Economia Aziendale Online

Business and Management Sciences
International Quarterly Review

Impacts of Irrigation Investment on Agricultural Productivity, Food Security and Poverty. The Case of Masvingo District, Zimbabwe

Bezzel Chitsungo

Pavia, December 31, 2023
Volume 14 - N. 4/2023
DOI: 10.13132/2038-5498/14.4.1183-1200

www.ea2000.it
www.economiaaziendale.it

PaviaUniversityPress

Electronic ISSN 2038-5498
Reg. Trib. Pavia n. 685/2007 R.S.P.

Economia Aziendale Online – Business and Management Sciences International Quarterly Review
SPECIAL ISSUE - Vol. 14-4/2023 - DOI: 10.13132/2038-5498/14.4.1183-1200

Impacts of Irrigation Investment on Agricultural Productivity, Food Security and Poverty. The Case of Masvingo District, Zimbabwe

Bezzel Chitsungo
Graduate School of Business.
P O Box 32379. University of Zambia, Lusaka, Zambia

Corresponding Author:

Bezzel Chitsungo

Eng.Chitsungo@gmail.com

Cite as:

Chitsungo, B. (2023). Impacts of Irrigation Investment on Agricultural Productivity, Food Security and Poverty. The Case of Masvingo District, Zimbabwe. *Economia Aziendale Online, 14*(4), 1183-1200.

Section: *Refereed Paper*

SPECIAL ISSUE 2023

Received: September 2023
Published: 31/12/2023

ABSTRACT

The role of irrigation in augmenting agricultural productivity cannot be overemphasised. Numerous studies indicate that there is a consistent trend of higher crop yields in regions with irrigation compared to those reliant on rainfall. The predominant focus of scholarly research has been on a singular dimension of the impact of irrigation, specifically its effects on agricultural productivity, poverty levels, or food security. This study aims to address the gap in existing scholarship by simultaneously examining all three aspects. Anchored on pragmatism research philosophy, this study employed a mixed methodology approach. The objective of this study is to provide a comprehensive viewpoint by concurrently analyzing the effects of irrigation on productivity, poverty, and food security. This approach aims to both quantify the relationship between irrigation investments and agricultural outcomes and provide a more nuanced understanding of the mechanisms by which irrigation affects livelihoods. The study discovered that irrigation influenced livelihoods in a variety of ways, including job creation and food and nutrition security. A new model for the sustainable management of group irrigation schemes is needed. In order to enhance their access to inputs, financing, and markets, it is imperative to establish cooperative organizations for the purpose of organizing group irrigation schemes into viable business entities.

Il ruolo dell'irrigazione nell'aumentare la produttività agricola non può essere enfatizzato abbastanza. Numerosi studi indicano che c'è una tendenza costante a una maggiore resa delle colture nelle regioni con irrigazione rispetto a quelle che dipendono dalle precipitazioni. L'attenzione predominante della ricerca accademica si è concentrata su una dimensione singolare dell'impatto dell'irrigazione, in particolare sui suoi effetti sulla produttività agricola, sui livelli di povertà o sulla sicurezza alimentare. Questo studio mira a colmare la lacuna negli studi scientifici recenti, esaminando simultaneamente tutti e tre gli aspetti. Ancorato alla filosofia di ricerca del pragmatismo, questo studio ha utilizzato un approccio metodologico misto. L'obiettivo di questo studio è quello di fornire un punto di vista completo analizzando contemporaneamente gli effetti dell'irrigazione sulla produttività, la povertà e la sicurezza alimentare. Questo

approccio mira sia a quantificare la relazione tra gli investimenti irrigui e i risultati agricoli sia a fornire una comprensione più sfumata dei meccanismi attraverso i quali l'irrigazione influisce sui mezzi di sussistenza. Lo studio ha trovato che l'irrigazione ha influenzato i mezzi di sussistenza in vari modi, tra cui la creazione di posti di lavoro e la sicurezza alimentare e nutrizionale. È necessario un nuovo modello per la gestione sostenibile degli schemi di irrigazione di gruppo. Al fine di migliorare il loro accesso ai fattori di produzione, ai finanziamenti e ai mercati, è imperativo stabilire organizzazioni cooperative allo scopo di organizzare schemi di irrigazione di gruppo.

Keywords: irrigation development, investments, poverty, food security, agricultural productivity.

1 – Introduction

In adopting Hargreaves (1998) definition, this study characterizes *irrigation as the artificial supply of water to agricultural crops, designed to facilitate farming in arid climates and mitigate drought effects in semi-arid regions*. As emphasized by van Averbeke *et al*., (2011), irrigation plays a crucial role in maintaining adequate soil moisture, addressing a primary constraint in plant growth caused by water deficits. Over the course of history, irrigation has been instrumental in enhancing natural production, particularly in arid and semi-arid regions, resulting in increased agricultural output (Bhattarai *et al*., 2004).

Positioning our study within the broader scholarly landscape, we acknowledge the pivotal role of irrigation in agricultural development (Lipton, 2007; Lipton *et al*., 2003). While past research has explored the connection between irrigation investments and productivity in developing nations (Fan & Hazell, 2001; McCartney *et al*., 2019), there persists a need to integrate and analyze the multifaceted impacts on poverty alleviation, food security, and overall agricultural productivity.

Addressing the literature gap, existing studies often concentrate on isolated aspects of irrigation development. However, our study aims to contribute a holistic perspective by simultaneously examining its impact on productivity, poverty, and food security. Through this approach, we seek not only to quantify the relationship between irrigation investments and agricultural outcomes but also to provide a nuanced understanding of the mechanisms through which irrigation influences livelihoods.

The *purpose* of this study is to fill existing gaps by adopting a mixed-methods approach to explore the intricate connections between irrigation investments and their broader socio-economic impacts. By delving into the employment creation, food, and nutrition security aspects, we aim to provide valuable insights for policymakers, practitioners, and researchers.

The central argument of this study posits that irrigation investments, when strategically organized, can yield positive outcomes across various dimensions, including poverty reduction, improved food security, and enhanced agricultural productivity. Through a comprehensive literature review and empirical analysis, we seek to substantiate this argument.

To guide our empirical investigation, the following research questions will be addressed:

1. How do irrigation investments influence agricultural productivity in different regions?

2. What is the impact of irrigation investments on poverty alleviation in diverse socio-economic contexts?

3. How do irrigation investments contribute to food and nutrition security, considering varying agricultural practices?

In terms of organization, this introduction sets the stage by defining irrigation, establishing its historical significance, and outlining the scope of irrigation investments. Subsequent sections will delve into the empirical evidence, methodological approach, and findings to support our central argument. The *contribution* of this study lies in its holistic examination of the impacts of irrigation investments, addressing the limitations of prior research that often focused on isolated dimensions. Our findings aim to inform policies and practices related to irrigation development, emphasizing the need for cooperative organizations in optimizing the benefits of group irrigation efforts.

