MUSIKA

Making Agricultural Markets Work for Zambia

Key Enablers of Irrigation Use by Smallholder Farmers in Zambia

July 2020

Foreword

This report was generated to serve as a reference document for Musika Development Initiatives (Musika) and its implementing partners. Musika is a non-profit company that works to stimulate private sector investment in rural agricultural markets. It does this by helping businesses develop mutually beneficial and transparent commercial relationships with smallholder farmers that integrate the provision of information and technology adoption, and provides long term incentives for farmers to invest in their farming businesses. It provides its clients with high quality, commercially focused technical advice and business model support, and were relevant smart subsidies to bring down the initial risks of doing business with the smallholder market. Musika also supports innovative market-based solutions to environmental issues and strives to ensure that women are key participants in improved agricultural markets. Musika acknowledges and appreciates the financial support from the Swedish Embassy in Lusaka.

Disclaimer:

The views and information expressed in this report are those of the author(s). Whilst due diligence was employed in preparing this document, Musika accepts no liabilities for any losses or damages of whatsoever kind which any person or institution may suffer as a result of any action or decision taken on the basis of information contained herein. The 2010/11, 2013/14 and the 2017/18 agricultural seasons are in this study also referred to as 2012, 2015 and 2019 survey years, respectively.

Acknowledgements

The authors would like to sincerely thank Indaba Agricultural Policy Research Institute (IAPRI) for organising the Rural Agricultural Livelihood Survey (RALS) from which the data used in this study was obtained. Many thanks also go to the Musika staff who took part in the entire exercise leading up to the collection of this data.

Executive Summary

Despite having one of the largest water resources in Southern African region, the use of irrigation systems remains relatively low in Zambia. Literature further goes on to say, modern, efficient irrigation systems can substantially increase agricultural productivity, resulting in improved livelihoods, reduced risk associated with drought, efficient use of limited water resources, and greater food production. It is against this background that this study focused on determining the key enablers of smallholder farmers' irrigation use in Zambia. Below are the highlights of the study findings:

1. **The level of irrigation use by smallholder farmers in Zambia has generally been low:** About 18% of the smallholder farmers irrigated at least one of their fields during the 2010/11 agricultural season, with only 17% in the 2013/14 season. However, the 2017/18 agricultural season saw an increase of 6% in the proportion of households irrigating at least one of their fields from 17% in 2013/14 to 23%.
2. **Southern province had the highest percentage (33%) of households irrigating their fields:** Copperbelt, Lusaka, Eastern and Western complete the top five (5) provinces with households who used irrigation in the 2017/18 agricultural season while North-western had the lowest proportion (12%) of households irrigating their fields.
3. **A higher proportion of male-headed households irrigated at least one of their field crop fields than female-headed households:** Only 2% of the female-headed households irrigated their field crop fields, while 3% of the male-headed households irrigated.
4. **There has been a slow and steady increase in the proportion of rural households irrigating field crops throughout the years:** 0.8% of the households irrigated land under field crops in the 2010/11 season, 1.4% in the 2013/14 season and 2.3% in the 2017/18 season.
5. **There has been consistency in the number of households irrigating fruits and vegetables since 2011:** An average of 33% of households irrigated their fruit and vegetable fields.
6. **Traditional (Informal) irrigation is still the most commonly used irrigation system by smallholder farmers:** Of the households that irrigated their fruits and vegetables, 88% in the 2012 survey year, 85% in 2015 and 82% in 2019 had irrigated their fields

using a well or river or stream with the aid of a bucket. Worth noting is the marginal increase in adoption of more advanced types of irrigation such as the motorized kits, hand or treadle pumps etc.

7. **Irrigation was not among the most selected strategies smallholder farmers used to prepare for the next negative weather event:** Only 4.1% cited irrigation as the most important strategy.
8. **Only a minority of the smallholder farmers own irrigation equipment:** A measly 4% of farmers owned at least a water/treadle pump with 7% owning other irrigation equipment.
9. **The bulk of the irrigated fields were in wetlands/dambos, of which most were used for growing fruits and vegetables:** the majority (over 50%) of the irrigated fruit/vegetable fields have been in wetlands/dambos since 2011.
10. **Gross income and landholding play a key role in the adoption of modern irrigation equipment:** Households with a higher gross income used more of the motorized irrigation equipment and hand/treadle pumps than those with lower gross incomes. Same applied to landholding, households with larger own-cultivated fields used more of the modern irrigation equipment than those with smaller landholdings.
11. **Maize was the most irrigated field crop by smallholder farmers:** 34% of the maize fields were irrigated, followed by groundnuts, rice and cassava with 17%, 13% and 11% respectively.
12. **The average yield of smallholder farmers who irrigated their field crops was higher than that of farmers who did not irrigate their crops:** The average yield for smallholder farmers that irrigated their maize, rice and soya bean fields was higher than that of farmers who did not irrigate.

Table of Contents

List of Figures

List of Tables

Abbreviations and Acronyms

ACAPS	Assessment Capacities Project
COVID-19	Coronavirus Disease
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
GDP	Gross Domestic Product
Ha	Hectare
IAPRI	Indaba for Agricultural Policy Research Institute
Kg	Kilogram
MSA	Market Systems Approach
Musika	Musika Development Initiatives
NTE	Non-Traditional Export
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PSU	Primary Sampling Unit
RALS	Rural Agricultural Livelihood Survey
SADC	Southern African Development Community
SEA	Standard Enumeration Area
UNEP	United Nations Environment Programme

1.0 Introduction

1.1 Background

Irrigation is increasingly seen as a necessary means to build resilience in smallholder rain-fed farming systems, and to increase productivity to meet growing food demands in Sub-Saharan Africa (Ngoma et al. 2017). Achieving Africa's agricultural growth potential will require a significant increase in historically low levels of productivity. This is an area where irrigation can play a critical role. Modern, efficient irrigation systems can substantially increase crop yields, resulting in improved livelihoods, reduced risk associated with drought, efficient use of limited water resources, and greater food production **(Mendes et al. 2014)**. Scholars and development practitioners advocate irrigation as an important means to achieve increased agricultural production and food security. In a region such as Sub-Saharan Africa where droughts are prevalent, irrigation could be a key factor in enhancing food security through improved agricultural production **(Kodamaya, 2015)**. In the publication, Africa environment Outlook 2, it is argued that rapidly increasing the area under irrigation, especially small-scale irrigation, will provide farmers with opportunities to raise output on a sustainable basis (UNEP, 2006). Rain fed agriculture is directly exposed to the hazards of climate change. Around Southern African Development Community (SADC), rainfall patterns are characterized by high and unpredictable variability over seasons, years, and decades **(Akayombokwa et al. 2015)**.

The following categories of irrigated farming are found in Zambia:

- Informal irrigation by small-scale farmers;
- Smallholder irrigation schemes;
- Former quasi-government schemes;
- Private or commercial irrigation schemes;

Since time immemorial, small-scale farmers all over the country have practiced informal irrigation in their gardens, i.e. they applied water in an undocumented, casual, artificial way using buckets, watering cans and hosepipes to grow vegetables, fruits and crops along streams, rivers and in dambos. This form of irrigation is usually not capital intensive, is farmer-operated and is often spontaneous in origin, responding to the needs felt by individual farmers. Drought occurrences, for example, directly prompt the genesis of such irrigation development (FAO, 2005).

The use of irrigation systems remains relatively low despite the country having one of the largest water resources in Southern Africa region. International Center for Tropical Agriculture and World Bank (2017) estimates that 523,000 hectares of land in Zambia is irrigable but only 29% so far is equipped with irrigation; commercial farmers dominate irrigation use with modern and sophisticated irrigation methods whilst smallholder farmers' irrigation facilities range from simple to archaic irrigation methods. While research has been carried out on the development of irrigation and irrigation markets in Zambia, there is still a dearth of knowledge on the key enablers of irrigation use by smallholder farmers in Zambia especially in the wake of droughts.

This study will seek to fill this gap by expanding on the current literature of the key enablers of irrigation use in Zambia, especially in the wake of the recent droughts. This study will also provide insights on the trends of irrigation use by smallholder farmers over the past years.

The findings from this study will give stakeholders the much-needed information on the current state of irrigation uptake by smallholder farmers, and also some of the key enablers of irrigation use by smallholder farmers in Zambia.

