain their livelihoods.

4.6 Factors affecting maize contribution to household income

The results of the multiple linear regression analysis showed that area under irrigation and average maize yield when tested at 5% significant level were statistically significant and had a positive effect on contribution of maize to household income. The age of household head significantly affected the contribution of maize to household income positively at a 10% level of significance and Table 4 is showing that. An increase with one unit of average maize yield will result in a 7.5% increase of maize contribution to household income. Holding all factors constant, if one unit of the area under irrigation is added, it will result in a positive 9% maize contribution to household income.

The study by Mutambara *et al*. (2014) in Irrigation schemes found in the low veld of Zimbabwe concluded that a lot of challenges affect irrigation productivity which included limited access to agricultural inputs, educational level, and training in appropriate farming skills, lack of collateral which enables farmers to access loans or working capital, erratic irrigation water supply. Dube, (2016) also discovered that a well-managed irrigation scheme, with mature farmers in terms of age and wisdom resulted in community economic development.

The R-Square value indicated that 73% of the variation of maize contribution to household income was explained by independent variables. The adjusted R-Square further strengthens that 71% of the variation of maize contribution to household income was explained by the independent variables and only 29% was explained by the disturbance term hence a high degree of goodness of fit of the model.

According to Katundu *et al*. (2014) citing Wooldridge (2001) advocated that the Variance inflation factor (VIF) and tolerance level are the most common tools used to detect the presence of multicollinearity in a regression model. The presence of two or more independent variables in the regression model that resembles to be highly correlated is multicollinearity (Katundu *et al*., 2014). He further emphasized that multicollinearity is a matter of degree and if you measure it using VIF, the average value should not exceed the value of 10. If the value exceeds 10, it means the model has a high degree of collinearity. On average the results of the study show the VIF value of 1.3 which means there is no multicollinearity. Tolerance level was also used to complement and the average tolerance value was 0.79 hence there was no presence of multicollinearity.

Furthermore, to detect the presence of the autocorrelation Durbin Watson test was used. The test assumes that when the D-W value is close to zero, there is a greater indication of a positive correlation. The D-W value closer to four shows greater indication of negative correlation and the D-W value of two simply means there is no autocorrelation. Table 4 shows the D-W value of 1.9 which means there is no autocorrelation since it is closer to 2. Standard form report for multiple linear regression model is as follows:

Y= (2.365) + 0.153 *age* + 0.039*household size* + 7.517 *average maize yield*
(19.572) (0.81) (0.415) (2.266)
+ 0.003*price per tonne* + 0.000*plant population* + 9.042*area under irrigation*
(0.08) (0.01) (0.978)
**R^2 = 73%

Table 4: factors affecting maize contribution to household income

Variables	Coefficients	Standard error	Significance	Collinearity statistics	
				Tolerance	VIF
(Constant)	-2.365	19.572	0.904		
Age	0.153	0.81	0.064	0.693	1.442
Total household size	0.039	0.415	0.925	0.695	1.439
Average maize yield	7.517	2.266	0.002	0.887	1.128
Price ($/t)	0.003	0.08	0.719	0.798	1.253
Plant population	0.000	0.01	0.907	0.890	1.123
Area under irrigation	9.042	0.978	0.000	0.647	1.545
R-square	0.731				
Adjusted R-Square	0.706				
Durbin-Watson	1.946				
f-statistics	28.575				
Prob>F	0.000				

Dependent variable: Maize contribution to household income

Source: [survey data: 2019]

4.7 Recommendations

Irrigation farmers should get agricultural extension education, use improved hybrids of maize seeds, use optimum fertilizer applications and use recommended pesticide dilutions to improve maize yields. Young farmers in the irrigation scheme should receive agriculture training and education to acquire more experience from expertise to improve maize yields since age has been found to have an effect on the contribution of maize on household income. It is recommended again that the farmers practice sustainable intensification of land use to increase maize output per area through adoption of modern farming technologies.

4.8 Conclusion

The main challenge being faced in the schemes was mis-management of irrigation resources by irrigation scheme management. The contribution of irrigation maize farming to household income was significantly affected by the area under production, age of household heads and average maize yield. Therefore, the use of improved maize varieties and farmer trainings may increase the maize yields which in turn will improve household's income and food security.

CHAPTER 5

RESULTS

AN ASSESSMENT OF SMALLHOLDER MAIZE IRRIGATION FARMERS' ACCESS TO FOOD IN TOKWANE NGUNDU IRRIGATION SCHEME, ZIMBABWE.