In conclusion, this research is significant as it expands the current understanding of irrigation's broader impacts, offering insights that extend beyond productivity metrics. By integrating various elements within the introduction, we aim to provide a comprehensive framework for readers to engage with the study's objectives and contributions.

2 – Literature review

2.1 – *Importance of Irrigation*

Irrigation plays a vital role in increasing agricultural productivity. (Lipton, 2007; Lipton *et al*., 2003) noted that crop yields are consistently greater in irrigated areas than in rain-fed ones everywhere. Water is a vital input in agricultural production, and irrigation covers a portion or all of the water needs of crop production in many developing countries (Calzadilla *et al*., 2011). Irrigation may provide numerous benefits to the agricultural sector. To begin with, irrigation expands cultivatable lands beyond what is possible under rainfed conditions. Second, irrigation increases crop yields by preventing crop water stress and by combining irrigation with high-yielding crop varieties, fertilizers, and herbicides, (Expósito & Berbel, 2017). Irrigation addresses the risks of crop failure normally associated with dry land farming whereby in the event of mid season dry spells, irrigation will provide the supplemental water required to save the crop from wilting thereby achieving full growth. According to Smith (2004), farmers can increase output and decrease vulnerability to water shortages and seasonal droughts by irrigating their crops throughout the growth period.

With increasing rainfall variability and drought conditions, Aslam (2016) suggests that irrigation has considerably contributed to increasing India's food output and building grain surpluses that can be utilized as a drought buffer. In addition, Malakar *et al*., (2019) posit that irrigated agriculture has benefited some households in the Tigray region by providing an opportunity to boost agricultural productivity through double cropping and by taking advantage of contemporary technologies and high-yielding crops that require intensive farming.

The importance of irrigation is framed within the context of agricultural production economics, emphasizing the role of irrigation as a critical factor in increasing agricultural productivity. Scholars such as Lipton (2007) and Calzadilla *et al*. (2011) have contributed to this perspective by highlighting the economic benefits of irrigation, such as expanding cultivatable lands, increasing crop yields, and mitigating risks of crop failure. The lens here is centered on the economic principles governing agricultural production and the pivotal role water plays as a resource in this context. This leads us to the research hypothesis that posits: The economic

benefits of irrigation, encompassing expanded cultivatable lands and increased crop yields, playing a pivotal role in enhancing overall agricultural productivity. The existing literature predominantly highlights the economic aspects of the impact of irrigation on poverty, leaving a gap in understanding how irrigation investment influences non-economic dimensions of poverty, such as education and political rights.

2.2 – *Impact of irrigation on agricultural productivity*

With recent increases in food costs and increased demand for non-agricultural land usage, increasing agricultural productivity is more critical than ever. Irrigation investment empirical research has tended to indicate that the investment has a beneficial effect on changes in agricultural productivity (Mango *et al*., 2018). Between 1961 and 1985, (Liang *et al*., 2017) investigated the relationship between irrigation investments and productivity in eighteen developing nations using quantitative methodology. They discovered a positive link between investment and agricultural productivity using a non-parametric technique. In Latin America, however, Expósito & Berbel, (2017a) has shown that such investments have only a minor impact on production. Furthermore, the introduction and widespread use of irrigation has played a vital part in helping to attain greater agricultural yields. Irrigation enables agricultural development in arid or semi-arid environments where precipitation is insufficient to meet crop water requirements. A prime example of this is cropland west of the 98th Meridian, where annual precipitation is less than 500 mm, (Nikolaou *et al*., 2020), with a large percentage falling outside of the agricultural growing season.

The lens of development economics is applied to understand the impact of irrigation investments on agricultural productivity. Liang *et al*., (2017) and Expósito & Berbel (2017b) contributed to this framework by investigating the relationship between irrigation investments and productivity in developing nations. The lens considers economic development indicators, focusing on how investments in irrigation contribute to increased agricultural output, especially in regions where water scarcity is a significant constraint.

While existing studies, exemplified by (Haji *et al*., 2013), have delved into the impact of irrigation investment on household poverty reduction, a critical research gap remains. The definition of poverty is multidimensional, extending beyond income and consumption to encompass aspects such as access to education, and respect for political and human rights. Moreover, the multifaceted impact of irrigation on poverty, including its potential to raise land prices and affect landless or small farmers, requires a more nuanced understanding.

2.3 – *Irrigation development- the key accelerator behind the global cereals boom*

According to a study by (Faurèsa *et al*., 2002) cited by (Gibremichael, 2014), irrigation is responsible for up to 40% of the growing global cereal crop production. Irrigated agriculture, according to (Bhattarai *et al*., 2004), cited in Gibremichael (2014), not only ensures food security but also helps keep rural communities afloat by providing jobs, fostering the spread of innovative technologies, and ensuring steady incomes for farmers. Minimizing the extent to which a farmer must rely on adequate or timely precipitation is especially important in regions where such conditions are common. This, in turn, generates additional on- and off-farm job opportunities, which has the potential to raise rural households' earnings and standard of living.

Irrigation development is approached through the lens of global agriculture and food systems. Faurèsa *et al*. (2002), as cited by Gibremichael (2014), provides insights into how

irrigation is a major driver behind the global cereal crop production. The lens focuses on the interconnectedness of global agricultural practices, emphasizing how irrigation influences not only food security but also job creation, technological innovation, and income stability in rural communities. The existing literature lacks a detailed exploration of how the benefits of irrigation development are distributed, specifically in relation to its potential implications for the landless poor.

2.4 – *Irrigation and food security*

Different academics have offered different ways to define food security. Mc Carthy *et al*. (2018) argued that when all people have the means (financial, social, and physical) to obtain enough food that meets their dietary requirements and food preferences to support an active and healthy lifestyle, we can say that food security has been achieved. In this sense, it is possible to say that this is the most commonly accepted definition of food security. Food availability, access to food, utilization and stability, and the nutritional dimension are the four pillars of food security, as outlined by (El Bilali *et al*., 2019)

Hussain *et al*., (2020) argues that irrigation water for agriculture is a major contributor to ensuring food security, mitigating the effects of drought, and allowing for greater diversity in crop production.Nhamo *et al*., (2016) conducted research in Malawi showing that irrigation practice has significantly improved food security for over 70% of all adopters who were previously food insecure before irrigation was implemented. Terry (2020), following some studies in Swaziland showed that irrigation increases food security. Kadiresan, (2018) also found that irrigation increases family nutrition. In 2005, the International Fund for Agricultural Development (IFAD) released a report detailing how the development of small-scale irrigation systems in Ethiopia had increased production, income, and dietary diversity in the Oromia and Southern Nation and Nationalities People (SNNP) regions, (Jambo *et al*., 2021).