1.2 Specific Objectives

The specific objectives of this study were;

- To assess the current state of smallholder farmers' irrigation uptake, and use in Zambia
- To analyze the effects of irrigation on smallholder farmers' productivity in Zambia
- To establish some of the key enablers of irrigation use by smallholder farmers in Zambia

1.3 Methodology and Data

The household data used was from the Rural Agricultural Livelihoods Surveys (RALS) conducted by the Central Statistical Office (CSO) in partnership with the Ministry of Agriculture and Livestock (MAL) and the Indaba Agricultural Policy Research Institute (IAPRI). The RALS is a panel survey that was carried out every after three years and the 2019 RALS was the last wave of the first panel which started in 2012. The sampling frame for the first wave was based on the 2010 Census of Housing and Population. The first stage involved identifying the Primary Sampling Unit (PSU). The PSU was defined as one or more Standard Enumeration Areas (SEAs) with a minimum of 30 agricultural households. The SEA is the smallest area with well-defined boundaries identified on census sketch maps. At the second stage, all households in selected SEAs were listed and agricultural households identified. Listed agricultural households were then stratified into three categories, A, B, and C, on the basis of total area under crops; presence of some specified special crops; numbers of cattle, goats and chickens raised; and sources of income. Systematic sampling was then used to select 20 households distributed across the three strata in each SEA (IAPRI 2015). This study analyzed the three-wave panel data collected in 2012, 2015 and 2019, hereafter also referred to as RALS 2012, RALS 2015 and RALS 2019, respectively. RALS 2012 interviewed a total of 8,839 households, RALS 2015 re-interviewed a total of 7,254 households while RALS 2019 re-interviewed a total of 7,241 households.

A point-biserial correlation was used to measure the relationship between irrigated fields and the yield obtained from the specific crops grown on that field. Point-biserial correlation is the preferred statistical procedure for calculating a simple correlation coefficient between a continuous variable and a dichotomous (binary) variable. With the continuous variable here being yield and the binary variable being if the household irrigated the field i.e. Yes=1 and No=0. The point-biserial correlation measures the strength of association or co-occurrence between two variables and tests if the coefficient is significant from zero; whilst this does not show causality, it does establish whether or not a significant link exists between variables of interest. It is a true and special case of the Pearson product-moment correlation and therefore the assumptions underlying Pearson's r apply. The equation Stata uses for calculating a point-biserial correlation coefficient is:

$$\boldsymbol{r_{pbi}} = \frac{\boldsymbol{\bar{X}_P - \bar{X}}}{\boldsymbol{S_x}}\sqrt{\frac{\boldsymbol{p}}{\boldsymbol{q}}}$$

In this formula S_x = the standard deviation of the continuous variable; $\boldsymbol{\bar{X}_P}$= a value of the continuous variable when the binary variable = 1; $\bar{X}$ = any value of the continuous variable; p = the proportion of the binary variable equal to one; and q = the proportion of the binary variable equal to zero..

2.0 Key Findings

2.1 Demographic characteristics

This section summarizes the characteristics of the interviewed smallholder households in this study. Table 2.1 below shows the demographic characteristics of this study's sample. A total of 7,241 households were interviewed, the majority of which came from Eastern province (1,917 households). The average household size was 7 members with the household head's average age being 52 years. The majority of the households interviewed were headed by a male (76%). The study also highlighted that Western province had the highest number of female (30%) headed households followed by the Copperbelt (27%). It was further observed that the majority of the household heads were monogamously (65%) married. Furthermore, the majority of household heads had obtained some form of primary (57%) school education seconded by secondary education (27%). Luapula province had the highest number of household heads who had attended at least primary level of education, with just 6% having no formal education. The study further highlighted that 5% of the household heads were still attending some form of school at the time of the interview.

Table 2. 1: Demographic Characteristics

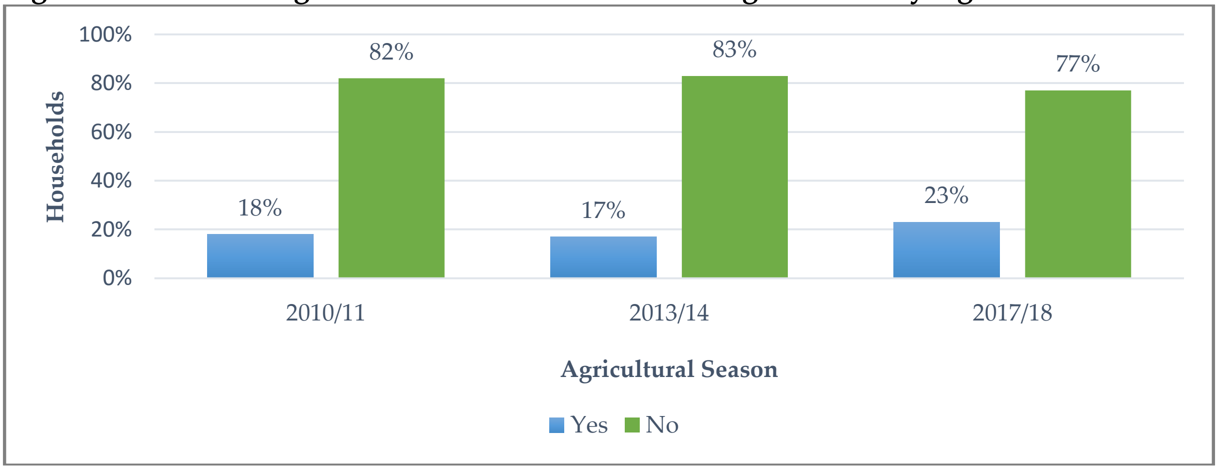
Characteristics	Total/Average	Central	Copperbelt	Eastern	Luapula	Lusaka	Muchinga	Northern	North-Western	Southern	Western
No. of Households	7241	566	502	1917	615	404	680	707	486	810	554
Household size	7	8	7	7	7	7	6	7	7	8	7
HH's Age	52	53	54	51	52	55	50	52	52	52	54
Sex HH head											
Male	76%	78%	73%	76%	77%	77%	76%	78%	77%	79%	70%
Female	24%	22%	27%	24%	23%	23%	24%	22%	23%	21%	30%
Marital status											
Never married	1%	1%	2%	1%	0%	2%	1%	0%	3%	1%	3%
Monogamous	65%	64%	68%	64%	71%	72%	64%	68%	69%	55%	63%
Polygamous	11%	12%	2%	13%	6%	1%	13%	10%	5%	25%	5%
Divorced	7%	7%	8%	7%	8%	6%	5%	6%	8%	6%	9%
Widowed	15%	16%	20%	14%	13%	16%	14%	14%	15%	12%	17%
Separated	1%	1%	1%	1%	1%	3%	3%	2%	1%	1%	3%
HH head's Education level											
Non/Missing	13%	9%	8%	21%	6%	13%	9%	11%	11%	9%	11%
Primary	57%	58%	55%	55%	62%	44%	58%	61%	57%	60%	58%
Secondary	27%	30%	33%	21%	26%	32%	30%	27%	26%	28%	27%
Tertiary	4%	2%	4%	2%	6%	11%	4%	2%	6%	3%	3%
Attending School	5%	2%	3%	4%	5%	5%	4%	5%	8%	4%	7%

Source: *RALS 2019 and author's computations*

2.2 Current State of Smallholder Farmers' Irrigation Use

An opportunity which is yet to be fully exploited in Africa is irrigated agriculture (UNEP 2006). Although irrigation in Africa has the potential to boost agricultural productivity by at least 50%, food production on the continent is almost entirely rainfed. The area equipped for irrigation, currently slightly more than 13 million hectares, makes up just 6% of the total cultivated area (You and Wood-sichra 2010). The level of irrigation use by smallholder farmers in Zambia has generally been low throughout the years. As shown in figure 2.2.1, on average about 18% of the smallholders irrigated at least one of their fields during the 2010/11 agricultural season, this dropped by one percent in the 2013/14 agricultural season as only 17% of the smallholders irrigated at least one of their fields. However, the 2017/18 agricultural season saw an increase of 6% in the percentage of households irrigating at least one of their fields from 17% in 2013/14 to 23%. Zambia has suffered from numerous droughts and prolonged dry spells in recent years, impacting agricultural production. The 2017/2018 rainfall season had prolonged dry spells, affecting mainly the southern half of the country (ACAPS 2019). Therefore, the increase in households who irrigated at least one of their fields in the 2017/18 agricultural season could be partly attributed to this.

