UNIVERSITY FOR DEVELOPMENT STUDIES

THE EFFECTS OF PARTICIPATION IN GASIP PROGRAMME ON SMALLHOLDER FARMERS' FOOD SECURITY IN UPPER EAST REGION OF GHANA

BY

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UDS/MEC/0006/22

THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND FOOD ECONOMICS, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

AUGUST, 2025

DECLARATION

Student

I hereby declare that this thesis titled The Effects of Participation in GASIP Programme on Smallholder Farmers' Food Security in Upper East Region of Ghana" is the result of my own original work, and that no part of it has been submitted for another degree in this University or elsewhere.

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I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

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ABSTRACT

In the face of increasing climate variability, rising food insecurity, and the pressing need for sustainable agricultural transformation, understanding the effectiveness of development programs has become imperative for policy and practice. Smallholder farmers, who form the backbone of Ghana's agricultural sector, remain particularly vulnerable to these challenges. This study examines the effects of participation in the Ghana Agricultural Sector Investment Programme (GASIP) on smallholder farmers, with a specific focus on household food security and the adoption of Climate-Smart Agricultural Practices (CSAPs). The study is grounded in the Random Utility and the Household Utility Maximization Theory, which explain farmers' decisions to participate in GASIP and adopt CSAPs based on utility maximization under resource constraints. Using a comprehensive dataset of 410 households collected in 2024 from three districts in the Upper East Region, the study employs a multi-stage sampling procedure involving purposive, stratified, and simple random sampling. Descriptive statistics are used to summarize key household and farm characteristics, while Probit models identify factors influencing GASIP participation. The Endogenous Switching Poisson Regression Model assesses the effect of GASIP participation on CSAP adoption, and the Endogenous Switching Regression Model estimates the impact on household food security indicators, addressing potential selection bias. The findings reveal that GASIP participation has positive effects on both food security and CSAP adoption. Specifically, GASIP participation leads to higher Household Dietary Diversity Scores (HDDS), while also contributing to reductions in food insecurity as measured by the Food Insecurity Experience Scale (FIES) and Coping Strategy Index (CSI). In addition, variables such as age, education, landownership, remittance, farm output, FBO membership, TLU, and GASIP awareness positively influence food security, while sex, farm experience, climate training, and crop diversification

emerge as negative determinants. influencing food security outcomes. Female-headed households demonstrate higher food security levels compared to male-headed households, indicated by better HDDS and lower food insecurity scores. In terms of CSAP adoption, positive effects are associated with education, crop diversification, and GASIP participation, highlighting the program's role in promoting sustainable agricultural practices.

Based on these results, the study recommends that government agencies (MoFA), NGOs, and donor organizations(IFAD) intensify awareness creation through community engagement and local media, promote education and capacity-building initiatives, implement gender-sensitive agricultural programs to empower women farmers, encourage crop diversification as a key food security strategy, strengthen agricultural extension services to better support smallholder farmers, and integrate Climate-Smart Agricultural practices into national agricultural policies to foster long-term resilience and sustainability in the agricultural sector.

ACKNOWLEDGEMENTS

Firstly, I want to thank God Almighty for His unwavering love, care, and support during my master's programme. Second, I want to express my sincere gratitude to my supervisors, Dr. Shamsudeen Abdulai and Prof. Benjamin Tetteh Anang, for their unwavering support, wise criticism, and helpful advice, their knowledge and guidance have been crucial in forming and completing this research. I sincerely appreciate the time and work they have put into offering helpful critique and assistance during this endeavor.

I would also like to extend my heartfelt thanks to Eli Andrews Akorsikumah and Maxwell Asale for their exceptional assistance in developing my Stata commands for statistical analysis required for this study. Their technical expertise and willingness to help were crucial in overcoming many challenges during the data analysis phase.

To my beloved wife, Amomba Esther, and my mother, Rose Apumbora, I am especially appreciative of their unwavering love, tolerance, and assistance. My strength along this journey has been your understanding and support.

To all my friends, family, and colleagues who provided encouragement, advice, and moral support, I am truly thankful. This accomplishment would not have been possible without your unwavering support.

Finally, I thank everyone who contributed to this research in various capacities. Your support has been deeply appreciated, and I am grateful for your contributions to this work.

DEDICATION

This work is dedicated to God Almighty, whose direction and grace have sustained me throughout this journey.

To my late father Francis Xavier Apumbora, my wife, Amomba Esther, and my mother, Rose Apumbora, whose love, support, and encouragement have been my greatest source of strength.

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AAGDS	Accelerated Agricultural Growth and Development Strategy
ATE	Average Treatment Effect
ATT	Average Treatment effect on the Treated
ATU	Average Treatment effect on the Untreated
CAADP	Comprehensive African Agriculture Development Program
CARI	Competitive Africa Rice Initiative Programme
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CSA	Climate-smart agriculture
CSAPs	Climate-smart agriculture Practices
CSI	Coping strategy index
ESRM	Endogenous switching regression model
FANTA	Food And Nutrition Technical Assistance
FAO	Food and Agriculture Organisation
FASDEP	Food and Agricultural Sector Development Policy
FBOs	Farmer-Based Organizations
FCS	Food Consumption Score
FIES	Food Insecurity Experience Scale
FtF	Feed the Future
GASIP	Ghana Agricultural Sector Investment Program
GCX	Ghana Commodity Exchange
GoG	Government of Ghana
GPRS II	Growth and Poverty Reduction Strategy

HDDS	Household Dietary diversity score
HFIAS	Household Food Insecurity Survey Module
HHS	Household Hunger Scale
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated pest management
IPWRA	inverse probability weighted regression adjustment
METASIP	Medium-Term Agriculture Sector Investment Plan
MoFA	Ministry of Food and Agriculture
NEPAD	New Partnership for Africa's Development
NFAIP	National Food and Agricultural Investment Plan
PCU	Program Coordination Unit
PFJ	Planting for Food and Jobs
PSM	Propensity Score Matching
SAPs	structural adjustment programs
TLU	Total Livestock unit
UN	United Nations
VoH	Voices of the Hungry
WFP	World Food Programme
ZCOs	Zonal Coordination Offices

CHAPTER ONE

INTRODUCTION

1.0 Background

Globally, agriculture remains a fundamental pillar of many economies, serving as a critical source of food, employment, and economic growth, particularly in developing regions. It supports the livelihoods of nearly 500 million smallholder farmers who are responsible for 70–80% of food production in regions such as Sub-Saharan Africa and Asia (Ali *et al*., 2023; FAO, 2022). Smallholder farmers, who often operate on limited resources, play a central role in ensuring food production, providing rural employment, and contributing significantly to poverty alleviation and sustainable development (World Bank, 2023; Acheampong *et al*., 2023). Moreover, agricultural growth is shown to be two to four times more effective in reducing poverty compared to growth in other sectors, especially in low-income agrarian economies (World Bank, 2022; Adjei-Nsiah *et al*., 2021). Despite their importance, smallholder farming systems worldwide face numerous constraints, including restricted access to land, credit, agricultural inputs, and markets, which undermine their productivity and sustainability (Sabo *et al*., 2017; Giller *et al*., 2021).

In Africa, agriculture continues to shape both the economic landscape and the daily livelihoods of millions. Smallholder farmers, who are predominant in the region, are vital to food security, economic development, and rural poverty reduction (Gomez & Paloma, 2020). Their welfare, measured through income levels, food security, and overall well-being, directly influences the stability and growth of national and regional economies (Abdul *et al*., 2018). However, agricultural production in Africa faces persistent challenges such as low productivity, limited access to technology and extension services, weak market linkages, and vulnerability to climate change, all of which restrict the potential of smallholder farming systems (Giller *et al*., 2021).

In Sub-Saharan Africa (SSA), smallholder farmers form the backbone of agricultural production, accounting for the majority of farm outputs and engaging a significant share of the labor force. Yet, these farmers operate within fragile agricultural systems characterized by poor infrastructure, high production risks, and low levels of technology adoption (Gomez & Paloma, 2020). The region's food systems are further stressed by climate variability, price volatility, and structural bottlenecks in agricultural value chains, making it increasingly difficult for smallholders to sustain productivity and secure stable livelihoods.

Ghana exemplifies many of the challenges and opportunities facing smallholder agriculture in SSA. The country's agricultural sector contributes approximately 21% to its Gross Domestic Product (GDP) (Kyei *et al*., 2023) and remains central to national strategies for food security, poverty alleviation, and rural development (Ru *et al*., 2023). Smallholder farmers dominate Ghana's agricultural landscape, providing the bulk of food supply and rural employment (Hudson *et al*., 2017). However, they face numerous structural and operational constraints. These include low productivity, inadequate infrastructure, limited access to markets, insecure land tenure arrangements, poor access to credit and finance, and limited availability of agricultural extension services (World Bank, 2020; FAO, 2019; IFAD, 2018). Additionally, pest and disease outbreaks, high post-harvest losses, and the impacts of climate change pose significant risks to smallholder farming systems.

To overcome these challenges, Ghana has pursued various agricultural development strategies involving government interventions, public-private partnerships, and development assistance. Key policy measures include enhancing technological innovations, promoting climate-resilient agriculture, expanding extension services, and facilitating access to finance and input markets (Djido *et al*., 2021; Rogito *et al*., 2020). Such efforts aim to transform the sector, improve food security, and boost rural incomes.

Among these interventions, the Ghana Agricultural Sector Investment Programme (GASIP) stands out as a comprehensive initiative designed to establish a long-term framework for enhancing investments in agricultural value chains, particularly targeting smallholder farmers and resource-poor households. GASIP, which was implemented from May 2015 to June 2023, aimed to improve the efficiency, profitability, and resilience of smallholder farmers by addressing multiple production and market-related constraints simultaneously (GASIP, 2023). The program placed special emphasis on vulnerable groups, including women, youth (15–34 years), and climate-risk-exposed farmers, through the Adaptation for Smallholder Agriculture Programme (ASAP) Grant, which focused on those engaged in rain-fed cereal cropping and small-scale irrigation systems.

GASIP's primary objective was to contribute to sustainable poverty reduction in rural Ghana. It was designed to be implemented in phases, each lasting approximately three years, with inter-cycle reviews conducted to assess progress and justify continued funding. The program operated under three core components: Value Chain Development**,** Rural Value Chain Infrastructure Development**,** and Knowledge Management and Policy Coordination Support (GASIP, 2023). It was strategically aligned with Ghana's Medium-Term Agriculture Sector Investment Plan (METASIP) and the Comprehensive Africa Agriculture Development Programme (CAADP) framework, ensuring coherence with national and regional agricultural development goals (IFAD, 2018). GASIP's unique approach integrated infrastructure provision, climate-smart agriculture, financial services, capacity building, and market linkages, positioning it as a key vehicle for promoting inclusive and climate-resilient agricultural growth in Ghana.

1.1 Problem statement

Smallholder, resource-poor farmers remain highly vulnerable to poverty and food insecurity, particularly in developing countries where agriculture forms the foundation of rural livelihoods. Studies such as Stewart *et al*. (2015) highlight that smallholder farmers often face systemic challenges including limited access to productive resources, poor market integration, and climate-induced risks. In Ghana, smallholder farmers contribute approximately 80% of national agricultural output (Kamara *et al*., 2019), yet they remain disproportionately affected by poverty, food insecurity, and production shocks, particularly in the northern ecological zones.

These farmers frequently encounter significant constraints, such as limited access to credit, agricultural inputs, extension services, and agricultural insurance, alongside unfavorable government policies that often prioritize large-scale commercial farming (Teye *et al*., 2019). Recent empirical evidence from Anang *et al*. (2020) reinforces the argument that improving the efficiency and resilience of smallholder farming through targeted government interventions such as agricultural mechanization, input subsidies, credit schemes, and irrigation infrastructure can substantially reduce poverty and enhance rural food security.

Despite agriculture being recognized as the backbone of Ghana's economy and food security, the persistence of poverty and food insecurity among smallholder farmers underscores the limited effectiveness of many past government interventions. Programs such as Planting for Food and Jobs (PFJ)**,** Rural Enterprise Program (REP)**,** and the Ghana Commercial Agriculture Project (GCAP) have been implemented with the goal of improving access to finance, promoting climate-smart agricultural practices, and strengthening market access (Asafo *et al*., 2016). However, studies by Danso-Abbeam *et al.* (2020) and Abdulai *et al*. (2021) show that many of these interventions exhibit partial or short-term impacts, with major structural issues such as low adoption of improved technologies, weak extension systems, and poor market infrastructure persisting, especially in Northern Ghana.

In particular, Northern Ghana, characterized by erratic rainfall, degraded soils, and underdeveloped infrastructure, presents unique agricultural challenges that conventional interventions have struggled to address (Issahaku & Abdulai, 2020). Many studies have evaluated the effects of government programs in Ghana using descriptive and econometric methods but often lack rigorous methodologies capable of addressing selection bias and endogeneity, especially regarding program participation and food security outcomes (Owusu *et al*., 2018; Danso-Abbeam *et al.,* 2020). Additionally, few studies have focused **on** Climate-Smart Agricultural Practices (CSAPs) adoption in the context of integrated programs like GASIP, leaving an important research gap.

The Ghana Agricultural Sector Investment Programme (GASIP) offers a relatively unique intervention in Ghana's agricultural sector, delivering a comprehensive package including financial support, input access, specialized training, infrastructure development, climate-smart agriculture promotion, market linkages, and value chain integration (GASIP, 2023). Unlike previous interventions, GASIP simultaneously targets multiple bottlenecks in smallholder production systems. However, there is currently limited empirical evidence on the specific effects of GASIP on smallholder farmers' welfare, particularly regarding food security and the adoption of climate-resilient agricultural practices in Northern Ghana. Moreover, little is known about how such integrated approaches perform in agro-ecologically vulnerable regions like the Upper East Region.

This research, therefore, seeks to fill these empirical and methodological gaps by rigorously evaluating the effects of GASIP participation on food security and Climate-Smart Agricultural Practices (CSAPs) adoption among smallholder farmers in the Upper East Region of Ghana. By applying advanced econometric methods such as the Endogenous Switching Regression and Endogenous Switching Poisson models this study explicitly addresses issues of selection bias and unobserved heterogeneity, which have been largely overlooked in previous research. The study's focus on Northern Ghana's specific agro-ecological and socioeconomic conditions further provides localized policy insights, offering a much-needed empirical basis to guide future interventions by government agencies, development partners, and donor organizations targeting the resilience and sustainability of smallholder farming systems in Ghana and similar contexts in Sub-Saharan Africa.

1.2 Research Questions

The study is guided by the main research question, which seeks to investigate the effect of GASIP on smallholder farmers' food security in the Upper East Region? The specific research questions are:

- What factors influence the participation of smallholder farmers in GASIP?
- What is the effect of smallholder farmers' participation in GASIP programme on the adoption of climate-smart agriculture practices?
- How does participation in GASIP affect the food security status of smallholder farmers?

1.3 Research objectives

The main objective is to evaluate the effect of GASIP on smallholder farmer's food security in Upper East Region.

The specific objectives are to:

1. Identify the factors that influence smallholder farmers' participation in GASIP programme.
2. Assess the effect of smallholder farmers' participation in GASIP programme on the adoption of climate-smart agriculture practices.
3. Assess the effect of GASIP participation on the food security status of smallholder farmers.

1.4 Justification

This study will contribute to academic discourse by filling the existing research gap regarding the specific impacts of the Ghana Agricultural Sector Improvement Program (GASIP) on smallholder farmers. While GASIP has been widely recognized for its agricultural development objectives (GASIP, 2023), little empirical research has been conducted to rigorously evaluate its effectiveness, particularly in relation to the adoption of climate-smart agricultural practices (CSAPs) and food security outcomes. The findings will offer a valuable reference for future studies, enriching the academic literature on agricultural policy interventions, climate-smart agriculture, and rural development in Ghana and other developing economies.

The study will provide NGOs and development organizations with evidence-based insights into the effectiveness of GASIP interventions. This will enable these organizations to better design and target agricultural development programs, particularly those focused on promoting climate-resilient farming techniques and improving food security among vulnerable rural populations. The results will also help NGOs to identify best practices that can be replicated or scaled up in similar contexts.

Smallholder farmers, who are the primary beneficiaries of GASIP, stand to gain significantly from this research. By assessing the extent to which GASIP enhances the adoption of climate-smart practices and improves food security, the study will provide practical lessons that can help farmers optimize their participation in such programs. This can lead to improved farm productivity, higher incomes, and greater food security, thereby reducing vulnerability to climate change and market shocks (IFAD, 2018).

The study indirectly benefits consumers by promoting sustainable agricultural practices that ensure the continuous availability of diverse and safe food products. By supporting interventions that boost local agricultural production and food security, the research can contribute to stabilizing food supply and potentially lowering food prices for consumers.

The study's findings will be crucial for government agencies and policymakers involved in agricultural planning and rural development. By providing robust evidence on the impact of GASIP, the research will guide future policy decisions related to agricultural investment, climate adaptation strategies, and food security programs. It will also assist in aligning national policies with global sustainable development goals (SDGs), particularly those related to ending hunger, promoting sustainable agriculture, and building climate resilience (FAO, 2019).

1.5 Organization of the Study

The entire thesis is structured into five (5) main chapters, beginning with Chapter one, that introduces the background of the study, the research problem, addresses the research questions, specifies the objectives and concludes with the justification of the study. Chapter two provides a comprehensive review of relevant literature related to the study. In Chapter three, the methodologies employed for obtaining study results are detailed, encompassing an overview of the study area, the data collection process, the theoretical framework guiding the research, and a description of variables. Chapter four is dedicated to presenting the results and initiating discussions. Lastly, Chapter five encapsulates the key findings, conclusions, and policy recommendations derived from the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a comprehensive review of the existing literature relevant to the study. It begins by examining the Ghana Agricultural Sector Investment Programme (GASIP), which forms the focal intervention of this research. The review then broadens to cover the evolution of agricultural policies and programmes in Ghana, spanning both the colonial and post-colonial eras, highlighting how past and current policies have shaped the agricultural landscape.

Subsequently, the chapter provides an in-depth analysis of the concept of food security, exploring its definitions and relevance within the Ghanaian context. It further examines the current state of food security in Ghana, offering a situational overview supported by recent evidence. This is followed by a detailed discussion of key food security indicators including the Food Insecurity Experience Scale (FIES), Household Dietary Diversity Score (HDDS), and the Coping Strategy Index (CSI) which are critical tools for measuring food security outcomes in empirical research.

The chapter also reviews literature on the interconnectedness between food production, climate change, and the growing importance of climate-smart agricultural practices (CSAPs) in enhancing resilience and ensuring food security among smallholder farmers. In addition, it discusses theoretical frameworks that underpin the study, such as the Random Utility Theory, and Utility Maximization Theory, which collectively explain farmers' participation in agricultural programmes and their adoption of CSAPs in pursuit of improved food security.