Irrigation schemes in South Africa have increased employment opportunities, stabilized and increased rural wage rates, and increased family food consumption by improving food availability, reducing levels of consumption shortfall, increasing irrigation incomes, and lowering food prices, ensuring food security (Tesfamariam *et al*., 2018). In a recognition of the significance of the link between land and water, Rukuni (1988) was cited by Nhundu & Mushunje (2012) who agreed that for areas at risk of famine due to drought brought on by climate change, small-scale irrigation projects have been heralded as the answer. In addition, Chemada *et al*., (2021) suggests that rain-dependent agriculture cannot completely boost food production in areas that receive insufficient or unreliable rainfall. The literature review does not sufficiently explore how different dimensions of food security, beyond traditional indicators like crop production and income, may be influenced by irrigation investments, leaving a gap in understanding the broader implications for poverty.

The lens of food security studies is applied to understand the intricate connections between irrigation and food security. The work of Hussain *et al*. (2020), Nhamo *et al*. (2016), and Kadiresan (2018) contributes to this framework, exploring how irrigation water for agriculture contributes to food security, improves dietary diversity, and mitigates the effects of drought. The lens here involves examining the various dimensions of food security, including availability, access, utilization, and stability. This leads us to the research hypothesis: Irrigation, by ensuring water availability for agriculture, significantly contributes to achieving food security by enhancing crop production, dietary diversity, and mitigating the effects of drought.

Thus, the research hypothesis is formed: Investment in irrigation positively impacts the economy by enhancing agriculture productivity, promoting food security, and contributing to increased employment and foreign exchange earnings.

2.5 – *Economics of irrigation development*

According to Owuor *et al*., (2007), which was cited by Gibremichael, (2014), agricultural output in Kenya fell short of population growth in the twenty years leading up to the turn of the century. Irrigation research and development offers the greatest potential for boosting agricultural output to counteract this problem. According to the findings of Owuor *et al*., (2007), the three most significant advantages that irrigation offers to the country's economy are increased levels of food security, improved levels of employment, and increased levels of foreign exchange earnings.

The investment in irrigation can help bolster agriculture productivity and promote food security, as suggested by van Averbeke *et al*., (2011), who argue that rain-fed agriculture cannot fully support food production in areas with insufficient and unreliable rainfall. Given the country's widespread poverty, rain-fed agriculture in Nigeria is no longer viable for long-term food security. The results of this study will corroborate those of Darko *et al*., (2016)who found that irrigation increases food security in dry regions.

Nhundu *et al*., (2010) conducted a cost-benefit analysis of irrigation projects and found that in low-rainfall regions, small-scale irrigation projects improved food security for local households. Some academics, however, raise concerns about the practicality of small-scale irrigation by pointing to the costs involved. Food aid, according to Peacock(1995), is a more cost-effective way to guarantee food security in communities than developing and investing in irrigation. Since most of the schemes in Zimbabwe have failed to recoup their initial capital investment costs, Rukuni (1984) raised doubts about their long-term viability in achieving their goal of ensuring food security in the country. This doubt is echoed in Mtonga (2014).

Smallholder irrigation is seen by many as a key strategy to enhance agricultural production, ensure food security for households, and reduce rural poverty in the developing world (Burney & Naylor, 2012; Fanadzo, 2012). A comprehensive review of World Bank-assisted irrigation projects from 1994 to 2004 and a review of irrigation projects in Asia funded by the International Water Management Institute confirmed the important role that irrigation plays in poverty reduction and economic growth. Irrigation has both direct and indirect effects on poverty reduction(Hamududu & Ngoma, 2020) Improved irrigation access greatly contributes to rural poverty reduction through improving jobs and livelihoods within a region, in addition to enhancing crop output and farm and family incomes (Namara *et al*., 2010; Nhundu & Mushunje, 2012). Irrigation is crucial in alleviating poverty, as evidenced by China's security boom during the 1960s and 1970s. Chilinda *et al*. (2021) found a highly positive link between access to irrigation and household income, resulting in poverty reduction and equitable income distribution.

This section is approached through the lens of agricultural economics and cost-benefit analysis. Scholars like Owuor *et al*., (2007) and Nhundu *et al*., (2010) contribute to this framework by highlighting the economic advantages of irrigation, including increased food security, employment, and foreign exchange earnings. The lens involves assessing the economic feasibility and benefits of irrigation projects, considering factors such as costs, returns, and overall economic impact. This leads us to the research hypothesis: Improved smallholder

irrigation access significantly contributes to rural poverty reduction by enhancing jobs, livelihoods, crop output, and overall farm and family incomes.

3 – Research Methodology

This study used *pragmatism* as a research philosophy. Pragmatists generally agree that all knowledge in the world is socially constructed, but some versions of those social constructions more closely match individuals' experiences than others (Johnson *et al*., 2017). Pragmatists doubt that reality can ever be definitively determined (Lohse, 2017). They consider reality to be a normative concept and believe that reality is what works. As a result, they argue that knowledge claims are inextricably linked to contingent beliefs, habits, and experiences (Johnson *et al*., 2017). In addition, pragmatism, as a research paradigm, avoids debating contentious metaphysical concepts such as truth and reality. Instead, it accepts that there can be single or multiple realities that can be investigated empirically, (Martins *et al*., 2018). Pragmatist scholars have argued that there is an objective reality that exists apart from human experience. This reality, however, is rooted in the environment and can only be encountered through human experience (Lohse, 2017). Therefore, pragmatism was used in this study to obtain information on the impacts of irrigation investment on agricultural productivity, poverty, and food security.

The descriptive correlational research design was used in this study because it allows the researcher to collect a large amount of data from a variety of sources. The researcher chose the descriptive research strategy because it gave an accurate and valid portrayal of the aspects pertinent to the inquiry. The approach also enables the researcher to collect secondary data, which is then used to draw relevant conclusions and provide suggestions.

3.1 – *The research approach and design*

The study adopted both quantitative and qualitative methodology, otherwise known as triangulation, which draws on the strength of both methods according to Mertens & Hesse-Biber (2012), to test the theories and concepts of irrigation investment and poverty and food security. A total 35 smallholder farmers were randomly selected Mushandike Block 22 (where there is a total of 420 farmers) and Rupike irrigation schemes (where there is a total of 200 farmers) The data was collected using in-depth semi-structured interviews as well as focus group discussions. The reliability of these instruments was checked through the consistencies that emerged.