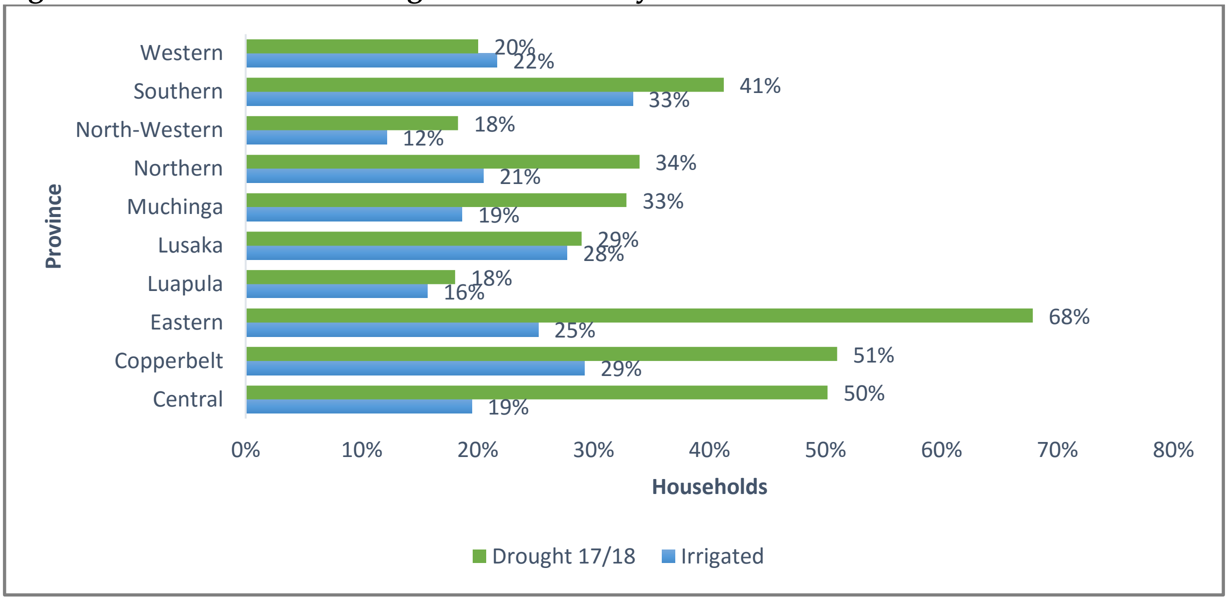
Figure 2.2. 1: Percentage Distribution of Household Irrigation Use by Agricultural Season



Source: *RALS 2012,2015, 2019 and author's computations*

A combination of prolonged, severe drought in Western and Southern province of Zambia over the past two rainy seasons in 2017 and 2018, and floods in the north, have increased hunger (OCHA 2019). The southern half of the country was largely affected by prolonged dry spells in 2017/2018 rainfall season. Therefore, it is no surprise that Southern, Lusaka, Eastern and Western were among the top five (5) provinces with households which used irrigation in the 2017/18 agricultural season, with Southern province having the highest percentage of households (33%), see figure 2.2.2. There seems to be some correspondence between drought and irrigation use as most of the provinces that were badly hit by droughts had a significant proportion of irrigating households. The fact that Zambia's staple food (maize) is predominantly grown in Southern province substantiates the findings in figure 2.2.2 as most smallholder farmers irrigated their maize fields.

Figure 2.2. 2: Percentage Distribution of Households Using Irrigation in the 2017/18 Agricultural Season and Drought Occurrence by Province



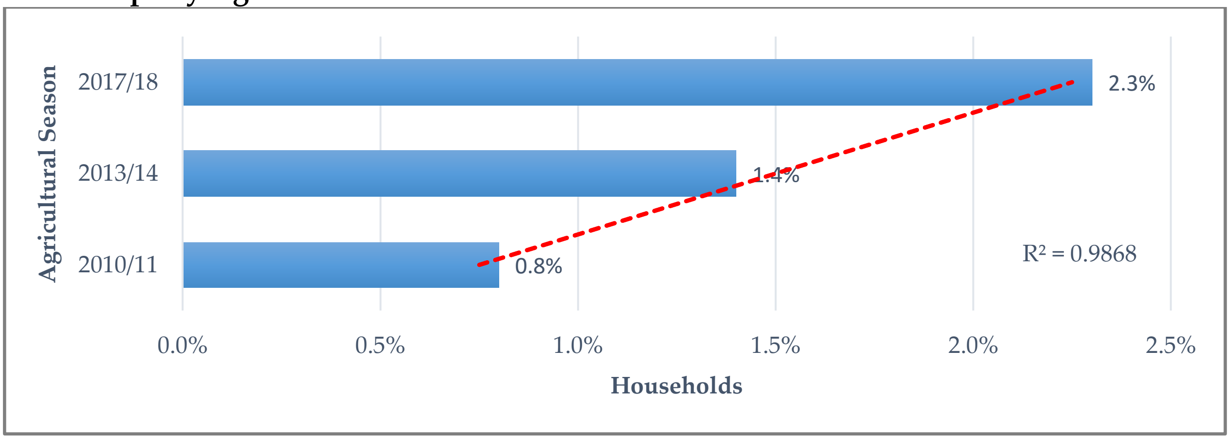
Source: *RALS 2019 and author's computations*

Traditionally, men and women play different roles in small-scale agriculture. Men often control household finances and decisions regarding purchases of agriculture technology and inputs. This social aspect may make men more likely to adopt new agriculture technology (DiGennaro 2010). Modesty is a gender issue sometimes cited as a limitation to adoption of an agriculture technology such as the treadle pump. Some women have been reported to be uncomfortable using a treadle pump because of the elevated position and stepping motion required for operation (Kay and Brabben 2000). This and other labour requirements are some of the reasons irrigation use is still low among female-headed households. Only 2% of the female-headed households irrigated at least one of their field crop fields compare to 3% of the male-headed households. A larger proportion of both male and female-headed households irrigated their fruits and vegetables than they did field crops, with male-headed households irrigating 12% more than the female-headed; the study established that 36% of the male headed households irrigated their fruits and vegetables. This could also be partly because of the larger proportion of male-headed households.

There has been a slow and steady increase in the proportion of rural households irrigating field crops throughout the years. Although Zambia has witnessed an increase in the proportion of smallholder farmers irrigating their fields, it is largely those who irrigate their gardens, and these are located mostly in the dambos (wetlands). Field crop irrigation is almost nonexistent as shown in figure 2.2.3, less than 1% of the households irrigated land under field crops in the 2010/11 agricultural season while just slightly over 1% irrigated land under field crops in the 2013/14 agricultural season. This proportion nearly doubled in the 2017/18 agricultural season as 2.3% of the households irrigated at least one field for field crops. These findings are similar to those found in (Ngoma et al. 2017). The general increase in the need to irrigate could be due to climate change which has affected wetlands with an increase in drought occurrences over the last few years (Mpundu and Sichilima 2020).

Food availability within a given year is determined largely by the timing and performance of Zambia's seasons, which interacts significantly with the country's reliance on rain-fed agriculture. In a normal year, the peak lean season begins in November and lasts until February, when the first harvests begin. A variety of factors, drought inclusive, can lead to inter-annual variation in agricultural production, particularly for maize (FEWS NET 2013). With this said, it is imperative for smallholder farmers to increase their field crop irrigation use as it can play a major role in increasing food availability which has been volatile in recent years.

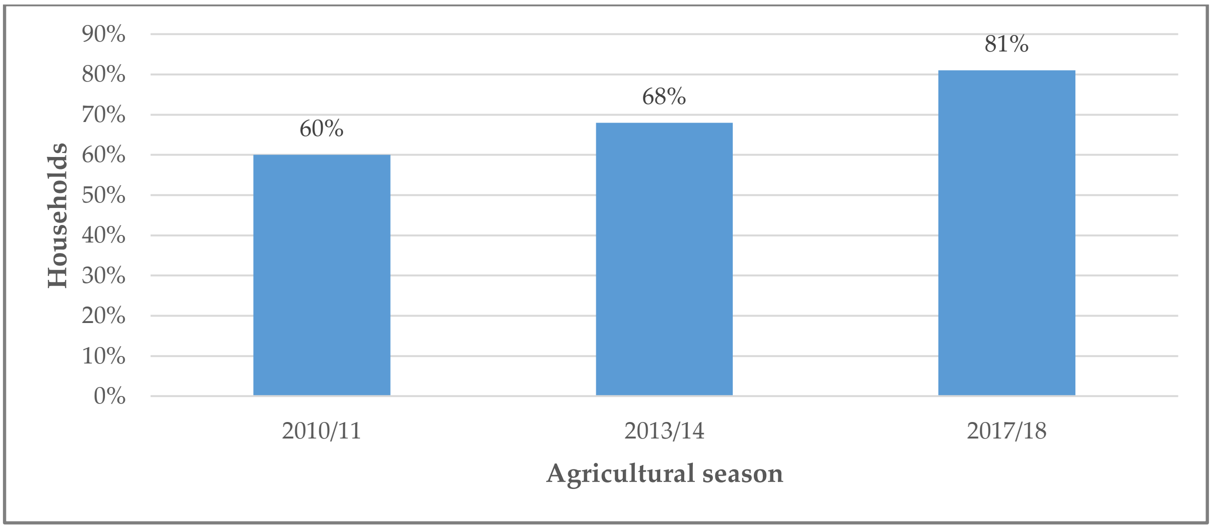
Figure 2.2. 3: Percentage Distribution of Households that Irrigated at least One Field for Field Crops by Agricultural Season