Lastly, an empirical review synthesizes findings from previous studies on agricultural programme participation, adoption of climate-smart agricultural practices, and food security outcomes. Particular attention is given to identifying gaps in existing research, especially concerning the limited application of advanced econometric methods to jointly assess programme participation, CSAP adoption, and food security. These gaps provide the foundation for the current study, which seeks to contribute new evidence by applying rigorous analytical approaches within the Ghanaian context.

2.1 Ghana Agricultural Sector Investment Programme (GASIP)

Promoting sustainable poverty reduction in Ghana's rural communities is the goal of the Ghana Agricultural Sector Investment Programme (GASIP). Its primary development objective is to increase smallholder farmers' and agribusinesses' resilience to climate change and profitability. The Ministry of Food and Agriculture oversees the implementation of the program. GASIP functions as a national initiative over a six-year period, divided into two three-year phases. The program officially began in May 2015 and was set to conclude on June 30, 2021, with final closure on December 31, 2021. The overall implementation of GASIP is managed by a Program Coordination Unit (PCU) situated in Accra, supported by four Zonal Coordination Offices (ZCOs) (GASIP, 2023).

At its outset, GASIP set a target to engage by the end of the second cycle, 86,400 farmers will be involved, operating through 4,000. Farmer-Based Organizations (FBOs) structured within value chain groupings. The first cycle of the program was financed by an International Fund for Agricultural Development (IFAD) loan of US$ 36.6 million and an Adaptation for Smallholder Agriculture Program (ASAP) grant of US$ 10 million (GASIP, 2023).

Using a value chain development technique, GASIP helps agribusinesses and Farmer-Based Organizations (FBOs) establish safe marketing relationships with value chain drivers. Prior to each production season, value chain drivers and FBOs sign agribusiness partnership agreements whereby the latter agrees to purchase the farmer's crops based on predetermined standards for quantity, quality, and price. By enabling FBOs, providing matching grants for crop production operations, and enhancing value chain infrastructure, GASIP helps to implement these agreements. Furthermore, GASIP promotes the implementation of climate-resilient practices. Among the noteworthy achievements are the formation of alliances with 1,200 FBOs and 53 value chain drivers, with an emphasis on the production of vegetables, rice, maize, soy, and cassava in Ghana's several agroclimatic zones. Through the value chain drivers, GASIP ensured that recipients had access to high-quality inputs by providing USD 13.6 million in matching grant support. According to crop yield surveys, recipients' yield increased by more than 70% as a result of timely and high-quality input access and technical assistance from government extension agents and value chain drivers.(GASIP, 2023).

In 2019, GASIP achieved 60% financial progress in just one year, demonstrating the strong demand for its services from Farmer-Based Organizations (FBOs) through the private sector value chain drivers. It has also addressed IFAD is integrating its Strategic focuses by involving women (34%) and youth (45%) in value chain partnership initiatives. The program has devised a comprehensive approach and roadmap to strengthen the capability of Farmer-Based Organizations (FBOs), which includes establishing Memoranda of Understanding (MoUs) with District Departments of Agriculture and MOFA Directorates. This facilitates training for Agricultural Extension Agents, which subsequently benefits smallholder farmers and value chain drivers. In addition, GASIP partnered with GIZ - Competitive Africa Rice Initiative Programme (CARI) to enhance market access through capacity building for women rice processors. Collaboration with Nestlé focused on enhancing the skills of Farmer-Based Organizations (FBOs) and Agricultural Extension Agents in areas related to food safety and quality, in anticipation of accessing high-quality industry markets. GASIP also partnered with the Ghana Commodity Exchange (GCX) to facilitate value chain drivers and smallholder farmers to engage fully with the GCX electronic trading platform.

Additionally, the program established Conservation Agriculture demonstration and learner plots covering 53 hectares and reached 1,320 smallholder farmers directly. These farmers were trained in Climate Smart Agriculture technologies and provided access to weather information services, supported by the installation of ten automatic weather stations in the beneficiary districts of the northern zone. These weather stations provide real-time weather information services to smallholder farmers (GASIP, 2023).

2.2 Agricultural Policies and Programmes in Ghana

2.2.1 Ghana's Colonial Era Policies

During the colonial period, agricultural policies were primarily aimed at producing export crops and raw materials that were in demand in Britain. Throughout this time, government policies placed greater emphasis on the requirements of rising urban elites, foreign food importers, and colonial officials, who emphasized the importance of export crop production (Wayo *et al.,* 2002). The Department of Agriculture's main goals included educating and advising farmers to enhance both the volume and standard of agricultural produce intended for export. The introduction of the poll tax law in the early 20th century forced peasant farmers and fishermen to look for wage jobs or participate in the production of export crops, especially cocoa to earn enough income to pay their taxes. This change disrupted long-standing trade relationships between Ghana and the North African coast, resulting in a shift in economic ties toward the colonial government (Sawers *et al.,* 2017). The focus on export production prompted infrastructural developments in Southern Ghana, specifically aimed at enabling the extraction of valuable resources from forested areas. The success of these initiatives led to urbanization, the growth of mining industries, and an increase in labor migration to Southern Ghana (Wayo *et al.,* 2002). Simultaneously, it stimulated the expansion of both internal and external markets, promoting commodity production. In light of these economic opportunities, small farmers in Southern Ghana turned the country into a major global cocoa producer by 1911. By 1920, cocoa represented nearly 83% of the total export value, and duties on cocoa facilitated an assertive food import policy (Remi *et al.,* 2012). The importation of staples, such as rice, wheat, dried fish, tinned meat, dried milk, and corn, met essential food needs in urban and cash crop-producing regions. Unlike other regions globally, large-scale cocoa plantations did not gain traction in Ghana, and the growth of the cocoa industry showcased the resourcefulness of small farmers who effectively responded to price signals and economic opportunities. The expansion of agricultural produce trade and the capital of European merchants also fostered the rise of indigenous Ghanaian entrepreneurs, having an important influence in the success of the export-oriented agricultural economy. The accomplishments of cash cropping and the thriving export-based economy in the South had repercussions on the northern savannah areas, primarily through the provision of labor for the export economy in the South, while the north retained its predominantly subsistence agricultural character (Rémi *et al.,* 2017).

Notably, all political and economic institutions set up for the expansion of merchant capital were primarily located in Southern Ghana until the 1950s, when the colonial government began to take a greater interest in the economic progression of the northern savannah areas. By the end of the colonial period in 1957, Ghana's economic structure was clearly dualistic, marked by the coexistence of traditional, labor-intensive production methods alongside modern, capital-intensive approaches (Wayo *et al.,* 2002). This dual structure continued into the post-independence era, with the cocoa industry being entirely controlled by indigenous players, while many modern industries functioned as enclaves, relying on minimal domestic resources and contributing only modestly to the national economy. To conclude, agricultural policies in the colonial era aimed to establish the Gold Coast (Ghana) as a supplier of raw materials and a safeguarded market for manufacturers and farmers in the metropolitan area, focusing on the production of export crops and encouraging reliance on food imports (Wayo *et al.,* 2002).

2.2.2 Ghana's Post-Colonial Era Policies

Ghana's, post-colonial agricultural policies and programs have undergone various stages of development, influenced by internal and external factors. After gaining independence from British colonial rule in 1957 (Beckman 1981, Puplampu 1998), Kwame Nkrumah, Ghana's first prime minister, focused his agricultural policies on cocoa output to increase revenue for the country's development. In addition to cocoa, policies pertaining to other crops included one or two of the following: promoting private sector investment in large-scale automated farms; enhancing circumstances for small-scale farmers; and state-sponsored large-scale mechanical farming. The agriculture industry was connected to the government through a complex system of institutions. The degree of dependence between the state and society, in a relationship aimed at achieving political goals, was opened and strengthened by these institutions. When assessing the effectiveness of agricultural policies It is essential to consider the socioeconomic group that controlled the resources, how they were used, and the impact on patterns of production, marketing, and consumption. (Puplampu *et al.,* 1998).

Kwame Nkrumah introduced ambitious agricultural policies aimed at achieving rapid modernization and self-sufficiency. The Accelerated Development Plan for Agriculture (ADPA) was launched to increase agricultural productivity through large-scale mechanization, irrigation projects, and the establishment of state farms. Land reform programs aimed to redistribute land to smallholder farmers and promote cooperative farming initiatives (Asuming *et al.,* 2013).

During the 1960s and 1970s, Ghana pursued import substitution industrialization (ISI) policies, emphasizing industrial development over agriculture. Agricultural policies focused on supporting cash crops such as cocoa, timber, and palm oil for export earnings to finance industrial projects (Breisinger *et al.,* 2011). The Cocoa Marketing Board (CMB) played a central role in regulating and promoting cocoa production, which remained a key driver of the Ghanaian economy (Breisinger *et al*., 2011).

Economic decline and debt crises in the 1980s forced Ghana to implement structural adjustment programs (SAPs) mandated by international financial institutions. SAPs led to the elimination of subsidies, privatization, and agriculture market liberalization of state-owned enterprises, including agribusiness ventures. Agricultural extension services were scaled back, leading to a decline in support for smallholder farmers and rural development initiatives (Bolliger *et al*., 2017). Since the early 2000s, Ghana has shifted towards market-oriented agricultural policies aimed at promoting private sector investment, commercialization, and value chain development. The National Food and Agricultural Investment Plan (NFAIP) was initiated to improve food security and boost agricultural productivity, and promote sustainable land management practices. Initiatives such as the Planting for Food and Jobs (PFJ) program was introduced to offer subsidized inputs, extension services, and market access to smallholder farmers (Pauw *et al*., 2021).

In 1996, Ghana launched the Accelerated Agricultural Growth and Development Strategy (AAGDS) as part of the broader Ghana Vision 2020 (1996-2001). This 25-year development plan aimed to elevate Ghana to middle-income status by 2020, positioning it to be the first African nation to achieve developed status between 2020 and 2029, and ultimately to become a newly industrialized country between 2030 and 2039 by integrating science and technology into governmental programs (Boafo *et al*., 2019). Agriculture was slated to play a pivotal role, with expectations of accelerated growth within the sector to drive overall economic expansion. The primary objectives of the policy were to facilitate structural transformation within the Ghanaian economy, rectify socioeconomic disparities, encourage private sector involvement, bolster infrastructure, and provide greater social and economic amenities (Ferreira *et al*., 2022).

However, the implementation of AAGDS faced significant challenges, as identified by the Government of Ghana (GoG) in 2003. These challenges included insufficient human resources, limited irrigation, escalating food insecurity, and restricted access to land, among others. A critical evaluation of the policy's achievements revealed that inadequate institutional coordination, coupled with budgetary allocations below the required levels, hindered the realization of program objectives (Al-Hassan *et al.,* 2009). Subsequently, the Food and Agriculture Sector Development Policy (FASDEP I) emerged as a strategic blueprint for modernizing Ghana's agricultural sector, with a focus on catalyzing rural transformation (Baah *et al.,* 2017). The policy prioritized food security and agricultural development, building upon the foundational elements of AAGDS and highlighting the private sector's role as a key driver of growth. To ensure practical implementation and the attainment of FASDEP I objectives, the Ministry of Food and Agriculture worked with stakeholders to create a comprehensive Medium-Term Agriculture Sector Investment Plan (METASIP).

However, an assessment of FASDEP I revealed shortcomings, including inadequate targeting of the poor within the agricultural sphere, limited access to credit and technology, infrastructure deficiencies, and ineffective market linkages (MoFA,2007). In response, the government formulated FASDEP II, adopting an integrated approach and drawing insights from existing policies within the African diaspora. Developed within the framework of the Growth and Poverty Reduction Strategy (GPRS II) and aligned with the Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD), FASDEP II sought to address these challenges comprehensively.

Value addition and market access were the main focuses of FASDEP II's value chain approach to agricultural development. Emphasizing capacity building to meet international quality standards and the policy sought to improve competitiveness and integration into both domestic and foreign markets by raising productivity along the value chain. Additionally, FASDEP II delineated strategies for achieving national food security, particularly among smallholders, with objectives encompassing food security, income growth, market competitiveness, sustainable land and environmental management, The use of science and technology in agriculture, along with enhanced coordination among institutions. (MoFA.,2007).

The Medium-Term Agriculture Sector Investment Plan (METASIP) was introduced as a comprehensive strategy to guide investments in Ghana's agricultural sector over a medium-term period. METASIP aimed to address key challenges facing the sector and capitalize on opportunities for sustainable growth and development. It encompassed various components aimed at enhancing different aspects of agriculture; thus, METASIP focused on enhancing crop production through improved access to inputs such as seeds, fertilizers, and pesticides, as well as the promotion of sustainable farming practices and technologies (MoFA, 2014). The plan included initiatives to promote the development of the livestock sector, including breed improvement programs, disease control measures, and the provision of veterinary services and infrastructure.

Moreover, METASIP aimed to promote sustainable fisheries management through the implementation of policies and programs to combat illegal fishing practices, conserve marine resources, and support the livelihoods of artisanal fisher folk. The plan also emphasized the importance of rural infrastructure development, this includes transportation networks, irrigation infrastructure, storage units, and market facilities designed to bolster and advance agricultural production, processing, and sales. Implemented through partnership between government departments, development partners, and the private sector, with funding support from domestic and international sources, METASIP contributed to significant improvements in agricultural productivity, income levels, and food security outcomes across various regions of Ghana. However, challenges such as limited funding, inadequate infrastructure, and climate change impacts have affected the full realization of METASIP's objectives, highlighting the need for continued investment and policy support in the agricultural sector (MoFA ,2014)

The Planting for Food and Jobs (PFJ) program, launched by the Government of Ghana in 2017, is a flagship agricultural initiative aimed at boosting food security, enhancing agricultural productivity, and creating employment opportunities, particularly for smallholder farmers. The program provides subsidized inputs such as improved seeds and fertilizers, alongside extension assistance and technological support for agricultural producers. PFJ seeks to transform Ghana's agricultural sector, decrease reliance on food imports, and promote sustainable rural development. The program has been implemented in two phases: Phase 1 (2017–2020), which focused on increasing food production through government subsidies, and Phase 2 (2023–2025), which shifts toward private sector involvement and value chain development to address challenges from the initial phase. The (PFJ) Program Phase 1 initiative aimed at promoting food security, improving agricultural productivity, and fostering employment prospects for smallholder farmers in Ghana. PFJ provides participating farmers with subsidized inputs, including improved seeds, fertilizers, and agrochemicals, to enhance crop yields and reduce production costs. In addition to input provision, the program offers extension services and technical assistance to farmers, concentrating on enhancing agricultural techniques, managing pests and diseases, and optimizing post-harvest processes. (MoFA, 2017).

Moreover, Phase 2 of PFJ actively facilitates market linkages for farmers by establishing aggregation centers, farmer cooperatives, and partnerships with agribusinesses and food processors. The program also includes initiatives designed to engage youth in agriculture through training, capacity-building, and entrepreneurship programs, promoting youth employment and encouraging active participation in the agricultural sector (MoFA, 2017).

Implemented extensively across various regions of Ghana, PFJ has garnered substantial participation from smallholder farmers, resulting in beneficial effects on agricultural productivity, income levels, and food security outcomes. Despite facing challenges such as inadequate funding, logistical constraints, and limitations in extension services capacity, the government remains committed to addressing these hurdles and expanding the reach and impact of PFJ. These ongoing efforts underscore the government's dedication to fostering sustainable agriculture and rural development in Ghana (USDA, 2023)

The Ghana Agricultural Sector Investment Program (GASIP), launched in 2015 with support from the World Bank, aims to enhance agricultural productivity, market access, and competitiveness for smallholder farmers and agribusinesses in Ghana. GASIP invests in rural infrastructure, this encompasses roads, irrigation systems, storage facilities, and market infrastructure, all aimed at promoting agricultural production. processing, and marketing (GASIP, 2023).

The program supports the development of agricultural value chains by promoting agribusiness ventures, market linkages, and value-added activities, thereby enhancing the competitiveness and profitability of smallholder farmers. GASIP also provides training, technical guidance and support for farmers and other stakeholders to enhance their capacity-building efforts to improve farming practices, business management skills, and market participation. GASIP promotes the adoption of innovative technologies and practices, such as climate-smart agriculture, digital solutions, and precision farming techniques, to boost productivity, strengthen resilience, and promote sustainability in the agricultural sector. Implemented in collaboration with government agencies, development partners, and the private sector, GASIP emphasizes inclusive and participatory approaches to program design and implementation (GASIP,2023)

Despite progress, Ghana's agricultural industry still encounters difficulties like low productivity and restricted access to financing and inputs, land tenure issues, and climate change impacts (Antwi *et al.,* 2015). Future agricultural policies need to prioritize smallholder farmer support, rural infrastructure development, agribusiness entrepreneurship, and climate-smart agricultural practices. Enhancing institutional capacity, promoting research and technology transfer, and fostering multi-stakeholder partnerships are crucial for attaining sustainable agricultural growth and ensuring food security in Ghana. (Antwi et al., 2015).

2.3 Definition of Food Security

Food security, as defined by the 1996 World Food Summit, refers to the consistent access to sufficient, safe, and nutritious food that meets dietary needs and preferences for a healthy and active life. This concept encompasses four key dimensions that provide a comprehensive understanding of the complex nature of food security (World Bank, 2024). The first dimension is the physical availability of food, which addresses the supply side" of food security. This includes factors such as food production levels, stock availability, and net trade. While having an adequate quantity of food at the national or international level is essential for overall food security, mere availability does not ensure food security at the household level. The second dimension emphasizes both economic and physical access to food. This dimension recognizes that access to food involves factors beyond the national or international supply, emphasizing the importance of incomes, expenditures, markets, and prices in achieving food security objectives. The third dimension, food utilization, delves into how the body processes nutrients from the food consumed (world Bank 2024). Achieving sufficient energy and nutrient intake requires good care and feeding practices, diverse diets, proper food preparation, and fair intra-household distribution. This dimension determines the nutritional status of individuals, reflecting the holistic impact of consumption practices, and lastly, stability and utilization emphasize the need for consistent and reliable access to food over time. Stability in availability, access, and utilization is crucial for maintaining food security (FAO, 2022). This involves stable incomes, continuous access to food, and effective utilization practices, ensuring that individuals and communities are not only food-secure at a point in time but can sustain this security over the long term.

Food security encompasses access to sufficient, high-quality food for a healthy life, while food insecurity results from a lack of consistent access to an adequate amount of food due to financial constraints or other limitations. The measurement of food security is intricate, especially during emergencies or among vulnerable populations, involving an assessment of availability, access, utilization, and stability (Clapp *et al.,* 2022). Key indicators, such as the Food Consumption Score (FCS), the Coping Strategy Index (CSI), expenditures, and access indicators, aid in analyzing food insecurity. The FCS evaluates the diversity and frequency of food consumption within households, determining the likelihood of achieving nutrient adequacy and classifying households into different consumption groups (Sumsion *et al*., 2023)

The CSI is a vital measure providing insights into how households manage limited food access, assessing the severity and frequency of various coping strategies adopted in response to food insecurity. Additionally, household expenditure information acts as a proxy for purchasing power, offering insights into resource allocation, including spending on food (Collins *et al.,* 2016). The percentage of spending on food is particularly crucial, as households allocating a significant share of income to food are considered vulnerable to food deprivation. Food security, viewed as a critical aspect of ensuring access to enough nutritious food for a healthy and active life, requires comprehensive assessment and targeted measures, especially in challenging circumstances or vulnerable contexts (World Bank, 2024).