Some questions on the questionnaire were revised to make them easier to understand, and were administered in both vernacular and English languages drawing lessons from Saunders & Bezzina, (2015) who stressed that qualitative research is conducted in a natural setting to get first-hand rich data.

Due to time and resource constraints Mushandike and Rupike(Nyajena) were selected, on the basis that they provide two extremes that may help in fairly understanding the prevailing scenarios at most irrigation schemes in Masvingo province. They are both group schemes communally managed through Irrigation Management committees (IMCs).

Mushandike Irrigation scheme was constructed in 1939 with funding from the Government and has several blocks amounting 613ha, though currently there are illegal extensions which have stretched the scheme to 1 000ha. Mushandike, a wholely gravity surface technology irrigation scheme is located within 40km from Masvingo city.

Rupike Irrigation scheme was founded by the Rio Tinto foundation in collaboration with the government of Zimbabwe in 1989 and has 100ha functional irrigation infrastructure. Rupike is a pumped sprinkler technology irrigation scheme located some 60km from Masvingo city. Both schemes have a long history of existence, punctuated by success, failure and recovery over decades.

They have both been rehabilitated at least once and have received national accollades at some point in time for having been instrumental in addressing food security and uplifting the livelihoods of their rural communities.

3.2 – *Data analysis*

Following the principles of the thematic study cited by Braun & Clarke, (2023) and cited in Friese *et al*., (2018), the examination of qualitative data in this study was followed through the stages of presentation and interpretation of the experiences, perceptions, and descriptions of the farmers' life situations. The qualitative data analysis involved collecting the responses that are similar and forming patterns, interpreting the patterns within the collected data, and frequently quoting them to give insight into the problem statement, Castleberry & Nolen, (2018). Raw data transcription was followed by the organization of data by assigning different codes and labels to participants for examination and the identification of any further patterns. The codes were used to group ideas and other keywords for the purposes of maintaining anonymity for this study.

Quantitative data was analysed using the Statistical Package for Social Sciences (SPSS) version 25. During the data analysis, the data describing the sample was generated first in the form of demographics.

Descriptive statistics (means and standard deviations) were calculated. The mean and standard deviation, as a form of descriptive statistics, indicate how measurements of a group are spread out from the average or the expected value. Cronbach's alpha coefficients were calculated for each factor to determine the internal consistency and reliability of factors. According to Bell & Bryman (2007), the closer the alpha value is to 1, the better the internal consistency (reliability) of the scale.

The lowest reliability co-efficient will be 0.00. Correlation coefficients were calculated using Pearson's r-coefficient. Also known as the Pearson product-moment correlation, (Menkveld *et al*., 2021), defines co-efficient as the ratio of the covariance of two variables representing a set of numerical data, normalised to the square root of their variances. This was done to determine if any meaningful relationships existed. A combination of variables was analysed to assess how a combination of variables relates.

Regression analysis was done to determine the linear relationship between two or more variables (Gunst & Mason, 2018; Mason & Gunst, 1985).

Regression is primarily used for prediction and causal inference (Richard Hahn *et al*., 2020). In its simplest (bivariate) form, regression shows the relationship between one independent variable (X) and a dependent variable (Y) (Kalnins, 2018).

Regression can also show us how variation in one variable co-occurs with variation in another. This was done to ascertain if combining variables can predict the dependent variable in a meaningful manner.

A one-way analysis of variance was undertaken to assess the homogeneity of mean scores between participants.

4 – Discussion

4.1 – *Qualitative Study Findings*

4.1.1 – The effect of irrigation investment on crop yields remains unknown.

This study observed that 95% of the participants agreed that irrigation investment increases crop yields, whilst 5% indicated that irrigation investment did not have an effect on crop yields. This confirmed that irrigation investment increases crop yields as indicated by the majority of the participants, a position aligned with Svoma and Balling (2010), who discovered that with increasing precipitation variability, drought conditions have increased commodity prices in certain periods, and irrigation has had a significant impact on increasing grain yields. The study agrees with Faurese *et al*. (2002), who noted that about 17% of global agricultural land is irrigated and accounts for up to 40% of the global production of cereal crops, which is still on the increase and are consistent with (Aslam, 2016), who discovered that irrigation has also considerably contributed to increasing India's food output and building grain surpluses that can be utilized as a drought buffer.

4.1.2 – The impact of irrigation schemes on small-scale farming.

The study noted that 90% of the participants agreed that irrigation schemes have an impact on small-scale farming, whilst 10% of the participants indicated that irrigation schemes do not have an impact on small-scale farming. The increase in productivity emerged as the major theme in the study on small-scale farming, as indicated by the interview responses below. Respondent 1 gave the following remarks:

"With the power cuts that are happening constantly, because we are doing small-scale farming, our crops are always watered because the area needed to be watered is small compared to other farms that operate on a large scale." As a result, our crops always grow evenly. (R,1).

"*Farming on a small scale reduces other costs, such as those incurred by substituting electricity for other means of running irrigation schemes effectively*." "*Small-scale farming increases crop yields as there are no crops that do not ripen due to lack of water*." (R, 2).

Another participant said:

"*Small-scale irrigation has the potential to increase output and, consequently, food availability during the dry season, benefiting income, food security, nutrition, and health*." Irrigation can help mitigate production risks caused by insufficient rainfall during the rainy season. (R, 3).

Irrigation investment increases productivity through increasing crop yields, as indicated by the majority of the participants which is aligned with Mango *et al*. (2018), who noted that irrigation investment empirical research has tended to indicate that the investment has a beneficial effect on changes in agricultural productivity.

4.2 – *Quantitative Study Findings*

4.2.1 – The impact of irrigation investment on agricultural productivity.

The impact of irrigation investment on agricultural productivity is shown Table 1. The study noted that irrigation expands cultivatable lands, as indicated by a mean of 1.31 and a standard deviation of 0.471. Moreover, participants of the study also found that irrigation investment increases crop yields as yielded by a mean of 1.55 and a standard deviation of 0.632.

Furthermore, the participants also revealed that irrigation allows double cropping through taking advantage of contemporary technologies, as indicated by a mean of 1.46 and a standard deviation of 0.637. From the findings, participants also indicated that irrigation investment enables the farmer to control the available water throughout the growing season, as indicated by a mean of 1.52 and a standard deviation of 0.574. Furthermore, the findings from the study indicated that irrigation investment reduces water shortfalls or seasonal droughts as indicated by a mean of 1.52 and a standard deviation of 0.688.