Source: *RALS 2012,2015, 2019 and author's computations*

Fresh fruits and vegetable production in Zambia has mainly been done on a small scale and for local informal markets. Significant quantities of fruits and vegetables continue being imported despite Zambia having the potential to produce to satisfy the local demand and have surplus to export (Mumba et al. 2016). With the increase in population and calls for consumption of nutritious foods in recent years, vegetables have been on high demand. The government of Zambia has recognized the potential contribution that fruits and vegetables have in terms of income generation as a Non-Traditional Export (NTE). In trying to understand the nationwide production trends from 2011, the study found that there has been an increase, in households producing fruits and vegetables, of 8% between 2011 and 2014 while between 2014 and 2018 there was an increase of 13%. Overall, there has been an increase in fruits and vegetables production of 21% between 2012 and 2019, see figure 2.2.4. Because of the COVID-19 pandemic, borders were closed in Zambia and this affected the importation of various goods and services including fruits and vegetables. This is expected to increase demand for locally produced goods. This could actually present Zambia with an opportunity to boost local production as it already is on an upward trend, then adopt the mercantilist approach to boost horticulture's contribution towards the GDP. For this to happen, however, there is need for policies that facilitate production and packaging this produce in internationally acceptable standards.

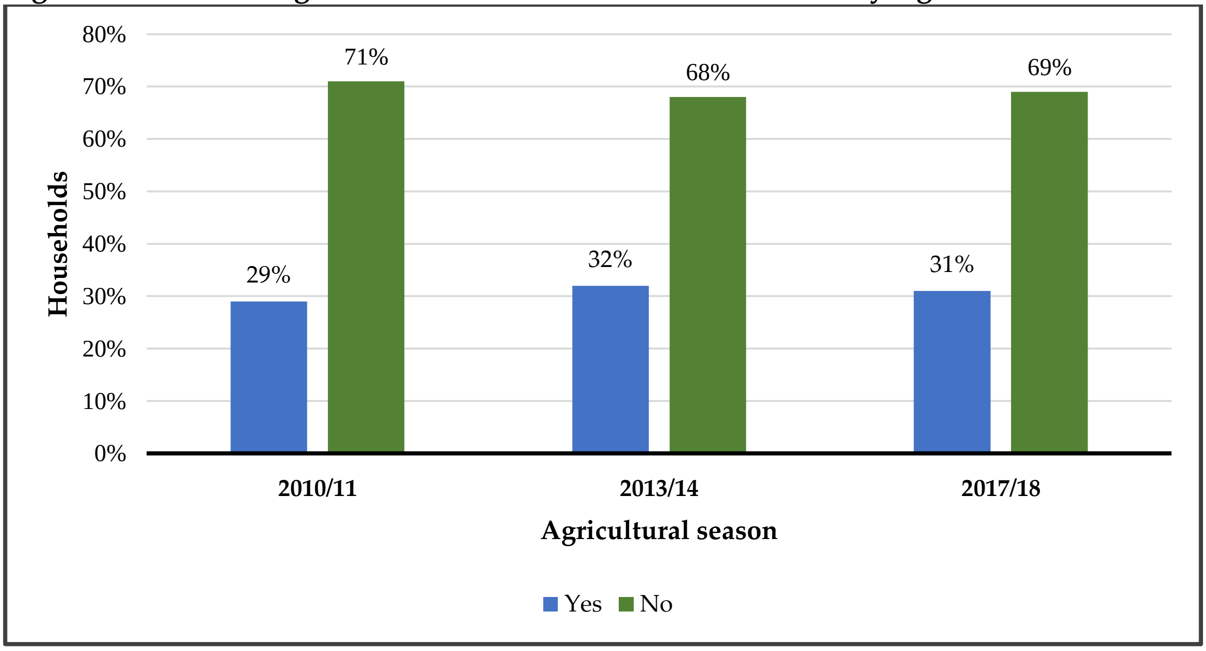
Figure 2.2. 4:Percentage of Households that Produced Fruits and Vegetables by Agricultural Season



Source: *RALS 2012, 2015, 2019 and author's computations*

The majority of the farmers in Zambia are subsistence farmers meaning they produce to primarily consume and sell the surplus. But because most of these rural farmers are almost entirely dependent on agriculture as a means of livelihood, it is important that they earn some income from their production to purchase what they need but cannot produce. In Zambia it is common that farmers engage in growing fruits and vegetables especially after the rain season, and so this study tried to assess what proportion of these farmers sold some of their produce. As shown in figure 2.2.5, there has been no significant change since 2011 in the proportion of households selling their fruits and vegetables produced. An average of 31% of households sold their produce. This could be due a lot of factors including: 1) the lack of access to structured markets, 2) no capacity (including water scarcity in the wake of climate change) to produce excess to sell, 3) no capacity to store or transport fresh produce which leads to post harvest losses, and 4) lack of capacity to meet certain standards to be able to supply to big buyers or unavailability of proper standards policies (IAPRI 2015, Gashu et al. 2019).

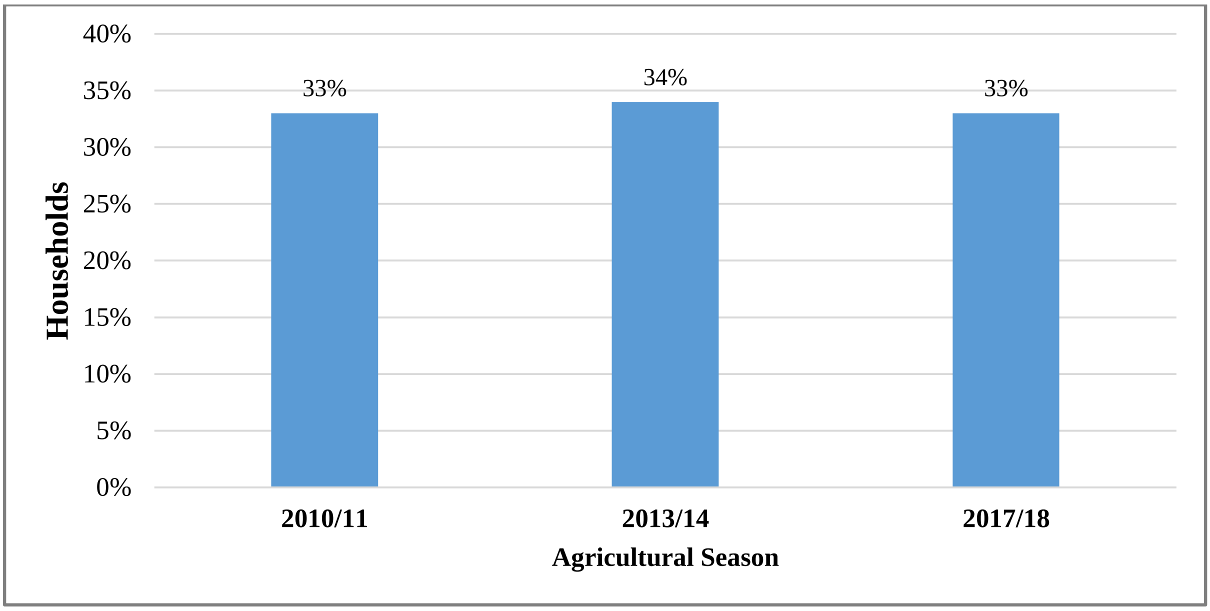
Figure 2.2. 5: Percentage of Households that Sold their Produce by Agricultural Season



Source: *RALS 2012, 2015, 2019 and author's computations*

As highlighted earlier, water scarcity is one of the challenges that fruits and vegetable farmers face especially now when Zambia, like the rest of the world, is grappling with the effects of climate change. But because most horticultural crops require irrigation, the study tried to check the trend over the years in terms of households irrigating their fruits and vegetables (PennState University 2001). It was shown that there has been consistency in the number of households irrigating fruits and vegetables, this is despite a 1% increase between 2011 and 2014. The minimal decrease (1%) in the number of households irrigating their fruits and vegetables between the 2013/14 and 2017/18 agricultural seasons could be due to climate change which has affected wetlands with an increase in drought occurrences over the last few years, as most smallholder farmers still use the traditional way of irrigation. Furthermore, the low use of irrigation over the years could be because most common fruits were not irrigated and some vegetables were grown in the rain season together with cereals such as maize. These results show an opportunity for irrigation technology companies to tap into this market so that farmers can have access to irrigation equipment. To increase uptake of these equipment, these firms should try the hire purchase approach to ensure that farmers have flexible payment plans.