Food security operates at multiple levels, and Table 2.1 outlines these various levels, providing a clear understanding of how hunger is measured across global, national, regional, household, and individual dimensions. At the global level, food security focuses on the availability and reliability of food worldwide, considering factors such as global production, trade, and supply chains (FAO, 2022). The national level deals with a country's ability to maintain sufficient food production, reserves, and imports to meet the needs of its population, with implications for food policies and strategic reserves (Barrett *et al*., 2023).

The regional level addresses disparities in food availability within different geographic areas, often driven by climatic conditions or infrastructure challenges, which can affect access to food at more localized levels (Teng *et al*., 2022). At the household level, food security involves assessing the physical and economic access to food for individual families, taking into account factors such as income, food prices, and market availability (Ahmed & Otieno, 2023). Lastly, the individual level recognizes that even within food-secure households, food is not always equally distributed, and vulnerable groups, particularly women and children, may face higher levels of food insecurity (Molla *et al*., 2023).

Table 2 1 Levels of analysis

Level of Analysis	Description
Global	Refers to the availability and reliability of food worldwide.
National	Refers to the availability and reliability of food at a national level, the production of food within countries, and the levels of food reserves that should be maintained consistently.
Regional	Refers to the availability and reliability of food at a regional level.
Household	Refers to a household's physical and economic access to food, their levels of vulnerability, and their utilization of food.
Individual	Refers to an individual's physical and economic access to food (recognizing that food is not always evenly distributed at the household level), their levels of vulnerability, and their utilization of food.

Note: The table gives descriptions of different levels in which experiencing hunger is measured (Sumsion *et al*., 2023)

2.4 Overview of Ghana's food security

Food security in Ghana is a multifaceted challenge shaped by numerous factors, such as the availability of food, its accessibility, proper utilization, and consistency (Darfour *et al*., 2016). According to the 2020 Comprehensive Food Security and Vulnerability Analysis (CFSVA), food insecurity in Ghana stands at 11.7%, equating to approximately 3.6 million individuals. Of this number, the analysis reveals that around 5.2%, or roughly 1.6 million people, experience severe food insecurity, while about 6.5%, or 2 million people, face moderate food insecurity (FAO &

WFP, 2022). The Upper East region exhibits the highest levels of food insecurity, with as many as 28% of its population experiencing food security challenges (FAO & WFP, 2022). Food insecurity remains a critical development challenge in Ghana, despite significant progress in agricultural development and poverty reduction over recent decades. According to the 2020 Comprehensive Food Security and Vulnerability Analysis (CFSVA) Report by the Ghana Statistical Service (GSS), about 12% of the population approximately 3.6 million people are food insecure, experiencing either severe or moderate levels of food insecurity (GSS, 2020).

As illustrated in Figure 2.1, food insecurity in Ghana exhibits clear spatial disparities. The northern regions of Ghana namely, the Upper East, Upper West, and Northern Regions record the highest prevalence of food insecurity, with rates exceeding 30%. Specifically, the Upper East region reports an alarming 49% food insecurity rate, followed by the Upper West at 33% and the Northern Region at 31%. These regions are predominantly agrarian and highly vulnerable to climatic shocks, such as droughts and floods, which severely affect crop yields and household food availability (GSS, 2020). In contrast, the southern and coastal regions report much lower levels of food insecurity, typically below 10%. Regions such as Greater Accra, Central, and Western show relatively better food security outcomes, which may be attributed to diversified livelihoods, better market access, and improved infrastructure.

The data further indicate that food insecurity is significantly higher in rural areas compared to urban settings. Rural food insecurity stands at 18%, which is three times higher than the 6% recorded in urban areas. This difference reflects the limited livelihood options, lower incomes, and weaker social protection systems in rural communities (GSS, 2020).

Additionally, the report highlights that male-headed households are generally more food insecure than their female-headed counterparts in both rural and urban areas. This trend challenges the common narrative and suggests that female-headed households in Ghana may have more resilient coping strategies, better targeting by social programs, or differing livelihood profiles (GSS, 2020).

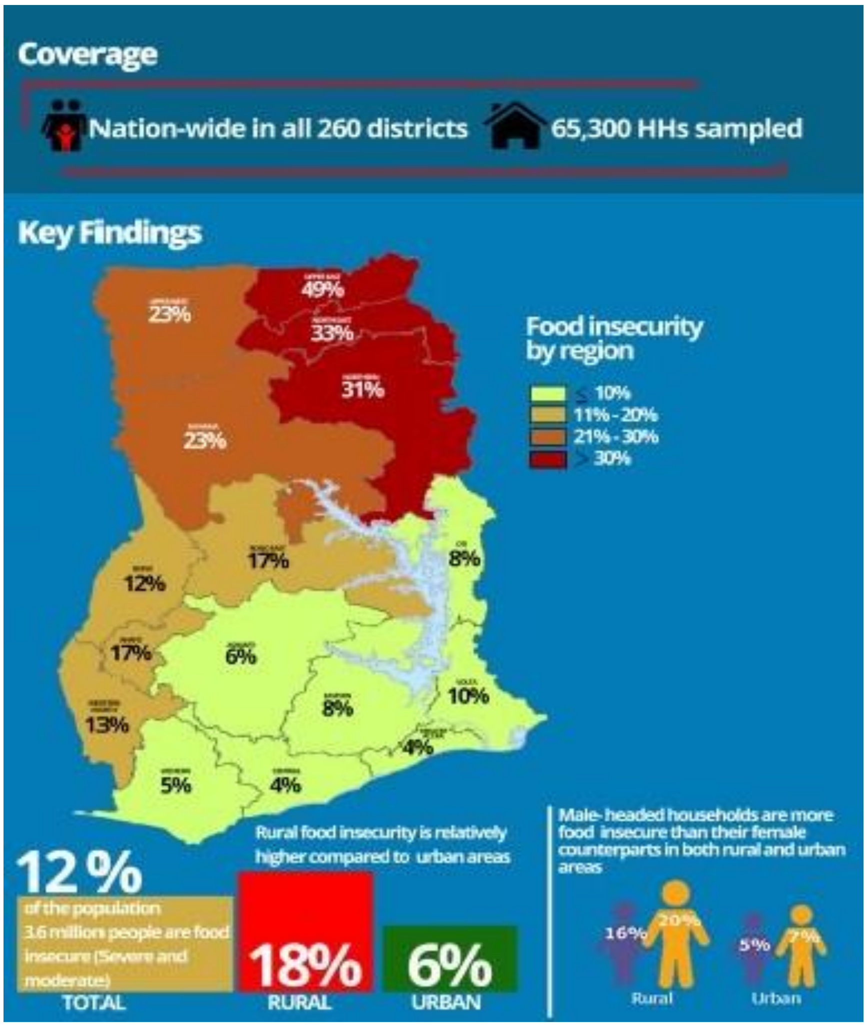

Figure 2.1: Food insecurity prevalence by region in Ghana

Source: Ghana Statistical Service, 2020).

In recent years, agricultural growth has outpaced that of non-agricultural sectors, with an average annual growth rate of 5.5%, in contrast to 5.2% for the broader economy. However, agricultural growth is largely reliant on rainfall patterns, and the current growth is primarily fueled by land expansion rather than productivity gains. Ghana meets 51% of its cereal requirements, 60% of its fish needs, 50% of its meat supply, and produces less than 30% of the raw materials necessary for agro-based industries (Darfour *et al*., 2016).

The World Food Programme (WFP) is offering technical assistance to Ghana's food security and social protection initiatives while aiding in the development of policies and frameworks for these programs. Additionally, WFP is enhancing the private sector's ability and motivation to produce and market affordable, nutritious foods, promoting gender equality, and building sustainable food systems. Additionally, the WFP is supporting the Government of Ghana has implemented a comprehensive program aimed at ensuring food security and improving nutrition. aimed at enhancing the country's food systems and bolstering social protection initiatives (WFP, 2024).

Ghana's food security landscape is complex, shaped by a variety of factors, including agricultural productivity, climate change impacts, market dynamics, and socio-economic inequalities (Bailey *et al*., 2017). Despite notable progress, challenges persist, especially in rural areas and among vulnerable populations. Agricultural production constraints, coupled with issues of access, utilization, and stability, are key concerns. Climate change exacerbates these challenges, causing erratic rainfall patterns, soil degradation, and water scarcity. Socio-economic factors such as poverty, inequality, and limited access to education and healthcare further exacerbate the situation (Guodaar *et al*., 2023)

While Ghana has seen growth in sectors like cocoa and poultry production, persistent challenges like low yields, outdated farming practices, and inadequate infrastructure hinder the sector's potential. Malnutrition is prevalent, with both under nutrition and over nutrition affecting various communities due to poor dietary diversity, micronutrient deficiencies, and restricted access to clean water and sanitation facilities. Market dynamics and food access are critical determinants of food security (Bailey *et al*., 2017). High food prices, inadequate transportation infrastructure, and unequal distribution channels limit access to nutritious food, especially for marginalized groups. Existing policies and interventions have had mixed success in addressing food security challenges. While steps have been taken to promote agricultural development, improve market access, and enhance social protection mechanisms, gaps remain in policy coherence, implementation, and monitoring. Gender dynamics also play a crucial role, with women often facing disproportionate barriers to accessing resources and benefiting from agricultural interventions (Dwomoh *et al*.,2023). Addressing gender inequalities is essential for achieving sustainable food security. Looking ahead, holistic approaches integrating climate-smart agriculture, gender-responsive policies, and social protection measures are crucial. Strengthening resilience, promoting sustainable food systems, and fostering collaboration among stakeholders are key for advancing food security goals in Ghana (Darfour *et al.*, 2016)

2.5 Food Security Indicators

Despite years of economic growth and technological progress in agriculture and the broader economy, attaining global food security continues to be a significant challenge (Poudel *et al.*, 2021). Food is a fundamental necessity for sustaining life, as emphasized by the World Food Summit's definition of food security as ensuring all individuals have access to sufficient, safe, and nutritious food for an active and healthy life. However, despite widespread acceptance of this concept, food insecurity persists as a significant scientific and social challenge, exhibiting substantial temporal and spatial variability in its mitigation efforts (Poudel *et al*., 2021)

Numerous national and international agencies have developed indicators to measure food security, applicable at both individual nation and global levels. Traditionally, these indicators aim to gauge the disparity between a nation's food supply or availability and the consumption needs of its population (Carletto *et al.*, 2013).

Food security remains a critical concern globally, impacting people's health, productivity, and even survival. Precise measurement of food security is crucial for the effective policy formulation, targeted assistance to vulnerable populations, and program evaluation. However, measuring food security is often challenging due to its complexity and multifaceted nature (WHO 2019). Despite these challenges, scientific indicators have been systematically designed and tested to measure food security, primarily focusing on assessing people's food and nutritional requirements. Experts recommend using information on specific conditions, experiences, and behaviors to reduce biases and ensure accuracy in food security measurement (Iversen *et al.*, 2023).

Various indicators, including food consumption scores, months of adequate food provision, and household food expenditure, have been utilized to assess food security within and across countries, as well as at individual and household levels (Young *et al.*, 2023). The choice of indicators depends on the researcher's discipline and area of study. Economists and poverty analysts often focus on expenditure and dietary diversity measures, while food security analysts prioritize food availability, and nutritionists concentrate on actual food consumption quantities. Consumption expenditures and dietary diversity measures are among the commonly used indicators in economic literature (Young *et al*., 2023)

2.5.1 Food Insecurity Experience Scale (FIES)

The Food Insecurity Experience Scale (FIES) is part of the Data4Diets platform, joining other scales like the Household Hunger Scale (HHS), the Household Food Insecurity Access Scale (HFIAS), and the Latin American and Caribbean Food Security Scale (ELCSA). Developed by the Food and Agriculture Organization (FAO) through the Voices of the Hungry (VoH) initiative, the FIES builds on earlier methodologies such as the USDA Household Food Insecurity Survey Module (HFIAS) and the ELCSA. Adapted from the ELCSA's adult-oriented questions, the FIES provides a standardized measure of food insecurity experiences, applicable across various cultural contexts (Data4Diets 2024, FAO 2024)

Since 2014, FAO has utilized the Gallup World Poll (GWP) to gather FIES data, surveying representative samples of adults annually across nearly 150 countries. Through this collaboration, the (VoH) project has developed analytical procedures enabling global assessment of food security based on personal experiences. This facilitates cross-country and sub-national comparisons of food insecurity rates (FAO, 2024).The FIES directly assesses the severity of food insecurity through individuals' responses, offering a cost-effective tool to pinpoint vulnerable populations and inform policy interventions. Its timely and reliable data on food access complement existing indicators, contributing to gain a deeper insight into the underlying causes and impacts of food insecurity. As its use expands globally, the FIES is increasingly employed by numerous countries to shape their food security strategies.

Its growing acceptance stems from its simplicity, reliability, and ability to yield practical insights, bolstering worldwide efforts to combat food insecurity. Through initiatives to enhance capacity and provide technical support, the Voices of the Hungry Project assists countries in implementing the FIES in surveys, aiding in the reporting of Sustainable Development Goal (SDG) indicator 2.1.2 and guiding evidence-based policymaking in food security (Data4Diets 2024, FAO, 2024).

Figure 2.1 presents the Food Insecurity Experience Scale (FIES) framework, categorizing food insecurity into three distinct levels: mild, moderate, and severe. It effectively communicates the progression of food insecurity, beginning with uncertainty in food access and moving toward severe conditions where individuals may go a full day without eating. The visualization includes key markers such as compromising on food quality and quantity, skipping meals, and running out of food entirely. This structured representation aids in understanding the nuances of food insecurity and the diverse impacts it has on individuals and households.

The figure aligns with the methodology developed by the Food and Agriculture Organization (FAO) to measure food insecurity globally, emphasizing the psychological and behavioral aspects of food access limitations. Its simplicity and color coding make it an excellent educational tool for raising awareness about food insecurity severity and its implications.

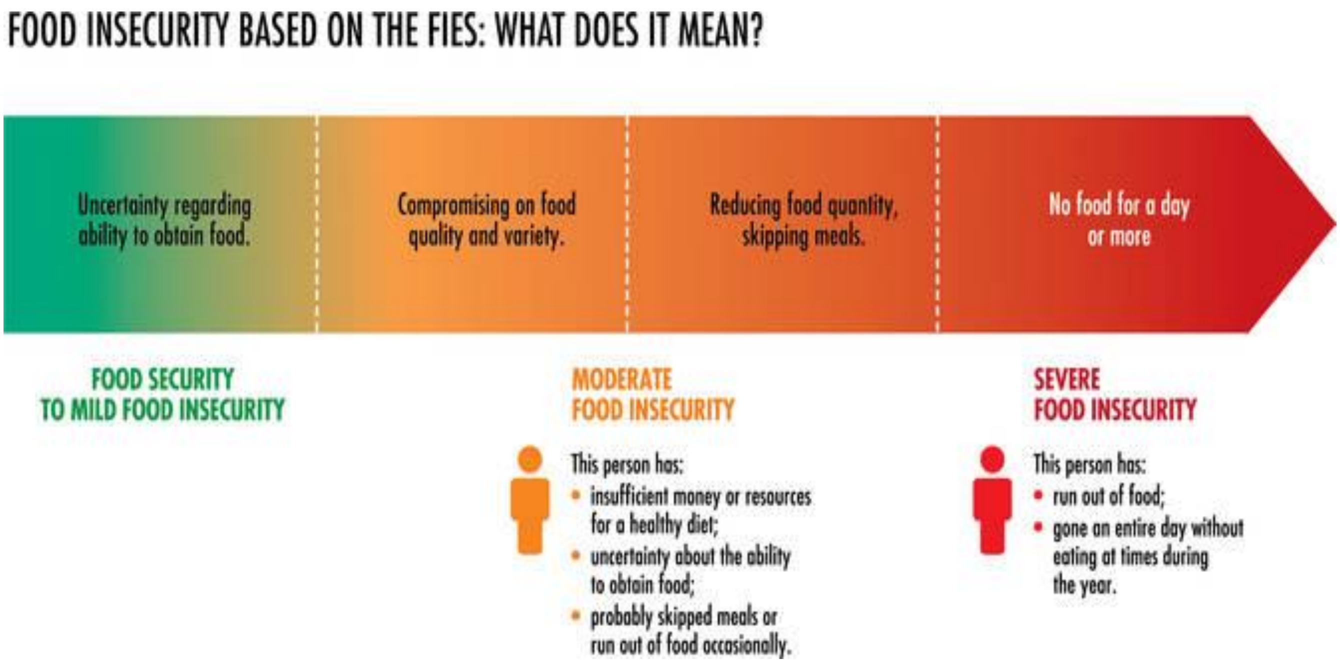

Figure 2 2 Food insecurity based on FIES

Source:(Data4Diets 2024)

Figure 2.2 illustrates the measurement of food insecurity along a continuum of food security scores, segmented into categories representing varying levels of food insecurity severity. The spectrum progresses from extreme food insecurity (indicated by red) to moderate food insecurity (yellow), and finally toward greater food security (green and blue). The use of distinct colors effectively highlights the severity levels, making it easier to interpret the thresholds between food insecurity and relative food security.

This representation is valuable for tracking food security dynamics and identifying households at different risk levels. By linking food security scores to distinct severity categories, this framework aids researchers and policymakers in targeting interventions to alleviate food insecurity effectively.

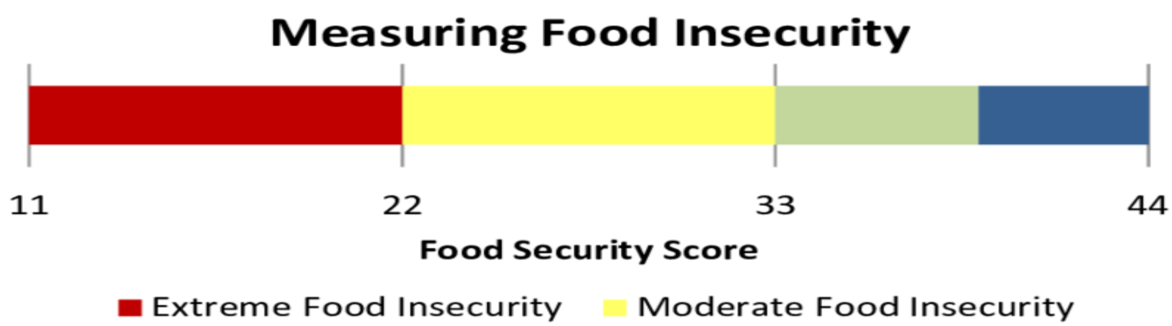

Figure 2 3 Measuring Food Insecurity

Source: (Data4Diets, 2024)

2.5.2 Household Dietary Diversity Score (HDDS)

The Household Dietary Diversity Score (HDDS) has emerged as a vital tool for assessing food security at the household level. Developed in 2006 as part of the FANTA II Project, the HDDS reflects the variety of foods consumed by household members over a given period, serving as a proxy for both diet quality and household economic access to food (Schmitz *et al.*, 2016). As food security remains a global concern, particularly in low- and middle-income countries, understanding the role and implications of HDDS is crucial for policymakers and stakeholders.