Table 1 – The impact of irrigation investment on agricultural productivity

Item	N	Min	Max	Mean	Std. Deviation
Irrigation expands cultivatable lands	35	1	2	1.31	0.471
Increases crop yields by preventing crop water stress	35	1	3	1.55	0.632
Allows double cropping by taking advantage of contemporary technologies	35	1	3	1.46	0.637
Boosts production through allowing the farmer to control the available water throughout the growing season	35	1	3	1.52	0.574
Reduces exposure to water shortfalls or seasonal droughts	35	1	3	1.52	0.688
Valid N (listwise)	35				

These findings are consistent with (Malakar *et al*., 2019) who posited that irrigated agriculture has benefited some households in the Tigray region by providing an opportunity to boost agricultural productivity through double cropping and by taking advantage of contemporary technologies and high-yielding crops that require intensive farming and is supported by (Expósito & Berbel, 2017a) who discovered that irrigation expands cultivatable lands beyond what is possible under rain-fed conditions. Irrigation increases crop yields by preventing crop water stress and by combining irrigation with high-yielding crop varieties, fertilizers, and herbicides. In addition, (Smith, 2004) pointed out that irrigation gives farmers the ability to exert control over the quantity of water that is available to them throughout the growing season. This not only increases production but also lessens their vulnerability to water shortages and droughts that occur during specific times of the year.

4.2.2 – The impact of irrigation investment on food security

This impact is shown in Table 2. This study also found out that irrigation investment has a positive effect on food security because irrigation increases crop yields, as indicated by a mean of 1.62 and a standard deviation of .677. Moreover, the study also revealed that irrigation increases the income of farmers through cash crops, hence enabling them to acquire a lot of food, as indicated by a mean of 1.62 and a standard deviation of .820. Furthermore, the findings of the study also revealed that irrigation increases the opportunity for multi-cropping and

diversification, yielding a mean of 1.76. In addition, the findings of the study also revealed that irrigation lowers food prices, as indicated by a mean of 1.62 and a standard deviation of .561. These findings are supported by (Ali *et al*., 2023) who observed that irrigation increased yields per hectare, income, consumption, and food security in Ethiopia.

Table 2 – The impact of irrigation investment on food security

Item	N	Min	Max	Mean	Std. Deviation
Irrigation investment increases yields	35	1	3	1.62	0.677
Irrigation investment increases income through growing cash crops	35	1	5	1.62	0.82
Irrigation investment increases the opportunity for multi cropping and diversification	35	1	3	1.76	0.739
Irrigation investment lowers food prices	35	1	3	1.62	0.561
Valid N (listwise)	35				

Tesfamariam *et al*. (2018) discovered that irrigation schemes in South Africa have increased employment opportunities, stabilized, and increased rural wage rates, and increased family food consumption by improving food availability, reducing levels of consumption shortfall, increasing irrigation incomes, and lowering food prices, thereby ensuring food security. Furthermore, (Darko *et al*., 2016) conducted case studies that demonstrated the benefits of improved irrigation water accessibility, and the findings revealed that food shortages could be reduced in addition to an extended growing season, a greater variety of food and cash crops, and, as a result, an increase in cash income.

4.2.3 – The extent to which irrigation investment increases food security

The research study shows that 10% of the participants agreed that irrigation investment has an impact on food security to a moderate extent, whilst 5% of the participants revealed that irrigation investment has an impact on food security to a lesser extent (see Figure 1).
However, 80% of the participants revealed that irrigation investment has an impact on food security to a greater extent. These findings are in line with (de Vrese & Hagemann, 2016) who posited that numerous empirical studies conducted around the world have found that irrigation improves household food security and poverty.

5 – Discussion

5.1 – *The impact of irrigation investment on poverty reduction*

Therefore, these findings clearly reveal that irrigation plays a vital role in alleviating poverty. Accordingly, these findings are consistent with those of van Averbeke *et al*. (2011), who stated that access to good irrigation not only enables poor people to increase their production and income, but it also amplifies their chances to broaden their income base and reduces their frailty

to the seasonal variation of agricultural output and external shocks. Furthermore, these findings are supported by (Liang *et al*., 2017), who opined that irrigation directly helps farm production by increasing crop yields and diversifying cropping patterns and crop technology. This leads to increased household income, consumption, and employment. Improved irrigation access greatly contributes to rural poverty reduction through improving jobs and livelihoods within a region, in addition to enhancing crop output and farm and family incomes.

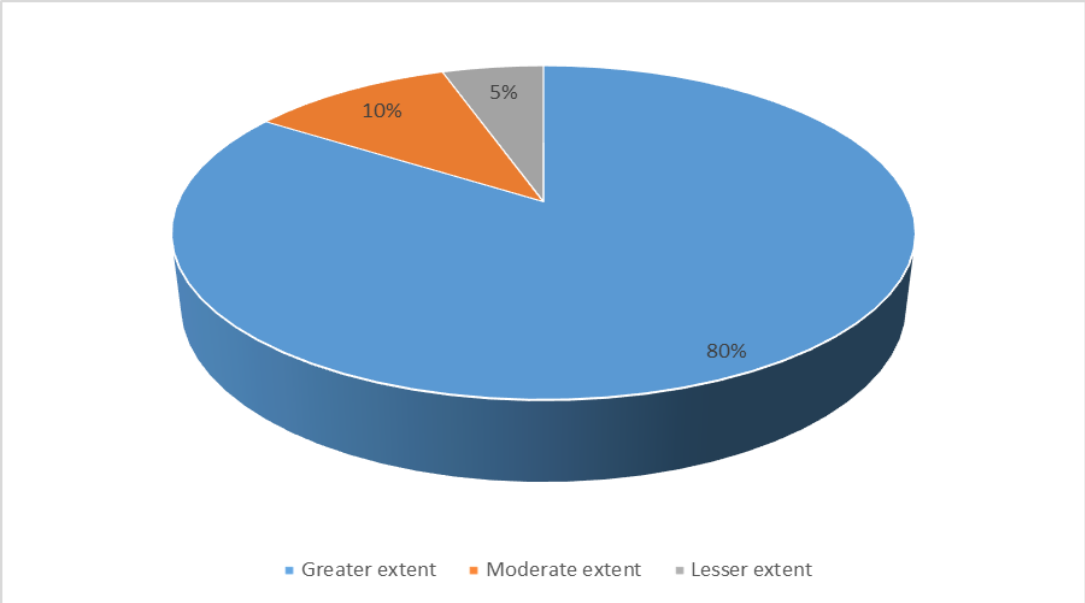

Figure 1 – The extent to which irrigation investment increase food security
(Source: Primary data 2022)

5.2 – *Hypothesis Testing*

In this study, the hypothesis was tested using multiple linear regression analysis using SPSS. This test was used to determine the effect of independent variables, which are strategic planning and learning, on the dependent variable, which is performance. Multiple regression is a statistical technique that can be used to analyze the relationship between a single dependent variable and several independent variables. The objective of multiple regression analysis is to use independent variables whose values are known to predict the value of the single dependent variable.

