BINDURA UNIVERSITY OF SCIENCE EDUCATION

Faculty of Agriculture and Environmental Science

Department of Agricultural Economics, Education and Extension

THE CONTRIBUTION OF SMALLHOLDER IRRIGATION DEVELOPMENT TO FOOD AND NUTRITION SECURITY AMONG VULNERABLE SMALLHOLDER FARMERS IN SEMI-ARID REGIONS OF ZIMBABWE. A CASE OF THE BANGA IRRIGATION SCHEME IN MASVINGO.

BY

TANAKA CHITSATO

B200702B

A Dissertation Submitted in Partial Fulfilment of the Requirements of the Bachelor of Science Honours Degree in Agricultural Economics and Management

SUPERVISOR: DR I. GOVERE

31 MAY 2024

RELEASE FORM

AUTHOR: TANAKA CHITSATO

REG NUMBER: B200702B

DEGREE TITLE: BACHELOR OF AGRICULTURAL SCIENCE HONOURS DEGREE IN AGRICULTURAL ECONOMICS AND MANAGEMENT.

PROJECT TITLE: THE CONTRIBUTION OF SMALLHOLDER IRRIGATION DEVELOPMENT TO FOOD AND NUTRITION SECURITY AMONG VULNERABLE SMALLHOLDER FARMERS IN SEMI-ARID REGIONS OF ZIMBABWE. A CASE OF THE BANGA IRRIGATION SCHEME IN MASVINGO.

Permission is hereby granted to the Bindura University of Science Education Library to produce a single copy of this dissertation and lend such copy for private, scholarly, or scientific research only.

AUTHORS ADDRESS: 7298 KUWADZANA 3, HARARE

SIGNED: ……

DATE …….

APPROVAL FORM

The undersigned certify that they have supervised and recommended to Bindura University of Science Education for acceptance of the dissertation entitled **'the contribution of smallholder irrigation development to food and nutrition security among vulnerable smallholder farmers in semi-arid regions of Zimbabwe: A case of the Banga irrigation scheme in Masvingo.'**

Submitted in partial fulfillment of the Bachelor of Agricultural Science Honours Degree in Agricultural Economics and Management.

Name of supervisor: Dr I. Govere

Signed …….

Date …….....

DECLARATION

I, Tanaka Chitsato, declare that this dissertation titled "An Assessment of the Contribution of Smallholder Irrigation Development to Food and Nutrition Security among Smallholder Farmers in Semi-Arid Regions of Zimbabwe: A Case of Banga Irrigation Scheme in Chivi District, Masvingo Province" is my original work and has not been submitted elsewhere for any degree or qualification. I acknowledge that I have received guidance and support from my supervisor, Dr Govere, and other academic staff during this research, but the intellectual content and presentation of this dissertation are entirely my own. I have followed the guidelines and regulations of the Bindura University of Science Education regarding plagiarism and academic integrity, and I have properly cited and referenced all sources of information used in this dissertation.

Author: **Tanaka Chitsato**

Reg Number: **B200702B**

Signature: …….

Date: …….

DEDICATION

This research study is dedicated to my mother (Anna Zharare), who has been a constant source of love, support, and encouragement throughout my life. And to my late father who instilled in me the value of hard work and perseverance. Your legacy lives on in my heart, and I hope this work will make you proud. This work is dedicated to you both, with gratitude and love.

ACKNOWLEDGEMENTS

First and foremost, I want to thank GOD the ALMIGHTY for life and for giving me the strength to partake in this study. Exceedingly, I would like to thank my family for their unwavering support, love, patience, and understanding. Thank you for granting me all the resources that were needed for this research to be a success, your support has been a constant source of strength and inspiration to me.

I extend my gratitude and appreciation to my supervisor, Dr I. Govere, for his patience, efforts, and assistance throughout this research journey. His expertise and encouragement have been valuable to me. I also acknowledge all the lecturers in the Department of Agricultural Economics, Education, and Extension for their academic support and guidance throughout the research process.

I am also grateful to the smallholder farmers in Chivi District, Masvingo Province, who participated in this study, sharing their experiences and insights with me. Their contributions have enriched this research and have helped to shed light on the importance of smallholder irrigation development in promoting food and nutrition security. Not forgetting the Banga Irrigation Scheme management and staff for their cooperation and support during the data collection process.

Finally, I would like to thank my colleagues and friends, Janet, Munashe, and Mitchell who have supported me throughout this journey, providing valuable feedback, encouragement, and motivation. Their presence has made a significant difference in my life and work.

ABSTRACT

Smallholder irrigation development has been recommended as a potential solution to addressing food and nutrition security among smallholder farmers in semi-arid regions of Zimbabwe. However, there is limited research on the impact of smallholder irrigation development on dietary diversity among beneficiary households. The main objective of this study was to assess the contribution of smallholder irrigation development to food and nutrition security among smallholder farmers in the semi-arid regions of Zimbabwe, using the Banga Irrigation Scheme in Chivi District, Masvingo Province as a case study. A mixed-method approach was used, combining quantitative and qualitative data collection and analysis methods. Multistage sampling was used to select the study area, and random sampling was used to choose 57 respondents from both beneficiary and non-beneficiary households of the Banga irrigation scheme. Data was collected through structured questionnaires, key informant interviews, and focus group discussions. Descriptive statistics, inferential statistics, and multinomial logistics regression were used for data analysis. The major findings revealed that 70.2% of the beneficiaries and 29.8% of non-beneficiaries are found to be food secure. The difference in mean Household Dietary Diversity Score (HDDS) between beneficiary and non-beneficiary households was not statistically significant. Seven statistically significant independent variables were identified out of the hypothesized ten variables by estimating a multinomial logistic model. The results indicated that among the factors considered in the model, education level, livestock holding, irrigation access, and household gender significantly and positively affected household food and nutrition security. In contrast, the age of the household head, the health status of the household head, and marital status significantly and negatively affected household food security. The study concluded that smallholder irrigation can be a viable solution to secure household food needs and diversify their diet composition in the study area. It is therefore recommended that the developed irrigation schemes should be implemented through a combination of training and capacity-building programs for smallholder farmers to secure food access and diet composition. The government of Zimbabwe and non-governmental organizations should continue to expand access to smallholder irrigation for smallholder farmers in semi-arid regions to improve their food and nutrition security.

Keywords: smallholder irrigation development, irrigation scheme, dietary diversity, food and nutrition security.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms and Abbreviations

ADF:	African Development Bank
ANOVA:	Analysis of Variance
BIS:	Banga Irrigation Scheme
FAO:	Food and Agriculture Organisation
FANTA:	Food and Nutrition Technical Assistance Project
GCA:	Global Centre for Adaptation
GOZ:	Government of Zimbabwe
HDDS:	Household Dietary Diversity Score
HFIAS:	Household Food Insecurity Access Scale
IFAD:	International Fund for Agricultural Development
MDD-W:	Minimum Dietary Diversity for Women
MLAFWRD:	Ministry of Lands Agriculture Fisheries Water and Rural Development
NGO:	Non-Governmental Organisations
OFID:	OPEC Fund for International Development
SIRP:	Smallholder Irrigation Revitalization Programme
SPSS:	Statistical Package for Social Sciences
WASH:	Water Sanitation and Hygiene
WFC:	World Food Conference
WFP:	World Food Programme
WFS:	World Food Summit
WHO:	World Health Organisation
ZimVAC:	Zimbabwe Vulnerability Assessment Committ

CHAPTER 1

INTRODUCTION

1.1 Background of the study

In many developing nations, expanding irrigated agriculture is seen as a crucial strategy to achieve the United Nations Sustainable Development Goals (SDGs) 1 and 2 by the year 2030. The aim is to secure food supplies and alleviate poverty through this approach (McCartney et al., 2019; Hanjra and Williams, 2020). Specifically, SDG 1 focuses on reducing poverty, while SDG 2 aims to end hunger, improve nutrition, and enhance food security (McCartney et al., 2019). Smallholder irrigation development has been recognized as a crucial strategy for enhancing food and nutrition security in many developing countries, particularly in semi-arid regions where rainfall variability and drought are major challenges (Burney et al., 2013). It can enhance agricultural productivity, diversify crop production, and improve the resilience of smallholder farmers to climate variability and change (Nhundu & Mushunje, 2010). Irrigation also enables smallholder farmers to increase crop yields, and extend cropping seasons, thereby improving household food availability and dietary diversity (Passarelli et al., 2018). Numerous studies have demonstrated the positive impacts of smallholder irrigation on food security and nutrition outcomes. For instance, a study by Passarelli et al. (2018) in Ethiopia showed that access to irrigation was associated with improved dietary diversity, particularly for women and children.

Zimbabwe, a landlocked southern African country, has a total land area of over 39 million hectares, with 33.3 million hectares dedicated to agricultural purposes (Ministry of Lands, Agriculture, Fisheries, Water and Rural Development [MLAFWRD], 2020). Agriculture plays a vital role in Zimbabwe's economy, accounting for 18% of the country's Gross Domestic Product (GDP) (World Bank, 2020). Despite its relatively small arable land surface compared to major food producers in Africa, Zimbabwe's agriculture was thriving from 1961 to 2001 (FAO, 2020). The country has strong foundations for accelerating future economic growth and improving living standards, with private sector-led growth critical to maximizing its potential (World Bank, 2020).

Historically, Zimbabwe was one of Africa's countries with the highest living standards, bolstered by a skilled workforce and superior infrastructure (World Bank, 2020). However, the government has taken steps to promote the cultivation of sorghum and millet, which are more ecologically compatible with Zimbabwe's semi-arid areas (MLAFWRD, 2020). Zimbabwe has the potential to irrigate 366,000 hectares, with an equipped area of 181,000 hectares, although only 124,000 hectares are irrigated (FAO, 2020).

The crop sub-sector is the mainstay of the agricultural sector, with maize being the country's staple crop and accounting for a substantial proportion of arable land cropped and inputs applied (MLAFWRD, 2020). Maize is produced by 85% of rural farmers, with an average national yield of 1.39 metric tons per hectare (FAO, 2020). Zimbabwe's economic growth potential largely depends on developments in its agricultural sector (World Bank, 2020).

The country has 4,130,000 hectares of arable land, with 25% cultivated using animal and manual draught power (FAO, 2020). Following the government's fast-track land reform program, which began in 2000, irrigation infrastructure deteriorated, and most new landowners depend on rain rather than irrigation for their crops (MLAFWRD, 2020). The government grants 99-year leases for agricultural land, but the protections of such leases are too weak to serve as collateral for financing, hindering agricultural investment (World Bank, 2020).

Zimbabwean farmers' face various challenges, including a lack of resources to buy inputs and equipment, poor rains in some areas, poor road networks to transport produce, and lack of participation in policies to support their activities (MLAFWRD, 2020). Food insecurity is one of the main challenges to Africa's development. Zimbabwe's current droughts and food security have remained stagnant over the past decade. According to the Zimbabwe Vulnerable Assessment Committee [ZimVAC] (2023), over 1.5million people in Zimbabwe are estimated to be food insecure. Food insecurity is a complex problem with direct and underlying drivers that involve many sectors and contextual factors. ZimVAC based its analysis on the availability of food, access to food, the safe and healthy utilization of food, and the stability of food availability, access, and utilization. According to FAO, IFAD, UNICEF, WPF, and WHO (2017), food security is defined as a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Therefore, food insecurity

can be best seen as a condition of lack of access, improper utilization, non-availability of food, and instability for a period. Because of food insecurity, at-risk populations become vulnerable.

Masvingo Province, where the Banga Irrigation Scheme is located, is one of the driest regions in Zimbabwe, with an average annual rainfall of 600 mm (ZIMSTAT, 2020). The province is characterized by poor soil fertility, limited water resources, and high temperatures, making it difficult for smallholder farmers to produce enough food to meet their household needs (Moyo et al., 2017). According to the Zimbabwe Vulnerability Assessment Committee (ZimVAC), 27% of the population in Masvingo Province experienced food insecurity in 2023 (ZimVAC, 2023). Smallholder farmers in Masvingo Province face numerous challenges, including limited access to irrigation, markets, and credit, which hinder their ability to produce enough food to meet their household needs (FAO, 2022). As a result, food insecurity is prevalent in the province, with 30% of children under five experiencing stunting due to malnutrition (ZIMSTAT, 2020). Women of reproductive age in the province are also disproportionately affected by malnutrition, with 31% experiencing anaemia (ZIMSTAT, 2020).

Chivi district in Masvingo is one of the districts that has been struggling for decades to be food insecure, with its population depending mostly on rain-fed agriculture without substantive irrigation. Crops grown in this region include maize, millet, rapoko, sorghum, soya beans, sugarcane, and fruits. The communities in the area depend mostly on food aid programs from Non-Governmental Organisations (NGOs) such as CARE International because their crops constantly fail in most cases. As a result of the decrease in agricultural production, high food shortages and poor living standards in the area make irrigation development a prerequisite. However, according to ZINWA, Masvingo has 28 dams making it the most dammed province in Zimbabwe, with a high potential for irrigation system development. Therefore, the Government of Zimbabwe (GOZ) has identified irrigation development as a key strategy for drought mitigation. This led to the development of small-scale irrigation schemes through the Smallholder Irrigation Revitalization Programme (SIRP). The Government of Zimbabwe in partnership with the International Fund for Agricultural Development (IFAD) and the OPEC Fund for International Development (OFID) implemented the Banga Irrigation Scheme in Chivi district Masvingo to reduce the vulnerability of households to food and nutrition insecurity, climate change effects and economic shocks.

Under the same program, the following are some of the small-scale irrigation schemes, which undertook some rehabilitation work to increase productivity: Tshovani irrigation scheme in Masvingo, Guyu, and Silalabhuwa irrigation schemes in Matabeleland South Province and the Hamamavhaire and Insukamini irrigation schemes in Midlands. According to the SIRP Final Report (2023), all eight irrigation schemes developed in semi-arid regions of Zimbabwe, including the Banga irrigation scheme, showed significant success in achieving its objectives. However, despite these efforts, the Banga irrigation scheme remains undermined. The efforts of the scheme are not yet fully realized since the government and non-governmental organizations are still supplying food hand-outs.

Therefore, this study aims to assess the contribution of smallholder irrigation development to food and nutrition security among smallholder farmers in semi-arid regions of Zimbabwe, using the Banga Irrigation Scheme as a case study.

1.2 Statement of the Problem

Masvingo Province is one of the provinces in Zimbabwe which faces significant food and nutrition security challenges, particularly among smallholder farmers. Despite efforts to address these challenges, food insecurity persists, and government and non-governmental organizations continue to provide food hand-outs to vulnerable communities. However, smallholder irrigation schemes offer an opportunity to enhance food security, reduce vulnerability to climate change and economic shocks, and improve smallholder farmers' dietary and nutritional status.

Smallholder farmers in the province are vulnerable to various shocks and hazards, including drought, water logging, floods, cash shortages, and food price changes, which impact their productivity and contribute to food insecurity. Currently, the Chivi District of Masvingo province faces significant food security challenges, with high levels of undernourishment, food insecurity, poverty, and malnutrition (ZimVAC, 2019; United States Agency for International Development, 2024). According to ZimVAC (2023), the current food security status (as of 2023) is that only 65% of households in Chivi District were food secure. The food insecurity status in the District must be decreased from 63% to 20% by 2025 (ZimVAC, 2022). This can be achieved through programs that enhance food availability, access, and utilization, such as

food assistance, crop production support, and nutrition education (United States Agency for International Development, 2024).

The Banga Irrigation Scheme was implemented to support smallholder farmers in Chivi District with the main aim of increasing crop yields, improving food availability, and enhancing nutrition security. However, the scheme's effectiveness in achieving these goals is unclear. There is still an existing gap between the desired food insecurity status and the current food security situation. Therefore, the study aims to assess the contribution of the Banga Irrigation Scheme to food production, dietary status, and nutritional status among vulnerable smallholder farmers in Masvingo Province.

1.3 Research Questions

1. What is the difference in dietary diversity between the beneficiary and non-beneficiary households of the Banga irrigation scheme?
2. What is the dietary diversity of women of reproductive age participating in the Banga irrigation scheme?
3. What are the socioeconomic factors that affect the dietary diversity of beneficiary households of the Banga irrigation scheme?