The HDDS is widely recognized as a robust indicator for measuring household food security, especially where more comprehensive data are unavailable. Recent studies underscore its effectiveness in capturing dietary diversity and, by extension, nutritional adequacy (Jeremiah *et al.*, 2024). A study by Ruel *et al* (2022) found that a higher HDDS was significantly associated with reduced stunting and wasting among children under five in Ethiopia, indicating that dietary diversity directly impacts nutritional outcomes and overall food security.

HDDS is typically calculated by scoring households based on the consumption of 12 distinct food groups over a specified reference period, such as 24 hours. Each food group is scored as 1 if consumed and 0 if not, with possible scores ranging from 0 to 12. This measure is used to assess household economic access to food, reflecting both caloric and protein adequacy (Swindale *et al.*, 2006). As a practical tool, HDDS is relatively easy to administer and analyze, which makes it particularly useful in large-scale surveys (Swindale *et al*., 2006).

Several factors influence HDDS, including socioeconomic status, agricultural practices, access to markets, education, and gender dynamics. Socioeconomic status, particularly household income, remains a primary determinant of HDDS. Households with higher incomes tend to have more diverse diets, as they can afford a wider range of foods (Cattaneo *et al.*, 2023). Additionally, agricultural practices, such as crop diversification, play a crucial role in enhancing HDDS. A study by Naji *et al.*(2024) highlighted that households engaged in crop diversification had significantly higher HDDS scores in rural Ethiopia.

Access to markets and infrastructure also significantly affects HDDS. Households closer to markets have better access to diverse food sources, resulting in higher HDDS (Usman *et al.,* 2022). Education, particularly women's education, has been shown to positively impact HDDS. Women with higher levels of education are more likely to understand the importance of diverse diets and make informed food choices (Gillespie *et al.,* 2019). Moreover, gender dynamics, such as the status of female-headed households, are increasingly recognized as crucial determinants of HDDS. Research by Mwaura *et al.(*2022) indicates that female-headed households often exhibit higher HDDS due to better management of food resources and decision-making autonomy.

Higher HDDS is consistently linked to improved food security outcomes across various settings. Recent studies have demonstrated that households with higher HDDS are less likely to experience food insecurity (Manikas *et al.,* 2023). A cross-sectional study in Bangladesh found that households in the highest HDDS quartile were significantly less likely to report food insecurity compared to those in the lowest quartile (Hasan *et al.* 2023). Similarly, a study in Nigeria Oluwatofunmi *et al.*(2023) showed that households with greater dietary diversity were more resilient to food security shocks, such as droughts and price hikes. HDDS is increasingly used to monitor the effectiveness of food security programs. For example, Safari *et al.(*2022) analyzed the impact of a food aid program in Malawi and found that participants who received regular support had significantly higher HDDS compared to non-participants, demonstrating HDDS as a useful tool for program evaluation.

While HDDS is a valuable measure of dietary diversity and food security, it has limitations. One critique is that it does not account for the quantity or quality of food consumed, focusing solely on the diversity of food groups (Kennedy *et al.,* 2011). Consequently, two households with the same HDDS may have vastly different nutritional intakes depending on the types and quantities of foods consumed. HDDS may not capture seasonal variations in food consumption, particularly in agrarian communities where food availability fluctuates with harvest cycles

The HDDS is also limited by its lack of validation as a proxy for micronutrient adequacy, making it less suitable for studies focused on specific nutrient intakes (Leroy *et al*., 2015). Therefore, some researchers advocate complementing HDDS with other measures, such as the Food Consumption Score (FCS) and the Coping Strategies Index (CSI), to provide a more comprehensive assessment of food security (Manikas *et al*., 2023)

Recent literature highlights the growing application of HDDS in urban contexts, where traditional measures of food security are less applicable. Studies have shown that HDDS can effectively capture dietary changes in rapidly urbanizing areas, where food environments are more complex (Arimond *et al.*, 2024). Furthermore, there is increasing interest in integrating HDDS with digital tools, such as mobile-based surveys, to improve data collection efficiency and accuracy (Shively *et al.*, 2023).

Moving forward, researchers advocate for more context-specific adaptations of HDDS, considering cultural, economic, and environmental factors that influence dietary (Mulatu *et al.*, 2024). There is a call for longitudinal studies to better understand the temporal dynamics of HDDS and its relationship with food security outcomes over time (Jones *et al*., 2020). The Household Dietary Diversity Score (HDDS) remains a critical tool for assessing food security, particularly in low- and middle-income countries

2.5.3 Coping Strategy Index

The Coping Strategy Index (CSI) serves as a valuable instrument utilized in food security evaluations to assess households' approaches in managing and alleviating the repercussions of food insecurity and economic instability (Maxwell *et al.*, 2003). It offers insights into the spectrum and severity of coping mechanisms employed by households grappling with food shortages or constraints in resources. Developed as a low-cost tool, the CSI was initially created through a collaborative initiative between the World Food Programme (WFP) and CARE, implemented in Uganda, Ghana, and Kenya. The first field-methods manual for the CSI was established in 2003, with subsequent revisions introduced in 2008 to address identified flaws (Maxwell *et al.*, 2008). Since then, it has been widely adopted across numerous countries in Africa, the Middle East, and Asia, serving as a means to monitor food insecurity levels and provide timely assessments of the prevailing food insecurity status in specific contexts or locations.

The Coping Strategy Index (CSI), when integrated into a household survey, can serve as a quick and cost-effective tool. However, it requires some initial effort to ensure that the index is suitably tailored and adapted to the local context (Maxwell *et al.*, 2008). The coping mechanisms will vary by location, shaped by cultural and socioeconomic factors.

A notable strength of the CSI lies in its capacity to comprehensively capture both the diversity and severity of coping strategies employed by households. Through the evaluation of different coping strategies like reducing meal portions, borrowing food or money, and selling assets, the CSI facilitates a nuanced understanding of households' adaptive responses to challenging circumstances. This insight is pivotal in identifying vulnerable populations and devising targeted interventions to address their unique needs (Corbett *et al.*, 1988, Maxwell *et al.*, 2008). Moreover, the CSI demonstrates flexibility and adaptability to diverse contexts, allowing for customized assessments aligned with local conditions and cultural norms. This adaptability enhances the pertinence and efficacy of food security interventions by tailoring strategies to meet the specific requirements of affected communities (Collins *et al.*, 2016)

However, it is imperative to acknowledge certain limitations associated with the CSI. While it offers valuable insights into coping strategies, the CSI may not fully encompass the enduring impacts of food insecurity on households' overall well-being and resilience (Corbett *et al.*, 1988).

2.6 Food production and climate change

Climate change has profound implications for global food security and the stability of food systems (Liverman *et al.*, 2012). It is anticipated to result in disruptions in production, limitations in local availability, price hikes, disrupted transport routes, and compromised food safety, among other factors (Davis *et al.*, 2021). These consequences can impact food availability, access, utilization, and stability, ultimately leading to food insecurity (Misselhorn *et al.*, 2012). The impacts of climate change on agriculture and food supply encompass alterations in temperature, rainfall patterns, and the frequency and intensity of extreme weather events, posing challenges to crop cultivation, livestock rearing, and fisheries (Duchenne *et al.*, 2021). The United Nations highlights those different phases of the food supply chain such as production, processing, transportation, distribution, and consumption play a role in generating greenhouse gas emissions. Increasing levels of carbon dioxide in the atmosphere can also reduce the nutritional value of plants, which could pose risks to human health. (UN, 2024).

Also, Climate change has been a key topic in policy discussions over the past four decades, raising significant global concerns about its impact on the environment and livelihoods (Naaminong *et al.,* 2016). The recent focus on climate change is driven by the threats it poses to food security, the ecosystem, along with human life, particularly in less developed nations (Intergovernmental Panel on Climate Change [IPCC]). The ongoing rise in greenhouse gas (GHG) levels in the atmosphere has sparked concern regarding climate change, affecting global temperature and precipitation patterns (Mbow *et al.,* 2021) In Ghana, the mean temperature rising by 0.21°C per decade and is projected to increase further, reaching 1.7°C to 2.04°C by 2030 (Etwire *et al.,* 2018). Additionally, rainfall has decreased across all ecological zones in Ghana over the past four decades, while sea levels are expected to rise from 5.8 cm in 2020 to 16.5 cm by 2050 (Tetteh *et al.,* 2022). Climate change directly impacts temperature, precipitation, and extreme events like droughts and floods, making the agricultural sector particularly vulnerable (Kumar *et al.,* 2018) Africa, including Ghana, faces increased risks due to its reliance on rain-fed agriculture and traditional farming methods (Derbile *et al.,* 2016).

Although Ghana's economy is transitioning towards services and industry, the agricultural sector remains vital, despite its declining contribution to GDP, agriculture is crucial for employment, raw materials, and food production (Awunyo *et al.,* 2018). The susceptibility of staple food crops to climate change threatens food security and rural livelihoods, mainly due to dependence on rain fed agriculture, Potential outcomes include reduced crop yields, loss of arable land, and increased pests and diseases, exacerbating food insecurity and rural unemployment (Gitz *et al.,* 2016).

Given agriculture's significance in Ghana's economy and its alignment with Sustainable Development Goals (SDGs), understanding the impact of climate change on food production is crucial (Zougmoré *et al.,* 2021).

2.7 Climate Smart Agricultural Practices

Climate-smart agriculture (CSA) represents a strategy for reshaping and adapting agricultural systems to safeguard food security amidst the evolving landscape of climate change (Autio *et al.*, 2021). Shifts in rainfall and temperature patterns pose significant threats to agricultural output, heightening the vulnerability of those reliant on agriculture for their livelihoods, particularly the world's impoverished populations (Kotir *et al.,* 2011). Climate change disrupts food markets, posing widespread risks to food availability. However, these threats can be mitigated by enhancing farmers' adaptive capacity, bolstering resilience, and improving resource efficiency within agricultural production systems (Fanzo *et al.*, 2018). CSA advocates for coordinated efforts among farmers, researchers, the private sector, civil society, and policymakers to pursue climate-resilient trajectories through four primary action areas: (1) generating evidence; (2) enhancing local institutional effectiveness; (3) fostering alignment between climate and agricultural policies; and (4) integrating climate and agricultural financing (Lipper *et al.*,2014). Unlike conventional approaches, CSA prioritizes the ability to implement adaptable, context-specific solutions, bolstered by innovative policy and financial interventions (Lipper *et al*., 2014).

Climate-Smart Agriculture (CSA) practices play a vital role in mitigating climate-related shocks experienced by smallholder farmers in Ghana. CSA seeks to achieve three core objectives: (1) sustainably boost agricultural productivity and incomes; (2) enhance farmers' ability to adapt and fortify resilience; and (3) curtail greenhouse gas emissions (Aidoo *et al.*, 2022). These practices encompass various techniques, including zero/minimum tillage, residue management, and agroforestry, alongside traditional methods and indigenous knowledge widely utilized by farmers to address climate risks (Aidoo *et al*., 2022).

Ghana has endeavored to promote CSA through its sustainable agricultural development policy, culminating in the formulation of a National Climate-Smart Agriculture and Food Security Action Plan (Zundel *et al.*, 2017). Despite these initiatives, CSA uptake remains limited among smallholder farmers in many regions of Ghana. Research indicates that factors such as educational attainment, farming experience, and access to climatic information influence the adoption of CSA practices among smallholder farmers (Aidoo *et al*., 2022).

The adoption of Climate-Smart Agriculture (CSA) practices in Ghana is a critical endeavor aimed at enhancing agricultural resilience, sustainability, and productivity in the face of climate change (Quarshie *et al.,* 2023). CSA encompasses a range of techniques and strategies tailored to mitigate climate-related risks and promote sustainable farming practices (Matteoli *et al.* 2020). Despite its potential benefits, the widespread adoption of CSA practices among smallholder farmers in Ghana faces several challenges and barriers (Antwi *et al.,* 2021). One key challenge is the limited awareness and understanding of CSA principles among farmers. Many smallholder farmers in Ghana may not be familiar with CSA practices or their potential benefits in mitigating climate risks and improving agricultural productivity (Essegbey *et al.*, 2015). Additionally, there may be a lack of access to information, extension services, and training programs on CSA techniques, hindering adoption efforts. In addition, financial constraints and limited access to credit pose significant barriers to the adoption of CSA practices. Implementing CSA techniques often requires upfront investments in infrastructure, equipment, and inputs, which may be beyond the means of many smallholder farmers in Ghana (Aidoo *et al*., 2022). Without access to affordable financing options and support mechanisms, farmers may struggle to invest in CSA technologies and practices. Institutional and policy challenges also impede the widespread adoption of CSA in Ghana (Anuga *et al.,* 2019) There may be inadequate policy support and institutional frameworks to promote and incentivize CSA adoption. Additionally, existing agricultural policies and practices may not fully align with CSA principles, creating barriers to implementation and scaling up (Essegbey *et al*., 2015).

Despite substantial efforts by the government and international organizations to encourage their adoption, the uptake of Climate-Smart Agriculture (CSA) practices remains low among smallholder farmers in many regions of Ghana. Factors such as educational attainment, years of farming experience, and access to climatic information influence the adoption of CSA practices by smallholder farmers in Ghana (Aidoo *et al*., 2022).

A study conducted in the Upper East and North-East Regions of Ghana revealed that farmers' attitudes, subjective norms, and perceived behavioral control significantly influenced their intentions and adoption of Climate-Smart Agriculture (CSA) practices (Aidoo *et al*., 2022). Additionally, the research indicated that social pressure on farmers to adopt CSA practices had a notable effect on their adoption behavior (Aidoo *et al*., 2022). To tackle these challenges, it will be necessary to take appropriate action by adopting an integrated approach to agriculture and environmental management, enhancing risk preparedness, promoting sustainable energy production, modernizing transportation systems, and developing more resilient infrastructure (Robert *et al.*, 2023). The World Bank estimates that without urgent climate action, at least one million additional people may be pushed into poverty due to climate-related disasters, and incomes for poor households could decrease by as much as 40% by 2050 (Mukhi *et al*., 2020).

2.8. Theoretical Review

2.8.1 Random Utility Theory (RUT)

Random Utility Theory (RUT), developed by McFadden (1974), serves as a behavioral foundation for analyzing discrete choice decisions, including programme participation and technology adoption. RUT assumes that individuals select options that maximize their perceived utility, even though some components of utility are unobservable to researchers. In agricultural research, this theory is widely used to model farmers' decisions to participate in programmes or adopt technologies based on anticipated benefits relative to costs and risks.

In this study, RUT underpins the use of the Probit model to analyze the determinants of GASIP participation and CSAP adoption. Prior research by Abate *et al*. (2022) and Abdulai *et al*. (2021) has applied RUT to evaluate farmers' decision-making processes in relation to agricultural programmes and climate-smart practices in developing countries.

2.8.2 Utility Maximization Theory

Utility Maximization Theory, a central concept in neoclassical economics, assumes that individuals make decisions aimed at maximizing their utility subject to constraints such as income, prices, and available resources (Becker, 1965). In the context of this study, households are assumed to participate in agricultural programmes or adopt CSAPs if these choices are expected to improve their utility in terms of increased income, enhanced productivity, or improved food security.

This theory is particularly applicable to food security analysis, where households are expected to optimize their resource allocation to maximize food consumption and nutrition. Studies such as those by Ahmed *et al*. (2023) and Asfaw *et al*. (2016) have applied utility maximization theory to explain farmers' adoption of agricultural technologies aimed at improving food security and livelihoods.

2.8.3 Empirical Review

2.8.4 Agricultural Programme Participation, CSAP Adoption, and Food Security

Empirical evidence from multiple contexts demonstrates that participation in agricultural programmes and the adoption of CSAPs are positively associated with food security outcomes. Abate *et al*. (2022) revealed that agricultural extension programmes significantly enhanced food security among Ethiopian farmers by promoting sustainable farming practices and increasing farm productivity. In Ghana, Abdul-Rahaman and Abdulai (2018) found that participation in farmer groups improved rice yields and food security through knowledge-sharing and collective action.

Research further highlights that combining agricultural programme participation with CSAP adoption yields stronger food security outcomes. Ahmed *et al*. (2023) demonstrated that households engaging in both agricultural interventions and CSAPs reported higher dietary diversity and resilience in Ghana and other African countries. Likewise, Antwi-Agyei (2021) showed that CSAPs such as improved seed varieties, soil conservation, and water harvesting significantly enhanced food production and reduced food insecurity risks among smallholder farmers in Ghana.

Acheampong *et al*. (2022) and Amoako *et al*. (2022) similarly found that agricultural development programmes, when integrated with climate-smart technologies, increased household food availability and access through higher yields and improved market linkages.

2.8.5 Determinants of Programme Participation and CSAP Adoption

Numerous studies have investigated the socio-economic and institutional factors that influence farmers' decisions to participate in agricultural programmes or adopt CSAPs. Adu *et al.* (2022) identified education, gender, access to extension services, and credit availability as significant determinants of agricultural programme participation in Ghana. Similarly, Antwi-Agyei (2021) emphasized that risk perceptions, institutional support, and farm resource endowments strongly influence the likelihood of CSAP adoption.

Other studies highlight the roles of land ownership, household size, off-farm income, and social capital in driving participation decisions (Abay *et al*., 2021; Asravor *et al*., 2020). Farmers with greater access to agricultural services and institutional support tend to have higher adoption rates of CSAPs, leading to better food security outcomes.

2.8.6 Impact on Food Security Indicators (FIES, HDDS, CSI)

Several empirical studies have explicitly evaluated the effects of agricultural interventions and CSAP adoption on key food security indicators such as the Food Insecurity Experience Scale (FIES), Household Dietary Diversity Score (HDDS), and Coping Strategy Index (CSI). Ahmed *et al*. (2023) and Abate *et al*. (2022) found that programme participation significantly improved HDDS and reduced FIES scores, indicating better food consumption and lower vulnerability to food insecurity.

Similarly, Abdul-Rahaman and Abdulai (2018) observed that membership in farmer groups reduced households' dependence on negative coping mechanisms, as reflected in lower CSI scores. Adoption of CSAPs also contributed to improved food security by stabilizing yields, enhancing dietary diversity, and reducing reliance on food-related coping strategies (Antwi-Agyei, 2021; Anuga *et al*., 2019).