From the Table 3, the model summary indicates that R of 0.875 means that there is a moderate positive relationship between irrigation investment and productivity, food security and poverty and R square is 0.719 which means about 71%.

Table 3 – Regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.875[a]	.766	.719	.25788

Predictors: (Constant), Irrigation investment increases agricultural productivity, increases food security and reduces poverty.

Table 4 shows ANOVA statistics indicates that the regression model predicted the dependent variable (fraud detection) significantly well.

Table 4 – ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	767.489	10	76.749	452.432	.000[a]
	Residual	65.988	389	.170		
	Total	833.478	399			

Predictors: (Constant), Irrigation investment increases agricultural productivity, increases food security and reduces poverty

The regression model significantly predicted the outcome variable (that is, it was a good fit for the data). F statistics (F = 452.432) and (Sig = 0.000). This shows that the whole model was significant. In other words, this means that there is a positive influence between irrigation investment and productivity, poverty and food security.

6 – Summary, Conclusions, and Recommendations

6.1 – *The impact of irrigation investment on agricultural productivity*

The findings from the questionnaires and interviews revealed that irrigation investment has an impact on agricultural productivity because irrigation expands cultivatable lands and also increases crop yields by preventing crop water stress. Moreover, the findings from the study also revealed that irrigation allows double cropping by taking advantage of contemporary technologies; hence, this results in an increase in productivity. Furthermore, the findings of the study also revealed that irrigation boosts production by allowing the farmer to control the available water throughout the growing season and also reduces exposure to water shortfalls or seasonal droughts.

6.2 – *The impact of irrigation investment on food security*

The study noted that irrigation investment has an impact on food security. The findings revealed that irrigation investment increases crop yields. Hence, this ensures that they have sufficient food for consumption. The findings also revealed that irrigation increases income through the growing of cash crops, hence ensuring that they buy other non-farm products. Moreover, the findings of the study also revealed that irrigation investment increases the opportunity for multi-cropping and diversification. Furthermore, the study findings also revealed that irrigation investment lowers food prices because if supply is on the rise, the prices of commodities decline, hence allowing everyone to afford them.

6.3 – *The impact of irrigation investment on poverty reduction*

The study revealed that irrigation has an impact on poverty reduction because it increases food supply, which enables people to have an adequate food supply. As the increase in food supply means a decline in prices, more people will be able to afford the basic commodities, which improves their living standards. Expanding area under irrigation can trigger increased

employment opportunities in rural regions, impacting incomes and thereby improving living conditions.

6.4 – *Recommendations*

A new model for the sustainable management of group irrigation schemes is needed. It is therefore recommended that group irrigation schemes need to be organised into cooperative organizations so that they can have better access to inputs, financing, and markets.

The study underscores the imperative for concerted efforts from government and financial institutions to extend financial assistance to smallholder farmers engaged in irrigated agriculture. This support is deemed critical for ensuring access to capital for essential inputs and the sustained maintenance of irrigation infrastructure. Notably, the establishment of cooperative organizations is particularly accentuated as a strategic measure to optimize the collective benefits derived from group irrigation efforts.

6.5 – *Limitations and Future Research Avenues*

Despite providing valuable insights, this study has inherent limitations. Its reliance on stakeholders' perceptions at the household level in smallholder irrigation schemes within Masvingo province necessitates caution in generalizing findings to all irrigation schemes in Zimbabwe. Future research initiatives should adopt a more diversified approach, exploring various irrigation contexts to foster a more comprehensive understanding of the nuanced impacts of irrigation investment. Furthermore, the study advocates for an in-depth exploration of both positive and negative effects, urging data collection from diverse irrigation farming regions. It also encourages further qualitative investigations to delve deeper into the intricate complexities surrounding the impact of irrigation on poverty.

6.6 – *Theoretical and Practical Implications*

The study's findings bear significance for both theoretical frameworks and practical applications. The theoretical underpinning underscores the pivotal role of irrigation in augmenting agricultural productivity, fortifying food security, and alleviating poverty. From a practical standpoint, the study highlights the exigency for targeted support mechanisms, the establishment of cooperative structures, and financial assistance to fully leverage the positive impacts of irrigation on the livelihoods of smallholder farmers. These implications align cohesively with broader agricultural development strategies and underscore the need for informed policy considerations. By recognizing the interconnectedness of theoretical insights and practical applications, the study provides a foundation for comprehensive and effective interventions in the realm of agricultural development.

In *conclusion*, this study contributes a nuanced understanding of the multifaceted impacts of irrigation investment, providing a foundation for informed policy decisions and guiding future research in the realm of agricultural development.

7 – References

Ali, H., Menza, M., Hagos, F., & Haileslassie, A. (2023). Impact of climate smart agriculture on households' resilience and vulnerability: An example from Central Rift Valley, Ethiopia. *Climate Resilience and Sustainability*. DOI: https://doi.org/10.1002/cli2.54

Aslam, M. (2016). Agricultural productivity current scenario, constraints and future prospects in Pakistan. *Sarhad Journal of Agriculture*, *32*(4), 289–303. DOI: http://dx.doi.org/10.17582/journal.sja/2016.32.4.289.303

Bhattarai, M., Narayanamoorthy, A., & Others. (2004). Impact of irrigation on agricultural growth and poverty alleviation: Macro level analyses in India. *Water Policy Research Highlight*, *12*, 1–7. Retrieved from http://www.iwmi.org/iwmi-tata

Bell, E., & Bryman, A. (2007). The ethics of management research: An exploratory content analysis. *British Journal of Management*, *18*(1), 63–77. DOI: 10.1111/j.1467-8551.2006.00487.x

Braun, V., & Clarke, V. (2023). Toward good practice in thematic analysis: Avoiding common problems and be(com)ing a knowing researcher. *International Journal of Transgender Health*, *24*(1), 1–6. DOI: 10.1111/j.1467-8551.2006.00487.x

Burney, J. A., & Naylor, R. L. (2012). Smallholder Irrigation as a Poverty Alleviation Tool in Sub-Saharan Africa. *World Development*, *40*(1), 110–123. DOI: https://doi.org/10.1016/j.worlddev.2011.05.007