1.4 Research Objectives

1.4.1 Main Objective

To assess the contribution of smallholder irrigation development to food and nutrition security among vulnerable households in semi-arid regions of Zimbabwe

1.4.2 Specific Objectives

1. To compare the dietary diversity of beneficiary and non-beneficiary households of the Banga Irrigation scheme.
2. To assess the dietary diversity of women of reproductive age participating in the Banga irrigation scheme
3. To determine the socioeconomic factors that affect the dietary diversity of beneficiary households of the Banga irrigation scheme.

1.5 Hypothesis

$\boldsymbol{H_0}$ **:** There is no significant difference in dietary diversity between beneficiary and non-beneficiary households of the Banga Irrigation scheme.

$\boldsymbol{H_1}$: There is a significant difference in dietary diversity between beneficiary and non-beneficiary households of the Banga Irrigation scheme.

$\boldsymbol{H_0}$: There is no significant relationship between socioeconomic factors (educational level, health status, poverty level, gender, livestock holding, etc.) and the dietary diversity of beneficiary households of the Banga irrigation scheme.

$\boldsymbol{H_1}$: There is a significant relationship between socioeconomic factors (educational level, health status, poverty level, gender, livestock holding, etc.) and dietary diversity of beneficiary households of the Banga irrigation scheme.

1.6 Significance of the Study/ Justification

The study is of great importance to different stakeholders interested in the promotion of agricultural production, food security, and rural development. The research will be useful to the development practitioners and policymakers to improve their approaches for improving food production, reducing food insecurity, and enhancing the nutritional status of vulnerable communities in semi-arid areas through promoting smallholder irrigation development and discovering new methods of developing the projects. The study also emphasizes the importance of empowering vulnerable smallholder farmers with technical skills, infrastructure support, and capacity-building initiatives to overcome the challenges they face in running irrigation schemes. Overall, the results of this study will contribute to the advancement of knowledge and understanding of how smallholder irrigation can positively impact food and nutrition in semi-arid regions.

1.7 Scope and limitation of the study

The study focuses specifically on the Chivi District in Masvingo, Zimbabwe with a detailed examination of the Banga irrigation scheme in the Ngundu communal area. By concentrating on this specific location, the research provides a localized perspective on the impacts of smallholder irrigation development in semi-arid regions. The research also aims to assess the relationship between smallholder irrigation development and food and nutrition security among smallholder farmers. By addressing these interconnected dimensions, the research offers a comprehensive assessment of the contribution of irrigation to food and nutrition security. The

study analyses the socioeconomic impacts of smallholder irrigation development, such as income generation, employment opportunities, and community resilience. There is also an exploration of the existing policies, support mechanisms, and institutional arrangements that govern smallholder irrigation in Zimbabwe and how they impact food and nutrition security.

Limitations of the study

The research was conducted within the specific context of Masvingo, which may limit the transferability of the findings to other regions with different socioeconomic and environmental conditions. The researcher faced financial and time challenges when conducting data collection. The researcher also faced the challenge of access to accurate and reliable data especially data regarding household food consumption, nutrition, and socioeconomic status of the vulnerable households. Another limitation of the study is limited cooperation from the community.

1.8 Organisation of the Research

The study is organized into five chapters. The first chapter is the introduction which comprises the background of the study, statement of the problem, research questions, research objectives, hypothesis, significance of the study, scope, and limitation of the study. Chapter two contains the literature review whereby reviews from other scholars on smallholder irrigation development and its contribution to household food security are presented. It also contains literature on the concept of food and security, vulnerable smallholder farmers, smallholder irrigation development, conceptual framework, and explanation of variables of the study. Chapter three consists of the methodology of the research which includes the type of research design, description of the study area, target population, data collection methods, sampling technique, and data analysis methods. Chapter four includes data analysis, presentation, and interpretation of the research findings. Finally, chapter five concludes the whole research by presenting the summary of the findings, conclusion, and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this literature review, the researcher's main interest is to familiarize with previous findings made by other researchers on the contribution of smallholder irrigation development to food and nutrition security in semi-arid region areas. The discussion starts by exploring the concepts and definitions of key terms which include irrigation, smallholder irrigation development, food and nutrition security, and dietary diversity. There are also reviews on the conceptual framework of irrigation, food and nutrition security linkages, and an empirical review of the objectives of the study. This discussion helps to identify the gaps that the previous scholars left in their previous research and how the researcher intends to address the gaps. It also helps with the final assessment of the contribution of smallholder irrigation development to household food and nutrition security in Masvingo.

2.2 Concepts and Definition of Key Terms

2.2.1 Irrigation

Irrigation is the deliberate and controlled water delivery to cultivated areas to supplement rainfall, alleviate drought, and meet specific crop production objectives (Tlou et al., 2006). This technique is essential for maintaining stable food production, particularly in areas with irregular rainfall patterns and low soil water retention capacity (FAO, 2022). Irrigation is similarly defined as the artificial application of water to land for agricultural purposes (Martin et al., 2021), and it plays a critical role in supporting crop growth and productivity in regions with water scarcity (Odada & Mathai, 2018). Effective irrigation systems can mitigate the risks associated with traditional rain-fed agriculture and ensure optimal crop yields (SIRP, 2022).

2.2.2 Smallholder Irrigation

Smallholder irrigation refers to the practice of providing water to agricultural fields or gardens on a small scale, typically through localized systems and technologies (FAO, 2022). This approach supplements natural rainfall and promotes optimal crop development and productivity. Smallholder irrigation techniques vary depending on the context, available resources, and farmers' specific needs (IFAD, 2020). It involves the precise water supply to the

root zone, reducing water loss and increasing crop productivity (Wandera et al., 2020). Smallholder irrigation schemes in Zimbabwe typically feature plot-holding sizes ranging from 0.1 to 1.5 ha, shared infrastructure, self-management or joint management between farmers and government, communal land tenure, and a community committee (Mupangwa et al., 2022). These schemes, where a group of farmers irrigates together using a shared water source and delivery line, have a significant impact on the sector's performance, participation opportunities, and long-term development challenges (Makombe et al., 2022).

2.2.3 Smallholder Irrigation Development in Zimbabwe

Food insecurity remains a persistent challenge in Zimbabwe, with far-reaching consequences for the country's economic development. The nation's heavy reliance on rain-fed, smallholder agriculture renders its population vulnerable to the devastating effects of droughts and unpredictable rainfall patterns (Musemwa et al., 2022). As a result, crop failures and poor harvests have become increasingly common, leading to widespread food shortages that reverberate through the broader economy.

One of the primary impacts of food insecurity is the reduction in agricultural output and exports (Moyo et al., 2020). Zimbabwe's agricultural sector is a crucial source of foreign currency earnings, and the decline in crop production has weakened the country's trade balance and limited its ability to import essential goods. This, in turn, has contributed to rising inflation and the erosion of purchasing power among households (FAO, 2022).

To mitigate the immediate effects of food shortages, the Zimbabwean government has had to allocate significant resources towards importing food and providing emergency aid to affected populations (IFAD, 2020). This diverts funds away from other critical development priorities, such as infrastructure, healthcare, and education, further constraining the country's economic growth.

The prevalence of malnutrition, particularly among children, is another consequence of food insecurity (Mupangwa et al., 2022). Prolonged exposure to under nutrition can impair human capital development, with adverse effects on workforce productivity and public health costs. This, in turn, undermines the long-term economic prospects of the country.

Moreover, the hardships caused by recurring food crises can contribute to social unrest and political instability, further exacerbating the challenges faced by Zimbabwe's economy (Roder, 1965). The disruption of industrial activities, such as food processing and transportation, also hampers overall economic productivity.

In Zimbabwe, irrigation projects date back to the 1930s, initiated by white missionaries who recognized the potential for economic growth (Moyo et al., 2020). Irrigation has proven successful, enabling farmers to increase their wealth and productivity, surpassing dry land farmers and even employees of white farmers (Roder, 1965). According to recent research, developing irrigation in communal areas is crucial to enhance output per unit area and mitigate drought effects (Mupangwa et al., 2022). Farmers face challenges due to unpredictable rainfall, resulting in lower maize yields (FAO, 2022). Sustainable irrigation enables farmers to intensify crops, adopt new techniques, and boost productivity and returns (IFAD, 2020).

To address the root causes of food insecurity, the Zimbabwean government has partnered with international organizations like IFAD and OFID to implement the Smallholder Irrigation Revitalization Program (SIRP, 2022). SIRP focuses on rehabilitating and upgrading existing irrigation schemes, promoting climate-resilient agriculture, and enhancing the capacity of smallholder farmers to manage irrigation systems effectively (SIRP, 2022). By supporting smallholder farmers, SIRP contributes to national food security, poverty reduction, and economic growth (IFAD, 2020). With Zimbabwe's annual maize requirement standing at 2.1 million metric tonnes (Musemwa et al., 2022), analysing the current state of national food security could inform government investment in irrigation development to promote maize production.

2.2.4 Food Security

The concept of food security has evolved over the years, expanding from a sole focus on food availability to a multidimensional approach encompassing accessibility, utilization, and stability (Gernaat et al., 2022). Initially, the 1974 World Food Conference defined food security in terms of supply, emphasizing availability and price stability (WFC, 1974). Later, the Food and Agriculture Organization (FAO) refined the definition to include access, highlighting the balance between demand and supply (FAO, 1983). The 1996 World Food Summit further broadened the definition to encompass physical, social, and economic access to sufficient and

nutritious food for a healthy and active life (FAO, 2006). The latest definition that refined the one adopted in the 1996 World Food Summit states that food security is a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO et al.,2017). This definition covers the aspects of availability, access, utilization, and the stability of the individuals, households, or nation to be food secure. More recent definitions, such as the one proposed by Gernaat et al. (2022), also emphasize the importance of all four dimensions - availability, access, utilization, and stability - to ensure food security at individual, household, and national levels.

2.2.5 Nutrition Security

The concept of nutrition security differs from food security in that it also considers the aspects of adequate caring practices, health, and hygiene in addition to dietary adequacy (FAO, 2013). Nutrition security occurs when households attain secure access to a couple with a sanitary environment, adequate health environment, and knowledgeable care (Benson, 2006). Shakir (2006) added that nutrition security also exists when food security, coupled with a hygienic environment, adequate health services, and proper care and feeding practices, ensures a healthy life for household members. According to FAO et al (2017), nutrition security is defined as a situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment and adequate health services and care, to ensure a healthy and active life for all household members.

2.2.6 Food and Nutrition Security

The concept of Food and Nutrition Security has undergone constant modifications. It has progressed from a food supply-focused concept to a multidimensional approach that touches on the different elements of Food and Nutrition Security. According to Weingarten (2010), food and nutrition security is defined as a condition under which adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily utilized by all individuals at all times to live a healthy and happy life. The 2012 Committee for World Food Security broadened food and nutrition security and defined it as an existence when all people at all times have physical, social, and economic access to food, that is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services, and care, allowing

for a healthy and active life." According to this definition, food security depends on four main interlinked pillars: availability, access, utilization, and stability. These pillars are briefly explained below:

Food availability

According to Simelane & Worth (2020), food availability is defined as the extent to which food is within reach of households, for example, in local shops and markets, both in terms of sufficient quantity and quality. In general, the food availability dimension reflects the supply side and will therefore be affected by all the drivers and determinants that have an impact on the domestic supply of food and the ability to finance food imports (Jones et al., 2013).

Food access

Household-level food access is achieved when a household has the opportunity to obtain sufficient and nutritious food to ensure a safe diet (Gernaat et al., 2022). This requires not only local food availability but also household resources to acquire food (Mupangwa et al., 2022). Key factors influencing food access include household resources, food prices, food preferences, and socio-political factors like discrimination and gender inequality (Mason et al., 2020; Ruel et al., 2022).

Food utilization

Food utilization refers to an individual's dietary intake and his/her ability to absorb nutrients contained in the food that is eaten (Pieters et al., 2013). Hence, food utilization relates not only to the quantity of food that is eaten but also to the quality of the diet (Jones et al., 2013). In particular, the food consumed by an individual must be of sufficient quantity and quality to satisfy not merely subsistence needs, but also energy needs for daily activities, notably income generation (Galhena et al., 2013). However, Barrett et al., (2009) argue that food access is a necessary but not a sufficient condition to ensure an adequate food and nutrition status.

Stability

Stability refers to the time frame over which food and nutrition security is being considered (Simelane & Worth, 2020). There is always a prevailing possibility, that at any time, food security could be lost or gained. This suggests that, even if one's food consumption is optimum today, one may still be food and/or nutrition insecure if access to the correct food cannot be sustained as long as it is needed. Specifically, intermittent access to food is associated with compromised nutritional status. Therefore, to sustain food and nutrition security, stresses and shocks such as climatic conditions, conflicts borne of unstable political environment, and economic attributes, for example, unemployment and rising food prices need to be managed as they may have an impact on food and nutrition security status.

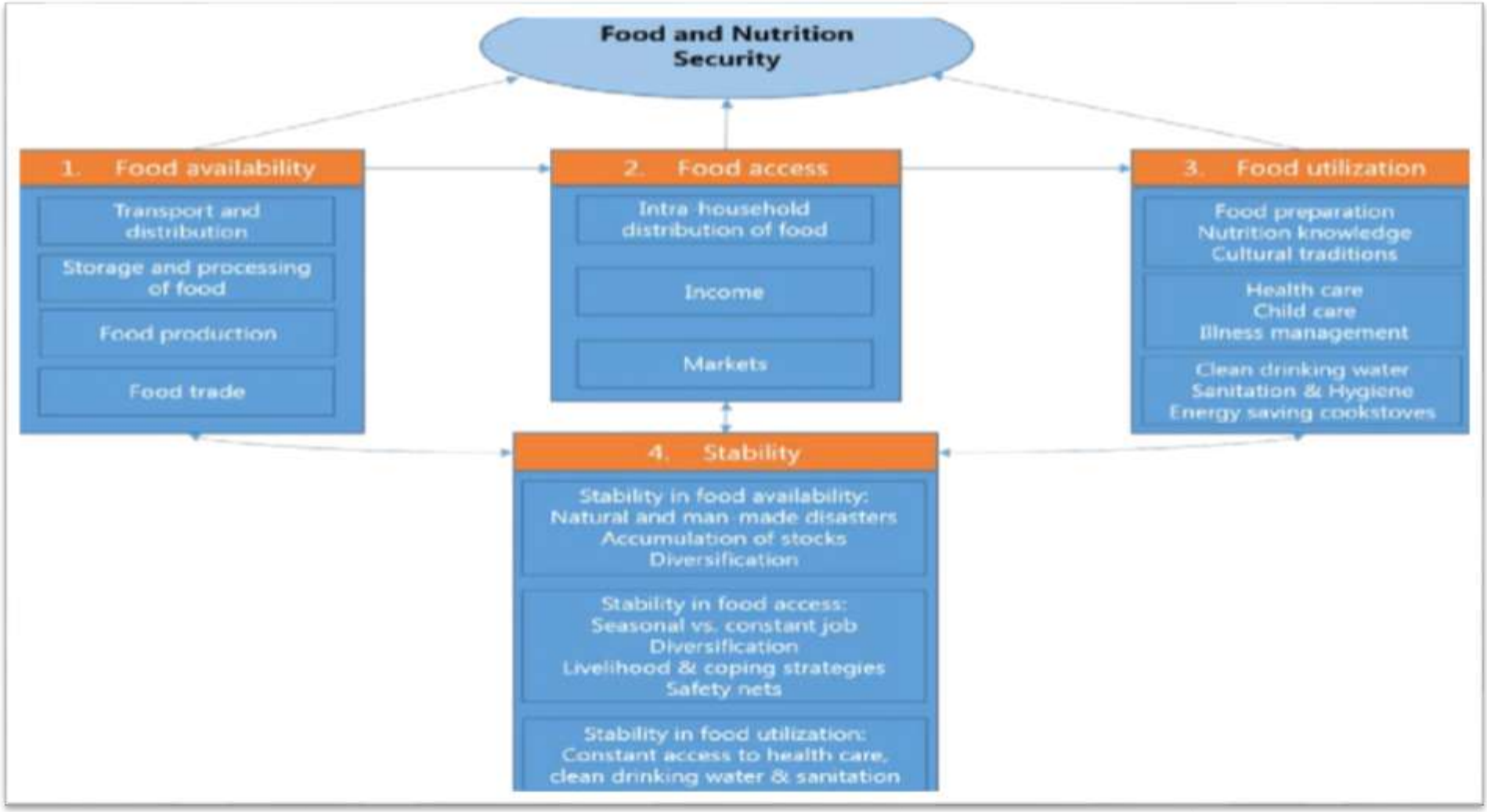

Figure 1. *Building blocks of the concept of food and nutrition security*

Source: Burchi, Fanzo and Frison (2011)

2.2.7 Dietary Diversity (DD)

Dietary diversity refers to the variety of food groups or types consumed within a specific period (Gernaat et al., 2022). The dietary diversity questionnaire assesses a household's dietary variety score by categorizing food groups based on their nutrient content (Mupangwa et al., 2022). An increase in dietary diversity enhances a household's likelihood of achieving food security (FAO, 2021). Dietary diversity can be measured at the household or individual level, with the Household Dietary Diversity Score (HDDS) indicating a household's ability to access food and its socioeconomic status (Kennedy et al., 2011). The HDDS is calculated based on the number of food groups consumed by a household over a given reference period, typically 24 hours (Mason et al., 2020).