2.8.7 Conceptual Framework

This study is anchored on a conceptual framework that adapts and modifies the Sustainable Livelihoods Framework (SLF), originally developed by the UK Department for International Development (DFID, 1999). The SLF emphasizes that households' livelihoods are shaped by their access to five key types of capital: human, social, financial, natural, and physical capital. These capitals collectively determine the livelihood strategies available to households and directly influence welfare outcomes such as food security, income, and resilience to shocks. In addition to these capitals, the SLF also recognizes the critical role of institutional processes, policies, and external interventions in shaping livelihoods, particularly for smallholder farmers in resource-constrained settings.

In this study, the SLF has been modified to specifically reflect the institutional, environmental, and socio-economic conditions prevailing in Northern Ghana. The focus is on capturing how smallholder farmers' participation in the Ghana Agricultural Sector Investment Programme (GASIP) influences their adoption of Climate-Smart Agricultural Practices (CSAPs) and household food security. This modification is necessary given the acute challenges faced by smallholder farmers in the region, such as persistent poverty, food insecurity, market access limitations, and exposure to climate-related risks (Manda *et al*., 2022; Ahmed *et al*., 2023). Within this adapted framework, GASIP is positioned as an institutional intervention that facilitates farmers' access to livelihood-supporting services, including agricultural inputs, credit, irrigation infrastructure, training in sustainable practices, and improved market linkages.

Farmers' participation in GASIP is understood as a decision shaped by several interrelated factors corresponding to the various forms of capital outlined in the SLF. Human capital, including attributes such as age, gender, education, household size, and farming experience, influences farmers' decision-making capacities and willingness to engage with agricultural programs (Abdulai *et al*., 2021; Amoako *et al.*, 2022). Natural capital, particularly land ownership and access to water for irrigation, determines farmers' ability to increase agricultural productivity and adopt new technologies (Barrett *et al*., 2022). Financial capital, such as access to credit and financial services, enables farmers to invest in productivity-enhancing technologies and practices. Social capital, reflected in membership in farmer-based organizations, participation in agricultural networks, and access to extension services, plays a critical role in information sharing, collective learning, and the diffusion of new agricultural practices (Ojo *et al*., 2023). Physical capital, including farm machinery, storage facilities, transportation, and irrigation infrastructure, also significantly affects farmers' production capacities and access to markets.

Through participation in GASIP, smallholder farmers gain access to a wide range of agricultural services. These include credit and financial assistance, improved agricultural inputs such as high-yielding seed varieties and fertilizers, irrigation infrastructure to support dry-season farming, technical training on CSAPs, and enhanced market linkages that help farmers sell their produce more effectively. These program interventions are intended to strengthen farmers' productive capacities, promote sustainable farming practices, and improve their income-generating potential (GASIP, 2023; Osabohien *et al*., 2022).

The framework posits that participation in GASIP is likely to result in two main outcomes for smallholder farmers. The first expected outcome is improved household food security, driven by increased farm productivity, higher incomes, and better access to food markets. In this study, food security is assessed through the Household Dietary Diversity Score (HDDS), the Food Insecurity Experience Scale (FIES), and the Coping Strategy Index (CSI), which are internationally recognized metrics for measuring food security (Mwangi & Muturi, 2023; FAO, 2021). The second expected outcome is a higher level of adoption of Climate-Smart Agricultural Practices. These include the use of improved seed varieties, crop diversification, agroforestry, soil and water conservation techniques, efficient irrigation management, and integrated pest management—all practices designed to enhance farmers' resilience to climate shocks and promote long-term agricultural sustainability (Manda *et al*., 2022; Ahmed *et al*., 2023).

An important aspect of this conceptual framework is its recognition of potential feedback mechanisms. It is anticipated that improvements in household food security and increased adoption of CSAPs will strengthen farmers' resilience and further enhance their capacity to participate in agricultural programs and adopt new technologies in subsequent agricultural seasons. Such feedback loops create a self-reinforcing process where improved livelihoods and increased adaptive capacity enable sustained program engagement and continued agricultural innovation (Barrett *et al*., 2022; Kansiime *et al*., 2023).

In addition to its foundation in the Sustainable Livelihoods Framework, this conceptual framework incorporates key insights from Random Utility Theory (RUT) and Utility Maximization Theory (UMT). Random Utility Theory, as developed by McFadden (1974), posits that farmers make discrete choices regarding participation in agricultural programs or adoption of technologies based on their expected utility, which depends on both observable characteristics—such as access to services, household demographics, and program awareness—and unobserved factors such as preferences and attitudes toward risk. Utility Maximization Theory, elaborated by Becker (1965) and Lancaster (1966), assumes that farmers make decisions that maximize their household welfare, given their limited resources and available choices. In this context, farmers are expected to choose participation in GASIP and the adoption of CSAPs if doing so improves their expected utility in terms of food security, income, and resilience.

By integrating the Sustainable Livelihoods Framework with Random Utility Theory and Utility Maximization Theory, this conceptual framework offers a comprehensive analytical lens for understanding the pathways through which GASIP participation influences smallholder farmers' food security and adoption of CSAPs. It recognizes the multifaceted nature of farmers' decision-making processes, capturing both structural livelihood constraints and individual choice behaviors. This framework thus serves as the foundation for the empirical analysis in this study and provides clear pathways for identifying the direct and indirect impacts of agricultural interventions on rural livelihoods in Northern Ghana.

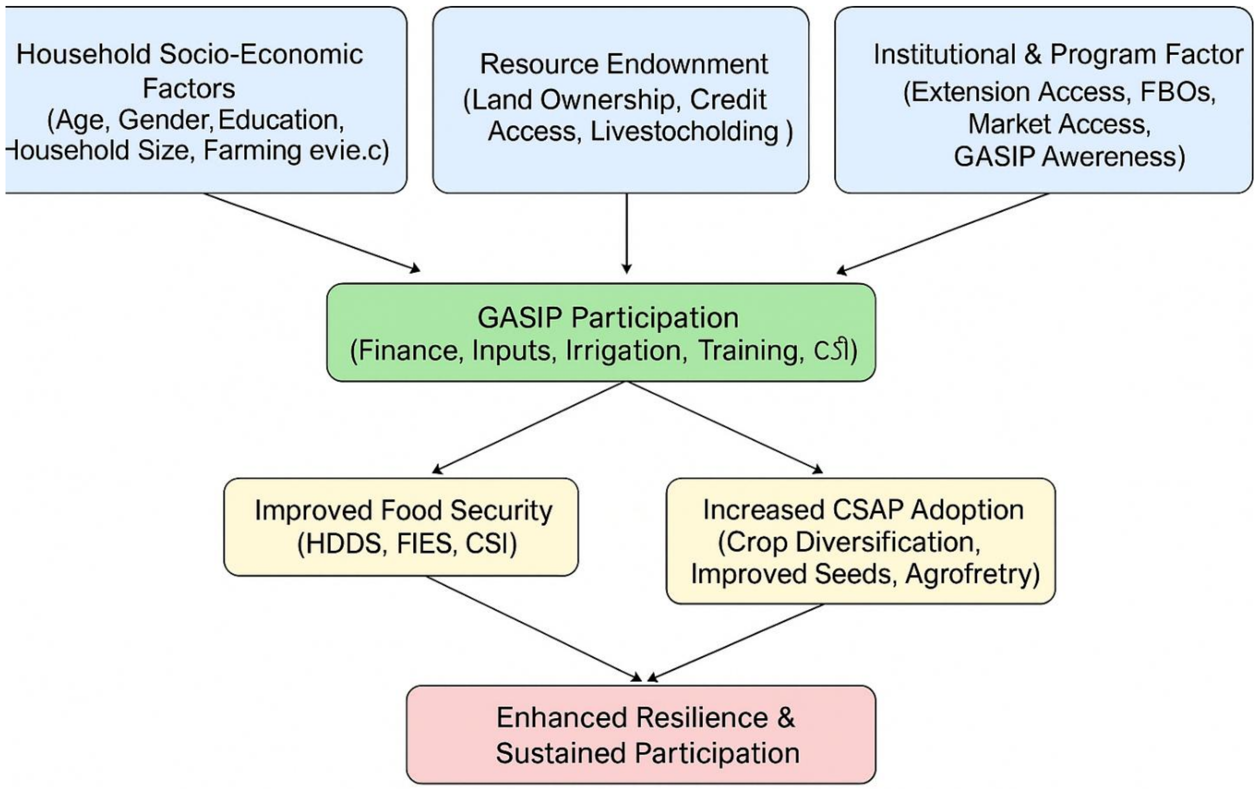

Figure 3.2 Conceptual Framework Linking GASIP Participation, CSAP Adoption, and Food Security Outcomes

Source: Modified from DFID (Department for International Development). (1999)

2.8.8 Theoretical Model

This study is anchored on the Random Utility Theory (RUT) and the Household Utility Maximization Framework. These theories provide a solid foundation for analyzing farmers' decisions to participate in the Ghana Agricultural Sector Improvement Programme (GASIP), adopt Climate-Smart Agricultural Practices (CSAPs), and improve household food security.

2.8.9 Random Utility Theory (RUT)

The Random Utility Theory (RUT) explains farmers' participation decisions under the assumption that farmers are rational and aim to maximize their utility.

Each farmer is assumed to derive a certain level of utility from participating in GASIP and a different utility from not participating.

The utility from participating in GASIP can be expressed as:

$$U_{i1} = V_{i1} + \varepsilon_{i1}$$

Where:

U_{i1} is the total utility from participating in GASIP.

V_{i1} is the observable component, determined by household socio-economic characteristics (such as age, education, household size, access to credit, farm experience, and access to extension services).

ε_{i1} is the unobservable or random component of utility.

Similarly, the utility from non-participation is:

$$U_{i0} = V_{i0} + \varepsilon_{i0}$$

A farmer will participate in GASIP if:

$$U_{i1} > U_{i0}$$

Which implies:

$$(V_{i1} - V_{i0}) > (\varepsilon_{i0} - \varepsilon_{i1})$$

This decision-making process justifies the use of a binary choice model such as the Probit or Logit model to estimate the probability of GASIP participation.

2.9. Household Utility Maximization Framework

This model is used to explain farmers' decisions regarding the adoption of Climate-Smart Agricultural Practices (CSAPs) and their food security status.

It assumes that farm households are utility maximizers, seeking to maximize their well-being from consumption, food security, and agricultural production.

The household's utility function is specified as:

$$\mathrm{U} = \mathrm{U}\,(\mathrm{F}, \mathrm{X})$$

Where:

F represents food security outcomes (dietary diversity, food availability, and coping strategies).

X represents other goods and services consumed by the household.

The household faces a budget constraint:

$$\mathrm{Y}=P_F F + P_X X$$

Where:

Y is household income (from farming, remittances, non-farm activities, etc.).

$P_F F$ and $P_X X$ are prices of food and other goods, respectively.

The decision to adopt CSAPs depends on whether the perceived benefits such as improved yields, better food security, and reduced vulnerability to climate shocks exceed the associated costs (e.g., input costs, labor, and risks).

Based on these theoretical foundations, the following econometric models are employed in this study:

Probit Model to estimate the probability of GASIP participation based on observable household and farm-level characteristics.

Endogenous Switching Poisson or Count Model to analyze the intensity of CSAP adoption, considering the number of climate-smart practices adopted by each household.

Endogenous Switching Regression Model (ESR) to estimate the impact of GASIP participation on food security outcomes (HDDS, FIES, and CSI) while controlling for self-selection bias and unobservable factors affecting participation.

These models provide a robust framework for assessing the interconnections between GASIP participation, CSAP adoption, and food security outcomes.

2.9.1 Conclusion

This chapter has provided an in-depth review of the literature on agricultural programme participation, climate-smart agricultural practices, and food security. The conceptual review examined the evolution of agricultural policies in Ghana, focusing on GASIP, and analyzed definitions and measurements of food security using established indicators such as FIES, HDDS, and CSI.

The theoretical review incorporated the Random Utility Theory, and Utility Maximization Theory, which together offer a robust explanation for the mechanisms through which agricultural programme participation and CSAP adoption affect food security outcomes. These frameworks explain how access to livelihood assets, behavioral decision-making under uncertainty, and utility optimization collectively influence household choices and welfare.

Empirically, the review revealed strong evidence that both agricultural programme participation and CSAP adoption significantly improve food security through increased productivity, enhanced dietary diversity, and reduced vulnerability to shocks. Key determinants of participation and adoption include education, access to extension services, gender, credit, and climate risk perceptions. However, few studies have simultaneously analyzed the joint effects of agricultural programme participation and CSAP adoption using advanced econometric methods.

This study addresses this gap by employing Probit models, Endogenous Switching Regression, and Endogenous Switching Poisson models to rigorously assess the causal impacts of GASIP participation and CSAP adoption on food security among smallholder farmers in Ghana. By accounting for both observed and unobserved heterogeneity, this study provides a more nuanced and accurate estimation of these relationships, contributing valuable insights to the literature on agricultural development and food security.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the methodological framework adopted to assess the effects of participation in the Ghana Agricultural Sector Investment Programme (GASIP) on smallholder farmers, with a specific focus on household food security and the adoption of Climate-Smart Agricultural Practices (CSAPs). The choice of methods is grounded in both theoretical and empirical considerations aimed at ensuring robustness and validity of results.

The chapter begins by describing the study area, highlighting the geographic, agro-ecological, and socio-economic features of the Upper East Region of Ghana one of the key intervention zones for GASIP. It proceeds to explain the research design, type of data collected, and the sampling procedures employed in selecting respondents from both beneficiary and non-beneficiary communities. The study uses a cross-sectional design, which facilitates the comparison of outcomes between GASIP participants and non-participants at a specific point in time.

Given the non-random nature of GASIP participation and the potential for selection bias, the study adopts a combination of econometric models including the Probit model, Endogenous Switching Poisson model, and Endogenous Switching Regression model to estimate the determinants and impacts of program participation. These models are grounded in the Random Utility Theory and the Household Utility Maximization Framework, which provide the theoretical basis for analyzing farmers' participation behavior and adoption decisions under resource constraints.

Finally, the chapter presents the conceptual framework, variable description, and model specifications. Together, these components provide a structured approach to addressing the study's objectives and contribute to generating empirical evidence on how institutional agricultural support programs influence livelihoods and sustainability among smallholder farmers in Northern Ghana.

3.1 Study Area

The Upper East Region of Ghana is situated in the northeastern section of the country, nestled between longitudes 0° and 1° West and latitudes 10°30' N and 11° N. It shares borders with Burkina Faso to the north, Togo to the east, the Sissala region in the Upper West Region to the west, and West Mamprusi in the North East Region to the south. Figure 3.1 illustrates the administrative districts within the Upper East Region.

The landscape is mainly flat, with some hills found in the eastern and southeastern parts. Spanning roughly 8,842 square kilometers, the region accounts for about 2.7% of Ghana's overall land area (Awuni et al., 2018). The soil is categorized as upland soil," primarily derived from granite rock, which is shallow, low in organic content, coarse in texture, and prone to erosion. In the valleys, soil types vary from sandy loams to saline clays, showing higher natural fertility but facing difficulties in farming due to seasonal waterlogging and flooding. The area is drained by the White and Red Volta Rivers, along with the Sissili River (UERCC, 2019).

The region's natural vegetation is made up of savannah woodland, featuring scattered, drought-resistant trees and grasses that often become parched from the sun or damaged by bushfires during the long dry season. Human activities have considerably changed the region's ecosystem, resulting in semi-arid conditions. Common economic tree species in the region include shea nut, dawadawa, baobab, and acacia. The climate is characterized by a single rainy season which usually occurs from May or June to September or October. Figure 3.1 presents the administrative map of the region. The region is divided into 15 administrative districts, each managed by a district chief executive. The capital city is Bolgatanga, which serves as a central hub for governance and commerce. Other significant towns include Navrongo, Paga, Sandema, Bongo, Bawku, and Zebilla. Maps illustrating these districts provide a clear visual representation of their boundaries and locations within the region.

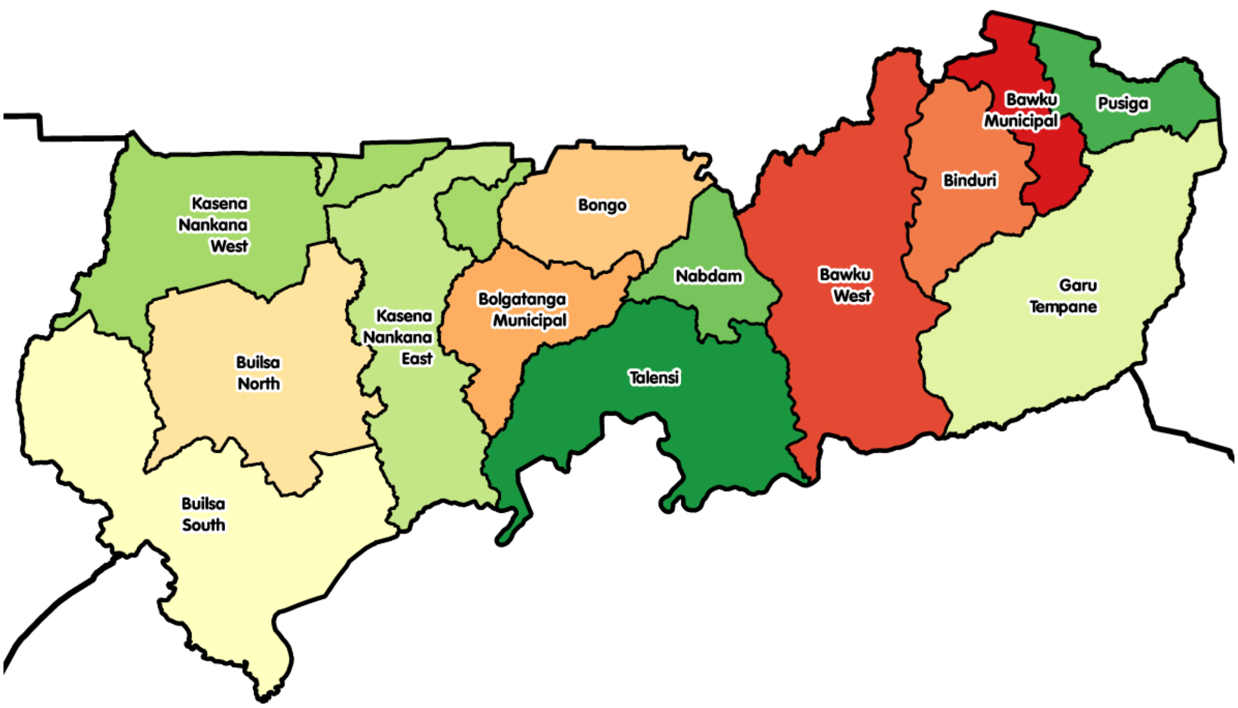

Figure 3.2 Administrative districts of the Upper East Region

The yearly average precipitation during this timeframe varies between 800 and 1,100 mm (Ampadu *et al*., 2019). The Upper East Region experiences its dry season from November to mid-February, marked by cold, dry, and dusty Harmattan winds. During this period, nighttime temperatures can fall to as low as 14°C and can rise above 35°C during the day. Bolgatanga, the capital city, acts as the population hub of the region. A considerable portion of the inhabitants (79%) resides in rural areas, spread across different settlements. In 2010, the population of the region was recorded at 920,089, which accounted for 4.6% of Ghana's overall population. The Upper East Region has a considerable and youthful labor force, with 55.7% of the population under the age of 35 (MoFA, 2024).