Figure 2.2. 6: Percentage of Households that Irrigated Fruits and Vegetables by Agricultural Season



Source: *RALS 2012, 2015, 2019 and author's computations*

Further analysis revealed that of the households that irrigated their fruits and vegetables, 88% in the 2012 survey year, 85% in 2015 and 82% in 2019 had irrigated using a well or river or stream with the aid of a bucket. This is the traditional way of irrigating. The reduction in the proportion of households using the traditional irrigation methods could be attributed to the observed marginal increase in adoption of more advanced types of irrigation such as the motorized kits, hand or treadle pumps etc. The importance of irrigation among smallholder farmers lies in boosting incomes and food security. There is evidence that the use of Market

Systems Approach (MSA) in irrigation schemes improves efficiency and this can increase productivity, incomes and livelihoods of smallholder farmers (Masasi and Ng'ombe 2019). In fact, replacing traditional methods of irrigation with improved modern ones improves efficiency as it saves water, farmers' energy and time spent in watering the fruits and vegetables.

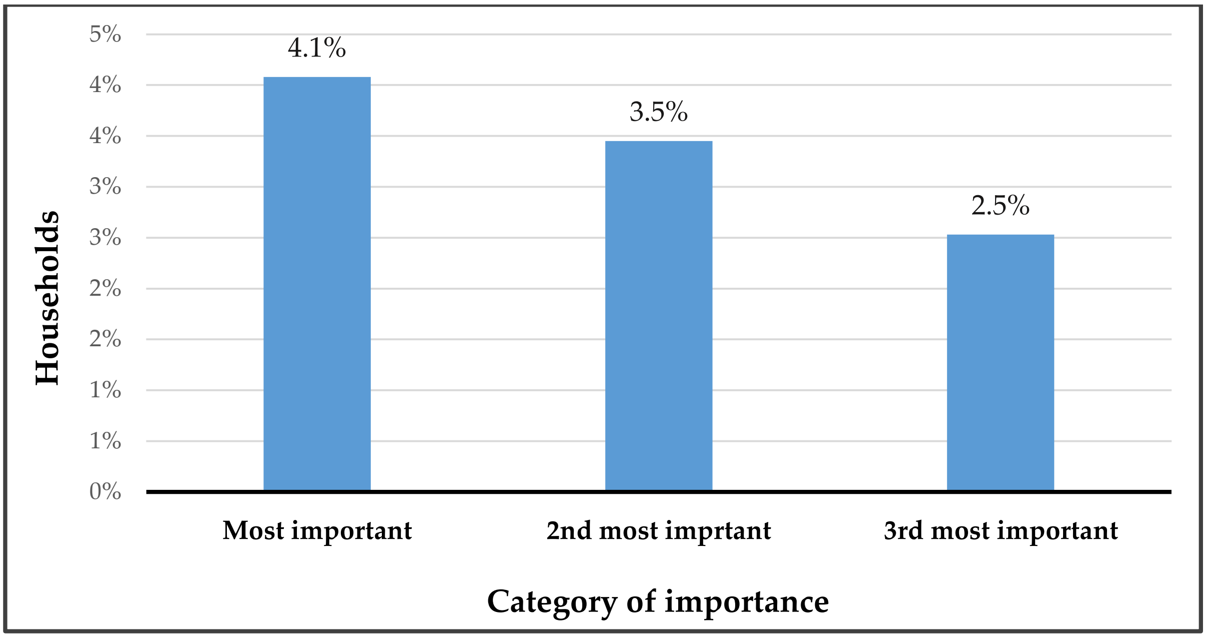
Table 2.2. 1: Types of Irrigation mainly Used for Fruits and Vegetables

Type of irrigation	Farmers		
	2012	2015	2019
Motorized	4%	6%	6%
Piped public water	1%	2%	2%
Well/river/stream and bucket	88%	85%	82%
Hand or treadle pump	4%	3%	5%
Irrigation canal	3%	4%	5%

Source: *RALS 2012, 2015, 2019 and author's computations*

In order to gauge the importance farmers had placed on irrigation in the fight against climate change, households were asked to highlight top three strategies of their preference, which they would use to prepare for the next drought event. Figure 2.2.7 shows that irrigation was definitely not among the most selected strategies. This could be because the farmers may be struggling with water sources for irrigation as the majority of smallholder farmers have their fields far away from rivers and lakes. Given that borehole drilling is relatively expensive for smallholder farmers, they would definitely prefer relatively cheaper and more convenient strategies. Because water is at the center of agricultural crop production, one solution to water deficits would be the establishment of irrigation schemes for fruit and vegetable farmers especially in regions with comparative advantage in terms of water resources over other reasons. This can boost this industry as there would be extensive training of farmers in these schemes on how to produce high quality fruits and vegetables. There is also an opportunity for fruit and vegetable standards application and improvement, contribution toward Zambia's GDP through the export of fresh produce, and value addition to produce various fruits and vegetable products.

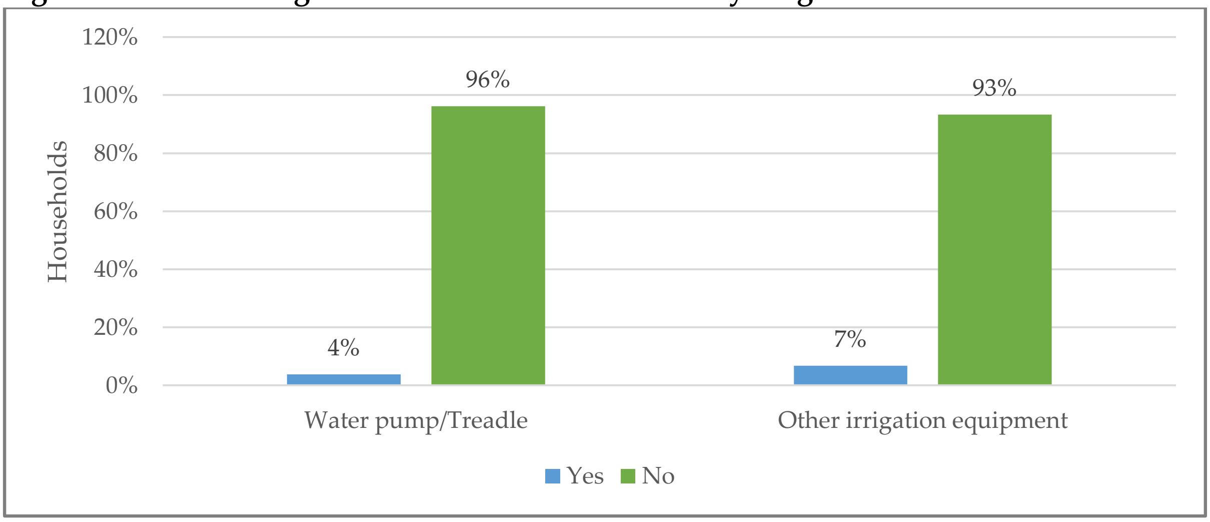
Figure 2.2. 7: Percentage of Households that Chose "Use irrigation" against Future Negative Weather Events



Source: *RALS 2019 and author's computations*

Figure 2.2.8 shows that a measly 4% of farmers owned at least a water/treadle pump with 7% owning other irrigation equipment. Smallholder farmers' lack of irrigation equipment indicates that they are still practicing traditional/informal irrigation. Zambia's potential irrigable land growth could be realized by promoting the use of motorized, and potentially solar, pumps for smallholders who currently irrigate using buckets (Mendes et al. 2014).