Studies have consistently shown a positive relationship between household dietary diversity and improved nutritional intake (Adam et al., 2017; Makonnen et al., 2022). However, critics argue that the HDDS has limitations, such as only being effective in households that consume common foods like cereals, vegetables, and meat (Swindale, 2007). Moreover, there is no consensus on the ideal number of food groups that indicate adequate dietary quality (FAO, 2008).

At the individual level, the Minimum Dietary Diversity for Women (MDD-W) is an indicator of dietary quality, specifically for women of reproductive age (FAO-FHI, 2016). MDD-W is defined as the consumption of at least five out of 10 food groups over the previous 24 hours, indicating a greater likelihood of meeting micronutrient needs (FAO, 2021). The proportion of women aged 15-49 who meet this minimum in a population can serve as a proxy indicator for higher micronutrient adequacy, a crucial aspect of diet quality (Ruel et al., 2022).

2.3 Determinates of Household Food Security

Food security at the household level is a complex and multifaceted concept influenced by a variety of social, economic, and environmental factors. One of the primary determinants of household food security is access to productive agricultural land and water resources (Murungweni et al., 2014). Smallholder farmers with access to reliable irrigation tend to have higher and more stable crop yields, which translates to improved food availability and dietary diversity at the household level (Giordano & de Fraiture, 2014).

The socioeconomic status of the household, including factors such as income, assets, and livelihood strategies, also plays a significant role in determining food security. Households with higher incomes and more diverse income sources are generally better able to access a variety of nutritious foods and cope with shocks that may disrupt food production or access (Alinovi et al., 2010).

Additionally, the educational level and gender of the household head can influence food security outcomes. Studies have shown that households headed by individuals with higher levels of education tend to have better nutritional knowledge and more effective food utilization practices (Malapit et al., 2015; Sraboni et al., 2014). Furthermore, research has highlighted the important role of women in ensuring household food security, as women are often responsible for food procurement, preparation, and distribution within the household (Gupta et al., 2019; Quisumbing et al., 1995).

Environmental factors, such as climate variability and the prevalence of pests and diseases, can also significantly impact household food security by affecting agricultural production and food availability (Dhraief et al., 2019; Thornton et al., 2006). Smallholder farmers in semi-arid regions, like the case study area of this research, are particularly vulnerable to these environmental shocks and stresses.

2.4 Empirical Literature Review

2.4.1 The impact of smallholder irrigation on household dietary diversity

Studies have consistently shown that small-scale irrigation has a positive impact on household food security and dietary diversity. In Ethiopia, Damtew (2017) found that irrigation-user households had a higher mean dietary diversity score than non-irrigating households, indicating a wider variety of foods consumed. Similarly, Mekonnen et al., (2022) found that irrigating households in Tanzania had a higher Household Dietary Diversity Score (HDDS) compared to non-irrigators, especially among households that faced drought.

In Kenya, Karanja et al., (2023) found that smallholder irrigating farmers had more diverse diets than non-irrigating farmers, with a higher proportion of irrigating farmers having diets

with a high diversity index (9 and above). Additionally, practicing irrigation increased the likelihood of a household having a more diverse diet by 8.6%.

Munjur et al., (2023) also found that irrigation-user households in Ethiopia had a higher dietary diversity score than non-irrigation users, using the HDDS and Household Food Insecurity Access Scale (HFIAS) as analytical tools. The study showed that households with high HFIAS scores experienced more food insecurity access, while households with low HFIAS scores experienced less food insecurity access.

Other studies have also shown that small-scale irrigation has a positive impact on household food security and dietary diversity. For example, Gernaat et al., (2022) found that irrigation improved household food security and dietary diversity in sub-Saharan Africa. Similarly, Mupangwa et al., (2022) found that small-scale irrigation improved household food security and nutrition in southern Africa.

2.4.2 The impact of smallholder irrigation on women's dietary diversity

Studies have examined the impact of irrigation on women's dietary diversity and nutrition outcomes in developing countries. Baye et al., (2019) conducted a longitudinal study in Ethiopia and found that women's dietary diversity was low and exhibited high seasonal variation, with diets predominantly plant-based and little consumption of nutrient-dense food groups. However, women from irrigating households were more likely to meet the Minimum Dietary Diversity for Women (MDDW) and had higher energy and calcium intake than women from non-irrigating households.

Similarly, Mekonnen et al., (2022) found that small-scale irrigation improved women's dietary diversity in Ethiopia and Tanzania, particularly among households that faced drought. Women in irrigating households had higher Women's Dietary Diversity Scores (WDDS) compared to non-irrigating households, and the impact of irrigation on WDDS more than doubled among households facing drought.

Other studies have also shown that irrigation has a positive impact on women's nutrition outcomes. For example, Gernaat et al., (2022) found that irrigation improved women's dietary diversity and reduced the prevalence of anaemia in sub-Saharan Africa. Mupangwa et al.,

(2022) also found that small-scale irrigation improved women's nutrition outcomes in southern Africa, particularly among households that faced food insecurity.

2.4.3 Socio-economic Factors Influencing Dietary Diversity

Socio-economic factors significantly influence dietary diversity, as demonstrated by various studies. Epherm (2008) investigated household food security in northeastern Ethiopia, identifying key factors such as the age of household head, dependency ratio, land size, livestock ownership, and farmer knowledge. Similarly, Fekadu (2012) used multivariate logistic regression analysis to show that dependency ratio, household size, and market accessibility negatively impact food security, while cultivable land size, access to irrigation, and livestock ownership have positive effects in Amhara Region, Ethiopia.

Elemo (2014) employed the logit model to examine the utilization of small-scale irrigation water in Kano State, Nigeria, finding that factors like age of household heads, farm size, insect and pest infection, and distance from the main road have negative effects. In contrast, education level, access to improved technology, oxen ownership, and family labor positively influence utilization. Abera (2015) used binary logistic regression to identify determinants of small-scale irrigation scheme use in Ethiopia Oromia Region, Ethiopia, including distance, livestock holding, income, market information, dependency ratio, age, and sex of household head.

Recent studies have further explored these factors. For instance, Gernaat et al., (2022) examined the impact of irrigation on dietary diversity in sub-Saharan Africa in Kenya, Tanzania, and Ethiopia, highlighting the importance of access to irrigation and technology. Mupangwa et al. (2022) similarly investigated the effects of socio-economic factors on food security in South Africa, Lesotho, and Swaziland, emphasizing the role of income, education, and market accessibility.

2.5 Conceptual Framework

2.5.1 Irrigation – Food and Nutrition Linkages

Agriculture plays a crucial role in addressing malnutrition by enhancing crop and livestock productivity. Irrigation, a vital component of agricultural development, has a significant impact on dietary diversity through increased productivity (Bhagowalia et al., 2012). By reducing crop

loss, enabling multiple cropping, and expanding irrigated land, irrigation directly improves agricultural productivity (Lipton et al., 2003; Hussain and Hanjra, 2004; Domenech, 2015).

Irrigation schemes often come with institutional support, providing access to essential farm inputs like fertilizers, agrochemicals, and improved seeds. This stability in food supply can lead to increased food intake and improved nutrition. Moreover, irrigation-generated non-farm activities can create employment opportunities, diversify livelihood sources, and increase total income (Hussain and Hanjra, 2004; Domenech, 2015). As income rises, farmers can afford better food and invest in healthcare (Domenech, 2015; Herforth and Ballard, 2016).

The conceptual framework below illustrates the pathways through which irrigation influences food security, nutrition, and health outcomes. Irrigation serves as a productive asset, transforming agricultural livelihoods through four key pathways which include food production, agricultural income, water supply, and women's empowerment, which can ultimately lead to changes in food and nutritional outcomes (Passarelli et al., 2018).

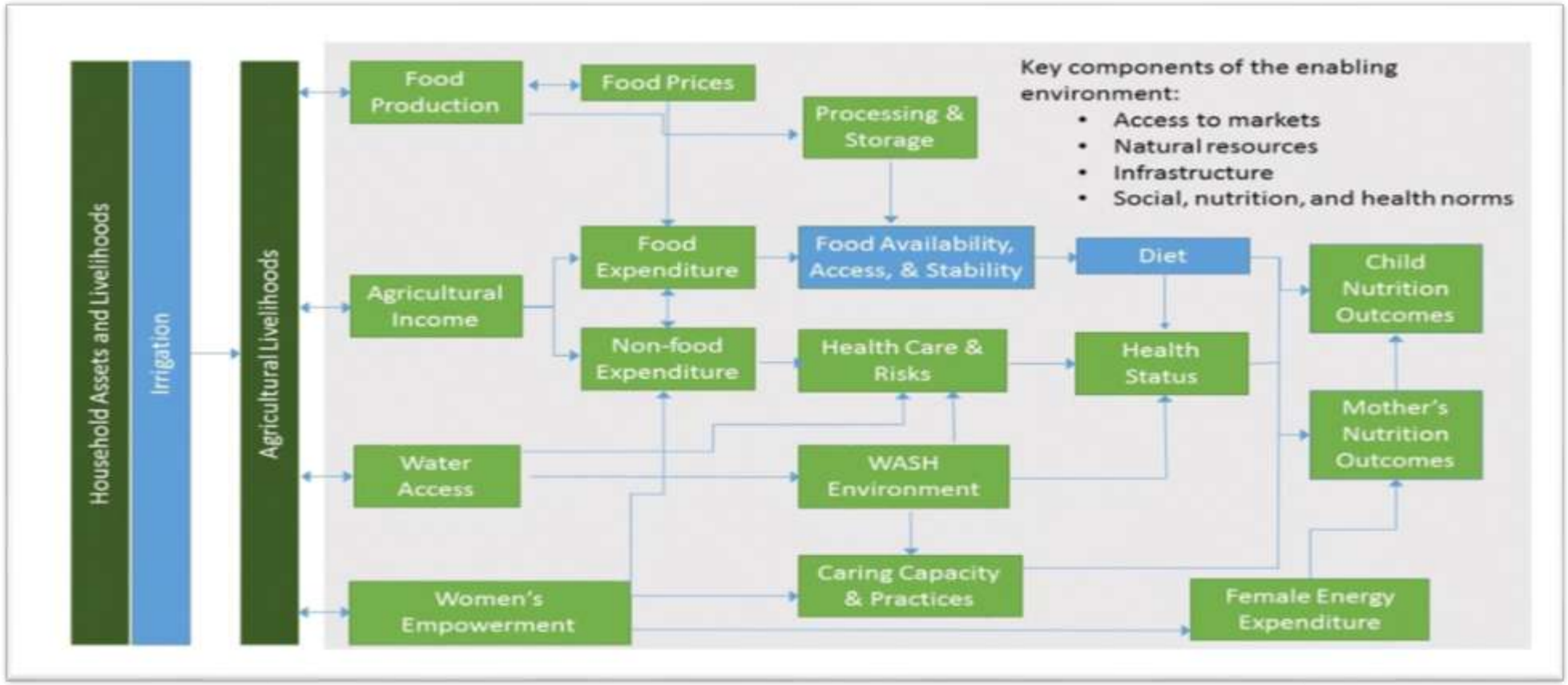

Figure 2. *Irrigation-Nutrition Linkages*

Source: Passarelli et al., 2018

As illustrated above, the four main pathways which include food production, agricultural income, water access, and women's empowerment are discussed below.

The production pathway

As illustrated in Fig.2 above, the first pathway is the food production pathway, which highlights the potential for irrigated agriculture to increase crop yields and food availability. Studies have consistently shown that the transition from rain-fed to irrigated farming can lead to substantial increases in crop production (Namara et al., 2010; Rockström et al., 2010). Irrigation enables farmers to cultivate crops during the dry season, reducing the likelihood of food scarcity and increasing food availability throughout the year. Additionally, irrigation is often used to grow high-value crops like fruits and vegetables, which provide both economic and nutritional benefits (Hanjra et al., 2012). For smallholder farmers in semi-arid regions, the implementation of small-scale irrigation schemes can significantly improve their food production and security (Burney et al., 2013; Makombe et al., 2017).

The income pathway

The second pathway in the framework is the agricultural income pathway. Numerous studies have demonstrated that small-scale irrigation can significantly increase the incomes of smallholder farmers (Horton et al., 2010; Burney et al., 2013). This increased income allows farmers to spend more on essential items such as food, healthcare, and risk prevention, which can lead to improved food availability, access, and utilization (Garrido et al., 2017). Improved access to nutritious foods and better health outcomes can, in turn, have positive implications for maternal and child nutrition (Hanjra et al., 2012; Makombe et al., 2017).

The water supply pathway

The significance of water, sanitation, and hygiene (WASH) in enhancing childhood nutrition is well-documented in the literature (UNICEF, 2018; WHO, 2019). Inadequate sanitation and hygiene conditions are linked to poor child nutrition and growth outcomes (Horton et al., 2010; Black et al., 2013). Reliable access to clean water for irrigation has the potential to improve nutrition through an improved WASH environment, provided that systems are designed to meet both agricultural and domestic needs (Garrido et al., 2017). However, changes in water supply due to irrigation can also increase health risks, such as vector-borne diseases like malaria (Kumar et al., 2016). Therefore, the water supply pathway can impact food utilization through changes in food preparation practices and consumption patterns, as well as through positive or negative effects on health status (Hanjra et al., 2012; Makombe et al., 2017).

The Women's Empowerment pathway

Research has consistently shown that women's empowerment is a crucial factor in improving diet quality and nutrition outcomes (Gernaat et al., 2022; Ruel et al., 2018). Women's decision-making authority, access to resources, and control over labor and income are essential elements of empowerment (Malapit et al., 2015; Sraboni et al., 2014; Yimer and Tadesse, 2015). The impact of irrigation on women's empowerment depends on various factors, including their control over technology adoption, labor contribution, and income management (Passarelli et al., 2018). Targeted interventions have shown that irrigated agriculture can lead to improved diet quality, food security, and nutrition outcomes in certain contexts (Iannotti et al., 2009; Olney et al., 2009; Burney et al., 2010). Irrigation can also influence women's energy expenditure and food utilization by reducing or increasing their labor burden (Horton et al., 2010; Kumar et al., 2016).

2.6 Insight from the Literature

Many studies reviewed in the literature such as Damtew (2017), Mekonnen et al., (2022), and Karanja et al., (2023) noted that there have been significant differences in diet diversity between irrigators and non-irrigators, suggesting that irrigation plays a role in enhancing food security through improved dietary diversity. This suggests that households with irrigation facilities may have a more diverse diet and better access to food compared to those relying solely on rain-fed agriculture. Irrigation likely enables a more consistent and varied food supply throughout the year, leading to improved dietary quality and quantity. This suggests that households practicing irrigation have access to a wider range of food groups, leading to a more balanced and nutritious diet. Among all the studies, researchers adopted the HDDS and HFIAS in analysing the impact of small-scale irrigation on food security. From the literature, it has been noted that many authors such as Damtew (2017), Mekonnen et al., (2022), Karanja et al., (2023), and Munjur et al. (2023) used the HDDS to analyse the impact of small-scale irrigation to food security.