Over 90% of farm holdings are less than 2 hectares (Nuhu *et al.*, 2022). Agriculture engages approximately 80% of the population. This reliance has propelled the region from its prior position as the poorest among Ghana's ten regions to its current standing at 9th, primarily attributed to advancements in agricultural performance (MoFA 2024).

Major agricultural commodities include millet, guinea-corn, maize, groundnut, beans, sorghum, and dry season tomatoes and onions. The region's agricultural canvas extends across diverse categories, encompassing cereals, legumes, fibers, roots and tubers, vegetables, and non-traditional export crops (Nuhu *et al.*, 2022).

3.2 Research Design

The study employed a cross-sectional research design to assess the impact of the Ghana Agricultural Sector Improvement Programme (GASIP) on the food security status and adoption of Climate-Smart Agricultural Practices (CSAPs) among smallholder farmers in the Upper East Region of Ghana. This research design was deemed appropriate because it allowed the researcher to collect data from a sample of respondents at a specific point in time, thereby capturing a snapshot of current farming practices, food security status, and participation in GASIP. Moreover, the design provided the flexibility to compare GASIP beneficiaries with non-beneficiaries to analyze differences in outcomes related to food security and climate-smart agricultural technologies.

Given the nature of the study, which focuses on the evaluation of a policy intervention, the research further applied a quasi-experimental approach, using appropriate econometric techniques to control for selection bias arising from non-random participation in the GASIP program. The combination of descriptive and econometric analyses under this research design ensured a robust assessment of the program's impact.

3.3 Data Type

The study relied entirely on primary data collected through a semi-structured questionnaire. This approach was chosen to obtain detailed, context-specific information from smallholder farmers in the study area. The questionnaire was carefully designed in line with the objectives of the study and covered key variables such as socio-economic characteristics, participation in GASIP, adoption of climate-smart agricultural practices, and household food security indicators. These included the Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and Coping Strategies Index (CSI). Additionally, the survey collected information on access to agricultural extension services, credit, livestock ownership, and off-farm activities.

The use of primary data allowed for the collection of both qualitative and quantitative responses necessary for the econometric analysis and for drawing inferences on the relationship between GASIP participation and food security outcomes.

3.4 Sampling Procedure and Sample Size

The study employed a multi-stage sampling procedure comprising purposive, stratified, and simple random sampling techniques to select the respondents. This approach was adopted due to the large population of farmers in the region and the need to ensure representativeness across districts, communities, and households.

In the first stage, purposive sampling was used to select the Upper East Region as the study area, based on its active participation in the GASIP project. Following this, three districts Bolgatanga Municipality, Bongo District, and Builsa North District were selected out of the fifteen districts in the region based on their involvement in the GASIP interventions and their diversity in terms of agro-ecological characteristics and farming activities.

In the second stage, stratified sampling was employed to select the farming communities within the selected districts. The communities were stratified into beneficiary and non-beneficiary communities based on whether they had participated in the GASIP project. This stratification ensured that both project participants and non-participants were adequately represented in the sample. Five non-beneficiary communities were systematically selected from the list of farming communities in each district. In selecting these non-beneficiary communities, care was taken to eliminate communities that shared direct boundaries with the beneficiary communities to minimize the risk of spill-over effects from the project interventions.

In the third stage, simple random sampling was used to select individual respondents from the beneficiary and non-beneficiary communities. In Bolgatanga Municipality, a total of 140 respondents were selected, consisting of 70 GASIP participants and 70 non-participants. Similarly, 130 respondents were selected from both Bongo District and Builsa North District, with each district contributing 65 participants and 65 non-participants. This sampling ensured a balanced representation of GASIP participants and non-participants across the study districts.

The selection of non-participant households followed a systematic sampling approach within the non-beneficiary communities, ensuring that respondents were drawn in a way that reflected the population structure of these areas.

The sample size for the study was determined using the Yamane (1976) formula for sample size determination with a 5% margin of error. The total population of farming households in the three selected districts was estimated at 260,188. Applying the formula:

$$S = \frac{N}{1+N(\alpha)^2}$$

Where N= sample population, (260188); S= sample size, α= error margin (5%).

$$S = \frac{260188}{1+260188(0.5)^2} = 399.034 \approx 400$$

Thus, a total sample size of 400 households was obtained for the study. This sample was then proportionally distributed among the selected districts and communities according to their farming

Table 3 1 Sampling Procedure Table

Beneficiary			Control communities	
District	**Communities**	**Sample**	**Communities**	**Sample**
Bolgatanga Municipal	5	70	5	70
Bongo	5	65	5	65
Builsa North	5	65	5	65
Sub-total	15	200	Sub-total	200
TOTAL			400	

3.5 Data Analysis

Data analysis was conducted using STATA 16. Descriptive statistics were utilized to present the results through frequency tables, graphs, and pie charts.

Research Objective 1: To identify the factors that influence smallholder farmers' participation in GASIP programme.

3.6 Probit Model

The probit model was employed to determine the factors affecting smallholder farmers' involvement in the GASIP programme due to its binary characteristic (ranging between 0 and 1) and its capacity to address the issue of heteroscedasticity (Asante *et al.*, 2011). Thus, the dependent variable, GASIP participation Y assumes only two values: 1 if a Farmer participate in GASIP and 0 if otherwise.

$Y = 1\ if\ Farmer\ participate\ in\ GASIP$

$Y = 0\ if\ otherwise$

$$P_I = P\left(Y = \frac{1}{X}\right) \ldots\ldots (3.1)$$

$$P_i = P(y_i^* < y_i) \ldots\ldots (3.2)$$

$$P_i = P\left(Z_i^* < \beta_o + \beta_i X_{ji}\right) = F(Y_i) \ldots\ldots (3.3)$$

$$P\left(Y = \frac{1}{X}\right) = F(XB) = \frac{1}{\sqrt{2\pi}} \int_{-\propto}^{z} e^{\frac{s^2}{2}}\, ds \ldots\ldots (3.4)$$

Where $X = \left(1, X_{1j}, X_{2j} \ldots \ldots . . X_{kj}\right)$ …………………………… (3.5)

$$\beta^i = \beta_o, \beta_1 \ldots \ldots \ldots, \beta_k$$

Where p is the probability that a farmer will make a certain choice, s is a random variable normally distributed with mean zero and a unit variance. Y_i is the dependent variable (GASIP participation) and y_i * is the threshold value of the dependent variable.

The estimate of the index Z_i is obtained by the inverse of the cumulative normal function by

$$yi = F^{-1}(P_I) = \beta_O + \sum \beta_{KI} X_{KI} + U_I \ldots\ldots (3.6)$$

The estimates of the parameter β_s from the probit model, in addition to revealing how changes in the explanatory variable impact the probability of participation, also indicate the relative influence of each explanatory variable on the likelihood of a farmer participating in GASIP. This information can be derived in the following way.

$$\frac{\partial P_I}{\partial X_{JI}} = \beta_{IJ} * F(Z_I) \ldots\ldots (3.7)$$

Where the mean of estimated probability that Farmer will participate in GASIP.

$F(Z_I) = F^{-1}(P_I)$.. (3.8)

The elasticity of the predicted probability is then computed as:

$\frac{\partial P_I}{\partial X_{JI}} = \beta_O * F(Z_I) * \frac{\times}{P_I}$...................................... (3.9)

The Empirical Model:

$$GASIP\ Participation = \beta_0 + \beta_1 Age + \beta_2 Sex + \beta_3 Education + \beta_4 Married + \beta_5 Remittance + \beta_6 Access\ to\ irrigation + \beta_7 HH\ size + \beta_8 Farming\ Experience + \beta_9 Farm\ size + \beta_{10} Land\ ownership + \beta_{11} Access\ to\ inputs + \beta_{12} Access\ to\ market + \beta_{13} Credit + \beta_{14} FBO + \beta_{15} Household\ income + \beta_{16} Non - farm\ income + \beta_{17}\ Farm\ output + \varepsilon_i \quad \text{..................... (3.10)}$$

β_i=parameters to be estimated, ε=error term

3.7 Endogenous-switching Poisson with count outcome

Research Objective 2: Assess the effect of smallholder farmers' participation in GASIP programme on the adoption of climate-smart agriculture practices.

The Endogenous-Switching Poisson Model is applied to assess smallholder farmers' adoption of Climate-Smart Agricultural Practices (CSAPs) under the Ghana Agricultural Sector Investment Program (GASIP). This model helps to account for both observed and unobserved heterogeneity, including the endogeneity arising from farmers' participation in GASIP. The adoption decision of CSAPs can be framed using the Random Utility Theory. Farmers adopt CSAPs if the perceived utility of adopting (U_1) exceeds that of not adopting (U_0). The farmer's utility of adopting is a function of the perceived benefits and the costs or risks associated with adoption.

Let the utility from adoption and non-adoption be represented as:

$U_1 = Z' i \delta + \beta GASIP + \varepsilon_i^{(1)}$

$U_0 = Z' i \delta + \varepsilon_i^{(0)}$

Where Z' is the vector of explanatory variables, β is the coefficient for GASIP participation and $\varepsilon_i^{(1)}$ and $\varepsilon_i^{(0)}$ are the stochastic error terms for adoption and non-adoption, respectively.

The decision to adopt occurs when $U_1 > U_0$, leading to the following decision rule:

Adopt CSAPs if $Z' i \delta + \beta GASIP + \varepsilon_i^{(1)} > Z' i \delta + \varepsilon_i^{(0)}$

This difference in utilities forms the basis for modeling the probability of adoption.

Since CSAPs are adaptation techniques, a count data model is chosen (Terza, 1998; Miranda, 2004). Adoption of CSAPs is expected to follow the standard Poisson distribution function, assuming an ith farmer from a random sample N = (1.............n) with a vector of independent variables Z_i, an endogenous dummy representing internal causes, and a stochastic term ε_i.

$$f\left(\frac{CSAPsi}{\varepsilon_i}\right) = \frac{\exp\{-\exp(Z' i \delta + \beta GASIP + \varepsilon_i)\}\{\exp(Z' i \delta + \beta GASIP + \varepsilon_i)\}y_i}{CSAPsi!} \quad (3.11)$$

The coefficients of socio-economic variables (z) and participation in GASIP to be estimated are denoted by δ andβ respectively. The loss of information and variables that are missing are measured by the stochastic error term ε_i. A following process takes into account GASIP participation given a vector of explanatory variables k_i, which may include any or all of the members of Z_i.

$$\text{GASIP}_i = \begin{Bmatrix} 1 \text{ if } k_i\alpha + g_i > 0 \\ 0 \quad \text{if otherwise} \end{Bmatrix} \tag{3.12}$$

Where:

k_i is a vector of explanatory variables influencing GASIP participation, α represents the coefficients of the variables that influence participation and g_i is a stochastic error term, and it is assumed that ε_i and g_i have joint normal distributions, with mean zero and covariance matrix:

$$\text{covariance matrix, } \Sigma = \begin{pmatrix} a^2\sigma\pi \\ \sigma\pi 1 \end{pmatrix} \tag{3.13}$$

Given that ε_i, GASIP_i, and CSAPs_i are independent. Based on the above, the joint restrictive probability density expression of CSAPsi and GASIP_i, given di can be illustrated as:

$$f\left(\text{CSAPs}\ \frac{\text{GASIP}_i}{d_i}\right) = \int_{-\infty}^{\infty} \begin{Bmatrix} \text{GASIP}_i f\left(\frac{\text{CSAPs}_i}{\text{GASIP}=1, d_i, \varepsilon}\right) \text{prob}\left(\text{GASIP}_i = \frac{1}{d_i, \varepsilon_i}\right) + (1 - \text{GASIP}_i) \\ f\left(\text{CSAPs}\frac{1}{\text{GASIP}=0, d_i, \varepsilon_i}\right) \text{prob}\left(\text{GASIPi} = \frac{1}{d_i, \varepsilon_i}\right) \end{Bmatrix} f(\varepsilon_i)\text{GASIP}_i \varepsilon_i \tag{3.14}$$

This integral accounts for the fact that GASIP participation and CSAP adoption are jointly determined, and the unobserved components of both processes may be correlated.

The model was estimated in two steps, In the first stage, a probit model was estimated to predict the probability of participation in GASIP:

$$\text{GASIP}_i = k_i\alpha + g_i \qquad \text{GASIP}_i = \begin{Bmatrix} 1 \text{ if } k_i\alpha + g_i > 0 \\ 0 \quad \text{if otherwise} \end{Bmatrix} \tag{3.15}$$

Where α is the vector of parameters to be estimated.

In the second stage, the number of CSAPs adopted was modeled using the Poisson specification, corrected for endogeneity using a control function approach. The control function λi was introduced to account for the correlation between the unobserved components of GASIP participation and CSAP adoption:

$$Log\langle \mathrm{E}(\mathrm{CSAPs}|\mathrm{GASIP}_i, \mathrm{Zi}, \lambda \mathrm{i})\rangle = \mathrm{Zi}'\delta + \beta \mathrm{GASIPi} + \rho\lambda \mathrm{i} \quad (3.16)$$

Where: $\lambda_i = \phi(\mathrm{k}_i{}'\alpha)/\Phi(\mathrm{k}_i{}'\alpha)$ is the inverse Mills ratio, capturing the selection bias from GASIP participation and ρ is the coefficient on the control function, capturing the extent of endogeneity.

$$GASIP\ Participation = \beta_0 + \beta_1 Age + \beta_2 Sex + \beta_3 Education + \beta_4 Married + \beta_5 Remittance + \beta_7 HH\ size + \beta_8 Farming\ Experience + \beta_9 Farm\ size + \beta_{10} Land\ ownership + \beta_{11} Access\ to\ inputs + \beta_{12} Access\ to\ market + \beta_{13} Credit + \beta_{14} FBO + \beta_{15} Household\ income + \beta_{15} Non - farm\ income + \beta_{16}\ Farm\ outputs + \beta_{17}\ CSAP + \varepsilon_i$$

The explanatory variables for GASIP participation include Age, Sex, Education, Household size, Farming experience, Farm size, Land ownership, Access to inputs, Access to market, Credit, FBO membership, Household income, non-farm income, Farm outputs, and Remittances. For CSAP adoption, the Climate-Smart Agricultural Practices include:

1. Agroforestry
2. Mulching
3. Mixed cropping
4. Mixed farming
5. Crop rotation
6. Improved seed varieties

7. Irrigation management
8. Changing planting time
9. More efficient use of fertilizer
10. Integrated pest management
11. Leaving crop residue
12. **12.** Minimum tillage

3.8 Endogenous-switching Regression

Objective 3: Assess the effect of GASIP participation on the food security status of smallholder farmers.

This study seeks to assess the effect of participation in GASIP activities on household food security. Household food security describes a situation in which all members of a household have consistent and reliable access to adequate, safe, and nutritious food that fulfills their dietary requirements and preferences for a healthy and active lifestyle. It involves not just only the availability of food but also the capacity of households to access and utilize it. it in a way that maintains their well-being. The study will use the following food security measures in understanding farmer's welfare (Boliko *et al*., 2019)

Food Insecurity Experience Scale (FIES) assesses the direct experiences of individuals in terms of food insecurity. It captures the occurrence and intensity of specific experiences related to inadequate access to food. The FIES scores are calculated based on reported experiences, and the severity of food insecurity is categorized into different levels. Higher scores indicate more severe food insecurity. The aggregate scores can be used for comparative analysis across regions or over time (Worldwide, 2013).

Food Consumption Score (FCS) assesses the amount and variety of food consumed by individuals or households. It includes indicators related to different food categories and the frequency of their consumption. The FCS is computed by assigning scores to various food groups based on their nutritional value (Marivoet *et al.*, 2019). The overall score reflects the nutritional quality of the diet the household's food consumption status categorized according to the following thresholds: 0-21: Poor; 21.5-35: Borderline; >35: Acceptable. Comparisons can be made across households or populations (Marivoet *et al*., 2019).

Coping Strategies Index (CSI) evaluates the coping strategies employed by individuals or households in response to food insecurity. It includes a range of strategies, from less severe to more severe measures. The CSI is calculated by assigning scores to reported coping strategies, with higher scores indicating more severe strategies. It provides insights into the adaptive capacity of households facing food insecurity (Maxwell *et al*., 2008).

The study assumes a household's decision to participate or not in GASIPs is not independently determined, but an outcome of self-selection, thus, the need to correct for selectivity bias (Heckman, 1967). There are several econometric techniques for addressing self-selection, including the Heckman model, Propensity Score Matching (PSM), Inverse Probability Weighted Regression Adjustment (IPWRA), and the Endogenous Switching Regression Model (ESRM). Given the ordered nature of food security defined above, this study favours the endogenous switching regression treatment effect model with ordered outcome developed by Gregory (2015). This model is grounded on the assumption that the variables affecting the ordered outcome (food security) vary between the treated (participants) and the untreated (non-participants). According to Gregory (2015), the selection equation which assesses the factors influencing the participation of households in GASIPs can be specified as:

$$GASIP_i f(x) = \begin{cases} 1 \ if \ GASIP_i^* = \beta_j X_{ij} + \varepsilon_i > 0 \\ 0 \ if \ GASIP_i^* = \beta_j X_{ij} + \varepsilon_i \le 0 \end{cases} \quad (.3.17)$$

Where NP_i is participation of farm household in GASIP activities (1 if the farm household participates and 0 if otherwise); X_{ij} denotes j^{th} independent variable and ε_i the error term of the i^{th} household.

The second stage of the switching regression model looks at the determinants of the outcome variable, food security (FS). The model handles the outcome for the treated (participants) and the untreated (non-participants) independently as specified in equations 8a and 8b:

For the participants of GASIPs (treated group)

$$FS_{1i} = \begin{cases} 0 \ if -\infty < \beta_1 X_{1i} + \omega_{1i} > \mu_{10} \\ 1 \ if \ \mu_{10} < \beta_1 X_{1i} + \omega_{1i} \le \mu_{11} \\ \dots \\ 3 \ if \ \mu_{13} < \beta_1 X_{1i} + \omega_{1i} \le \infty \end{cases} , \quad (3.18a)$$

And the non-participants (untreated group) of GASIPs

$$FS_{0i} = \begin{cases} 0 \ if -\infty < \beta_0 X_{0i} + \omega_{0i} > \mu_{00} \\ 1 \ if \ \mu_{00} < \beta_0 X_{0i} + \omega_{0i} \le \mu_{01} \\ \dots\dots\dots. \\ 3 \ if \ \mu_{03} < \beta_0 X_{0i} + \omega_{0i} \le \infty \end{cases} , \quad (3.18b)$$

Where $X_{ki} = k^{th}$independent factors influencing the i^{th} household FS; 0, 1, 2, 3 denoting the food security of farm households. Following Gregory (2015), the error terms between the treatment (selection equation) and the outcome equations is assumed to follow a bivariate normal distribution.