ABSTRACT

It is estimated that almost 2.4 million rural Zimbabwe will require food assistance between the period between October 2018 and March 2019 of which Masvingo has been projected to have the highest population estimated to be almost 470 000 suffering from food insecurity. Irrigation scheme communities are living in circles of poverty and are receiving food aid to secure food and yet they are the food producing communities. This research assessed household food access in Tokwane Ngundu irrigation scheme which is found in Masvingo district, under Masvingo province Zimbabwe. This research will help the community to improve food security for their households and family first before they sell agricultural outputs. A household can access food if it has the opportunity to obtain food of sufficient quantity and quality for a safe and nutritious diet. Food security was assessed using Household Food Insecurity Access Score (HFIAS) and Household Food Access Prevalence (HFIAP), where descriptive statistics with frequencies and means were used. The higher the HFIAS the more the household is food insecure. The average HFIAS for the interviewees was 9.7 and ranged from 0 to 13. Most of the study participants (48.6%) were severely food insecure, while 42.9% were moderately food insecure, 5.7% were mildly food insecure and only 2.9% were food secure. The majority of the participants in the irrigation scheme were in general food insecure. The researcher made recommendations that there is need for the provision of food aid within the scheme since some households were severely food insecure while other sustainable methods which include farmer training and provision of inputs are being put in place so as to avoid loss of life due to hunger.

Keywords: Food security, food insecurity, food access, irrigation, household

5.1 Introduction

The concept of food security was first originated in the mid-1970s, when the World Food Conference (1974), defined food security in terms of food supply assuring the availability and price stability of basic foodstuffs at the international and national level. Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life FAO (2008). Therefore, the concept of food security was defined in the World Food Summit (1996) to include food access, availability, food use and stability FAO (2006). The meaning of food security has experienced a significant evolution throughout the years, moving from a supply focused concept, mostly related to food availability to a multidimensional notion to consider also food accessibility, food utilization and food stability (Pieters *et al*., 2012). Food and Agriculture Organization (1983) analysis focused on food access, leading to a definition based on the balance between the demand and supply side of the food security equation.

Food accessibility is the physical access of food in the market and economic access at the household level, household purchasing power (Opara, 2013; FAO, 2008). A household can access food if it has the opportunity to obtain food of sufficient quantity and quality for a safe and nutritious diet (Pieters *et al*., 2013). The level of household income is a key determinant of a household's ability to spend on food which also measures household's food accessibility (Opara, 2013). In Zimbabwe, there are irrigation schemes that support food production by supplementing water throughout the year to defeat crop failure scenarios. These schemes, therefore, support a community of farmers who sustain their livelihoods upon irrigation farming. Therefore, this research focused much on the food security status of such communities and food access was assessed using Tokwane Ngundu irrigation scheme as a case study, in Masvingo province.

Food access for urban dwellers, hinges primarily on the household's ability to purchase food whereas for rural dwellers, food access rely highly on household's food production though in some instances may depend on household's ability to purchase food Muhihi *et al*. (2012), although every household has a limited amount of resources at its disposal, including assets, labor, human capital, and natural resources. Muhili *et at*. (2012) explained that the allocation of these resources to food

production, wage labor or other business activities allows the household to access food, either directly or indirectly.

Household food accessibility is influenced by both the level of income available at a household, the number of livestock products and the number of crops produced (Puma *et al*., 2015). The level of household income in most irrigation schemes of Zimbabwe depends on the sales of livestock products, cash crops produced and off-farm income (Chabayanzara, 1994). A lot of researches on crop performance and water use efficiency in Zimbabwe but little knowledge is known about the food security status of households in irrigation schemes. This research study seeks to assess the food security status of households in the Tokwane Ngundu irrigation scheme. This will help the community to improve food security for their households and the nation at large

5.2 Material and Methods

5.2.1 Description of the study area

Tokwane Ngundu is an irrigation scheme in the Masvingo District under Masvingo Province, which is found in the semi-arid region of Zimbabwe. It has minimal rainfall patterns of about 600mm per annum and the average annual temperature is about 20 degrees Celsius. A large part of the province is drought prone for example Region 5 such that most parts are unfit for agriculture, apart from cattle ranching. More details for this irrigation scheme study area refer to Chapter 3, section 3.2.

5.2.2 Research Design

A survey using a descriptive research method with both qualitative and quantitative techniques was done. Household Food Insecurity Access Scale and Household Food Insecurity Prevalence guide developed by FANTA were used as a questionnaire guide to collect information pertaining to food access in households. Details on research design refer to chapter 3, section 3.3

5.2.3 Data collection

A structured questionnaire was used to collect information concerning food insecurity status of households. The person responsible for food preparation and meals within the household was one who answered the questionnaire. The questionnaire comprised of nine frequency of occurrence

questions that determined how often the condition of food insecurity occurred in the household and the responses were ranked in 4 categories accordingly. In case of the respondent failing to understand the question, the interviewer had to prompt the respondent by reading any examples or contextual clarifications. There were pre-coded response options, but the interviewer did not read these options aloud to the respondent but rather allowed the respondent to answer in own words. The interviewer selected the most appropriate response option based on the respondent's reply, if the respondent had difficulty in replying the interviewer encouraged a response by listing the set of options again.