Calzadilla, A., Rehdanz, K., & Tol, R. S. J. (2011). Water scarcity and the impact of improved irrigation management: a computable general equilibrium analysis. *Agricultural Economics (Amsterdam, Netherlands)*, *42*(3), 305–323. DOI: 10.1111/j.1574-0862.2010.00516.x

Castleberry, A., & Nolen, A. (2018). Thematic analysis of qualitative research data: Is it as easy as it sounds? *Currents in Pharmacy Teaching & Learning*, *10*(6), 807–815. DOI: https://doi.org/10.1016/j.cptl.2018.03.019

Chemada, B. C., Dagnachew, L., Kebede, D. L., & Hailu, F. T. (2021). On-farm evaluation and pre-scaling up of improved finger millet technologies under rainfed condition in Western Oromia, Ethiopia: A case of East Wollega Zone, Ethiopia. *Journal of Agricultural Extension and Rural Development*, *13*(3), 165–172. DOI: https://doi.org/10.5897/JAERD2021.1241

Darko, R. O., Yuan, S., Hong, L., Liu, J., & Yan, H. (2016). Irrigation, a productive tool for food security – a review. *Acta Agriculturae Scandinavica. Section B. Soil and Plant Science*, *66*(3), 191–206. DOI: https://doi.org/10.1080/09064710.2015.1093654

de Vrese, P., & Hagemann, S. (2016). Asian irrigation, African rain: Remote impacts of irrigation. *Geophysical Research Letters*. DOI: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2016gl068146

El Bilali, H., Callenius, C., Strassner, C., & Probst, L. (2019). Food and nutrition security and sustainability transitions in food systems. *Food and Energy Security*, *8*(2), e00154. DOI: 10.1002/fes3.154

Expósito, A., & Berbel, J. (2017a). Agricultural irrigation water use in a closed basin and the impacts on water productivity: The case of the Guadalquivir river basin (southern Spain). *Water*, *9*(2), 136. DOI: 10.3390/w9020136

Expósito, A., & Berbel, J. (2017b). Sustainability implications of deficit irrigation in a mature water economy: A case study in southern Spain. *Sustainability*, *9*(7), 1144. https://doi.org/10.3390/su9071144

Fan, S., & Hazell, P. (2001). Returns to Public Investments in the Less-Favored Areas of India and China. *American Journal of Agricultural Economics*, *83*(5), 1217–1222. http://www.jstor.org/stable/1244811

Fanadzo, M. (2012). Revitalisation of smallholder irrigation schemes for poverty alleviation and household food security in South Africa: A review. *African Journal of Agricultural Research*. https://academicjournals.org/journal/AJAR/article-full-text-pdf/476944638399.pdf

Faurèsa, J. M., Hoogeveena, J., & Bruinsmab, J. (2002). *The FAO irrigated area forecast for 2030*.

Friese, S., Soratto, J., & Pires, D. (2018). *Carrying out a computer-aided thematic content analysis with ATLAS.ti*. https://pure.mpg.de/pubman/faces/ViewItemOverviewPage.jsp?itemId=item_2582914

Gibremichael, B. A. (2014a). The role of agricultural coops in promoting food security and rural women's empowerment in Eastern Tigray Region, Ethiopia. *Ethiopia. Journal of Developing Country Studies*, *11*.

Gibremichael, B. A. (2014b). The role of agricultural coops in promoting food security and rural women's empowerment in Eastern Tigray Region, Ethiopia. *Journal of Developing Country Studies*.

Gunst, R. F., & Mason, R. L. (2018). *Regression analysis and its application*. CRC Press. https://doi.org/10.1201/9780203741054

Haji, J., Aman, M., & Hailu, T. (2013). Impact analysis of Mede Telila small scale irrigation scheme on house poverty alleviation: case of Gorogutu district in eastern Haratghe Oromia national regional state Ethiopia. Interna*tional Journal of Development and Economic Sustainability*, *1*(1), 15-30.

Hamududu, B. H., & Ngoma, H. (2020). Impacts of climate change on water resources availability in Zambia: implications for irrigation development. *Environment, Development and Sustainability*, 22(4), 2817–2838. DOI: https://doi.org/10.1007/s10668-019-00320-9

Hargreaves, G. H. (1998). *Irrigation fundamentals*. Water Resources Publications.

Hussain, S., Malik, S., Masud Cheema, M. J., Ashraf, M. U., Waqas, M. S., Iqbal, M. M., & Afzal. (2020). *An overview on emerging water scarcity challenge in Pakistan, its consumption, causes, impacts and remedial measures*. DOI: http://doi.org/10.26480/bdwre.01.2020.22.31

Jambo, Y., Alemu, A., & Tasew, W. (2021). Impact of small-scale irrigation on household food security: evidence from Ethiopia. *Agriculture & Food Security*, *10*(1), 1–16. DOI: https://doi.org/10.1186/s40066-021-00294-w

Johnson, R. B., Onwuegbuzie, A. J., de Waal, C., Stefurak, T., & Hildebrand, D. (2017). Unpacking pragmatism for mixed methods research. In *The BERA/SAGE Handbook of Educational Research: Two Volume Set* (pp. 259–279). SAGE Publications Ltd.

Kadiresan, K. (2018). Rethinking irrigation for global food security. *Irrigation and Drainage*, *67*, 8–11. DOI: https://doi.org/10.1002/ird.2219

Kalnins, A. (2018). Multicollinearity: How common factors cause Type 1 errors in multivariate regression. *Strategic Management Journal*, *39*(8), 2362–2385. DOI: https://doi.org/10.1002/smj.2783

Liang, X.-Z., Wu, Y., Chambers, R. G., Schmoldt, D. L., Gao, W., Liu, C., Liu, Y.-A., Sun, C., & Kennedy, J. A. (2017). Determining climate effects on US total agricultural productivity. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(12), E2285–E2292. DOI: https://doi.org/10.1073/pnas.1615922114

Lipton, M. (2007). Farm water and rural poverty reduction in developing Asia. *Irrigation and Drainage*, *56*(2–3), 127–146. DOI: https://doi.org/10.1002/ird.302

Lipton, M., Litchfield, J., & Faurès, J.-M. (2003). The effects of irrigation on poverty: a framework for analysis. *Water Policy*, *5*(5–6), 413–427. DOI: https://doi.org/10.2166/wp.2003.0026

Lohse, S. (2017). Pragmatism, ontology, and philosophy of the social sciences in practice. *Philosophy of the Social Sciences*, *47*(1), 3–27. DOI: https://doi.org/10.1177/0048393116654869

Malakar, A., Snow, D. D., & Ray, C. (2019). Irrigation Water Quality—A Contemporary Perspective. *WATER*, *11*(7), 1482.DOI: https://doi.org/10.3390/w11071482