Therefore, to assess the dietary diversity of beneficiaries and non-beneficiaries of the Banga irrigation scheme, the researcher used HDDS because it has been employed in many studies by different authors. The researcher also used the HDDS as the analytical tool because it provides a simple and quick way to assess the quality and diversity of diets within a household, looking at the variety of food groups consumed, and indicating whether a household has a diverse and

balanced diet. In addition, HDDS can be used to monitor changes in dietary patterns over time, track the impact of interventions or programs aimed at improving nutrition, and evaluate the effectiveness of policies related to food and nutrition security. The researcher adopted the HDDS in the study because HDDS is a cost-effective tool that does not require complex data collection methods or specialized equipment, making it accessible where resources are scarce.

In assessing women's dietary diversity, it has been noted that only one study employed the MDD-W and others used the WDDS. Both studies indicated that small-scale irrigation improves women's dietary diversity. The researcher adopted the use of MDD-W because its simplified assessment approach, standardized measurement, focus on women's nutrition, and ability to identify areas for improvement make it a valuable tool for researchers and practitioners. By leveraging MDDW, they can promote better nutrition and health outcomes for women, supporting the achievement of global nutrition goals and contributing to a healthier and more equitable world.

The empirical literature review reveals that socio-economic factors such as income, education, and access to resources significantly influence dietary diversity. Analytical tools such as multivariate logistic regression, logit models, and binary logistic regression are effective in examining the complex relationships between socioeconomic factors and dietary diversity outcomes it has been noted that they have been used by many researchers in their studies. The researcher used multinomial logistic regression because it allows for modelling and predicting multiple categories of dietary diversity (food secure, mildly food insecure and food insecure) as outcomes, providing a more precise understanding of the relationships between socioeconomic factors and dietary diversity.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents a description of the study area and the research design used in the study. It also considers the population of the study, sampling techniques and sampling size, data collection procedures, types of data, and methods of data analysis.

3.2 Description of the Study Area

3.2.1 Location

The study was conducted in Chivi District, a rural area located in the western part of Masvingo Province, southern Zimbabwe. With a total area of 3534 km² and a population density of 47 people per km², Chivi District is one of the seven districts in Masvingo Province (Zimbabwe National Statistics Agency [ZNSA], 2017). The district shares borders with Mwenezi to the south, Zaka to the east, Chiredzi to the west, and Bikita to the north. Chivi District is characterized by high poverty rates, with 67.95% of the population living in poverty, 23.1% in extreme poverty, and a poverty gap of 29.0% (ZNSA, 2017). The poverty severity index is 15.1%, indicating a high level of poverty in the district. The map of the study area is shown in Figure 3, which highlights the location of Chivi District in Masvingo Province. Additionally, the district's proximity to Harare, approximately 400km, and its rural setting make it an ideal location for studying the impact of irrigation on smallholder farmers' livelihoods.

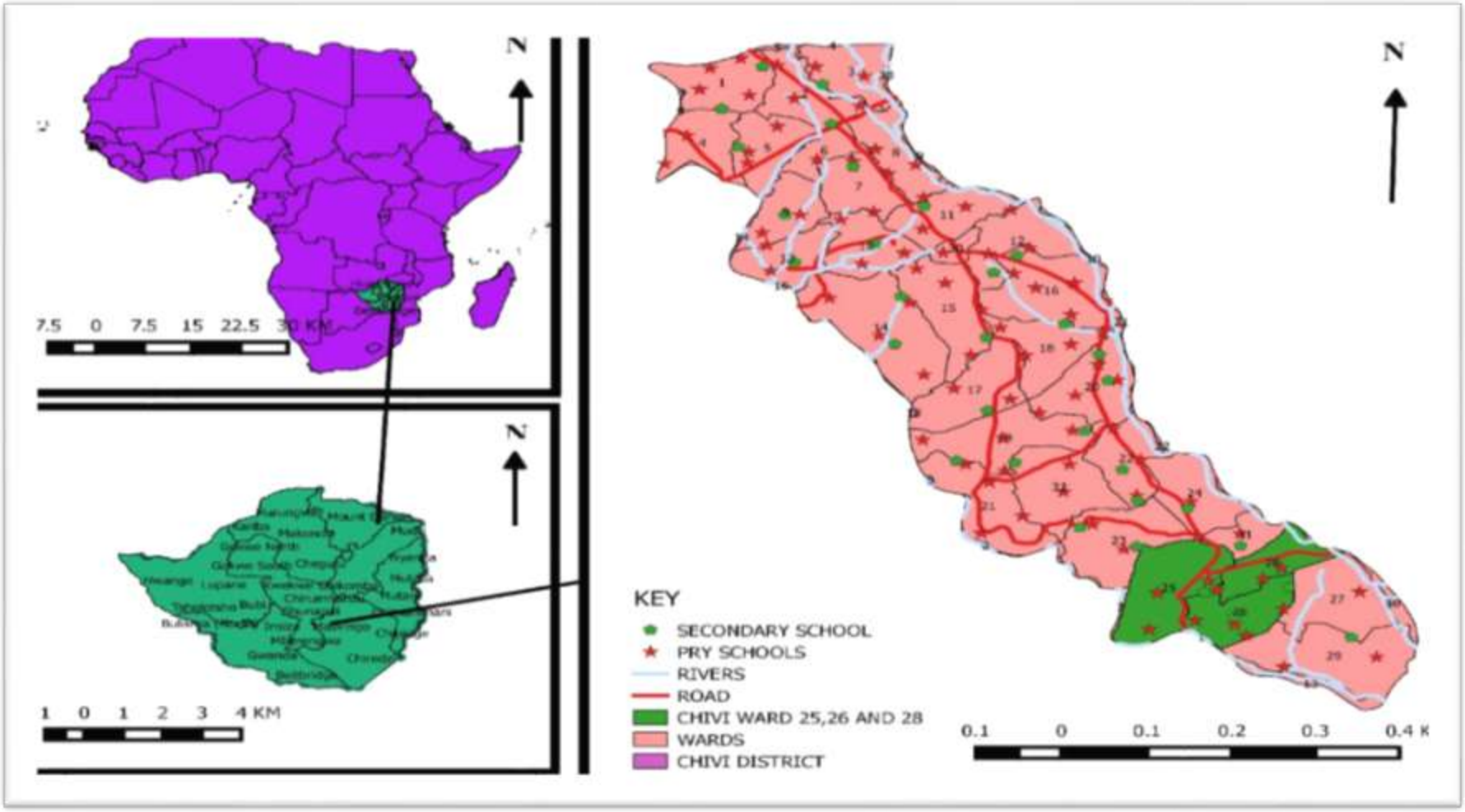

Figure 3. *Study Map of Chivi District of Masvingo Province*

Source: author

3.2.2 Population and Area Coverage

Chivi District, the focus of this study, has a population of 172,979 individuals, according to the 2022 population census (ZIMSTAT, 2022). This population is dispersed across 32 wards, with a gender breakdown of 54.4% females and 45.6% males. The Banga irrigation scheme, a key case study area, encompasses wards 25, 26, and 28, covering a significant portion of the district. Notably, the scheme serves a total of 1,500 households, with an average household size of 5.5 individuals (Ministry of Agriculture, 2020).

3.2.3 Climatic Conditions

Chivi district, located in Masvingo Province, is a climate hotspot area with a mean hazard index of 0.5971 (UNDP, 2015). Drought and dry spells are the most prevalent hazards, accounting for 32.54% of the district's mean hazard index (UNDP, 2015). The district falls within agro ecological natural regions IV and V, characterized by a high frequency of climate shocks, including drought, floods, and erratic rainfall patterns (Mugabe et al., 2018). The semi-arid region receives an annual rainfall of less than 650 mm, leading to periodic droughts and floods that pose significant challenges to agricultural activities (Manatsa et al., 2020). However, there is a 60-80% probability that rainfall in the area will exceed 500 mm, and maximum temperatures range from 28 to 30°C (Manatsa et al., 2020). Furthermore, the district's climate is projected to become even more unpredictable, with rising temperatures and changing rainfall patterns, which will likely exacerbate the existing climate-related hazards (IPCC, 2018).

3.2.4 Agricultural Activities

Agriculture is the mainstay of the population in the district and hence it contributes almost the largest share of the livelihood of the population. Mixed farming is the common practice prevailing in the district. As a result, livelihood sources in Chivi District primarily revolve around livestock rearing and cropping, with crops such as maize, small grains like rapoko, millet and sorghum, leguminous crops, and cotton which are adapted to the semi-arid conditions. However, crop yields are significantly impacted by poor soils and recurrent droughts. Livestock farming, particularly cattle and goats, is also common in the district. Due to the aridity of the region, agriculture in the Chivi district is predominantly rain-fed and highly dependent on seasonal rainfall patterns. Farmers in the area face challenges related to water scarcity, soil erosion, and desertification. Water management strategies, such as rainwater harvesting and small-scale irrigation, are increasingly being promoted to mitigate the impact of erratic rainfall patterns on agricultural productivity in the Chivi district.

3.2.5 Economic Activities

The economic activities of Chivi District are characterized by a mix of agriculture, mining, trade, tourism, manufacturing, and infrastructure development. The district's economy thrives on the utilization of natural resources, the entrepreneurial activities of its residents, and efforts to promote sustainable economic growth and development. Chivi District is endowed with mineral resources such as gold, tantalite, and lithium. Artisanal and small-scale mining activities are common in the district, providing employment opportunities and contributing to local economic development. Chivi District boasts natural attractions such as the Chivi Mountains, Chirumhanzu Hot Springs, and historical sites like the Great Zimbabwe Ruins. Tourism potential in the district is emerging, offering opportunities for eco-tourism, cultural tourism, and adventure tourism. Community-based tourism initiatives are being developed to showcase the unique heritage and biodiversity of Chivi District.

3.2.6 Banga Small Scale Irrigation Scheme

Banga is an irrigation scheme in the Chivi district of Masvingo province which is the case of the study. The scheme covers wards 25, 26, and 28 of the Chivi district. The Banga irrigation scheme was established in 1972 and draws water from the Banga River but with more water coming from Tugwi-Mukosi. The scheme is in Madzivire communal lands measures 64 hectares and has been expanded to 195 hectares under the Smallholder Irrigation Revitalization Programme (SIRP).

Overall, the economy of Chivi district is largely based on agriculture, with most households relying on farming for their livelihoods. However, there is potential for diversification into other sectors such as tourism, manufacturing, and services to further stimulate economic growth and development in the area.

3.3 Research Design

The study employed both quantitative and qualitative methods of data collection and analysis. A survey was conducted to collect data using structured questionnaires and interviews with both households and agricultural extension officers within the irrigation scheme.

3.4 Sampling Technique and Sample Size

A multistage sampling method was employed to select the sample. First, Chivi District was purposively selected due to its high number of irrigation schemes and drought frequency. Secondly, the Banga irrigation scheme, the largest in the district, was selected using purposive

sampling. The (Moyo, et al., 2016) scheme covers wards 25, 26, and 28 and has undergone expansion under the Smallholder Irrigation Rehabilitation Program (SIRP).

Thirdly, households were then stratified into beneficiary and non-beneficiary groups. Beneficiary irrigators are households that use irrigation systems during the production year, while non-beneficiary households are those that have not participated in irrigation activities despite being located in the same area as the Banga irrigation scheme.

Finally, a random sampling method was used to determine the sample size. Using the Slovin formula:

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

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

Where:

- N = 31942 (population size)
- e = 0.136 (level of significance)

$$n = \frac{31942}{1 + 31942(0.136^2)}$$

Therefore n= 57

From the above calculation, 57 households were sampled.

3.5 Data Collection Methods

Table 1. *Summary of Data Collection*

Objective	**Data to be collected**	**Data gathering tool**	**Respondents**
1. To compare the dietary diversity of beneficiary and non-beneficiary households of the Banga Irrigation Scheme	The number of different food groups (out of 12 food groups) consumed by each household in the past 24 hours	HDDS questionnaire, interviews	Household members both beneficiary and non-beneficiary households
2. To assess the dietary diversity of women of reproductive age participating in the Banga irrigation scheme	Number of food groups(out of 10 predefined food groups) consumed by women between the ages of 15 to 49 the previous day or night	MDD-W questionnaire, interviews	Women between the ages of 15 to 49 years who are actively participating in the scheme
3. To determine socioeconomic factors that affect the dietary diversity of beneficiary households	Household demographics, educational level, cultivated land size, off-farm income, livestock holding	Focus group discussions, key informant interviews	Household heads, village heads, agricultural officers

Source: survey data (2024)

The table above presents a summary of the data collection methods which are discussed below.

3.5.1 Data Types and Sources

This study employed a mixed-methods approach, combining both quantitative and qualitative data collection methods to gather primary data from beneficiaries and non-beneficiary irrigators of the Banga irrigation scheme. A pre-tested structured questionnaire was

administered to collect quantitative data on socio-economic characteristics, food security status, and dietary diversity among both groups of households. Additionally, key informant interviews and focus group discussions were conducted to gather qualitative data on local perceptions and opinions regarding the impact of irrigation on household food and nutrition security. This approach allowed for a comprehensive understanding of the research topic, enabling the triangulation of findings to increase validity and reliability. The questionnaire was designed to assess various aspects, including household demographics, agricultural practices, food consumption patterns, and perceived changes in food security and nutrition status. The qualitative component provided rich insights into the experiences and perspectives of the respondents, complementing the quantitative data and offering a more nuanced understanding of the research findings.

3.5.2 Data Collection Techniques

To collect comprehensive data at the household level, a structured questionnaire was employed, initially prepared in English and then translated into Shona, the local language, to ensure respondents' understanding. The questionnaire comprised sections on Household Dietary Diversity Score (HDDS), Minimum Dietary Diversity for Women (MDD-W), household demographics, and socioeconomic characteristics. A combination of close-ended and open-ended questions was used to gather both quantitative and qualitative data, providing direct answers and in-depth explanations. Additionally, two focus group discussions (FGDs) were conducted, each comprising 8-10 randomly selected men and women, including both beneficiary irrigators and non-irrigators from the Banga irrigation scheme. The FGDs aimed to gather qualitative insights into household food and nutrition security, challenges faced by farmers, and the impact of irrigation on their livelihoods. The output from the FGDs informed the design of the household questionnaire and provided supplementary qualitative evidence. Furthermore, key informant interviews were conducted with two conveniently selected informants, AGRITEX and the lead farmer, to gather expert insights into farming standards, current production status, and challenges faced by the irrigation scheme. This multi-faceted approach ensured a rich and comprehensive dataset, enabling a deeper understanding of the research topic.

3.6 Method of Data Analysis

Table 2. *Summary of Data Analysis*

Objective	Data collected	Data analysis methods
1. To compare the dietary diversity of beneficiary and non-beneficiary households of the Banga Irrigation Scheme	The number of different food groups (out of 12 food groups) consumed by each household in the past 24 hours	• Calculate the HDDS scores • Descriptive statistics • ANOVA test
2. To assess the dietary diversity of women of reproductive age participating in the Banga irrigation scheme	Number of food groups(out of 10 predefined food groups) consumed by women between the ages of 15 to 49 the previous day or night	• Calculate MDD-W scores • Descriptive statistics • ANOVA test
3. To determine socioeconomic factors that affect the dietary diversity of beneficiary households	Household demographics, educational level, cultivated land size, off-farm income, livestock holding	• Multinomial logistic regression

Source: survey data (2024)

The table above presents a summary of the data analysis method discussed below.

After data collection, editing, and coding, the data was entered into SPSS version 20.0 software for analysis. A mixed-methods approach was adopted, combining both quantitative and qualitative data analysis techniques. Descriptive statistics, including frequency distribution, charts, mean, maximum, minimum, percentage distribution, and standard deviation, were used to analyze the quantitative data. Inferential statistics, such as chi-square and independent t-tests, were employed to identify associations between categorical variables and compare mean differences between groups. Additionally, multinomial logistic regression was used to determine the socioeconomic factors influencing household food security. The Household Dietary Diversity Score (HDDS) and Minimum Dietary Diversity for Women (MDD-W) were calculated using the frequency-of-occurrence questions to assess food security status.

Qualitative data from key informant discussions and focus group discussions were analyzed thematically to provide a deeper understanding of the research findings.