Upon completing the questionnaire and before leaving the household, the interviewer checked over the questionnaires to ensure that all questions were asked and that the responses were complete and legible. Notes were written down on the margins next to any unusual responses or stories that emerged in relation to a particular question, these notes helped later on in interpreting the data from the entire sample. The administration of the questionnaire took approximately 15 minutes per household.

5.2.4 Data analysis procedure

5.2.4.1 Household Food Insecurity Access Scale Score

HFIAS score is a measure of the degree of food insecurity (access) of household recalling food consumption over the past four weeks (30 days). This method was developed by Coates *et al*. (2007) and is used annually to estimate the prevalence of food insecurity in the USA. In this investigation, it was calculated for each household by summing the codes for each frequency-of-occurrence question. HFIAS score was calculated for each household by summing the codes for each frequency-of-occurrence question. Data should code frequency-of-occurrence as 0 for cases where the answer to the corresponding occurrence question was no (if Q1=0 then Q1a=0 if Q2=0 then Q2a =0). The maximum score for a household is 27 (the household response to all nine frequency-of-occurrence questions was often coded with a response code of 3); the minimum score is 0. The higher the score, the more food insecurity (access) the household experienced. The lower the score, the less food insecurity (access) a household experienced.

HFIAS Score (0-27) = Sum of the frequency-of-occurrence during the past 4 weeks for the 9-food insecurity-related conditions.

= Sum frequency-of-occurrence question response code

(Q1a + Q2a + Q3a + Q4a + Q5a + Q6a + Q7a + Q8a +Q9a)

5.2.4.2 Household Food Insecurity Access Prevalence

The Household Food Insecurity Access Prevalence (HFIAP) status indicator is used to report household food insecurity (access) prevalence or instance. The HFIAP indicator can be reported in addition to the average HFIAS Score for program monitoring and evaluation. The HFIAP indicator categorizes households into four levels of household food insecurity (access) which are food secure, mild, moderately and severely food insecure and households are categorized as increasingly food insecure as they respond affirmatively to more severe conditions and/or experience those conditions more frequently.

A food secure household experiences none of the food insecurity (access) conditions or just experiences worry but rarely. A mildly food insecure (access) household worries about not having enough food sometimes or often and is unable to eat preferred foods or eats a more monotonous diet than desired or some foods considered undesirable. But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating). A moderately food insecure household sacrifices quality more frequently by eating a monotonous diet or undesirable foods sometimes or often or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions. A severely food insecure household has graduated to cutting back on meal size or number of meals often and experiences any of the three most severe conditions (running out of food, going to bed hungry, going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered severely food insecure as shown in Figure 8.