3.8.1 The Average treatment effects

Treatment effect quantify the magnitude of the impact of participation in GASIPs activities on the outcome variable (food security). The ATE measures the magnitude of the effect of participation in GASIPs activities on household food security for randomly selected households from the study area. The ATE can be specified as:

$$ATE_k^S = \frac{1}{N}\frac{1}{S}\sum_{I=1}^{N}\sum_{S=1}^{S}[\Phi\{\mu_{1k} - (X_{1i}\beta_1 + \delta + \lambda_1\eta_{is})\} - \Phi\{\mu_{1k-1} - (X_{1i}\beta_1 + \delta + \lambda_1\eta_{is})\}] - [\Phi\{\mu_{0k} - (X_{0i}\beta_0 + \lambda_0\eta_{is})\} - \Phi\{\mu_{0k-1} - (X_{0i}\beta_0 + \lambda_0\eta_{is})\}] \qquad (3.19)$$

$k = 1, \dots, K,\ K = J + 1, and\ J\ is\ the\ number\ of\ choices.\ \ \mu_0 = -\infty\ and\ \mu_k = \infty, and\ \ \Phi$ is the standard normal cumulative distribution. $T = \omega\ for\ \omega \epsilon (0,1)$ Implies that the treatment indicator has been set to 0 or 1. The S super script represents the switching regression model and N the number of observations.

The Average Treatment Effect on the Treated (ATT) estimates the variation in outcomes for households that participated in GASIP (treatment) by comparing the treated state to the untreated state for a specific household. It is specified as:

$$ATT_j^S = \frac{1}{N}\frac{1}{S}\sum_{I=1}^{N}\frac{1}{E\{\Phi(Z_i\gamma)\}}\left(\Phi\left(\sum_{s=1}^{S}\sum_{\omega=0}^{\omega}\{\mathrm{I} \times (T_i = \omega)\}\Phi(Z_i\ \gamma + \eta_{is}\right) \times [\Phi\{\mu_{1k} - (X_{1i}\beta_1 + \delta + \lambda_1\eta_{is})\} - \Phi\{\mu_{1j-1} - (X_{1i}\beta_1 + \delta + \lambda_1\eta_{is})\}] - \Phi\{\mu_{0j} - (X_{0i}\beta_0 + \lambda_0\eta_{is})\} + \Phi\{\mu_{0j-1} - (X_{0i}\beta_0 + \lambda_0\eta_{is})\}]\right) \qquad (3.20)$$

Table 3.3 below provided a comprehensive description of the variables used in the analysis, detailing their definitions, measurement units, and roles within the study. This table served as a crucial reference point for understanding the dataset's structure, ensuring clarity and consistency in interpreting the findings.

Table 3. 2: Variable Description

Variable	Description	Measurement	Prior expectation
Age	Age of farmer	*Years*	+
Sex	Gender of the farmer	*1 = Male 0 =Female*	+
Education	Educational status of the farmer	*Years*	+
Married	Marital status of the farmer	*1 =married 0 = otherwise*	+
Remittance	Receipt of remittance	*1=Yes, 0=No*	+
HH size	Farmer's household size	*Number of people*	+
HH income	Total income of the household	*GH cedis*	+
Farming Experience	Farmers experience in farming	*Years*	+
Farm size	Farmers farm size	*Hectares*	+
Land ownership	Farmer own land	*1=Yes, 0= No*	+
Extension service	Access to extension services	*1=Yes, 0= No*	+
Credit	Access to credit	*1=Yes, 0= No*	+
FBO	Member of an FBO	*1=Yes, 0= No*	+
Non-farm income	Amount of income from non-farm activities	*GHS*	+/-
GASIP Participation	Respondents GASIPs participation	*1=Yes, 0=No*	+
Farm output	Total yield from farm	*kg*	+
Food security (HDDS)	Food security status	*0=food secure, 1= moderately food insecure 2=severely food insecure*	
Food security (FIES)		*0= food poor, 1= borderline 2=acceptable*	
Food security (CSI)		*0=low or no coping, 1=medium coping and 2=high or severe coping*	

Age

Age refers to the number of years of the farmer. It is expected to have a positive relationship with agricultural productivity and food security. Older farmers often have more farming experience, accumulated knowledge, and well-established social networks, which may positively influence their ability to manage risks and adopt improved practices. Moreover, with age, farmers may become more risk-averse but also more skilled in resource allocation (Asfaw et al., 2021). However, in some cases, advanced age may reduce physical labor capacity, but the positive expectation here assumes that experience outweighs such limitations. According to Matshe and Young (2020), older farmers generally exhibit higher levels of farm productivity due to accumulated knowledge and better decision-making skills.

Sex

Sex refers to the gender of the farmer, where male is coded as 1 and female as 0. The expected sign is positive because male farmers often have greater access to productive resources such as land, credit, extension services, and agricultural inputs. In many rural contexts, men are more likely to participate in commercial farming and decision-making processes, which can enhance food security and productivity. Ragasa et al. (2021) observed that male farmers, due to social norms and structural advantages, often dominate farming activities that require access to resources and larger capital investments.

Education

Education represents the number of years of formal schooling of the farmer. A positive effect is anticipated since education improves farmers' ability to access and use information, adopt new technologies, and manage farm operations effectively. Educated farmers tend to have better farm planning, higher productivity, and improved household welfare. According to Asfaw et al. (2021), farmers with higher educational attainment are more likely to engage in agricultural innovations, which leads to improved food security outcomes.

Married

Marital status is a binary variable coded as 1 for married farmers and 0 for otherwise. A positive effect is expected because married farmers may benefit from larger household labor, shared responsibilities, and increased social capital. Marriage often provides stability and a broader household labor pool, which can boost agricultural productivity. According to Abdulai and Huffman (2020), married households are generally more food secure, partly due to better labor availability and pooling of resources.

Remittance

Remittance refers to whether a household receives financial support from relatives, coded as 1 for yes and 0 for no. The expected sign is positive because remittances serve as additional income sources that can be used for food purchases, farm investments, and other welfare-enhancing activities. Adams and Cuecuecha (2020) noted that remittances significantly improve household food security, especially in low-income rural areas.

Household Size

Household size indicates the number of people living in the household. A positive effect is expected because larger households may provide more labor for farming and other livelihood activities. While larger households also have greater consumption needs, the positive expectation assumes that the additional labor outweighs the consumption burden. Ulimwengu et al. (2021)

found that in many rural contexts, larger households with working-age members tend to have higher agricultural productivity and food security.

Household Income

Household income represents the total income of the household, measured in Ghanaian cedis. A positive effect is expected since higher income enables households to afford sufficient and diverse food, invest in agricultural inputs, and improve their overall welfare. According to the Food and Agriculture Organization (FAO, 2021), household income is one of the strongest determinants of food security, particularly in developing countries.

Farming Experience

Farming experience refers to the number of years the farmer has been involved in agricultural activities. The expected sign is positive because experienced farmers usually have better knowledge of agricultural practices, risk management, and resource use, which can lead to improved productivity. Abdulai and Huffman (2020) also highlighted that farming experience enhances farmers' ability to respond effectively to climate variability and market conditions.

Farm Size

Farm size measures the total area of land under cultivation, expressed in hectares. A positive relationship is expected because larger farms allow for more extensive agricultural activities, economies of scale, and surplus production for markets. Barrett et al. (2022) argue that farm size is a key determinant of agricultural productivity and food security, as larger landholdings often result in higher output levels.

Land Ownership

Land ownership is a binary variable indicating whether the farmer owns the land, coded as 1 for yes and 0 for no. A positive effect is expected because secure land tenure encourages long-term investments in land improvements, soil conservation, and technology adoption. Place (2021) notes that land ownership fosters greater investment in land productivity and enhances food security through increased access to credit and reduced vulnerability.

Extension Service

Extension service refers to farmers' access to agricultural advisory services, coded as 1 for yes and 0 for no. The expected sign is positive since extension services provide crucial information, training, and technology dissemination, leading to higher agricultural productivity and better food security outcomes. According to Jones (2021), extension services play a significant role in promoting improved farming practices and strengthening household food security.

Credit

Credit represents farmers' access to loans or credit services, coded as 1 for yes and 0 for no. A positive effect is expected because access to credit enables farmers to invest in inputs such as seeds, fertilizers, and machinery, which enhances productivity. Mwangi and Muturi (2023) found that access to credit significantly increases farm yields and household food security in many rural areas.

FBO Membership

This variable indicates whether the farmer is a member of a Farmer-Based Organization (FBO), with 1 denoting membership and 0 indicating non-membership. The expected effect is positive because FBO membership facilitates better access to inputs, markets, credit, and training programs, thereby improving agricultural productivity and household food security. Osabohien et al. (2022) reported that FBO participation enhances both income generation and food security by reducing market risks and transaction costs.

Non-farm Income

Non-farm income refers to income generated from non-agricultural activities, measured in Ghanaian cedis. The expected effect can be either positive or negative. On the one hand, non-farm income diversifies income sources, providing additional resources for food and investment, thus improving food security. On the other hand, heavy reliance on non-farm income may reduce attention to farming activities, potentially diminishing agricultural productivity. Ruben et al. (2020) suggest that the impact of non-farm income depends on how it complements or competes with agricultural labor.

GASIP Participation

GASIP participation captures whether a farmer participates in the Ghana Agricultural Sector Investment Programme, with 1 indicating participation and 0 otherwise. A positive effect is anticipated because participation in GASIP typically improves farmers' access to inputs, training, credit, and market linkages. GASIP aims to enhance productivity, food security, and rural livelihoods through targeted interventions (GASIP Annual Report, 2022).

Farm Output

Farm output refers to the total quantity of agricultural produce harvested by the household, measured in kilograms. A positive relationship is expected because higher farm output directly improves food availability for the household, increases income through market sales, and strengthens food security. Barrett et al. (2022) emphasized that farm output is a critical determinant of food security in both subsistence and market-oriented farming systems.

Conclusion

This chapter has outlined the methodological framework employed in investigating the effects of the Ghana Agricultural Sector Investment Programme (GASIP) on smallholder farmers' food security and the adoption of Climate-Smart Agricultural Practices (CSAPs) in the Upper East Region of Ghana. The study area was described in detail, highlighting the region's agro-ecological, climatic, and demographic features that influence agricultural activities. The study adopted a cross-sectional research design, leveraging primary data collected through structured questionnaires across selected districts. A multi-stage sampling technique was applied to ensure representation of both GASIP participants and non-participants, yielding a total sample size of 400 farming households.

The chapter also presented the theoretical and conceptual underpinnings of the study, grounded in the Sustainable Livelihoods Framework, Random Utility Theory, and Household Utility Maximization Theory. These frameworks support the examination of how participation in GASIP influences livelihood outcomes through enhanced access to resources and services.

To achieve the research objectives, the study employs robust econometric models. A Probit model is used to identify the determinants of GASIP participation. An Endogenous Switching Poisson Model captures the intensity of CSAP adoption while correcting for selection bias. Finally, an Endogenous Switching Regression Model (ESRM) is employed to estimate the impact of GASIP participation on food security outcomes, specifically the Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and Coping Strategies Index (CSI). These models allow for rigorous analysis of the interrelationships among program participation, technology adoption, and food security status, while accounting for potential endogeneity and self-selection.

The chapter concludes with a detailed description of all variables used in the study, including their measurements and expected relationships. The next chapter presents the empirical results and discussion based on the estimation of the models specified in this chapter.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the empirical findings derived from the analysis of primary data collected from smallholder farmers in the Upper East Region of Ghana. The chapter begins by providing a detailed overview of the socio-economic and demographic characteristics of the sampled households, laying the foundation for understanding the context within which agricultural decisions are made.It then proceeds to analyze the factors influencing farmers' participation in the Ghana Agricultural Sector Investment Programme (GASIP), using a Probit regression model to identify the significant socio-economic and institutional variables shaping participation decisions. This is followed by an exploration of the extent to which farmers adopt Climate-Smart Agricultural Practices (CSAPs), with particular emphasis on the influence of GASIP participation. The analysis employs an Endogenous Switching Poisson Regression model to account for both observed and unobserved heterogeneity in CSAP adoption outcomes.

The chapter further investigates the determinants of household food security, utilizing food security indicators such as the Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and the Coping Strategy Index (CSI). Finally, it assesses the causal impact of GASIP participation on household food security through an Endogenous Switching Regression model, which corrects for potential self-selection bias and provides robust estimates of the treatment effects. Collectively, the findings in this chapter provide critical insights into how agricultural policy interventions shape smallholder farmers' livelihoods and resilience to food insecurity in Northern Ghana.

4.1 Descriptive Statistics of Respondents

Table 4.1 presents the descriptive statistics, offering an overview of key socio-economic and agricultural variables used in the analysis of household food security. These variables capture essential household characteristics, resource access, and livelihood activities, offering a comprehensive snapshot of the sample population.

Table 4.1: Descriptive Statistics

Variable	Measurement	Mean	SD	Minimum	Maximum
Age	*Years*	44.751	11.553	20	78
Sex of household head	*1=Male 0=Female*	0.488	0.5	0	1
Marital status	*1 =married 0 = otherwise*	0.885	0.318	0	1
Education	*Years*	3.766	2.407	1	19
Household size	*Number of people*	7.12	3.265	1	25
Landownership	*1=Yes, 0=No*	0.771	0.421	0	1
Farm experience	*Years*	20.622	13.002	1	60
Household monthly income	*GH cedis*	1203.629	3482.628	65	45000
Remittance	*1=Yes, 0= No*	0.122	0.328	0	1
Non-farm activity	*GH cedis*	3163.086	4794.886	0	45000
Crop Diversification	*1=Yes, 0= No*	0.817	0.387	0	1
Farm output	*Kg*	17.292	14.311	0.4	45
TLU	*Unit*	4.019	8.358	0	74.05
Access to credit	*1=Yes, 0=No*	.239	.427	0	1
FBO	*1=Yes, 0=No*	.605	.489	0	1
Extension service	*1=Yes, 0=No*	.693	.462	0	1

Age

The age of farmers significantly impacts their ability to perform tasks, ultimately affecting the overall quality of the farm workforce. From the results estimated, an average age of around 44.75, the farmer population leans towards middle-aged. However, the wide range in ages, from a young farmer as young as 20 to a seasoned one at 78, indicates a diverse group. This variation in age can influence farming practices and productivity as experience and physical capabilities typically change throughout life. As research by Siva and Gupta et al. (2019) suggests, this likely means a farming population with a wealth of experience, balanced by the inclusion of younger individuals.

Sex of Respondents

The sex composition of household Leadership is essential in shaping the dynamics of smallholder farming and subsequent socio-economic outcomes. Research consistently emphasizes the importance of understanding sex disparities in agricultural contexts, as these disparities can significantly influence productivity, resource allocation, and overall well-being. Studies have demonstrated that the sex of the household head can impact the allocation of resources and decision-making processes within farming households Doss and Quisumbing et al. (2018). The data presented in the table indicates a near-parity distribution of male and female household heads, with a mean value of 0.49, suggesting that female-led households constitute a significant portion (almost 50%) of the sample. This finding aligns with the high standard deviation of 0.50, further reflecting a balanced representation of both male and female. Such a balanced sex distribution is critical for conducting robust assessments of the impact of agricultural policies and interventions. It ensures that evaluations account for the diverse experiences of both male and female household heads, leading to more comprehensive policy recommendations.

The near-equal distribution of male and female among household heads allows for a more nuanced analysis of sex-specific challenges and opportunities within the agricultural sector. Research by Doss et al. (2015) underscores the necessity of incorporating sex sensitivity into agricultural policy design to effectively address these challenges. Similarly, evidence from World Bank studies Power et al. (2018) highlights that equitable participation of both male and female in influencing agricultural decision-making can enhance both productivity and overall well-being outcomes.

Marital Status of Respondents

The marital status variable in the dataset reveals significant insights about the sample population. Marital status, coded as 1 = Married and 0 = Otherwise (single, divorced, or widowed), has a mean value of 0.885, indicating that 88.5% of the sampled individuals are married. This dominance is further reinforced by the frequency distribution, with 363 individuals (88.54%) married, 33 (8.05%) single, and 14 (3.41%) divorced. The standard deviation of 0.318 highlights limited variability, while the binary coding (minimum = 0, maximum = 1) confirms the appropriateness of the variable. The overwhelming prevalence of married individuals reflects societal norms, particularly in rural or agrarian communities where marriage facilitates economic cooperation and reliance on family labor for farming and livelihood activities. This aligns with Ahmed *et al*. (2023)**,** who emphasize that marital status influences household decision-making, resource allocation, and participation in agricultural programs. Similarly, Manda *et al*. (2022) report that married households are more likely to adopt Climate-Smart Agricultural Practices (CSAPs) due to shared resources and joint decision-making.

The low percentages of single (8.05%) and divorced (3.41%) individuals highlight their relative rarity in the dataset. However, as Mwangi and Muturi (2023) argue, single households may face unique challenges, such as limited labor availability and higher dependency ratios, which could negatively impact food security. Likewise, divorced individuals may experience economic hardships due to the dissolution of shared resources, as noted by Rahman *et al*. (2021). These findings underscore the importance of considering marital status heterogeneity when analyzing household dynamics and designing interventions.

The bar chart in figure 4.1 visually captures the disparity in marital status, with the "married" category towering over the "single" and "divorced" groups. This dominance underscores the need for targeted interventions that address the unique vulnerabilities of single and divorced individuals, despite their smaller representation.

Married households, with their larger family sizes, often benefit from enhanced labor availability and income diversification, which contribute to resilience against food insecurity **(**Rahman et al., 2021**).** Furthermore**,** Osabohien et al. (2022) found that married households tend to have better dietary diversity and food security outcomes compared to their non-married counterparts. This is consistent with the findings of this dataset, where marriage appears to be a key determinant of household well-being.