3.7 Multinomial Logistic Regression model

A multinomial logistic regression model was employed to determine the socioeconomic factors that affect the dietary diversity of beneficiary households in the Banga irrigation scheme. The dependent variable in the model was Dietary Diversity (DD), which represents the level of food group diversity consumed by the household. The multinomial logistic regression can be expressed as follows:

$$DD = \beta_0 + \beta_1 HHAGE + \beta_2 HSIZE + \beta_3 PSTAT + \beta_4 LHOLH + \beta_5 HSHH + \beta_6 HHEDU + \beta_7 MSTAT + \beta_8 GENHH + \beta_9 IRRACC + \beta_{10} CULTLAND + \varepsilon_i$$

Where:

- DD is Dietary Diversity (Food security status)
- β_0 is the intercept term
- β_1 to β_{12} are the coefficients for each independent variable
- ε_i is the error term
- HHAGE: Age of Household Head
- HSIZE: Household Size
- PSTAT: Poverty Status
- LHOLD: Livestock Holding
- HSHH: Health Status of Household Head
- HHEDU: Level of Education
- MSTAT: Marital Status
- GENHH: Gender of Household Head
- ACCIRR: Access to Irrigation
- CULTLAND: Cultivatable Land size

Table 3. *Summary of independent variables and expected hypothesized signs*

Code	**Variable description**	**Variable Type**	**Measurement**	**Expected sign**
HHAGE	Age of household head	Continuous	Years	+ve
HHEDU	Level of Education	Dummy	0= no education, 1= primary, 2= secondary, 3= tertiary	+ve
HSIZE	Household Size	Continuous	Number	-/+ve
PSTAT	Poverty Status	Dummy	1= very poor, 2= poor, 3= average, 4= well off	+ve
HSHH	Health Status of Household Head	Dummy	0= sick, 1= healthy, 2= sometimes sick	+ve
LH	Livestock Holding	Dummy	0= No, 1= Yes	+ve
MSTAT	Marital Status	Dummy	0= single, 1= married, 2= divorced, 3= widowed	-/+ve
GENHH	Gender of Household Head	Dummy	0= male, 1= female	+ve
ACCIRR	Access to Irrigation	Continuous	Hectares	+ve
CULTLAND	Cultivatable Land Size	Continuous	Hectares	+ve

Source: author

3.7.1 Description of explanatory variables

Age of Household Head (HHAGE): This variable represents the age of the primary decision-maker in the household, measured in years. from the table 3 above, it is classified as continuous because it represents a numeric value (years) that can take on any real number within a certain range, rather than being limited to a finite set of discrete categories. The age of the household head is a crucial factor in determining the dietary diversity of the household, as it can influence the household's food preferences, decision-making, and access to resources (Sraboni et al., 2014). This variable is expected to yield a positive impact on the household food security status.

Household Size (HSIZE): It is measured in the number of peoples living in the household converted in to adult equivalent. This variable is classified as continuous because it represents the number of individuals in the household, which can take on any whole number value. For farming activity, the labour force in the family is essential in order to be food secured (Damtew, 2017). Household size can affect the dietary diversity of the household, as larger households may face greater challenges in accessing and affording a diverse range of food items (Osei et al., 2017).

Livestock Holding (LHOLD): The livestock holding variable represents the number of livestock owned by the household, including cattle, goats, sheep, and poultry. This variable is classified as a dummy (categorical) variable because it represents a binary outcome (0 for no livestock holding, 1 for having livestock holding). Livestock ownership is an important asset that can contribute to household food security and dietary diversity through the provision of protein, dairy products, and income generation (Dhakal et al., 2015). Therefore, higher livestock size would increase significantly the household dietary diversity.

Poverty Status (PSTAT): Poverty status is a variable that takes the value of 1 for being very poor, 2 if poor, 3 for average, and 4 for being well off. This variable is classified as a dummy (categorical) variable because it represents different levels of poverty status, which are discrete categories (very poor, poor, average, and well-off). Poverty is a significant determinant of dietary diversity, as households with limited economic resources may have restricted access to a diverse range of food items (Sibhatu et al., 2015). This variable was expected to have a positive impact on the dietary diversity.

Health Status of Household Head (HSHH): This variable indicates the self-reported health status of the primary decision-maker in the household, coded as 0 for sick, 1 if healthy, and 2 if the household head is sometimes sick. This variable is classified as a dummy (categorical)

variable because it represents different health status categories (sick, healthy, and sometimes sick), which are discrete rather than continuous. The health status of the household head can impact the household's ability to engage in food production, access markets, and make informed decisions about dietary choices (Sraboni et al., 2014). Households with good health status were expected to influence the food security situation of the beneficiaries positively.

Level of Education (HHEDUC): This variable represents the highest level of education attained by the household head, ranging from no formal education to tertiary education. It is classified as a dummy (categorical) variable because it represents different levels of education, which are discrete categories rather than a continuous numeric value. The values 0, 1, 2, and 3 represent the different levels of education (no education, primary, secondary, and tertiary, respectively). Education can influence the household's knowledge, awareness, and decision-making related to nutrition, which in turn can affect the dietary diversity of the household (Osei et al., 2017).

Marital Status (MSTAT): This is an ordinal variable that takes the value of 0 if the household head is single, 1 if married, 2 if divorced, and 3 if widowed. This variable is classified as a dummy (categorical) variable because it represents different marital status categories (single, married, divorced, and widowed), which are discrete rather than continuous. Marital status can affect the household's resource allocation, decision-making, and access to social support, all of which can influence the dietary diversity of the household (Sraboni et al., 2014). Marital status expected to have both a positive and negative effect on the household food security status.

Gender of Household Head (GENHH): This is a binary variable that takes the value of 0 if the household head is male and 1 if female. It is classified as a dummy (categorical) variable because it represents a binary outcome (0 for male, 1 for female). Gender can play a role in the household's access to resources, decision-making power, and food allocation, which can impact the dietary diversity of the household (Sraboni et al., 2014). This variable was expected to yield a positive impact on household dietary diversity.

Irrigation Access (ACCIRR): This refers to the total size of owned irrigated land of each household after the implementation of the Banga irrigation scheme. This variable is classified as continuous because it represents the amount of cultivatable land with access to irrigation, which can take on any non-negative real number value. Access to irrigation can improve agricultural productivity and availability of a diverse range of food items, thereby enhancing

the dietary diversity of the household (Dhakal et al., 2015). Hence, the household that had access to irrigation was expected to have a positive impact on household dietary diversity.

Cultivatable Land Size (CULTLAND): This refers to the total size of cropping land cultivated by a household after the implementation of the irrigation scheme, measured in hectares. This variable is classified as continuous because it represents the size of cultivatable land, which can take on any non-negative real number value. The size of cultivatable land can influence the household's food production capacity and, consequently, the dietary diversity of the household (Sibhatu et al., 2015). Hence, the size of cultivated land was expected to have a positive effect on household food security status.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the findings and discussion of the study, divided into three sub-sections. The first sub-section presents the results of household dietary diversity among beneficiary and non-beneficiary households, using descriptive statistics such as mean, percentages, and frequencies to describe the characteristics of sampled households across various explanatory variables. This includes an analysis of demographic characteristics, agricultural practices, and food consumption patterns. The second sub-section focuses on assessing food security using the Minimum Dietary Diversity for Women (MDD-W) indicator, which measures women's dietary diversity in sample households. This section also examines the prevalence of food insecurity and its determinants among beneficiary and non-beneficiary households. Finally, the third sub-section presents the results of the econometric analysis, which identifies the socio-economic factors that significantly influence the dietary diversity of beneficiary households, including factors such as household income, education, and access to irrigation.

4.1 Availability and Consumption Patterns

Table 4. *Household Dietary Diversity Score (HDDS) by Beneficiary Type*

		BENEFICIARY TYPE (2 groups)		Total
		Beneficiary	Non-beneficiary	
Dietary Diversity (DDS)	Food insecure(3-4 food groups)	3.5%		3.5%
	Mildly Food insecure(5 food groups)	12.3%	3.5%	15.8%
	Food Secure (6-12 food groups)	54.4%	26.3%	80.7%
Total		70.2%	29.8%	100.0%

Source: Survey result 2024

The results of the survey in Table 3 show that out of 57 sampled households of the Banga irrigation scheme, beneficiary households had a high dietary diversity of 54.4% whilst non-beneficiary households had a high dietary diversity of 26.3%. Similarly, 12.3% and 3.5%, of beneficiary and non-beneficiary households respectively, had a medium dietary diversity of 5 food groups. It was found that only 3.5% of beneficiary households had low dietary diversity of less than 3-4 food groups. These results indicate that beneficiary households are highly food secure than non-beneficiary households. They also suggest that beneficiaries are also moderately food secure than non-beneficiaries. These results are further analysed below to observe the statistical significance of beneficiary status to dietary diversity.

Table 5. *Descriptive Statistics of HDDS by Beneficiary Type*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	40	6.98	1.717	.271	6.43	7.52	3	10
2	17	6.82	1.468	.356	6.07	7.58	5	11
Total	57	6.93	1.635	.217	6.50	7.36	3	11

Source: Survey result 2024, significant level at 1%

Table 4 above shows that the average mean dietary diversity score for the study area was 6.93. The beneficiary households of the Banga irrigation scheme, on average, consumed 6.98 food groups out of 12 food groups in the past 24 hours before the survey and the scores tend to vary around this average by approximately 1.717 points. Non-beneficiary households, on the other hand, consume 6.82 food groups with scores varying by approximately 1.468 points. This indicates that beneficiary households had a slightly higher mean HDDS than non-beneficiary households. The standard error of 0.271 indicates the precision of the mean estimate, suggesting that if multiple samples of beneficiary households were taken, and calculate the mean HDDS score each time, 95% of the time, the true population mean would fall within ±0.271. On the other hand, the standard error is slightly higher at 0.356 for non-beneficiary

households indicating a lower precision in estimating the population mean based on the sample mean. Overall, these results suggest that beneficiary households that had high mean dietary diversity scores have potentially more variability in dietary diversity compared to non-beneficiary households. Thus, beneficiaries had access, on average, to more diverse food leading to more food security compared to non-beneficiaries. The difference in the mean diversity scores between food secure and food insecure is significant at a 1% significant level. Further analysis is done below to assess the statistical significance between beneficiaries and non-beneficiaries of the Banga irrigation scheme.

Table 6. *Minimum Dietary Diversity for Women (MDD-W) by Gender of Household Head*

		A7. GENDER OF HH		Total
		Male-headed	Female-headed	
MDDW	Food insecure(<5 food groups)	33.3%	19.4%	52.8%
	Food secure(5-10 food groups)	30.6%	16.7%	47.2%
Total		63.9%	36.1%	100.0%

Source: Survey results 2024

Table 6 above illustrates the relationship between the gender of the household head (male-headed or female-headed) among the participants of the Banga irrigation scheme and the prevalence of food insecurity and food security based on MDD-W. The results show that 33.3% male-headed households were food insecure whilst 30.6% female-headed were food insecure. Similarly, 30.6% and 16%, male-headed and female-headed, respectively were food secure. These results suggest that there is a higher prevalence of food insecurity among male-headed households compared to female-headed households. This implies that male-headed households are more likely to experience food insecurity despite having a slightly higher percentage of food security. On the other hand, female-headed households show a lower percentage of food insecurity but also a smaller percentage of food security compared to male households. These findings suggest that the gender of the household head is a significant predictor of food security status. Male-headed households face unique challenges in accessing food, which may be attributed to various factors such as socioeconomic status, social and cultural norms, and access

to resources. Moreover, the results highlight the resilience and resourcefulness of female-headed households, who despite facing their own set of challenges, manage to achieve a higher level of food security. This suggests that female-headed households may be a valuable resource for knowledge sharing and support, and should be engaged in the development and implementation of food security interventions.

Table 7. *MDD-W by Household Category*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	23	4.70	1.743	.364	3.94	5.45	2	9
1	13	4.54	2.332	.647	3.13	5.95	2	10
Total	36	4.64	1.944	.324	3.98	5.30	2	10

Source: Survey results 2024

The table above illustrates descriptive statistics results for Minimum Dietary Diversity for Women (MDD-W) by household category (male-headed and female-headed). In the table above, male-headed is coded 0 whilst female-headed is coded 1. The overall mean MDD-W score is 4.64, indicating a moderate level of dietary diversity among women in the sample. Male-headed households have a slightly higher mean MDD-W score (4.70) compared to female-headed households (4.54). While the difference is small, it suggests that male-headed households may have a slightly higher level of dietary diversity. This could be due to various factors, such as differences in socioeconomic status, education, or access to resources. The standard deviation for female-headed households (2.332) is higher than for male-headed households (1.743), indicating more variability in MDD-W scores among female-headed households. This suggests that dietary diversity among female-headed households may be more inconsistent or unpredictable. This could result from various factors, such as limited access to resources, lack of knowledge about nutrition, or cultural or social factors that influence food choices. The results show a smaller standard error of the mean for male-headed households (0.364) compared to female-headed households (0.647) indicating that the estimate of the mean MDD-W score is more precise for male-headed households. This means that the mean MDD-

W score for male-headed households is more reliable and less likely to be influenced by random sampling error.

Therefore, the results suggest that there may be slight differences in dietary diversity between male-headed and female-headed households, with male-headed households having a slightly higher level of dietary diversity. This is also because, from the sample, the number of male-headed households was higher (23) than female-headed households (13). However, the differences are small and may not be statistically significant, which indicates that the difference is due to chance rather than a real underlying difference. Further analysis is conducted below, to determine whether the difference in means between male-headed and female-headed households is statistically significant.

Table 8. *MDD-W by Beneficiary Status*

		BENEFICIARY TYPE (2 groups)		Total
		Beneficiary	Non-beneficiary	
MDDW	1 (food insecure)	33.3%	19.4%	52.8%
	2 (food secure)	27.8%	19.4%	47.2%
Total		61.1%	38.9%	100.0%

Source: Survey results 2024

The table above reveals the association between beneficiary type and food security status. The results show that based on the MDD-W, beneficiary irrigators of the Banga irrigation scheme had the highest proportion of food security (27.8%) whilst non-beneficiaries had a proportion of 19.4% food security. Similarly, beneficiaries also had the highest proportion of food insecure (33.3%) compared to non-beneficiaries (19.4%). The findings indicate that the Banga irrigation scheme may not adequately address the underlying causes of food insecurity. This highlights the need to reassess and potentially modify smallholder irrigation development to address the needs of beneficiaries better and improve their food security outcomes. Figure 5 below is a graphical presentation illustrating the comparison of WDD-W by beneficiary status of the Banga irrigation scheme.