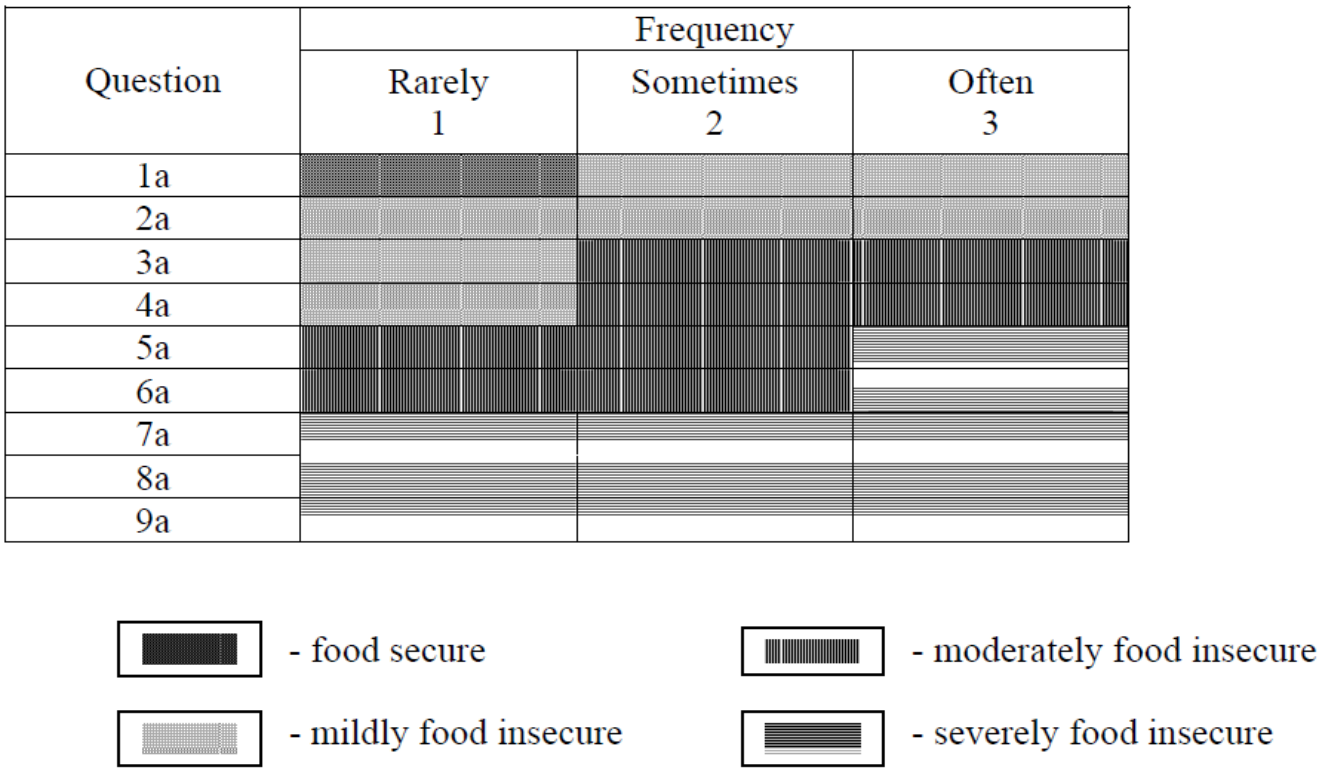

Figure 8: Categories of food insecurity (access)

[Source : Coates et al., 2007]

5.2.5 Challenges encountered during data collect

The most prevailing challenge experienced during data collection of food insecurity status of the participants in Tokwane Ngundu Irrigation scheme was that of recalling a period of four weeks. The questions in the questionnaire demanded information on the occurrence of conditions of food status over the past four weeks which was difficult for most participants. To try and get more reliable data from participating households, the researcher ended up calling other family members including children to help in recalling the occurrence of food insecurity conditions. Moreover, the researcher questioned the participants the same question but using a different way of questioning so as to verify the accuracy of the responses.

5.3 Results and analysis

5.3.1 General food security assessments

The majority (97%) of the study sample faced challenges of food shortages before harvesting and 77% suffered from food deficit after a drought and these are the same results that Odusina (2014) got on his study in Nigeria where that community also experienced hunger during drought periods. Rating the food access comparing with the previous season, 54% of participants testified that it was fair and 31% commented that food access was far off worse due to economic instabilities.

The minimum number of meals per day per household was 2 and the maximum was 4. On average the sampled households would get 3 meals per day. Maize reserved by the participants was a minimum of 1tonne and a maximum of 4tonnes as shown in table 5. On average the sampled households had a reserved maize of 2 tonnes. It is from these reserves that when there is an emergency, they sell some of them.

Table 5: Food insecurity assessment

	N	Minimum	Maximum	Mean	Std. Deviation
total household size	70	3	16	6.66	2.766
HFIAS	70	0	13	9.74	3.188
Reserve dry grain	70	1	4	2.00	0.692

Source [survey data, 2019]

5.3.2 Household food insecurity access score (HFIAS)

The average HFIAS for the interviewees was 9.7 and ranged from 0 to 13 as shown in Table 5. The higher the score, the more food insecurity (access) the household experienced and the lower the score, the less food insecurity (access) a household experienced. The households sampled in Tokwane Ngundu irrigation scheme from the face of the scores are food insecure since the maximum score recorded was 13 which is almost a midpoint of the score which ranges from 0-27. Odusina (2014) in his study in Nigeria discovered that households in the metropolis had adequate food access since the score ranged between 5.63 and 7.27 all less than 11 the cut off point for adequate food access. The food scores that he got indicated that the community was food secure.

Musemwa et al., (2015) in his study in South Africa found that the community under study had an average HFIAS of 12.41 and the scores ranged from 0 to 27 and he concluded that the sampled households were mildly food secure with recommendations made to improve food security status.