Mango, N., Makate, C., Tamene, L., Mponela, P., & Ndengu, G. (2018). Adoption of small-scale irrigation farming as a climate-smart agriculture practice and its influence on household income in the chinyanja triangle, southern Africa. *Land*, 7(2), 49. DOI: https://doi.org/10.3390/land7020049

Martins, F. S., da Cunha, J. A. C., & Serra, F. A. R. (2018). Secondary data in research--uses and opportunities. *PODIUM Sport, Leisure and Tourism Review*, *7*(3). https://periodicos.uninove.br/podium/article/view/12908. DOI: https://doi.org/10.5585/podium.v7i3.316

Mason, R. L., & Gunst, R. F. (1985). Outlier-induced collinearities. *Technometrics: A Journal of Statistics for the Physical, Chemical, and Engineering Sciences*, *27*(4), 401–407. DOI: 10.1080/00401706.1985.10488079

Mc Carthy, U., Uysal, I., Badia-Melis, R., Mercier, S., O'donnell, C., & Ktenioudaki, A. (2018). Global food security-Issues, challenges and technological solutions. *Trends in Food Science & Technology*, *77*, 11–20. DOI: https://doi.org/10.1016/j.tifs.2018.05.002

McCartney, M. P., Whiting, L., Makin, I., Lankford, B. A., & Ringler, C. (2019). Rethinking irrigation modernisation: realising multiple objectives through the integration of fisheries. *Marine and Freshwater Research*, *70*(9), 1201–1210. : DOI :https://doi.org/10.1016/j.tifs.2018.05.002

Menkveld, A. J., Dreber, A., Holzmeister, F., Huber, J., Johanneson, M., Kirchler, M., Razen, M., Weitzel, U., Abad, D., Abudy, M. (meni), Adrian, T., Ait-Sahalia, Y., Akmansoy, O., Alcock, J., Alexeev, V., Aloosh, A., Amato, L., Amaya, D., Angel, J. J., … & Bao, L. (2021). Non-standard errors. *SSRN Electronic Journal*. DOI: https://doi.org/10.2139/ssrn.3961574

Mertens, D. M., & Hesse-Biber, S. (2012). Triangulation and mixed methods research. *Journal of Mixed Methods Research*, *6*(2), 75–79. DOI: https://doi.org/10.1177/1558689812437100

Mtonga, M. (2014). *The impact of small scale irrigation projects on food security: The case of Inkosikazi Irrigation Project, instituted by World Vision in Wards 4 and 5, in the Bubi District …* https://uir.unisa.ac.za/handle/10500/18720

Namara, R. E., Hanjra, M. A., Castillo, G. E., Ravnborg, H. M., Smith, L., & Van Koppen, B. (2010). Agricultural water management and poverty linkages. *Agricultural Water Management*, *97*(4), 520–527.DOI: https://doi.org/10.1016/j.agwat.2009.05.007

Nhamo, L., Mabhaudhi, T., & Magombeyi, M. (2016). Improving water sustainability and food security through increased crop water productivity in Malawi. *Water*, *8*(9), 411. DOI: https://doi.org/10.3390/w8090411

Nhundu, K., & Mushunje, A. (2012). Irrigation development: A food security and household income perspective. In *Problems, Perspectives and Challenges of Agricultural Water Management*. InTech.

Nhundu, K., Gwata, C., & Mushunje, A. (2010). Impacts of Zimbabwe European Union micro-project programme (Zim/Eu MPP) in funding smallholder irrigation projects on food security and income levels: A case study of Mopane irrigation scheme in Zvishavane, Midlands province, Zimbabwe. *African Journal of Agricultural Research*. DOI: https://doi.org/10.5897/AJAR09.331

Nikolaou, G., Neocleous, D., Christou, A., Kitta, E., & Katsoulas, N. (2020). Implementing Sustainable Irrigation in Water-Scarce Regions under the Impact of Climate Change. *Agronomy*, *10*(8), 1120. DOI: https://doi.org/10.3390/agronomy10081120

Owuor, G., Ngigi, M., Ouma, A. S., & Birachi, E. A. (2007). Determinants of rural poverty in Africa: The case of small holder farmers in Kenya. *Journal of Applied Sciences (Faisalabad, Pakistan)*, *7*(17), 2539–2543. DOI: 10.3923/jas.2007.2539.2543

Peacock, T. (1995).Economic Aspects of Smallholder Irrigation in Zimbabwe & Prospects for Future Development in Water Development for Diversification within Smallholder …. *Monomotapa Hotel, Harare*.

Richard Hahn, P., Murray, J. S., & Carvalho, C. M. (2020). Bayesian Regression Tree Models for Causal Inference: Regularization, Confounding, and Heterogeneous Effects (with Discussion). *Bayesian Analysis*, *15*(3), 965–1056. DOI: 10.1214/19-BA1195

Rukuni, M. (1984). Organisation and management of smallholder irrigation: The case of Zimbabwe. *Agricultural Administration*, *17*(4), 215–229. DOI: https://doi.org/10.1016/0309-586X(84)90043-8.

Rukuni, M. (1988). The evolution of smallholder irrigation policy in Zimbabwe: 1928–1986. *Irrigation and Drainage Systems*, 2(2), 199–210. DOI: https://doi.org/10.1007/BF01102927

Saunders, M. N. K., & Bezzina, F. (2015). Reflections on conceptions of research methodology among management academics. *European Management Journal*, *33*(5), 297–304. DOI: https://doi.org/10.1016/j.emj.2015.06.002.

Smith, L. E. D. (2004). Assessment of the contribution of irrigation to poverty reduction and sustainable livelihoods. *International Journal of Water Resources Development*, *20*(2), 243–257. DOI:10.1080/0790062042000206084

Terry, A. K. (2020). The impact of the 2015-16 El Nino drought on the irrigated home gardens of the Komati downstream development project, Swaziland. *The South African Geographical Journal, Being a Record of the Proceedings of the South African Geographical Society*, *102*(1), 41–58. DOI: 10.1080/03736245.2019.1614477

Tesfamariam, B. Y., Owusu-Sekyere, E., Emmanuel, D., & Elizabeth, T. B. (2018). The impact of the homestead food garden programme on food security in South Africa. *Food Security*, *10*(1), 95–110. DOI: https://doi.org/10.1007/s12571-017-0756-1

van Averbeke, W., Denison, J., & Mnkeni, P. N. S. (2011). Smallholder irrigation schemes in South Africa: A review of knowledge generated by the Water Research Commission. *Water SA*, *37*(5), 797–808. DOI:10.4314/wsa.v37i5.17