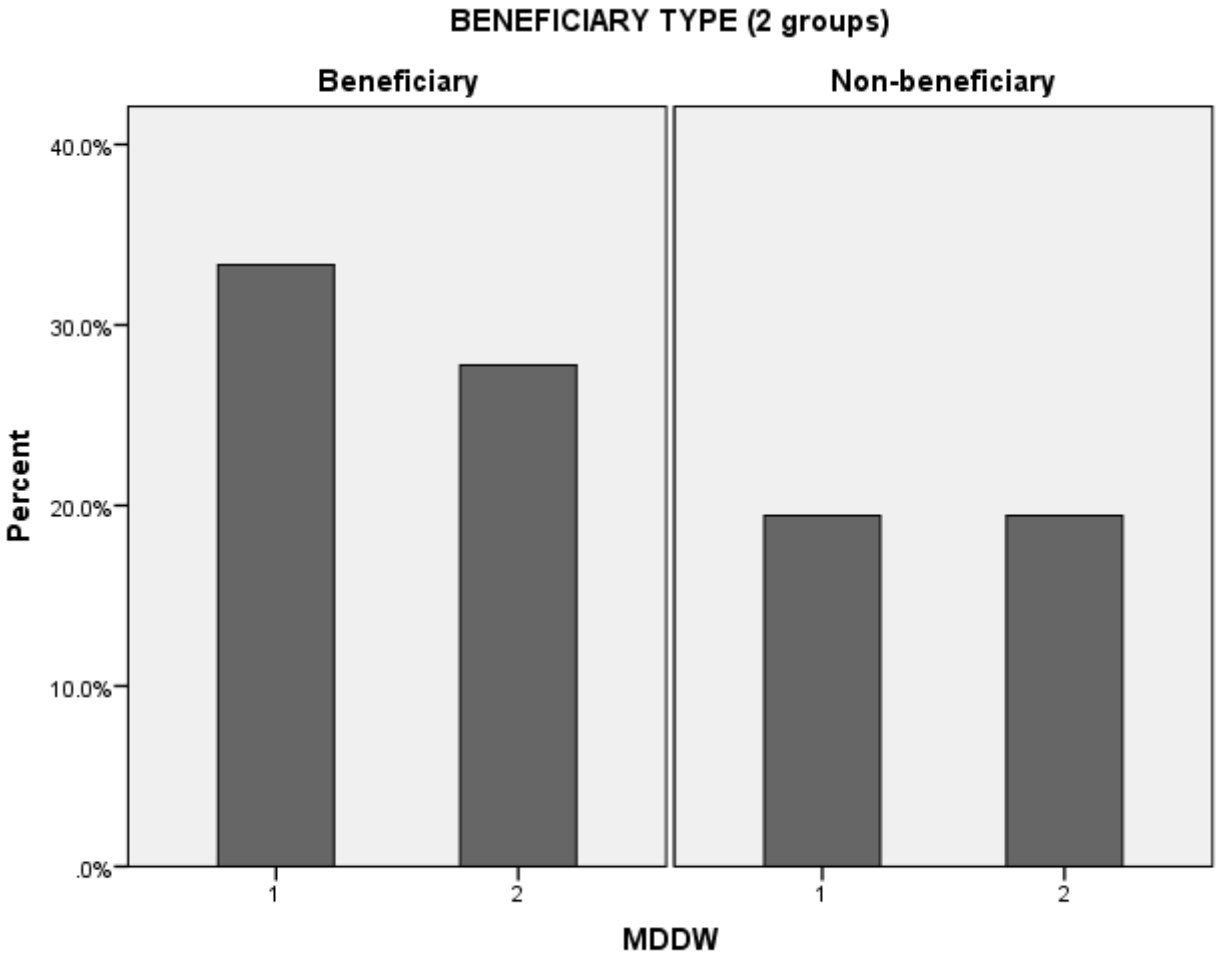

Figure 4. *MDD-W by Beneficiary Status*

The above results also suggest that non-beneficiaries may be relying on other resources or strategies to meet their dietary needs. This could include alternative forms of support, such as community-based initiatives or private enterprises. The fact that non-beneficiaries are just as likely to be food secure as food insecure suggests that they may be more resilient and better equipped to cope with food insecurity. To tackle food security and dietary diversity challenges, it's essential to consider various factors beyond irrigation development, including income, education, food availability, cultural practices, and household composition. By understanding these factors, strategies can be identified to enhance dietary diversity, nutrition, and health. Promoting irrigation development is crucial to improve food security and dietary diversity among women in irrigation schemes and rural areas, as it can increase crop yields, diversify production, and provide access to a variety of foods. Empowering women to participate in decision-making processes and improving their access to resources and services is also vital, as they play a critical role in household food security and nutrition.

These findings from the Banga irrigation scheme study align with and expand upon the existing literature on the relationship between household head gender, food security, and dietary diversity. Several studies have reported similar findings, where male-headed households tend to have a higher prevalence of food insecurity compared to female-headed households (Quisumbing et al., 2015; Kassie et al., 2018). However, the non-significant difference in dietary diversity between household head genders contrasts with some previous studies that have found gender-based disparities in dietary diversity (Doan et al., 2018; Akaichi et al., 2020). This suggests that the relationship between household head gender and dietary diversity may be more complex and context-specific, as highlighted by the higher variability in MDD-W scores among female-headed households.

4.2 Factors Influencing Participation in Irrigation Schemes

Firstly, a summary of the case processing and the distribution of the outcome variable, Dietary Diversity Score (DDS) was presented as shown in Table 10 below. The results in the Table below reveal that most households (83.3%) have a high dietary diversity score (6-12 food groups), indicating food security. This suggests that most households have access to various foods and can maintain a diverse diet. However, a small proportion of households (5.6%) have a low dietary diversity score (3-4 food groups), indicating food insecurity. This suggests that some households may be struggling to access a variety of foods and may be at risk of malnutrition. Furthermore, an even smaller proportion of households (11.1%) have a mildly low dietary diversity score (5 food groups), indicating mild food insecurity. This suggests that some households may be experiencing some difficulties in accessing a variety of foods, but are not yet experiencing severe food insecurity. The results also indicate that there may be some missing data, as 21 cases are missing out of a total of 57. However, the analysis is based on a subpopulation of 36 cases, which is 100% valid.

Table 9. *Summary of the Distribution of Dietary Diversity (DDS)*

		N	Marginal Percentage
Dietary Diversity (DDS)	Food insecure(3-4 food groups)	2	5.6%
	Mildly Food insecure(5 food groups)	4	11.1%
	Food Secure (6-12 food groups)	30	83.3%
Valid		36	100.0%
Missing		21	
Total		57	
Subpopulation		36[a]	

Source: Survey results 2024

Determining the socioeconomic factors affecting dietary diversity

Test of statistical significance of individual variable using multinomial logistic

Testing at 1% level if significance

$H_0 : \beta = 0$

Reject H_0 if p < 0.01, and conclude that the variable is statistically significant at 1% level of significance.

H_0 : There is no significant relationship between socioeconomic factors (educational level, health status, poverty level, gender, livestock holding, etc.) and the dietary diversity of beneficiary households of the Banga irrigation scheme.

Table 10. *The Multinomial logistic regression results*

Variables	**B**	**Std.Error**	**Wald**	**Sig.**	**Exp(B)/ Odds ratios**
Intercept	21.001	7.625	7.587	.006***	-
Age of Household	-.694	.50	189.492	.001***	4.99
Household Size	.360	.635	.322	.571	1.434
Cultivatable land size	-14.303	714.056	.000	9.84	6.142E-7
Level of education	1.863	.584	10.165	0.01***	6.441
Irrigation Access	0.222	0.948	0.001	.005***	7.183

Health Status of household head	-32.539	1.073	919.433	.002***	7384E-15
Livestock holding	4.155	1.428	8.349	.004***	63.747
Poverty Status	-.333	1.698	.039	8.44	.717
Household gender	44.319	1.545	823.026	.000***	1766E+19
Marital status	-5.698	1.021	31.142	.000***	0.003

*** Significant at 1% level of significance

Source: Survey results, 2024

The table above presents the multinomial logistic regression results of the socioeconomic factors affecting the dietary diversity of beneficiary households of the Banga irrigation scheme. From the above results, the intercept has a positive regression slope and is statistically significant, with a p-value of 0.006 greater than the significant level at 1%. The results indicate that several socioeconomic factors have a significant influence on the dietary diversity of households in the Banga irrigation scheme. Seven statistical significant independent variables were identified out of the hypothesized ten variables by estimating a multinomial logistic model. Among the factors considered in the model, education level, livestock holding, irrigation access and household gender significantly and positively affected household food security (dietary diversity). Age household head, health status of household head and marital status significantly and negatively affected household food security (Table 15).

The above results show that age of household heads affected dietary diversity at significant level of 1% (p-value<0.001) and negatively (-.694) related to dietary diversity in the study area. The negative relationship implies that as the household head gets older, the dietary diversity of the household decreases. This is possible because older household heads were less productive and they lead their life by remittance and gifts. They could not participate in other income-generating activities. The odds ratio is 4.99 indicating that having high dietary diversity increase by 4.99 for every year increase in age. This suggests that younger household heads are more likely to have a diverse diet. This finding is consistent with previous research which has found that younger households tend to have more diverse diets (Hoddinott & Yohannes, 2002; Koppmair et al., 2017). Younger household heads may be more open to trying new foods and incorporating diverse ingredients into their meals, whereas older heads of household may have more entrenched dietary preferences.

The analysis findings show that household education level is statistically significant at a 1% level of significance ($p<0.01$) and is positively associated with the dietary diversity of beneficiary households of the Banga irrigation scheme. The odds ratio is 6.441 indicating that the odds of having high dietary diversity increase by 6.441 times for every unit increase in education. This suggests that educated household heads are more likely to make informed decisions about their diet. This aligns with previous research which has found that more educated households tend to have more diverse diets, potentially due to greater nutrition knowledge, exposure to diverse foods, and purchasing power (Rashid et al., 2011; Koppmair et al., 2017). Investing in education, particularly nutrition education, may be an important strategy to improve dietary diversity in this context.

Access to irrigation is found to have a highly significant positive relationship ($p<0.001$) with dietary diversity. The odds of having high dietary diversity increase by 7.183 times for households with irrigation access. This suggests that irrigation access may provide households with a wider range of crops, leading to a diverse diet. This is consistent with the literature, which has established that access to irrigation can enhance year-round food production, thereby increasing the availability and accessibility of diverse foods for household consumption (Passarelli et al., 2018; Domènech, 2015). Ensuring reliable irrigation access appears to be a key factor in promoting dietary diversity among households in the Banga scheme.

The analysis reveals a highly significant positive relationship ($p<0.001$) between the household's livestock holding and dietary diversity. The odds ratio of livestock holding is 63.747 stating that the odds of having high dietary diversity increase by 63.747 times for every unit increase in livestock holding. This suggests that households with more livestock may have access to a variety of animal-source foods. This aligns with the literature, which has shown that asset ownership, including livestock, can improve access to diverse foods and thus dietary diversity (Rashid et al., 2011; Hoddinott & Yohannes, 2002). Promoting livestock rearing may be an effective strategy to enhance dietary diversity in this context.

The analysis indicates a highly significant negative relationship ($p<0.001$) between being in a married household and dietary diversity. However, the odds ratio of marital status is 0.003 indicating that married household heads are less likely to have high dietary diversity. This suggests that marital status may not have a significant impact on dietary diversity. This is an

unexpected finding, as some studies have suggested that married households may have greater access to diverse foods and labor for food preparation (Mango et al., 2014). Further investigation is needed to understand the nuances of how marital status influences dietary diversity in this context.

The results show a highly significant positive relationship ($p<0.001$) between female-headed households and dietary diversity. The odds ratio of household gender is 1766E+19 indicating that female-headed households are significantly more likely to have high dietary diversity. This suggests that gender may play a role in dietary decision-making. This aligns with previous research that has found female-headed households tend to have more diverse diets, potentially due to women's greater role in food procurement and preparation (Koppmair et al., 2017). Empowering women in the agricultural and food systems of the Banga scheme may be an effective way to improve dietary diversity.

However, the results indicated that poverty status, cultivated land size and household size are not statistically significant at a 1% level of significance. Contrary to expectations, the results do not indicate a significant relationship between household poverty status and dietary diversity ($p=0.844$). Also the odds ratio of poverty status is 0.717 stating that the odds of having high dietary diversity increase for households in the non-poor category. This suggests that poverty may limit access to diverse food options. While poverty is often associated with lower dietary diversity due to reduced purchasing power and access to diverse foods (Rashid et al., 2011; Mango et al., 2014), this finding suggests that other factors may be more important determinants of dietary diversity in the Banga irrigation scheme.

The multinomial logistic regression analysis revealed that several socioeconomic factors such as educational level, livestock holding, irrigation access and household gender significantly influence the dietary diversity of households in the Banga irrigation scheme. Poverty status, cultivated land size and household size were not statistically significant. Based on these results, the study therefore reject the null hypothesis.

4.3 Impact on Food and Nutrition Security

Table 11. *ANOVA Test for Comparison of HDDS by Beneficiary Type*

			Sum of Squares	df	Mean Square	F	Sig.
HDDS * BENEFICIARY TYPE	Between Groups	(Combined)	.274	1	.274	.101	.752
	Within Groups		149.446	55	2.717		
	Total		149.719	56			

Source: Survey results 2024

The results from Table 5 above indicate that there is no significant difference in mean HDDS between beneficiary (6.98) and non-beneficiary households (6.82), based on the ANOVA Post Hoc Tukey HSD test at a 5% significant level. The mean difference was 0.16. The results show a non-significant F-ratio of 0.101 with 56 degrees of freedom between groups and within groups. The p-value is 0.752, which exceeds the 0.05 significant level used in the test. This indicates that there is enough evidence not to reject the null hypothesis, suggesting that there is no significant difference in dietary diversity between beneficiary and non-beneficiary households. This means that the survey data does not provide enough support to conclude that being a beneficiary household of the Banga irrigation scheme had an impact on household dietary diversity. This lack of statistical significance implies that any observed difference in HDDS between beneficiary and non-beneficiary households could be due to random variation rather than a true underlying effect of being a beneficiary. Therefore, it is important to consider other factors that influence HDDS as they could provide a better understanding of the dietary diversity among smallholder irrigating farmers beyond just being a beneficiary.

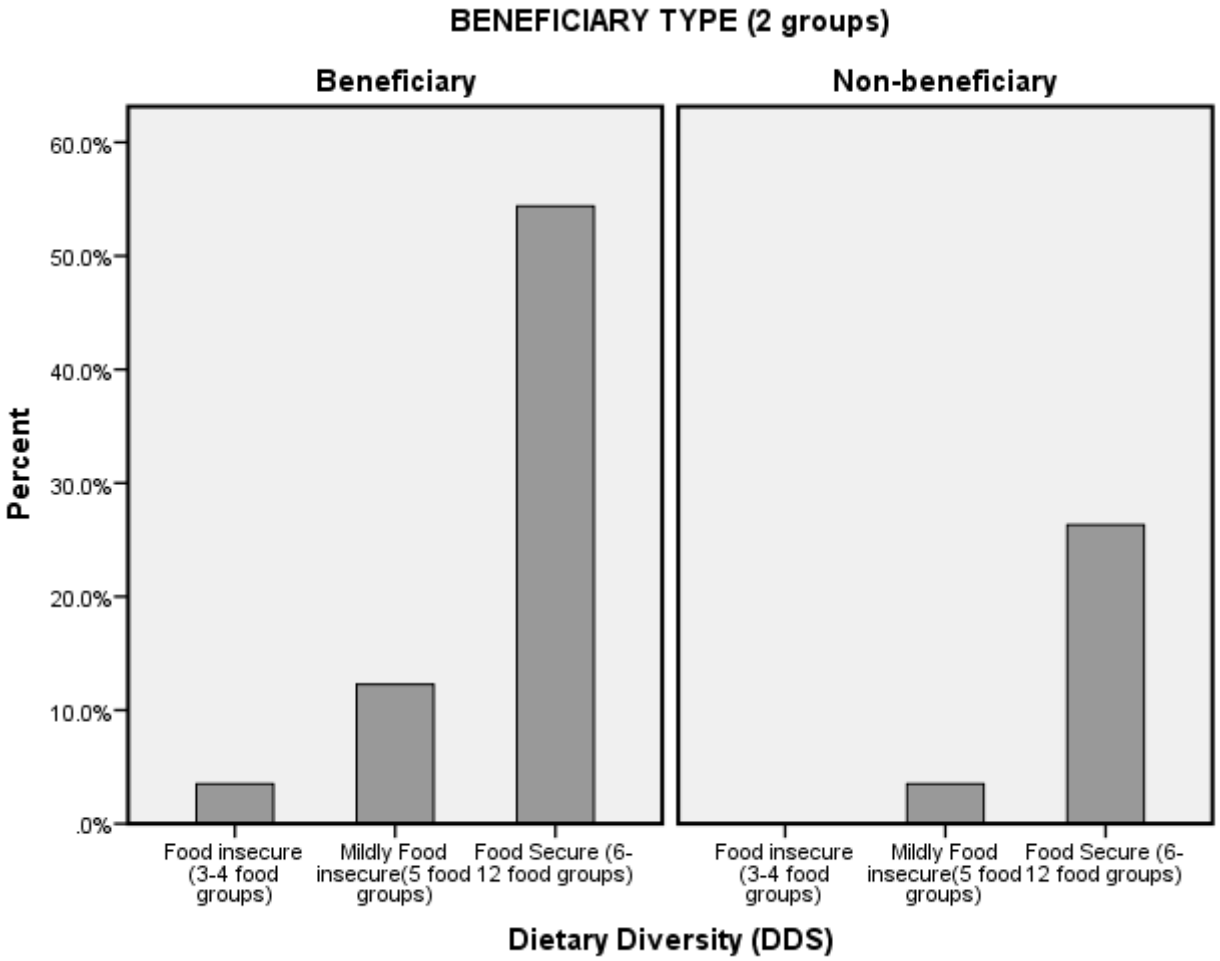

Figure 5. *Comparison of HDDS by Beneficiary Type*

The results in Figure 3 above indicate that beneficiaries of the Banga irrigation scheme had the highest proportion of food-secure households (54.4%) than non-beneficiaries (26.3%). The proportion of mildly food insecure households was highest among beneficiary households (12.3%) whilst non-beneficiaries (3.2%). The proportion of food-insecure households was only indicated among beneficiaries who had 3.5%. These results suggest that smallholder irrigation development has the potential to improve household food security by increasing dietary diversity and access to a variety of foods. However, the results also suggest that additional interventions may be needed to address the food security challenges faced by households that do not have access to smallholder irrigation and other vulnerable groups.