5.3.3 Household food insecurity access prevalence (HFIAP)

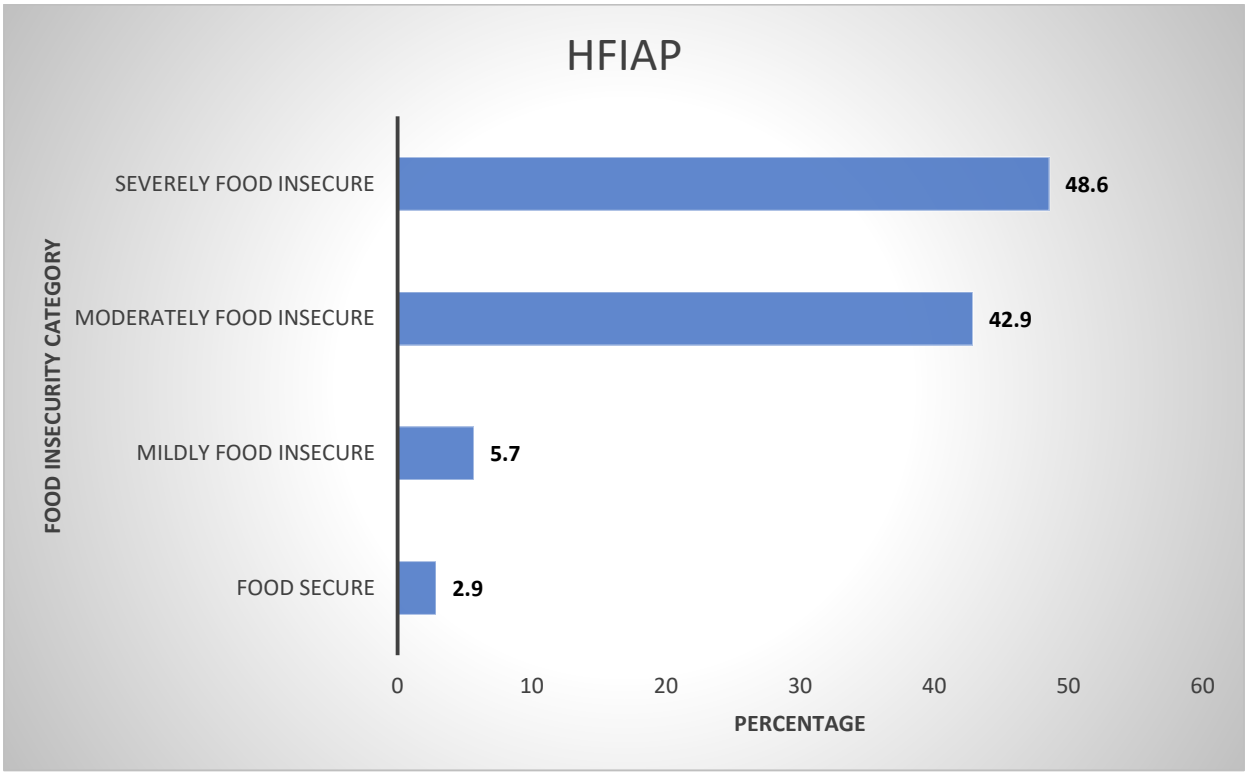

Figure 9: Household food insecurity access prevalence

[source: survey data 2019]

Most of the study participants (48.6%) were severely food insecure, while 42.9% were moderately food insecure, 5.7% were mildly food insecure and only 2.9% were food secure. The results clearly show that the majority of the interviewed maize irrigation farmers are food insecure meaning the irrigation scheme are not meeting the set objectives of producing excess food supplies to the nation. The results from the study are in line with findings by Musara *et al.* (2010) who observed that smallholder farmers in Zimbabwe, particularly in the low rainfall areas, are extremely food insecure. On average households sampled were moderately food insecure. Some farmers suffer

from low incomes, poor living standards, poor nutrition, poor housing, and health and cannot even send children to school (FAO, 2010).

5.4 Recommendations

The researcher made recommendations that there is need for the provision of food aid within the scheme since some households were severely food insecure while other sustainable methods which include farmer training and provision of inputs are being put in place so as to avoid loss of life due to hunger.

5.5 Conclusion

Food deficit is oftenly experienced before harvesting and after a drought. On average families in this irrigation scheme are getting 3 meals per day, which is standard. The results clearly show that the majority of the interviewed maize irrigation farmers are food insecure meaning the irrigation scheme are not meeting the set objectives of producing excess food supplies to the nation. There is a need for emergency response in this irrigation community in terms of food aid since some households have been discovered to be severely food insecure.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter is aimed at giving conclusion and recommendations of major findings of this study. It does so by logically presenting a summary of each objective finding before giving a conclusion on study hypothesis. Further, recommendations will be made on how best to address