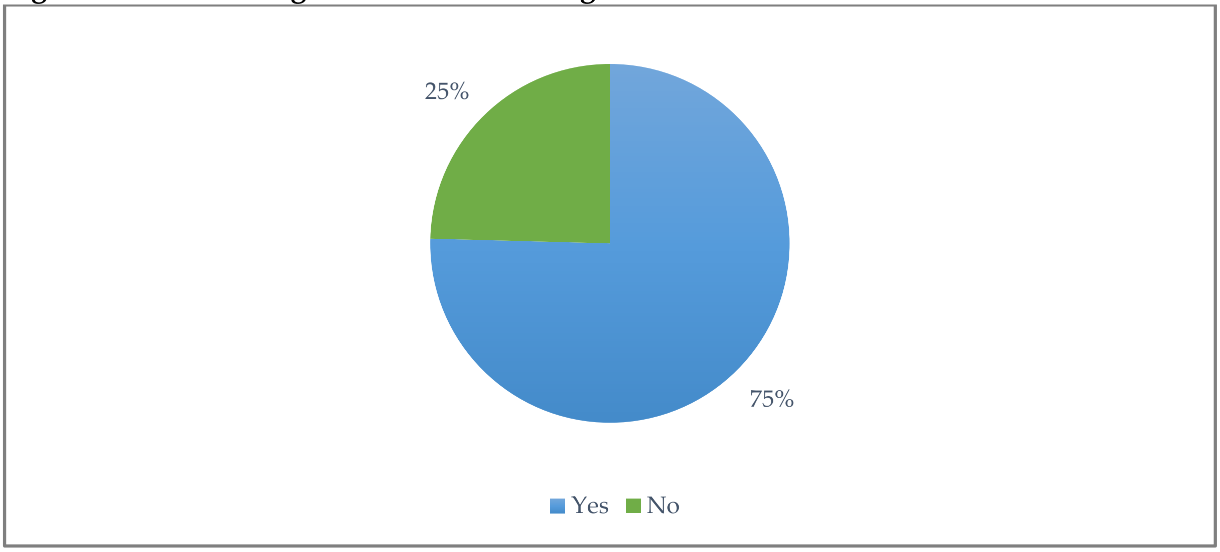
Figure 2.2. 8: Percentage Distribution of Households by Irrigation Assets Owned



Source: *RALS 2019 and author's computations*

The ecological conditions of dambos and other wetlands are susceptible to deterioration and the utilization of these wetlands for cultivation and irrigation may cause land degradation and depletion of resources (Kodamaya 2009). Therefore, smallholder farmers should be encouraged to shift from the traditional/informal way of irrigation to modern irrigation equipment such as motorised pumps. As shown in figure 2.2.9 below, 75% of the irrigated fields were in wetlands/dambos, this still shows that smallholder farmers are to a greater extent still practicing informal irrigation.

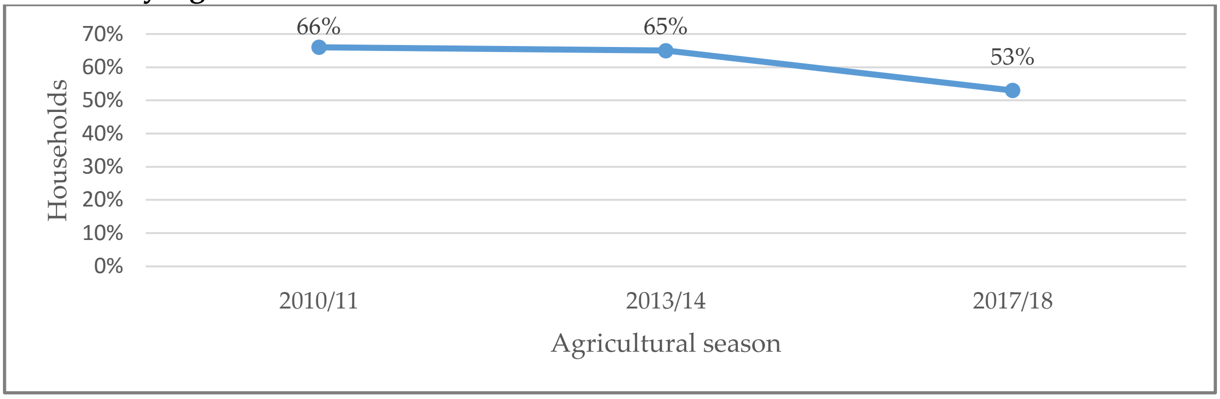
Figure 2.2. 9: Percentage Distribution of Irrigated Field Use in Wetlands/Dambos in 2017/18



Source: *RALS 2019 and author's computations*

Irrigation farming began as traditional or informal irrigation, whereby vegetables were grown in dambo gardens with the use of bucket irrigation (Kodamaya 2009). As earlier highlighted, the majority of the irrigated fields were in wetlands/dambos, of which most were used for growing fruits and vegetables. Informal irrigation for fruits and vegetables is more prevalent than for field crops among smallholder farmers in Zambia, with the majority of the irrigated fields located close to water sources (Dambos/wetlands) (Ngoma et al. 2017). This is coinciding with the findings of this study were the majority (over 50%) of the irrigated fruit/vegetable fields have been in wetlands/dambos since 2011.

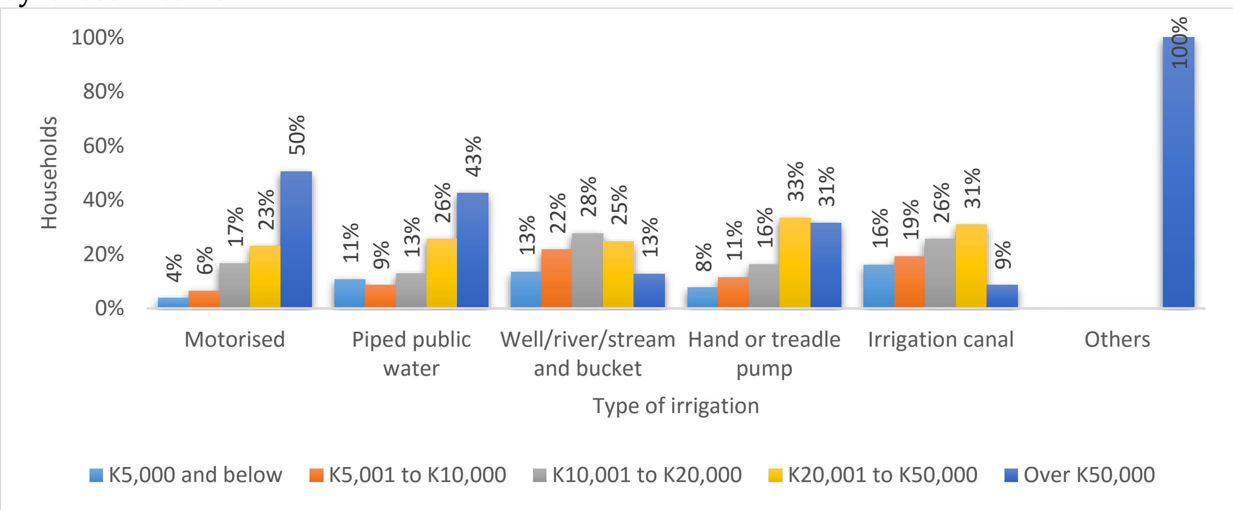
Figure 2.2. 10: Percentage Distribution of Irrigated Fruit/Vegetable Fields in Wetlands/ Dambos by Agricultural Season



Source: *RALS 2012, 2015, 2019 and author's computations*

Various literature has revealed that household income levels play a vital role in the adoption of agricultural technology by smallholder farmers. According to Adeoti et al. (2007), even with the low cost of treadle pumps, the purchase cost was seen as the most significant barrier to adoption. Therefore, households with a higher gross income are more likely to adopt irrigation technologies than those with lower gross income. This study confirms this as households in the higher income bracket used more of the modern irrigation equipment. About 50% of the households that used motorised irrigation equipment had a gross annual income of over ZMW50,000 while also 64% of the households that used hand or treadle pumps had a gross annual income of over ZMW20,000. Of the households that used motorised irrigation equipment and hand or treadle pumps, only 4% and 8% respectively, had a gross annual income of less than ZMW5,000.