These results present a more complex picture compared to some other studies that have found significant positive associations between irrigation access and dietary diversity. Similar studies from the literature have found conflicting results. For example, a study in Kenya found that

irrigation scheme beneficiaries had significantly higher dietary diversity compared to non-beneficiaries (Muriithi et al., 2020). Another study in Tanzania found no significant difference in dietary diversity between irrigation scheme beneficiaries and non-beneficiaries (Kulwa et al., 2018). The inconsistency in findings may be due to differences in study contexts, methodologies, and sample populations.

Table 12. *ANOVA Test for Comparison of MDD-W by Household Status*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.205	1	.205	.053	.820
Within Groups	132.100	34	3.885		
Total	132.306	35			

Source: Survey results 2024, at 5% significant level

Table 8 above reveals the ANOVA test results for the comparison of Minimum Dietary Diversity for Women (MDD-W) scores between male-headed and female-headed households. The statistical analysis yields a non-significant F-statistic (0.53) with a p-value of 0.820, indicating that the difference in MDD-W scores between the two household types is not statistically significant. This is because the p-value is greater than the significant level which is 0.05. The mean square values show that the variation within groups (3.885) is larger than the variation between groups (0.205). This suggests that the difference between male-headed and female-headed households is small compared to the individual variability within each group. The sum of squares values supports this conclusion, with the majority of the variation in MDD-W scores attributed to differences within groups (132.100) rather than between groups (0.205). This implies that other factors, such as socioeconomic status, education, or geographic location, may have an influence on dietary diversity than household status. Therefore, the ANOVA results indicate that there is no statistically significant difference in MDD-W scores between male-headed and female-headed households of the Banga irrigation scheme participants. The variation within groups is more significant than the variation between groups, suggesting that individual differences and other factors play a more critical role in determining dietary diversity than in household status.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary of the Key Findings

The study assessed the contribution of the Banga irrigation scheme in enhancing food and nutrition security among smallholder farmers in Zimbabwe's semi-arid regions. The food and nutrition security of beneficiary and non-beneficiary households was measured using the household dietary diversity score (HDDS). The results showed that 80.7% of the households in the study area were food secure, 15.8% were mildly food insecure, and 3.5% were food insecure. While 70.2% of beneficiary households were food secure, only 29.8% of non-beneficiary households were food secure. However, the difference in mean HDDS between beneficiary and non-beneficiary households was not statistically significant.

The analysis also examined the relationship between household head gender and food security, as well as dietary diversity among women of reproductive age. The results indicated a higher prevalence of food insecurity among male-headed households (33.3%) compared to female-headed households (30.6%). However, male-headed households also had a slightly higher percentage of food security (30.6%) compared to female-headed households (16%). This suggests that while male-headed households face greater challenges in achieving food security, they are also more likely to attain a higher level of food security when successful. In terms of dietary diversity, as measured by the Minimum Dietary Diversity for Women (MDD-W) score, the results showed that male-headed households had a slightly higher mean score (4.70) compared to female-headed households (4.54), but this difference was not statistically significant.

The multinomial logistic regression analysis revealed that several socioeconomic factors, such as educational level, livestock holding, irrigation access, and household gender, significantly influence the dietary diversity of households in the Banga irrigation scheme. Poverty status, cultivated land size, and household size were not statistically significant.

5.2. Conclusions

This study assessed the contribution of smallholder irrigation development in enhancing food and nutrition security among smallholder farmers in Zimbabwe's semi-arid regions using a case of Banga irrigation scheme. Effective irrigation management has been shown to boost sustainable food production by mitigating crop failure risks. Moreover, irrigation enables farmers to cultivate multiple crops per year and diversify their crops, thereby prolonging the productive growing season in areas with dry spells. This, in turn, contributes significantly to improved food and nutrition security for smallholder farmers.

The food and nutrition security of beneficiary and non-beneficiary households of the Banga irrigation scheme was measured using a commonly used measure of household food security status known as household dietary diversity score (HDDS). The results of the survey indicate that beneficiary households of the Banga irrigation scheme have a higher dietary diversity compared to non-beneficiary households. However, the ANOVA Post Hoc Tukey HSD test reveals that the difference in mean HDDS between beneficiary and non-beneficiary households is not statistically significant at a 5% significant level. This suggests that being a beneficiary household of the Banga irrigation scheme does not have a significant impact on household dietary diversity. This lack of significant difference is an important finding, as it implies that other factors beyond beneficiary status may be influencing dietary diversity among smallholder irrigating farmers.

The analysis of the data from the Banga irrigation scheme participants reveals important insights into the relationship between household head gender and food security, as well as dietary diversity among women of reproductive age. The findings highlight that the gender of the household head is a significant predictor of food security status. This may be attributed to various factors, such as socioeconomic status, social and cultural norms, and access to resources. Male-headed households appear to face unique challenges in securing adequate food for their families, which warrant further investigation. In terms of dietary diversity, as measured by the Minimum Dietary Diversity for Women (MDD-W) score, the results show that male-headed households had a slightly higher mean score (4.70) compared to female-headed households (4.54). However, this difference was not statistically significant, suggesting that household head gender may not be the primary determinant of dietary diversity. These findings suggest that other factors, such as socioeconomic status, education, or geographic location, may play a more significant role in shaping dietary diversity than household head

gender. The non-significant ANOVA results further support this conclusion, as the variation within groups was larger than the variation between groups.

The multinomial logistic regression analysis has provided valuable insights into the socioeconomic factors affecting dietary diversity among households in the Banga irrigation scheme. The multinomial logistic regression findings revealed that several socioeconomic factors such as educational level, livestock holding, irrigation access and household gender significantly influence the dietary diversity of households in the Banga irrigation scheme. Poverty status, cultivated land size and household size were not statistically significant. Based on these results, the study therefore reject the null hypothesis.

5.3. Recommendations

In light of the study's results, the following recommendations are suggested to improve household food security in the study area.

1. Improving agricultural production and crop diversification.
Policymakers should promote the cultivation of a wider variety of nutrient-dense crops, including fruits, vegetables, legumes, and whole grains. This can be achieved through the provision of agricultural extension services and training to farmers on sustainable and diverse farming practices. Additionally, investments in research and development to identify crop varieties well-suited to the local agro ecological conditions can significantly enhance the diversity of agricultural outputs.

2. Strengthening food supply chains and distribution is another essential component.
Enhancing infrastructure, such as roads, storage facilities, and market access, can improve the availability and affordability of diverse food items. Supporting the development of local food processing and preservation techniques can also help reduce post-harvest losses and ensure a more stable supply of diverse food products. Encouraging the establishment of farmer cooperatives and direct-to-consumer marketing channels can further empower smallholder farmers and improve access to nutritious foods.

3. To optimize the impact of interventions, it's essential to refine targeting strategies for non-beneficiaries of smallholder irrigation schemes in future programs. The study results reveal that current interventions have been more successful for irrigator beneficiaries. To better support vulnerable non-beneficiaries, tailored interventions are necessary. Enhancing outreach and effectiveness for non-beneficiaries through targeted, timely initiatives like honey production and post-harvest processing is crucial. While the Banga irrigation scheme had limited success with non-beneficiaries, customized interventions can address this gap. However, targeting strategies must prioritize farmers who demonstrate willingness, capacity, and a proven track record, to avoid perpetuating dependency and ensure meaningful engagement.

Finally, it is recommended that interventions aimed at improving dietary diversity among smallholder irrigating farmers be developed and implemented. These interventions could include training programs on crop diversification, nutrition education, and market access support. By addressing the underlying factors influencing dietary diversity, these interventions could help improve the food security and nutrition outcomes of smallholder irrigating farmers, regardless of their beneficiary status.

2. Scaling up interventions that promote women's economic empowerment, formal employment, and income generation is crucial to unlock their full potential. While the scheme has made notable strides in benefiting women, more targeted efforts are necessary to address the persistent gender gaps. Empowering women farmers through entrepreneurship initiatives, such as training and access to capital, can help them become drivers of economic growth and development. Moreover, increasing women's access to family planning services and reproductive healthcare is essential to enable them to make informed choices about their lives and livelihoods. By investing in women's economic empowerment and reproductive health, we can unlock a ripple effect of positive change, leading to more equitable and prosperous communities. Additionally, promoting gender-sensitive agricultural extension services and women-friendly markets can help address the specific needs and constraints faced by women farmers, further amplifying the impact of interventions.

3. Engage female-headed households in the development and implementation of food security interventions: The findings suggest that female-headed households exhibit resilience and

resourcefulness in achieving higher levels of food security despite facing their own set of challenges. Engaging these households in the design and delivery of food security programs can help leverage their knowledge and experiences to improve outcomes for all. The recommendations to engage female-headed households, investigate the factors influencing dietary diversity, and promote peer-to-peer learning are supported by the existing literature, which emphasizes the importance of inclusive and holistic approaches to improving food security and nutrition (Alaofè et al., 2017; Kumar et al., 2018).

4. Promote knowledge sharing and support between male-headed and female-headed households: Facilitate opportunities for male-headed and female-headed households to share their experiences, challenges, and successful strategies in achieving food security and dietary diversity. This peer-to-peer learning can help foster a supportive community and contribute to improved outcomes for all households.

5. Conduct a comprehensive needs assessment to identify the specific challenges and constraints faced by smallholder farmers in the Banga Irrigation scheme.

A thorough needs assessment is crucial to understand the complexities of the smallholder farmers in the Banga Irrigation scheme. This assessment should engage with the farmers, local communities, and other stakeholders to gather information on the current challenges and constraints faced by the farmers. The assessment should cover aspects such as agricultural production, market access, credit and financial services, technology adoption, and social and cultural factors affecting farming practices. The findings of the needs assessment will provide valuable insights into the specific areas that require intervention, enabling the development of a targeted and effective intervention package.

6. Implementing the intervention package, including training and capacity building for smallholder farmers.

The developed intervention package should be implemented through a combination of training and capacity-building programs for smallholder farmers. The training programs should aim to improve the farmers' technical skills, knowledge, and practices, while the capacity-building programs should focus on enhancing their social and cultural capital. The implementation of the intervention package should be done in collaboration with local stakeholders, including extension agents, community leaders, and local government officials.

5.4. Study Limitations and Future Research Directions

While this study has provided valuable insights into the role of smallholder irrigation development in enhancing food and nutrition security, it is important to acknowledge the limitations of the research and consider how future studies can build upon these findings.

One key limitation of the study is the reliance on a single case study, the Banga irrigation scheme. While this allowed for an in-depth examination of the dynamics within this specific context, the generalizability of the findings to other irrigation schemes or semi-arid regions of Zimbabwe may be limited. Future research could expand the scope to include multiple irrigation schemes or a broader geographic coverage to better understand the relationship between irrigation, food security, and dietary diversity.

Additionally, the study utilized a cross-sectional research design, which provides a snapshot of the situation at a particular point in time. Longitudinal studies tracking households over an extended period would be highly beneficial to better understand the long-term impacts of irrigation development on food and nutrition security. This would enable researchers to capture the dynamic changes in household food security and dietary diversity, as well as the potential influence of seasonal variations and other temporal factors.

The assessment of food and nutrition security in this study relied on the Household Dietary Diversity Score (HDDS) and the Minimum Dietary Diversity for Women (MDD-W) score. While these are well-established and widely used measures, they do not provide a complete picture of the multidimensional nature of food security. Future studies could consider incorporating additional indicators, such as food consumption patterns, nutrient intake, anthropometric measures, and subjective perceptions of food security, to obtain more precise information about nutritional status.

Furthermore, the study's analysis focused on the socioeconomic factors influencing dietary diversity but did not delve deeply into the underlying mechanisms and causal pathways. Qualitative research methods, such as in-depth interviews and focus group discussions, could provide valuable insights into the decision-making processes, cultural influences, and household dynamics that shape dietary diversity among smallholder irrigating farmers.

Finally, the study's findings suggest that factors beyond beneficiary status, such as socioeconomic status, education, and gender, may play a more significant role in determining dietary diversity. Future research could explore these factors in greater depth, potentially incorporating a more comprehensive set of variables and employing advanced statistical techniques to unravel the complex interrelationships between these factors and their impact on food and nutrition security.

REFERENCES

Abera, H., 2015. Determinants of small-scale irrigation scheme use in the Oromia Region, Ethiopia. *International Journal of Economic Behavior and Organization,* 3(6), pp. 52-59.

Barrett, C. et al., 2009. Smallholder participation in contract farming: Comparative evidence from five countries. *World Development,* 40(4), pp. 715-730.

Baye, K., Hirvonen, K., Dereje, M. & Remans, R., 2019. Dietary diversity and women's BMI among pastoralist communities in Ethiopia. *Public Health Nutrition,* 22(4), pp. 608-615.

Benson, T., 2006. *Africa's food and nutrition security situation: where are we and how did we get here? 2020 discussion paper 37,* Washington DC: International Food Policy Research Institute.

Bhagowalia, P., Headey, D. & Kadiyala, S., 2012. *Agriculture, income, and nutrition linkages in India: Insights from a nationally representative survey', IFPRI Discussion Paper 01195,* Washington, DC: International Food Policy Research Institute.

Burney, J. & Naylor, R., 2012. Smallholder irrigation as a poverty alleviation tool in sub-Saharan Africa. *World Development,* 1(40), pp. 110-123.

Burney, J., Naylor, R. & Postel, S., 2013. The case for distributed irrigation as a development priority in sub-Saharan Africa',. *Proceedings of the National Academy of Sciences,* 31(110), pp. 12513-12517.

Damtew, E., 2017. Assessing the Impact of Small-Scale Irrigation on Household Food Security: The Case of Dilfana Irrigation Scheme in East Shewa Zone, Oromia Regional State, Ethiopia. *Journal of Poverty Investment and Development,* Issue 35, pp. 1-15.

Damtew, N., 2017. impact of small-scale irrigation on household food security and dietary diversity in Ethiopia. *African Journal of Agricultural Research,* 12(8), pp. 561-568.

Dhakal, C. K. et al., 2015. Livelihood improvement of smallholder farmers through dairy and crop integration in Chitwan, Nepal. *Livestock Research for Rural Development,* 6(27), pp. 1-16.

Dillon, A., McGee, K. & Oseni, G., 2015. Agricultural production, dietary diversity, and climate variability. *The Journal of Development Studies,* 8(51), pp. 976-995.

Domenech, L., 2015. Improving irrigation access to combat food insecurity and undernutrition: A review. *Global Food Security,* Volume 6, pp. 24-33.

Elemo, K., 2014. Factors affecting utilization of small-scale irrigation water in Kano State, Nigeria. *African Journal of Agricultural Research,* 9(50), pp. 3597-3605.

Ephrem, T., 2008. Household food security in northeastern Ethiopia: The role of institutions, income, and diversity. *African Journal of Food, Agriculture, Nutrition and Development,* 8(3), pp. 352-367.

FAO, 1983. *World Food Security: a Reappraisal of the Concepts and Approaches,* Rome: Food and Agriculture Organization of the United Nations (FAO).

FAO, 2006. *Food Security: Policy Brief,* Rome: Food and Agriculture Organization of the United Nations (FAO).

FAO, 2013. *Food and Agriculture Organization of the United Nations (FAO).* Rome: Food and Agriculture Organization of the United Nations (FAO).

FAO, 2022. *Irrigation and Food Security,* Rome: Food and Agriculture Organisation.

FAO, et al., 2017. *The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security.* Rome: Food and Agriculture Organization of the United Nations (FAO).

Fekadu, B., 2012. Determinants of food security in rural households of central Ethiopia: An empirical analysis. *Quarterly Journal of International Agriculture,* 51(4), pp. 299-318.

Garrido, A. et al., 2017. Evaluating the economic and social sustainability of small farms with common land through building energy poverty indicators, *European Journal of Agronomy,* Issue 85, pp. 155-166.