6.2 Research summary

The research aim was to assess the challenges faced by maize farmers, factors affecting the contribution of irrigation maize to household income and food security status in Tokwane Ngundu Irrigation scheme in Masvingo province. Masvingo District was purposively selected and Tokwane Ngundu Irrigation scheme was also purposively selected, 70 out of 88 households were randomly sampled. Structured questionnaires, key informants' interviews and passive observations were used to collect data. To explore challenges, descriptive statistics was used, multiple linear regression was used to determine factors affecting the contribution of maize to household income. Food security was assessed using Household Food Insecurity Access Score (HFIAS) and Household Food Access Prevalence (HFIAP), together with descriptive statistics (frequencies and means). Mismanagement of irrigation resources by irrigation scheme management, water unavailability and high-water costs, inputs unavailability and input costs, market availability were discovered to be the main challenges affecting maize production in the irrigation scheme. Area under production and age of household heads significantly affected the contribution of maize to household income at 5% significance level while average maize yield was significant at 10% significance level. Maize contributed a minimum of 24% to household income and a maximum of 93%, and on average maize contributed 68,5% to household income in the sampled households. The average HFIAS for the interviewees was 9.7 and ranged from 0 to 13. Most of the study participants (48.6%) were severely food insecure, while 42.9% were moderately food insecure, 5.7% were mildly food insecure and only 2.9% were food secure. The results clearly show that the majority of the interviewed maize irrigation farmers are food insecure meaning the irrigation scheme is not meeting the set objectives of producing excess food supplies to the nation. Irrigation farmers should get agricultural extension education, use improved hybrids of maize

seeds, use optimum fertiliser applications and use recommended pesticide dilutions to improve maize yields. There is a need for emergency response in this irrigation community in terms of food aid since some households have been discovered to be severely food insecure.

6.3 Conclusions

It has been proven that irrigating maize contributes significantly to household income in irrigation scheme since factors like age of households' head, area under irrigation and yield per hectare significantly affect contribution of smallholder irrigation maize farming to household income. However, there are some socio economic, institutional, production and marketing challenges that may hinder the production of maize in irrigation schemes resulting in low yields which include mismanagement of irrigation scheme resources by the committee and unavailability of water, inputs and markets. Conclusively food access in irrigation communities is still very poor, it has been proven that some households in irrigation schemes despite that they are producing food, their families are food insecure given that the objectives of irrigation is to improve food security at household and of the nation at large. There is need for smallholder farmers in irrigation schemes to use improved maize varieties which in turn increase maize yields and this will increase the contribution of maize to household income.

6.4 Policy implication and recommendations

Irrigation farmers should get agricultural extension education, use improved hybrids of maize seeds, use optimum fertiliser applications and use recommended pesticide dilutions to improve maize yields. Young farmers in the irrigation scheme should receive agriculture training and education to acquire more experience from expertise to improve maize yields since age has been found to have an effect on the contribution of maize on household income. There is need for an emergence response in terms to this community of food aid since some households have been discovered to be severely food insecure falling in category 4 of HFIAP. Education and campaigns can be done in the irrigation schemes to encourage farmers on the benefits of diversifying crops when farming for the consumption of their families to improve food security. Assessments of nutrition knowledge can be further done so as to change behavior the behavior of most households in this community in terms of food balanced diets.

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APPENDICES

Appendix 1: Questionnaire

AN ASSESSMENT ON THE CONTRIBUTION OF SMALLHOLDER MAIZE IRRIGATION FARMING TO HOUSEHOLD INCOME AND FOOD SECURITY IN SEMI-ARID REGION OF ZIMBABWE: CASE OF TOKWANE NGUNDU IRRIGATION SCHEME, MASVINGO

BINDURA UNIVERSITY OF SCIENCE EDUCATION

My name is Vadzanayi Mushayi, I'm a student at Bindura University of Science Education, studying for an MSc. Degree in Food Security and Sustainable Agriculture doing my final year. As part of my degree program, I'm required to carryout a research and my research is on **ASSESSING THE CONTRIBUTION OF SMALLHOLDER MAIZE IRRIGATION FARMING TO HOUSEHOLD INCOME AND FOOD SECURITY IN SEMI-ARID REGION OF ZIMBABWE (CASE OF TOKWANE NGUNDU, MASVINGO)**. Since strategies and efforts are desperately needed to efficiently and effectively design irrigation programs, policies and interventions that improve irrigation scheme productivity in Zimbabwe and create high maize production for the sovereignty of the country, this research will help by identifying challenges and therefore make recommendations. Please NOTE that all information provided by interviewee is STRICTLY CONFIDENTIAL and will only be used for academic research and your participation in this study is voluntary. Thank you.