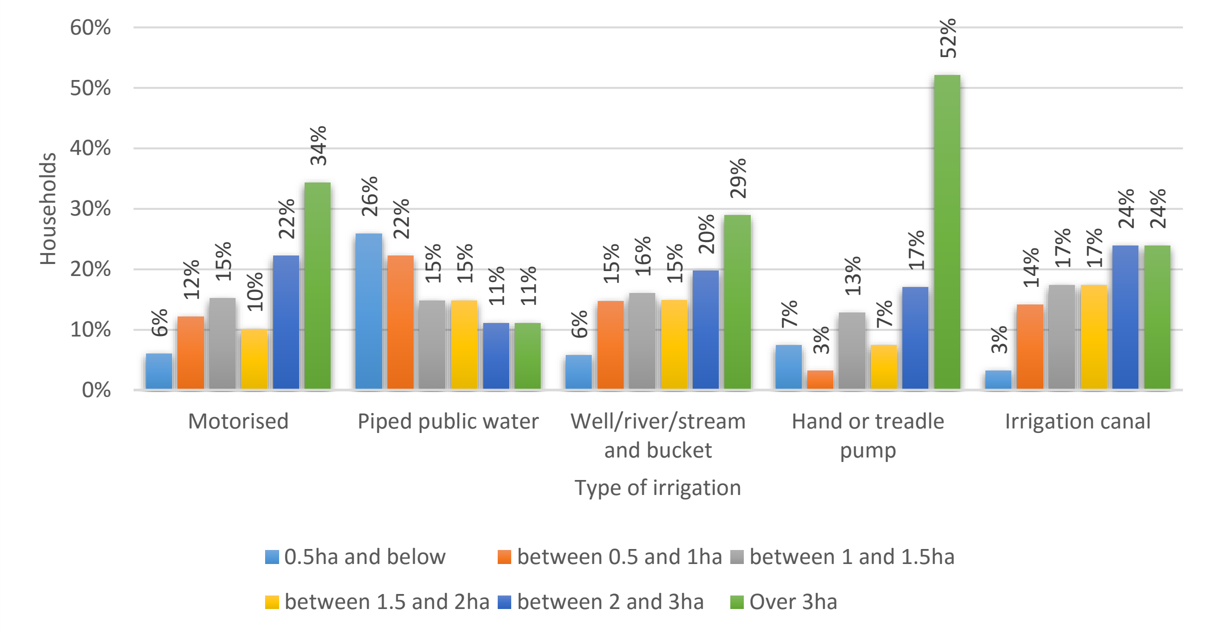
Figure 2.2.1 1 Percentage Distribution of Type of Irrigation used for Fruits and Vegetables by Gross Income



Source: *RALS 2019 and author's computations*

Pokhrel et al. (2018) findings indicate that the intensity of irrigation technology adoption increases as landholding increases. Therefore, implying that the total land owned plays a role in the number of irrigation technologies adopted. As shown in the figure below, the majority of the households that used motorised irrigation (34%) and hand or treadle pumps (52%) had own-cultivated land of over 3 hectares, while the minority had own-cultivated land of less than 0.5 hectares. This confirms that landholding plays a role in the adoption of irrigation technologies.

Figure 2.2.1 2 Percentage Distribution of Type of Irrigation used for Fruits and Vegetables by Size of Own-cultivated Land

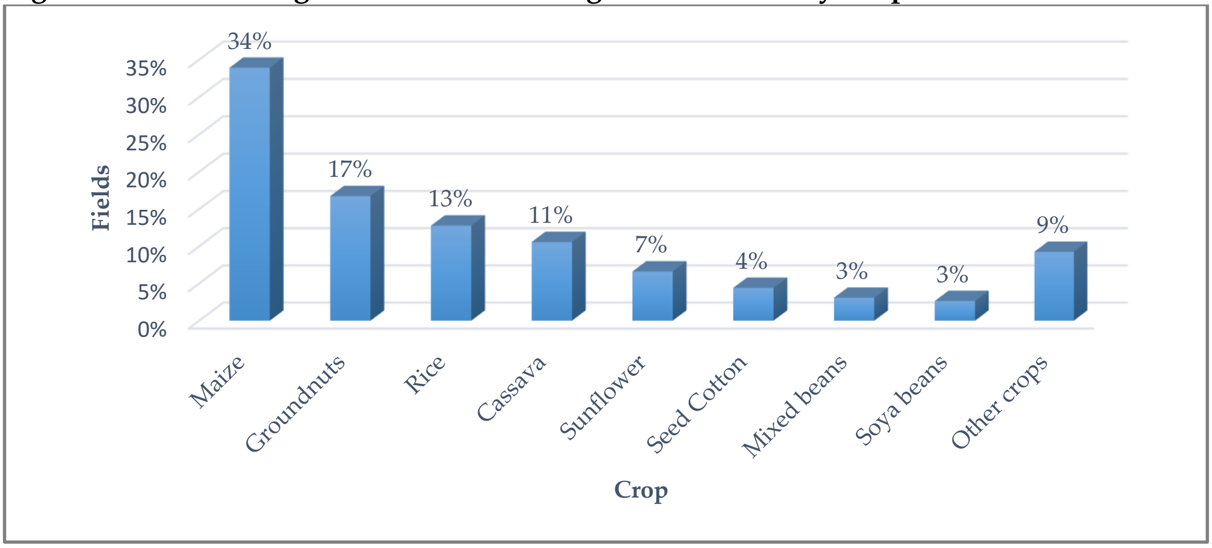


Source: *RALS 2019 and author's computations*

2.3 Crops on which Irrigation is mostly Used by Smallholder Farmers

In a region where droughts are prevalent, often destroying crops and exacerbating food insecurity, irrigation could be a key factor in enhancing food security. Irrigation increases yields of most crops by between 100% and 400% and it has been projected that in the next three decades, 70% of gains in cereal production globally would be from irrigated land (UNEP 2006). Crop production, with maize as the dominant staple crop, underpins food security for much of the country. Maize production is highest in Central, Southern and Eastern Zambia. Northern and North-western Zambia produce roughly equal amounts of maize and cassava (FEWS NET 2013). Therefore, it should come as no surprise that maize was the most irrigated field crop with 34% of the maize fields being irrigated, followed by groundnuts, rice and cassava with 17%, 13% and 11% respectively.

Figure 2.3. 1: Percentage Distribution of Irrigated Field Use by Crop in 2017/18



Source: *RALS 2019 and author's computations*

2.4 Effects of irrigation on smallholder farmer productivity

Lack of access to water and irrigation is one of the leading deterrents to agricultural productivity in Sub-Saharan Africa. Limited access to water limits the diversity of crops and also reduces the stability of yields among smallholder farmers. There is a strong belief that crop yields from marginalized land in Sub-Saharan Africa could be doubled, and in many cases quadrupled, when management practices are changed and irrigation is accessible (Nicoletti et al. 2011).

Irrigation is increasingly seen as a necessary means of increasing smallholder farmer productivity; therefore, it is no surprise that the average yield of smallholder farmers irrigating their field crop fields was higher than that of those who did not irrigate for some crops. The average maize yield for smallholder farmers that irrigated their maize fields was approximately 29Kg/ha higher than that of those that did not irrigate. This number could potentially increase if more smallholder farmers begin to irrigate their fields as emphasized by most scholars. A very notable variance in table 2.4.1 is the rice variance, the average rice yield for farmers that irrigated their rice fields was a substantial 618Kg/ha higher than that of those that did not irrigate. This could be attributed to the nature of the crop, rice requires a sizeable amount of water to grow, therefore, it is expected that farmers irrigating it obtain higher yields.

Similar to rice, soya beans also had a similar outcome, with farmers who irrigated their soya bean fields having an average yield of 471Kg/ha higher than those that did not irrigate. Unlike maize, rice and soya beans, farmers who irrigated their groundnut/mixed bean fields obtained a lower yield than those that didn't irrigate. This could be due to the low number of smallholder farmers who irrigated their field crop fields.

Table 2.4. 1: Crop Yield for Irrigated and Non-Irrigated Fields in 2017/18

Crop	Average (Kg/ha)	Irrigated field (Kg/ha)	Non-irrigated field (Kg/ha)	Variance (Kg/ha)
Maize	2302.9	2331.5	2302.6	28.9
Rice	1672.6	2251.3	1633.0	618.3
Groundnuts	687.0	680.0	687.1	-7.1
Soya beans	1027.5	1495.8	1024.8	471.1
Mixed beans	607.1	538.6	607.7	-69.1

Source: *RALS 2019 and author's computations*

The point-biserial correlation output between irrigation and yield shows that irrigating fields of maize, groundnuts and mixed beans was not statistically significant while irrigating fields of rice and soya beans was statistically significant at 1% and 10% significance levels respectively. This means, we can statistically conclude that there is a correlation between irrigating fields of rice/soya beans and high yield. The correlation coefficient for maize, groundnuts and mixed beans was essentially zero, this could be due to the low number of smallholder farmers who irrigated their field crop fields. Even though irrigating fields of maize was not statistically significant, the positive number indicates that farmers with irrigated maize fields are likely to have higher maize yields than farmers with non-irrigated maize fields.