Gelhena, D., Freed, R. & Maredia, K., 2013. Home gardens: a promising approach to enhance household food security and wellbeing. *Agriculture & Food Security,* 2(1), pp. 1-13.

Gernaat, A., Akullo, D., Muthuri, C. & Langat, B., 2022. The impact of irrigation on dietary diversity in Sub-Saharan Africa: Evidence from Kenya, Tanzania, and Ethiopia. *Agricultural Economics,* 53(3), pp. 445-462.

Gernaat, D. et al., 2022. Projected increases in crop production by 2050 are offset by projected decreases in nutritional quality. *Global Food Security,* Volume 32, p. 100593.

Gernaat, D. et al., 2022. The future of global water stress under socio-economic and climate change uncertainties. *Nature Communications,* 1(13), pp. 1-10.

Gernaat, H., Kinuthia, R. & van der Meji, N., 2022. The impact of small-scale irrigation on household food security and dietary diversity in sub-Saharan Africa: A systematic review. *Irrigation and Drainage,* 71(2), pp. 178-192.

Haddinott, J. & Yohannes, Y., 2002. *Dietary diversity as a food security indicator,* Washington, DC: Food and Technical Assistance Project, Academy for Educational Development.

Hanjra, M., Ferede, T. & Gutta, D., 2009. Reducing poverty in sub-Saharan Africa through investments in water and other priorities, *Agricultural Water Management,* 7(90), pp. 1062-1070.

Herforth, A. & Ballard, T., 2016. Nutrition indicators in agriculture projects: Current measurement, priorities, and gaps. *Global Food Security,* Volume 10, pp. 1-10.

Horton, S. et al., 2010. Scaling up nutrition: What will it cost?.. *The World Bank.*

Hussain, I. & Hanjra, M., 2004. Irrigation and poverty alleviation: Review of the empirical evidence. *Irrigation and Drainage,* 53(1), pp. 1-15.

Iannotti, L., Cunningham, K. & Ruel, M., 2009. Improving diet quality and micronutrient nutrition: Homestead food production in Bangladesh. *IFPRI Discussion Paper,* Issue 928.

IFAD, 2020. *Smallholder Irrigation Revitalization Programme (SIRP) Final Project Design Report,* Rome: International Fund for Agricultural Development (IFAD).

IPCC, 2018. *An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development,* Geneva: IPCC.

Johnson, N. et al., 2016. Gender, assets, and agricultural development: Lessons from eight projects. *World Development,* Issue 83, pp. 295-311.

Jones, A., Ngure, F., Pelto, G. & Young, S., 2013. What are we assessing when we measure food security? *Global Food Security,* 2(1), pp. 1-13.

Karanja, J., Kibet, L. & Mutai, B., 2023. Impact of smallholder irrigation on household dietary diversity in Kenya. *Agriculture and Food Security,* 12(1), pp. 1-12.

Karanja, S., Alders, R. & Kang'ethe, E., 2023. Smallholder irrigation farming, household dietary diversity and child nutrition: Evidence from Western Kenya. *Food Security,* 1(15), pp. 101-115.

Kassie, M., Ndiritu, S. & Stage, J., 2014. KassiWhat determines gender inequality in household food security in Kenya? Application of exogenous switching treatment regression.. *world Development,* Issue 56, pp. 153-171.

Koppmair, S., Kassie, M. & Qaim, M., 2017. Farm production, market access and dietary diversity in Malawi. *Public health nutrition,* 2(20), pp. 325-335.

Kulwa, K. et al., 2018. Impact of nutrition education on knowledge, attitude and practices among caregivers of young children in Singida district, Tanzania. *African Journal of Food, Agriculture, Nutrition and Development,* 4(18), pp. 13971-13993.

Kumar, S. & Vollmer, S., 2013. Does access to improved sanitation reduce childhood diarrhea in rural India?',. *Health Economics,* 4(22), pp. 410-427.

Makombe, G. et al., 2011. An assessment of the state of agricultural water management in Sub-Saharan Africa. *International Water Management Institute.*

Makonnen, D., Paulos, Z. & Lencha, B., 2022. The impact of small-scale irrigation on household food security and dietary diversity: Evidence from Tanzania and Ethiopia. *Food Security,* 14(1), pp. 151-167.

Makonnen, D. et al., 2022. Agricultural biodiversity, diet, and nutrition in the Kailash region of Sierra Leone. *Global Food Security,* Issue 32, p. 100601.

Malapit, H. & Quisumbing, A., 2015. What dimensions of women's empowerment in agriculture matter for nutrition in Ghana? *Food Policy,* Issue 52, pp. 54-63.

Manatsa, D., Zingore , S., Mukwada, G. & Jiri, O., 2020. The impact of climate variability and change on smallholder livelihoods in Zimbabwe. *Sustainability,* 4(12), p. 1369.

Mango, N. et al., 2014. Factors influencing household food security among smallholder farmers in the Mudzi district of Zimbabwe. *Development Southern Africa,* 4(31), pp. 625-640.

Ministry of Agriculture, 2020. *Smallholder Irrigation Revitalization Programme Annual Report 2020,* Harare: Ministry of Agriculture.

Ministry of Lands, A. W. C. a. R. R., 2020. *Irrigation Development Policy,* Harare: s.n.

Moyo, M., Van Rooyen, A., Chivenge, P. & Bjornlund, H., 2016. Irrigation Development in Zimbabwe: understanding productivity and opportunities at Mkoba and Silalatshani irrigation schemes. *International Journal of Water Resources Development,* 33(5), pp. 740-754.

Mugabe, F. et al., 2018. Trends in rainfall and temperature in semi-arid Zimbabwe. *Journal of Arid Environments,* Issue 147, pp. 55-65.

Munjur, E., Kabir, M., Siddique, M. & Hossain, M., 2023. Determinants of Dietary Diversity among Rural Households in Bangladesh: An Empirical Analysis. *Sustainability,* 3(15), p. 2286.

Munjur, E., Rahut, D. & Behera, B., 2023. Impact of small-scale irrigation on household food security and dietary diversity in Ethiopia. *Food Security,* 15(2), pp. 277-292.

Mupangwa, W., Dimes, J., Mazvimavi, K. & Ruswane, L., 2022. Socio-economic determinants of food security in Southern Africa: Evidence from South Africa, Lesotho, and Swaziland. *Food Security,* 14(3), pp. 667-682.

Mupangwa, W., Mutenje, M. & Mapfumo, P., 2022. Small-scale irrigation and household food security and nutrition in southern Africa. *Agricultural Systems,* Volume 195, p. 103279.

Muriithi, B., Matz, A., Kosec, K. & Woolverton, A., 2020. The role of rural seasonality in household food security and wellbeing: Evidence from Ethiopia.. *Food Security,* 1(12), pp. 73-87.

Odada, E. & Mathai, M., 2018. Irrigation and Food Security in Water-Scarce Regions. *Journal of Water Resources Planning and Management,* 145(5).

Olney, D. et al., 2009. Assessing impact and impact pathways of a homestead food production program on household and child nutrition in Cambodia. *Food and Nutrition Bulletin,* 4(30), pp. 355-369.

Osei, A. et al., 2017. Household food insecurity and nutritional status of children aged 6 to 23 months in Kailali District of Nepal. *Food and Nutrition Bulletin,* 3(38), pp. 392-400.

Oxfam, 2018. *Zimbabwe at a glance,* s.l.: s.n.

Passarelli, S., Makonnen, D., Bryan, E. & Ringler, C., 2018. Evaluating the pathways from small-scale irrigation to dietary diversity: evidence from Ethiopia and Tanzania. *Food Security,* 4(10), pp. 981-997.

Quisumbing, A. et al., 2014. Gender in agriculture: Closing the knowledge gap. *Springer Science & Business Media.*

Rashid, D. A., Smith, L. C. & Rahman, T., 2011. Determinants of dietary quality: evidence from Bangladesh. *World Development,* 12(39), pp. 2221-2231.

Ricker-Gilbert, J., Jayne, T. & Chirwa, E., 2011. Subsidies and crowding out: A double-hurdle model of fertilizer demand in Malawi. *American Journal of Agricultural Economics,* 1(93), pp. 26-42.

Rockstrom, J. et al., 2010. Managing water in rainfed agriculture—The need for a paradigm shift, *Agricultural Water Management,* 4(97), pp. 543-550.

Roder, P., 1965. Irrigation and Agricultural Development in Zimbabwe. *Journal of Agricultural Economics,* 16(3), pp. 257-265.

Ruel, M. & Aldermen, H., 2013. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition?',. *The Lancet,* 9891(382), pp. 536-551.

Shakir, S., 2006. Nutrition Security and Food Security: A Review. *Journal of Food Science,* 71(5), pp. 146-156.

Sibhatu, K. T., Krishna, V. V. & Qaim, M., 2015. Production diversity and dietary diversity in smallholder farm households. *Proceedings of the National Academy of Sciences,* 34(112), pp. 10657-10662.

Simelane, T. & Worth, S., 2020. Food Availability and Food Security: A Review. *Journal of Food Security,* 8(2), pp. 123-135.

Sraboni, E., Malapit, H., Quisumbing, A. & Ahmed, A., 2014. Women's empowerment in agriculture: What role for food security in Bangladesh?',. *World Development,* Issue 61, pp. 11-52.

UNDP, 2015. *Zimbabwe Disaster Risk Profile,* Harare: United Nations Development Programme.

United States Agency for International Development, 2024. *Poverty and Malnutrition in Zimbabwe: Findings from Masvingo Province,* s.l.: United States Agency for International Development.

Weingarten, P., 2010. Food and Nutrition Security: A Conceptual Framework. *Journal of Food Security,* 8(2), pp. 1-15.

WFP, 2018. *Zimbabwe Overview,* s.l.: World Food Program.

WHO, 2019. *Progress on Drinking Water, Sanitation and Hygiene: 2000–2017: Special Focus on Inequalities,* s.l.: World Health Organisation.

World Bank, 2020. *Zimbabwe Overview,* s.l.: World Bank.

Zimbabwe National Statistics Agency, 2017. *Poverty, Income, Consumption and Expenditure Survey,* Harare: ZNSA.

ZIMSTAT, 2020. *Zimbabwe National Statistics Agency Report,* Harare: ZIMSTAT.

ZIMSTAT, 2022. *Population Census: Preliminary Report,* Harare: Zimbabwe National Statistics Agency.

ZIMVAC, 2019. *Zimbabwe Vulnerability Assessment Committee Report,* Harare: Zimbabwe Vulnerability Assessment Committee (ZIMVAC).

ZIMVAC, 2023. *Zimbabwe Vulnerability Assessment Committee Report.,* Harare: Zimbabwe Vulnerability Assessment Committee (ZIMVAC).

APPENDICES

Appendix 1: *Household Survey Questionnaire*

THE CONTRIBUTION OF SMALLHOLDER IRRIGATION DEVELOPMENT TO FOOD AND NUTRITION SECURITY AMONG VULNERABLE SMALLHOLDER FARMERS IN SEMI-ARID REGIONS OF ZIMBABWE. A CASE OF THE BANGA IRRIGATION SCHEME IN MASVINGO.

BINDURA UNIVERSITY OF SCIENCE EDUCATION

My name is Tanaka Chitsato, a final year student at Bindura University of Science Education, a Bachelor of Science Honours Degree in Agricultural Economics and Management. As part of my degree program, I'm required to carry a research and my research is on **THE CONTRIBUTION OF SMALLHOLDER IRRIGATION DEVELOPMENT TO FOOD AND NUTRITION SECURITY AMONG VULNERABLE SMALLHOLDER FARMERS IN SEMI-ARID REGIONS OF ZIMBABWE (CASE OF THE BANGA IRRIGATION SCHEME IN MASVINGO).** Since smallholder farmers in semi-arid regions face food security challenges, strategies and efforts are desperately needed to efficiently and effectively design irrigation programs, policies, and interventions that improve irrigation scheme productivity in Zimbabwe. This research will help by identifying challenges and making recommendations. Your household has been selected by chance from a list of families that benefited from the Banga irrigation scheme. I want to ask some questions related to the

project. Participation in this interview is voluntary. Please NOTE that all information provided by the respondent is STRICTLY CONFIDENTIAL and will only be used for academic research and your participation in this study is voluntary. Thank you.

DEMOGRAPHIC INFORMATION		
A1	Gender of Household Head	1= Male 2= Female
A2	Household Head Age	…… years
A3	Marital status of Household Head	1= Single 2= Married 3= Widowed 4= Divorced
A4	Household Head Highest Educational Attainment	1= No education 2= Primary 3= Secondary 4= Tertiary 5= University Graduate 6= Post University
A5	Health status of Household Head	1= Healthy 2= Sometimes Sick 3= Sick
A6	Beneficiary Type	1= Beneficiary irrigator 2= Non-Beneficiary
A7	How many people including yourself live in this Household?	……Total
A8	Compared with other villagers in this community, in which of the following income categories do your households belong?	1= Well off 2= Average 3= Poor 4= Very poor

	Of these people who live with you how many are aged	Below 18years …… 18-35 years……. Over 35 years…….
B. PARTICIPATION IN THE PROJECT ACTIVITIES		
B1	Since when was your household involved in the Banga irrigation scheme (Year)?	……..
B2	In general, regarding how your participation in project activities has impacted on your living conditions, are you:	1= Very satisfied 2= Moderately satisfied 3= Not satisfied at all
B3	Are there other organizations active in your irrigation scheme or community that promote post-harvest handling and storage?	1= Yes 2= No
B4	If you answered yes to B3, to what extent is the contribution of the SIRP project to the benefits that have accrued to your household from participating in activities in postharvest handling and storage of agricultural products?	1= 0-25% low 2= 26-50% medium 3= 51-75% high 4= 76-100% very high
C. LAND USE, AGRICULTURAL PRODUCTION AND IRRIGATION		
C1.	Do you own productive land	1= Yes 2= No
C2	What is your cultivatable land area	……
C3	What is the size of your irrigated land area	…….
C4	Do you practice dry land cultivation	1= Yes 2= No

C4	If yes, what crops do you grow?	…….
C5	Do you use irrigation in any part of your crop production	1= Yes 2= No
C6	Which crops do you grow in an irrigation plot	…….
C7	Do you own any livestock?	……..
C8	Do you have off-farm income?	……..

Section Two

Appendix 2: *HDDS Questionnaire*

Number	**Food items**	**Yes= 1** **No = 2**
1	Did you or others in your household consume any sadza, mahewu maize, maize porridge, rice, sorghum, millet, bread, or other cereals yesterday?	**….**
2	Did you or others in your household consume any potatoes, sweet potatoes, yams, cassava, or any other tuber yesterday?	.....
3	Did you or others in your household consume any beans, peas, groundnuts, peanut butter, or cashew nuts yesterday?	**……**
4	Did you or others in your household consume any vegetables (leaves or roots) yesterday?	**….**
5	Did you or others in your household consume any fruits yesterday?	**…..**
6	Did you or others in your household consume any beef, goat, chicken, or pork yesterday?	**…..**
7	Did you or others in your household consume any eggs yesterday?	**….**
8	Did you or others in your household consume any fish or kapenta yesterday?	**….**
9	Did you or others in your household consume any milk, yogurt, or any other dairy product yesterday?	**….**
10	Did you or others in your household consume any sugar, honey, juice, sweets, or any other sugary foods or drinks	**…..**
11	Did you or others in your household consume any oils, fats, margarine, or butter added to food or used for cooking yesterday?	**….**

12	Did you or others in your household consume any tea, coffee, salt, any type of spice, or tomato sauce yesterday?	**….**

Section Three

Appendix 3: *MDD-W Questionnaire*

Is there a woman aged 15-49 in this household who can answer a few nutrition questions?		Yes = 1 No = 0
Can I ask you about the food you consumed yesterday from early morning until the time you went to sleep in your home or elsewhere? Please tell me what you ate and drank from early morning after you woke up in the morning to the time you went to bed at night (Questions only for women 15-49 years old)		
Number	Food item	Yes = 1 No = 0
1	Any food made from grains and any white roots or tuber or plantains	
2	Any beans or peas	
3	Any nuts or seeds	
4	Any milk or milk products	
5	Any meat, poultry and fish products	
6	Any eggs	
7	Any dark green leafy vegetables	
8	Any vitamin A-rich fruits, vegetables, and roots	
9	Any other vegetables	
10	Any other fruits	