A. HOUSEHOLD DEMOGRAPHIC INFORMATION				
1. the head of household				
a. Gender	Male		Female	
b. Marital status	Married	Single	Divorced	Widowed
c. Age in years				
d. what is the highest level of education of household head?				
No formal or informal education		Informal education		
e. what is the highest level of education of other household member?				
No formal or informal education		Informal education		
			Adults (≥18)	Children (<18)
	Male			

f. What is the size of your household?	Female		
2. CHALLENGES			
a. Institutional challenges			
Training services	contact hours of extension training		
Water costs	water availability	electricity availability	
b. Socio economic challenges			
Ownership	Boundaries		
Management committee	Inheritance		
c. **Production challenges**			
Rainfall influence	Droughts	Input availability	
Input prices	Pests and diseases		
Maintenance and servicing of irrigation system			
d. Marketing challenges			
Market availability	Selling price		
Distance to markets	Transport		
3 a. Do you own or you lease your land?		**YES**	**NO**
b. What is your total field area? (Ha)			
c. What is the area under production? (Ha)			
Irrigated farm		**Dry farm**	
e. What is your average maize yield per annum			
Irrigated yield	**Dry farm yield**		
f. What is your price per tonne(RTGS$)			

4.What are your sources of income? (Rank 1 as the most important source of income)

Source	**Amount per annum**	**Rank**
Maize		
Other crops		
Livestock		
Wages/allowances/salaries		
Pension/grants		
Trade (transport business, resale of goods)		
Wild fruits		
Craftwork (mats, baskets, pots)		
Community projects		

Other (specify)					
4. Income					
During the last season did you sell:					
Green cobs	**Y/N**	number of cobs		unit price	
Dry grain	**Y/N**	quantity (tonnes)		price per tonne	
How much maize did you reserve for your household consumption? (tonnes)					
How long do you think it will take you?					
Do have other grains in reserve for the family?					
How did you acquire them?					
5. HOUSEHOLD FOOD SECURITY STATUS					
a. What are your sources of food? (Rank 1 as the most important source of food)					
			RANK		
Irrigated maize					
Dry land farming					
Wild food and fruits					
Food aid					
livestock					
Trading					
Food for work					
Steal					
Food handouts					
Government					
Stocks					
relatives sending from out of country					
Fisheries					
Hunting					
Other sources of food(Specify):					
b. On average, how many meals do you have per day?					
c. Do you think you have access to enough food?			**Yes**	**No**	
d. On average what is your yield for:					
Green cob	**No. of cobs**		**Selling price**		
Dry grain	**Kgs**		**selling price**		
e. How do you rate your level of access to food nowadays as compared to last season?					
No change	**Better**		**Fair**	**Worse off**	
6. FOOD ACCESSIBILITY IN THE PAST 4 WEEKS (1 MONTH)					

If yes to the following questions, how often did this happen? **0=** Never**; 1** = Rarely (once or twice in the past four weeks); **2** = Sometimes (three to ten times in the past four weeks); **3**= Often (more than ten times in the past four weeks)	
a. Did you worry that your household would not have enough food?	
b. Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	
c. Did you or any household member have to eat a limited variety of foods due to a lack of resources?	
d. Did you or any household member have to eat some foods that you really did not want because of a lack of resources to obtain other types of food?	
e. Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	
f. Did you or any household member have to eat fewer meals in a day because there was not enough food?	
g. Was there ever no food to eat of any kind in your household because of lack of resources to get food?	
h. Did you or any household member go to sleep at night hungry because there was not enough food?	
i. Did you or any household member go a whole day and night without eating anything because there was not enough food?	

7. When do you encounter food shortages? (you may tick more than once)

Any time of the month	Just before month end	Before harvesting	After drought	**Other times:**

8. What are your copying strategies in times of food shortage

……...THANK YOU…….

Appendix 2: Key Informant Guide

My name is Vadzanayi Mushayi, I'm a student at Bindura University of Science Education, studying for an MSc. Degree in Food Security and Sustainable Agriculture doing my final year. As part of my degree program, I'm required to carryout a research and my research is on **ASSESSING THE CONTRIBUTION OF SMALLHOLDER MAIZE IRRIGATION FARMING TO HOUSEHOLD INCOME AND FOOD SECURITY IN SEMI-ARID REGION OF ZIMBABWE (CASE OF TOKWANE NGUNDU, MASVINGO)**. Since strategies and efforts are desperately needed to efficiently and effectively design irrigation programs, policies and interventions that improve irrigation scheme productivity in Zimbabwe and create high maize production for the sovereignty of the country, this research will help by identifying challenges and therefore make recommendations. Please NOTE that all information provided by interviewee is STRICTLY CONFIDENTIAL and will only be used for academic research and your participation in this study is voluntary. Thank you.