Table 2.4. 1: Output of the Point-Biserial Correlation between Irrigation and Yield in 2017/18

Crop	Correlation Coefficient	t-value
Maize	0.0019	0.154
Rice	0.1311	2.7101
Groundnuts	-0.0011	-0.0713
Soya beans	0.0546	1.7655
Mixed beans	-0.013	-0.3953

Source: *RALS 2019 and author's computations*

3.0 Conclusion

This study revealed that the level of irrigation use by smallholder farmers in Zambia has generally been low throughout the years. Zambia is yet to fully exploit its irrigation potential, growth could be realized by not only promoting the use of motorized, and potentially solar, pumps but also through sustainable water management. One strategy that can be employed by smallholder farmers in areas prone to flooding is rain water harvesting, this could be a prerequisite for irrigation, so that in drier times the harvested water can be used for irrigation. Unsurprisingly, given that maize is the most grown crop in the highest irrigating province, the Southern province, it is also the most irrigated field crop by smallholder farmers.

The study also highlighted that smallholder farmers largely irrigated fruits and vegetables as compared to field crops, with traditional/informal irrigation being the most commonly used method through bucket irrigation. It is of no surprise that the majority of smallholder farmers grew their vegetables in wetlands/dambos, as vegetables are water-intensive crops. Households with a high gross income used more of the motorized irrigation equipment and hand/treadle pumps on their fruits/vegetables while those with low gross income used less of these. Income plays a role because the cost of acquiring this equipment might be high, therefore subsidizing this modern irrigation equipment and devising strategies to help smallholder farmers acquire these will prove to be beneficial in the step towards increasing irrigable land and subsequently productivity. Same applies to landholding, households with larger own-cultivated fields used more of the modern irrigation equipment on their fruits/vegetables as compared to those with smaller landholding.

This study echoed the widely advocated notion by several scholars that irrigation is seen as a means of increasing farmer productivity. Even though very few farmers irrigated field crops, it was evidenced through a few crops that the average yield of those that irrigated was higher than that of those that did not irrigate. Therefore, irrigation has potential to increase smallholder farmer's crop productivity.

With the current below-average precipitation from the seasonal rains, Zambia is expected to become hotter and drier, especially in the western and southern regions. Therefore, the adoption of modern and affordable irrigation technologies by smallholder farmers in these regions is essential not only for increasing productivity but also for the country's food security. In addition to this, the fact that the staple food, maize, is predominantly grown in the southern region makes the current droughts affecting the region a major threat to the country's food security. Therefore, it is imperative for smallholder farmers to increase their field crop irrigation.

4.0 References

ACAPS. 2019. “Drought – Southern Province.”

Adeoti Adetola, Barry Boubacar , Namara Regassa, Kamara Abdul and Titiati Atsu, International Water Management Institute, Adetola Adeoti, Boubacar Barry, Regassa Namara, Abdul Kumara, and Atsu Titiati. 2007. *Treadle Pump Irrigation and Poverty in Ghana*. Vol. 117. https://doi.org/http://dx.doi.org/10.3910/2009.117.

Akayombokwa, I. M., B. van Koppen, and M. (Matete. 2015. “Trends and Outlook: Agricultural Water Management in Southern Africa. Country Report - Zambia. [Project Report Submitted to United States Agency for International Development’s (USAID’s) Feed the Future Program]. Pretoria, South Africa.” www.iwmi. cgiar.org/Publications/Other/Reports/PDF/ country_report_zambia.pdf.

DiGennaro, Simeon William. 2010. “Evaluation of the Livelihood Impacts of a Micro-Irrigation Project in Zambia” 9 (1): 76–99. https://doi.org/10.1558/jsrnc.v4il.24.

FAO. 2005. “AQUASTAT Country Profile - Zambia. Food and Agriculture Organisation of the United Nations (FAO). Rome, Italy.” *Small* 000 (July).

FEWS NET. 2013. “Zambia Food Security Brief.” *Usaid*, no. September 2009: 1–52.

Gashu, D., Demment, M. W., and Stoecker, B. J., 2019. Challenges and opportunities to the African agriculture and food system. *African Journal of Food, Agriculture, Nutrition and Development* [online], 19 (01), 14190–14217. Available from: https://www.ajfand.net/Volume19/No1/BLFB2000.pdf [Accessed 9 Jul 2020].

IAPRI, 2015. OPPORTUNITIES AND CHALLENGES IN ENHANCING AGRICULTURAL DEVELOPMENT IN ZAMBIA. [online]. Available from: http://www.renapri.org/wp-content/uploads/2017/01/IAPRI_white_paper.pdf.

IAPRI, 2015. *Rural Agricultural Liveslihood Survey 2015 Survey_Report__Final* [online]. Available from: https://images.agri-profocus.nl/upload/post/RALS_2015_Survey_Report__Finalv-_edited1456827249.pdf.

Kodamaya, Shiro. 2009. “Recent Changes in Small-Scale Irrigation in Zambia: The Case of a Village in Chibombo District Shiro Kodamaya Graduate School of Social Sciences, Hitotsubashi University, Tokyo, Japan.”

KODAMAYA, Shiro. 2015. “Fertilizer and Irrigation in Improving Smallholder Food Security:The Case of One Village in Central Zambia.” *Kikan Chirigaku* 66 (4): 239–54. https://doi.org/10.5190/tga.66.239.

Machado Mendes, Diogo, Lisa Paglietti, David Jackson, and Felix Chizhuka. 2014. “Zambia: Irrigation Market Brief.”

Masasi, B. and Ng’ombe, J. N., 2019. Does A Market Systems Approach Revitalize Smallholder Irrigation Schemes? Evidence from Zimbabwe. *Sustainable Agriculture Research* [online], 8 (2), 36. Available from: http://www.ccsenet.org/journal/index.php/sar/article/view/0/38881 [Accessed 6 May 2019].

Melvyn Kay, Tom Brabben. 2000. “Treadle Pumps for Irrigation in Africa. Rome, Italy: Food and Agriculture Organization of the United Nations, Knowledge Synthesis Report No. 1.” *Africa*.

Mpundu, C. and Sichilima, T., 2020. *Key climate change coping strategies used by smallholder farmers in Zambia* [online]. Lusaka Zambia: Musika Development Initiatives Ltd Zambia. Available from: https://www.musika.org.zm/research-reports/.

Mumba, M., Mwanamambo, B., Mwale, M., Sichivula, I., and Musaba, 2016. *Report-Horticulture-Subsector-in-Zambia.pdf* [online]. Available from: https://www.rvo.nl/sites/default/files/2016/08/Final-Report-Horticulture-Subsector-in-Zambia.pdf.

Ngoma, Hambulo, Byman Hikanyona Hamududu, Norwegian Water Resources, Energy Directorate, Peter Hangoma, and Paul Chimuka Samboko. 2017. “Irrigation Development for Climate Resilience in Zambia : The Known Knowns and Known Unknowns Irrigation Development for Climate Resilience in Zambia : The Known Knowns and Known Unknowns by Hambulo Ngoma , Byman Hamududu , Peter Hangoma , Paul Samboko ,.” *Research Gate*, no. January 2018: 48.

Nicoletti, Christopher Kevin, Gregory Graff, and Stephan Weiler. 2011. “Rural Prosperity

Initiative: Propensity-Score Analysis of Income and Crop Production Effects from a Comprehensive Micro-Irrigation Program in Zambia."

OCHA. 2019. "Zambia Humanitarian Dashboard," no. December 2019: 3–5.

Pokhrel, Bijay K., Krishna P. Paudel, and Eduardo Segarra. 2018. "Factors Affecting the Choice, Intensity, and Allocation of Irrigation Technologies by U.S. Cotton Farmers." *Water (Switzerland)* 10 (6): 1–12. https://doi.org/10.3390/w10060706.

The Pennsylvania State University, 2001. irrigation-for-fruit-and-vegetable-production.pdf. [online]. Available from: http://agalternatives.aers.psu.edu.

UNEP (United Nations Environment Programme). 2006. *Africa Environment Outlook 2 : Our Environment, Our Wealth. Nairobi : UNEP.*

You, Liangzhi, and Ulrike Wood-sichra. 2010. "What Is the Irrigation Potential for Africa ? A Combined." *IFPRI Discussion Paper 00993*, no. June. http://ageconsearch.umn.edu/bitstream/93736/2/ifpridp00993.pdf.