1. What is your average maize yield per annum
2. How big is this scheme?
3. How is land owned in this scheme?
4. What are the main crop planted in this scheme?
5. Where do most farmers get inputs from?
6. What is the status of market for the crops?
7. What are the selling prices of:
   (a) Green maize
   (b) Dry grain
8. What are the challenges that are being faced within the institution?
9. How would you compare irrigation maize farming to dry maize farming?

Appendix 3: Informed Consent Form for Study Participants

I…… …….of plot……..……..in…… …… Irrigation scheme is willing and do agree to participate in the research carried out by Vadzanayi Mushayi, a student at Bindura University of Science Education.

Participant signature……..… Date…….....

Researcher signature…….……. Date……

NB: You will be given a copy of this form, please keep it and if you feel you have been treated unfairly, you are welcome to contact the university Research Ethics Chairperson, Prof C Mahamadi on +263712646284, and please do not hesitate.

Thank you.

Appendix 4: Institutional Approval Letter

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE
DEPARTMENT OF AGRICULTURAL ECONOMICS, EDUCATION AND EXTENSION

P Bag 1020
Bindura
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BINDURA UNIVERSITY OF SCIENCE EDUCATION

The Provincial Irrigation Engineer
Department of Irrigation
Masvingo Province
35 Robert Mugabe Way
Masvingo

01 April 2019

RE : CONFIRMATION LETTER FOR MUSHAYI VADZANAYI

This is to certify that the above named is currently a student of Bindura University Science Education undertaking a Master's degree programme in Food Security and Sustainable Agriculture in the Faculty of Agriculture and Environmental Science.

As part of her studies, she is required to undertake a research project prior to completion of her master's degree. The research participants will at no time be placed at risk of physical or psychological harm during the course of the assessment. All information provided by interviewee will be treated as strictly confidential and will only be used for research purposes for mutual benefit of both the researcher and the respondents.

Any assistance given to her will be greatly appreciated.

Please contact us in case of any further clarifications.

Yours faithfully,

Dr. Lovemore Musemwa

Coordinator: MSc Programme in Food Security and Sustainable Agriculture

Appendix 5: Letter of Seeking for Authority

Harare Polytechnic

P.O Box CY407

Causeway

Harare

03 April 2019

THE PRINCIPAL IRRIGATION ENGINEER

Department of Irrigation

35 Robert Mugabe Way

Masvingo

Dear/Madam

Ref: Request for permission to carry out a research in Tokwane Ngundu Irrigation scheme.

I do here by seek your permission to carryout a research for my Msc Thesis entitled "AN ASSESSMENT ON THE CONTRIBUTION OF SMALLHOLDER MAIZE IRRIGATION FARMING TO HOUSEHOLD INCOME AND FOOD SECURITY IN SEMI-ARID REGION OF ZIMBABWE), in Tokwane Ngundu Irrigation Scheme during the month of April. I chose this particular irrigation scheme because through literature I discovered that it has all the variables that my research project seek to study around in the Semi-arid regions of Zimbabwe .

Im a second year student at Bindura University of Science Education and my student number is B1748347, and attached is my confirmation letter from my college.

Yours Sincerely

Vadzanayi Mushayi

Appendix 6: Letter of Permission to Conduct the Study

All correspondence should be addressed to
"THE PROVINCIAL IRRIGATION ENGINEER"

Tel: +263 39 265081/264334

Cell: +263 714900706

Department of Irrigation

Ministry of Lands, Agriculture, Water,
Climate and Rural Resettlement
Department of Irrigation
Ok. Post Office Building
35 Robert Mugabe Way
P.O. Box 1020
MASVINGO

04 April 2019

Vadzanayi Mushayi
Harare Polytechnic
P.O.Box CY407
Causeway
Harare

Dear Madam

APPROVAL TO CARRY OUT RESEARCH AT TOKWANE NGUNDU IRRIGATION SCHEME

This letter acknowledges that we have received and reviewed your to conduct a research project entitled "***An assessment on the contribution of smallholder maize irrigation farming to household income and food security in semi- arid region of Zimbabwe***" at ***Tokwane Nguadu irrigation scheme*** and I approve this research to be conducted at the targeted site.

One of our Agriculture Economist, Mr O Matutu will provide any assistance concerning the research project and can be conducted on 0712799505. We wish you the best and hope you will share with us your research findings

Sincerely,

PP

W. Goza
Provincial Irrigation Engineer

PROVINCIAL IRRIGATION ENGINEER
DEPT. OF IRRIGATION DEVELOPMENT
04 APR 2019
P.O. BOX 1020, MASVINGO
ZIMBABWE TEL: 039-265081/264334