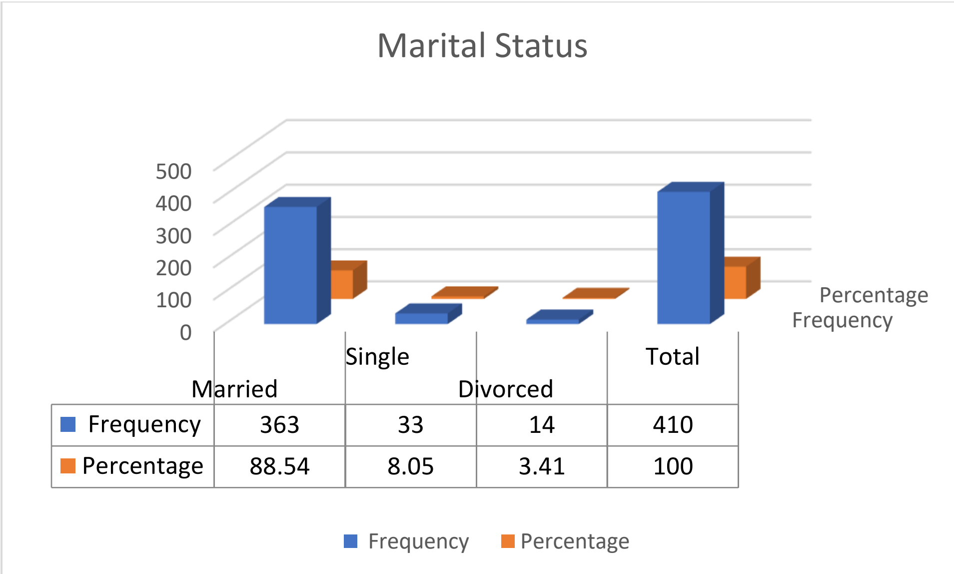

Figure 4 1 Marital Status of Respondents

The results reveal an average household size of approximately 7 members indicative of large families typically found in agrarian communities. However, a moderate to high level of variability is evident, as reflected by the standard deviation of 3.26 members. This signifies that while the average household comprises 7members, individual households can deviate from this mean by 3.26 members. The spectrum ranges from single-person household (1 member) to extended families or households with multiple generations (25 members).

These larger household sizes translate into increased demand for resources such as food, housing, education, and healthcare. While larger households offer the potential for greater agricultural labour force, thereby augmenting productivity, they also face amplified consumption needs, which can potentially impact their overall well-being. The observed heterogeneity in household sizes, encompassing single-person units to those with 25 members, underscores the necessity for adaptable interventions that cater to the specific requirements of diverse household structures. From an economic standpoint, larger households may benefit from economies of scale, such as shared household expenditures. However, they also experience intensified economic pressure to provide for a greater number of members, potentially compromising their overall welfare A study conducted by Coleman *et al*. (2022) investigating rural household dynamics documented that larger households often grapple with significant challenges in resource allocation, but benefit from the availability of shared labour for agricultural activities. Similarly, Upton, *et al*. (2021) highlighted the significant influence of household size on both consumption patterns and economic resilience within farming communities.

Based on the results on the Table 4.1, the sample shows an average educational attainment of around five years, corresponding to primary education and indicating a basic level of formal schooling. However, there is significant variability, as shown by a standard deviation of 5.74 years, indicating large disparities in educational achievement among individuals. The education levels range from zero years, indicating illiteracy or lack of access to schooling, to a maximum of nineteen years, potentially indicating a bachelor's degree or higher. These statistics highlight a concerning trend of educational inequality within the sample population. The variation in educational attainment has significant implications for economic opportunities. Individuals with more years of education likely have better job prospects and earning potential, while those with fewer or no years of education may face limited job opportunities and economic challenges.

These findings highlight the crucial need for targeted educational interventions. These should focus on improving literacy rates 0, ensuring access to basic education, and promoting continuous learning and vocational training programs to enhance the skills and employability of the population. The importance of addressing educational disparities is supported by recent research. Lee *et al*. (2022) found a positive correlation between educational inequality and reduced economic development and social mobility. Similarly, Domínguez *et al*. (2023) emphasized that improving access to education, especially in rural areas, leads to better economic outcomes and reduced poverty levels.

Land ownership

Land ownership is a crucial factor influencing agricultural productivity and economic stability among farmers. Analyzing the land ownership results from the sampled farmers provides valuable insights into its importance. The average value for land ownership is approximately 0.77, indicating that most of the sampled farmers own their land. With a standard deviation of 0.42, there is notable variability in land ownership status,

According to Smith *et al*. (2022) land ownership is essential for several reasons. Owning land provides farmers with the security needed to invest in agricultural practices, which is essential for long-term planning and sustainability in farming. Land ownership significantly enhances farmers' access to credit, as lenders often require collateral, and farm lands with documentation serves as a valuable asset for securing loans, enabling farmers to invest in better seeds, fertilizers, and equipment Farmers with land ownership are more likely to obtain essential agricultural inputs, such as fertilizers and improved seed varieties, which can boost productivity and crop yields.

Research indicates that land ownership correlates with increased economic stability for farmers. A study by Stukes *et al*. (2023) found that landowners are more likely to invest in sustainable practices, leading to improved long-term productivity. A report by the International Fund for Agricultural Development (2024) highlighted that land ownership increases the likelihood of obtaining loans by 40%, as banks view land as a reliable form of collateral. A meta-analysis by Chen *et al*. (2023) found that farmers with secure land tenure are 25% more likely productive compared to those without, primarily due to better investment in inputs and technology practices.

The above results show a significant level of expertise, averaging 20.62 years in agriculture. The standard deviation of 13 years indicates a broad spectrum of experience, including both newcomers with just 1 year and veterans with up to 60 years. This variation ensures a balanced representation of both novice and seasoned farmers. Studies affirm a positive correlation between farming experience and superior agricultural performance. Khuu *et al.* (2024) highlighted that experience enhances productivity and improves farm management practices. Recent research by Ntiamoah *et al.* (2024, a study on smallholder pineapple farmers found that those with more experience who adopted agricultural innovations achieved higher technical efficiency. Their expertise allowed them to effectively implement new practices and technologies, resulting in improved productivity.

Similarly, research by Sarpong *et al*. (2023) on soybean farmers in Northern Ghana showed that experience positively affects productivity. Farmers engaged in contract farming schemes, often those with more experience, achieved better results. These arrangements offered stability and resources that might be challenging for less experienced farmers to secure on their own. An investigation into agricultural extension services in Northern Ghana revealed that experienced farmers who participated in these programs saw significant boosts in productivity and income compared to non-participants. The programs provided valuable knowledge and resources that experienced farmers could utilize more effectively.

Additional study by Bannor *et al*. (2023) on rice farmers underscored the relationship between experience and access to credit. Farmers with extensive experience and access to input credit schemes demonstrated significantly higher productivity. Their experience enabled them to effectively use the credit to purchase high-quality inputs and manage their farms more efficiently.

Household Income

The average household monthly income among the sample was approximately 1,203.63 cedis, suggesting modest income levels. The substantial standard deviation of 3,482.63 cedis indicates significant variability, with some households earning far above or below the average. The minimum income of 0 reflects that some households may not have earned monetary income during the survey period, possibly due to seasonal variations in agricultural earnings or reliance on non-monetary resources like savings, in-kind transfers, or credit. In contrast, the maximum income of 45,000 cedis highlights a significant disparity, indicating varying levels of economic activities and access to income-generating opportunities among households. Recent studies support these findings. Abudu *et al*. (2023) found that household income in rural areas is highly influenced by access to markets, agricultural productivity, and diversification of income sources. Households better market access can mean higher output prices or the ability to sell at the farmer's convenience, but it is important to recognize that these benefits depend on whether households produce for sale or own consumption. Additionally, agricultural productivity directly impacts income levels; more productive farms generate higher revenues. Diversification of income sources, such as engaging in non-farm activities, also plays a critical role in boosting household income and reducing vulnerability to agricultural shocks.

A study on smallholder farmers in Ghana revealed that households with diversified income sources and access to credit facilities had higher and more stable incomes (Ehiakpor *et al.*, 2018). Furthermore, a study by Abudu *et al*. (2023) emphasized that access to agricultural extension services and input credit schemes significantly enhances household income by improving farm productivity and management practices.

Remittances

The findings suggest that only 12.2% of households in the sample received remittances, given the mean value of 0.122. This relatively small percentage suggests that Remittances do not serve as the main income source for most households. The high standard deviation of 0.328, compared to the mean, indicates significant variability in remittance receipt,

The low level of remittance receipt may be due to factors like limited migration opportunities, poor access to remittance channels, or a lack of family members in larger cities or abroad. Otame *et al.* (2023) explain that remittances can significantly enhance household welfare by supplementing income and providing a cushion against economic shocks. However, in this case, the limited reliance on remittances could suggest a vulnerability to income shocks, as these households may lack other sources of income.

Non-farm activities

Household income from non-farm activities averages 3,163.09 cedis, but the large standard deviation of 4,794.89 cedis indicates significant differences in earnings from these sources. The income range, which spans from 0 to 45,000 cedis, shows that while some households do not earn anything from non-farm activities, others make substantial amounts. This wide variation suggests that participation in non-farm activities varies considerably and likely depends on factors such as the availability of local employment opportunities, skills, and education. Non-farm activities are essential for diversifying household income, especially in rural areas where agricultural income can be unpredictable. Downs *et al*. (2021) highlights the importance of non-farm activities in stabilizing household income, reducing poverty, and enhancing resilience to agricultural shocks. Households with higher non-farm income tend to have improved access to markets, education, or a broader range of skills, enabling them to earn significantly more. In contrast, those with little or no non-farm income may be more exposed to agricultural risks, underscoring the need for policies that promote non-farm employment opportunities.

Crop Diversification

The mean value of 0.817 indicates that 81.7% of households practice crop diversification, with a standard deviation of 0.387 signifying some differences in how widely this practice is adopted among households. Thus, while most households diversify their crops, a smaller proportion do not, possibly due to limited resources or a lack of awareness about the benefits of diversification. Crop diversification is an important strategy for managing risk, particularly for agricultural households that rely largely on crop production for their livelihoods. By diversifying their crops, households can reduce the risk of complete crop failure and enhance food security, and create multiple income streams. Vernooy *et al*., (2022) explained that crop diversification can enhance soil health and boost resilience to climate change. The high level of crop diversification in this sample suggests that many households understand these benefits, although the variability indicates that some may lack the necessary resources or knowledge to implement these practices effectively.

Farm Output

From Table 4.1 farm output in the data show a mean of 17.292 bags, with a standard deviation of 14.311 bags, a minimum of 0.4 bags, and a maximum of 45 bags. This suggests significant variation in the amount of produce across households. While the average farm output is around 17 bags, some farmers produce very little (close to 0.4 bags), while others achieve higher yields (up to 45 bags). The relatively large standard deviation indicates considerable differences in farm output, which can be attributed to various factors influencing agricultural productivity. The mean of 17.292 bags represents the typical output for smallholder farmers in the dataset. This level of production is common in regions with small-scale, subsistence-oriented farming, where resources such as land, inputs, and access to markets may be limited. However, the high standard deviation of 14.311 bags reveals a wide variability in production. Some farmers may face constraints like poor soil fertility, inadequate access to modern farming inputs, or unfavorable weather conditions, leading to lower yields, while others may benefit from better access to resources or more effective farming practices, resulting in higher output.

The range between 0.4 and 45 bags further highlights this disparity. The minimum value of 0.4 bags could indicate that some households are producing only for subsistence or experiencing low productivity, possibly due to environmental factors or limited access to agricultural resources. On the other hand, the maximum value of 45 bags suggests that some farmers are able to achieve much higher levels of productivity, likely due to better access to inputs, advanced farming techniques, or favorable climatic conditions.

This pattern of variation in farm output is consistent with findings from recent studies. Barrett *et al*. (2022) emphasizes that agricultural outputs among smallholder farmers can vary significantly due to factors such as land access, input use, and market access. In many parts of sub-Saharan Africa, where smallholder farming predominates, low productivity is often linked to limited use of modern farming technologies, which aligns with the wide variation in your data.

Similarly, Osabohien *et al.* (2023) note that smallholder farmers in regions like Ghana often experience fluctuating yields due to environmental factors, such as irregular rainfall patterns. This variability can create income instability, which may explain the significant differences in farm output observed in the dataset. Furthermore, Rahman *et al*. (2021) discuss the various constraints on farm productivity, such as poor soil quality, lack of access to credit, and limited technical knowledge. These factors contribute to the large disparities in farm yields, as observed in your data. Farmers who have better access to extension services, training, and credit tend to perform better, which could account for the higher outputs seen in certain households.

Total Livestock Units (TLU)

The average Total Livestock Units (TLU) among the households is 4.019, with a standard deviation of 8.358, indicating significant variability in livestock ownership. The range of TLU ownership spans from 0 to 74.05, showing that while some households have no livestock, others own substantial herds, reflecting considerable differences in livestock assets.

Livestock ownership plays a crucial contribution to rural livelihoods by supplying food and generating income, and serving as a form of savings or insurance. Households with higher TLU are often better equipped to withstand economic shocks and benefit from diversified income sources. Thornton and Herrero (2014) highlight that livestock can enhance household resilience, particularly in areas where crop production is uncertain. The wide range in TLU ownership underscores disparities in wealth and resource access among households, which can impact their economic stability and ability to invest in other productive activities.

Access to Credit

In this sample, only 23.9% of households had access to credit, as reflected by the mean value of 0.239. The standard deviation of 0.427 highlights the variability in access to financial services, with a significant number of households lacking credit opportunities. The binary range (0 to 1) indicates that while some households can secure credit, the majority are unable to, which may limit their capacity to enhance productivity through investment enhancing activities.

Access to credit is vital for enabling households to invest in agriculture, start small businesses, or manage unexpected expenses. Macharia *et al*. (2021) found that access to credit can substantially improve agricultural productivity and household income by allowing farmers to purchase inputs and adopt better technologies. The limited credit access observed in this sample suggests that many households face financial constraints that impede their economic growth and ability to enhance their livelihoods.

Farmer-Based Organization (FBO) Membership

With a mean value of 0.605, the data shows that 60.5% of households are members of Farmer-Based Organizations (FBOs), with a standard deviation of 0.489 indicating some variability in membership. The range (0 to 1) shows that while FBO membership is relatively common, a notable minority of households are not members, potentially missing out on the benefits these organizations provide. FBOs play a critical function in supplying farmers with access to resources, training, and collective bargaining power. Kolavalli *et al*. (2020) emphasizes that FBOs help enhance smallholder farmers' access to resources and markets, leading to better economic outcomes. Membership in an FBO can enhance a household's ability to access resources, share knowledge, and market their produce more effectively. The variability in FBO membership in this sample suggests that while many households benefit from these organizations, others may be excluded due to factors such as geographical isolation, lack of awareness, or financial barriers.

Extension Service Access

The mean value of 0.693 indicates that 69.3% of households had access to agricultural advisory services, suggesting that a majority of households received advice and support to improve their farming practices. The standard deviation of 0.462 reflects some variability, and the range (0 to 1) shows that while access is relatively widespread, there are still households without it.

Agricultural extension services are crucial for spreading new technologies, best practices, and innovations that can enhance farm productivity. (Anang *et al*. 2020) found that access to extension services is strongly linked to improved farm productivity and income. The relatively high access rate in this sample suggests that many households are able to benefit from these services, though the variation indicates that some households may miss out on opportunities to improve their agricultural practices and income due to limited access.

4.2 Determinants of GASIP Participation

The Probit model on the determinants of GASIP participation, as presented in Table 4.2, provides insights into the factors influencing whether smallholder farmers engage in the program. The findings indicate that GASIP awareness is the most significant factor, strongly increasing the likelihood of participation. Other key factors positively associated with participation include age, education, crop diversification, landownership, and access to credit. However, factors such as gender, farm experience, household size, and ownership of a mobile phone negatively influence participation.

The pseudo-R-squared of the probit model value of 0.7602 suggests that the model accounts for a significant amount (76%) of the variation in GASIP participation, which is quite high for a probit model. The chi-square statistic of 113.27 with a p-value less than 0.01 confirms that the model is highly significant overall, meaning that the independent variables collectively have a strong explanatory power regarding participation.

Table 4. 2: Probit Model on Determinants of GASIP Participation

VARIABLES	Coefficients	Marginal Effects
GASIP Awareness	4.215***	0.379***
	(0.423)	(0.026)
Age	0.027**	0.002**
	(0.013)	(0.001)
Sex	-1.267***	-0.114***
	(0.287)	(0.027)
Farm experience	-0.017	-0.001
	(0.012)	(0.001)
Household size	-0.018	-0.002
	(0.041)	(0.004)
Education	0.109**	0.010**
	(0.054)	(0.005)
Farm size	-0.082	-0.007
	(0.053)	(0.005)
Crop Diversification	0.837**	0.075**
	(0.357)	(0.032)
Landownership	1.278***	0.115***
	(0.311)	(0.029)
Access credit	0.601**	0.054**
	(0.261)	(0.024)
Radio	-0.449*	-0.040**
	(0.270)	(0.024)
Bicycle	0.358	0.032
	(0.270)	(0.024)
Mobile	-0.733**	-0.066*
	(0.366)	(0.034)
Constant	-4.143***	
	(0.828)	
Observations	410	
Pseudo r-squared	0.7602	
Chi-square	113.27	
Prob > chi2	0.000	

Standard errors in parentheses where,
*** p<0.01, ** p<0.05, * p<0.1

The statistically significant (at 1%) with a positive coefficient for GASIP awareness indicates that being aware of GASIP has a positive effect on participating in the GASIP program. The marginal effect of 0.379 means that households who were aware of GASIP were 37.9% more likely to participate compared to those who were not aware. This finding aligns with the broader literature on, where awareness and access to information are consistently highlighted as key factors driving participation in agricultural programs (Bhanot *et al*., 2022). In the context of agricultural extension services and rural development programs, awareness often translates to increased engagement because it helps farmers understand the benefits and processes associated with the program (Feder and Murgai *et al*., 2004).

The positive coefficient for age with a significant level of 5%, though small, suggests that older individuals have a slightly higher probability of participating in GASIP. The marginal effect of 0.002 indicates that each additional year in age increases the likelihood of participation by 0.2%. This trend is consistent with findings in agricultural adoption studies, where older farmers are often found to have accumulated more experience and are better able to evaluate the potential benefits of new programs (Asfaw and Simane, *et al*., 2017). However, the small magnitude of this effect also suggests that age, while statistically significant, is not the primary driver of participation.

The negative and highly significant (at 1%) coefficient for sex (-1.267) indicated that likelihood of male farmers taking part in GASIP is lower than that of female farmers. Males are 11.4% less likely to participate, according to the marginal effect.

This result is significant as it suggests potential biases or differences in how the program is perceived or accessed by different sexes. Research by Doss and Meinzen-Dick. (2018) highlights that woman often have different roles and responsibilities in agriculture, which may align more closely with the objectives of programs like GASIP, making them more likely to participate since the program objective is targeting smallholder farmers and resource-poor rural people, in particular women and the youth

The statistically significant (at 5%) and positive coefficient for education (0.109) indicated that higher educational attainment increased the probability of GASIP participation. An extra year of education increased the likelihood of involvement by 1%, according to the marginal effect of 0.010. The adoption of new agricultural technologies and practices depends heavily on education since it gives farmers the information and abilities they need to understand and implement program components effectively (Ragasa and Lambrecht *et al*., 2018). Educated farmers are often better positioned to access information and resources, which enhance their participation in programs like GASIP.

The coefficient that is both positive and significant (at 5%) for crop diversification (0.837) signified that households that practised crop diversification were more likely to participate in GASIP. The marginal effect of 0.075 implied that such households had a 7.5% higher probability of participating than those who did diversify their crop production. Crop diversification is often associated with greater resilience to environmental and market risks, making diversified farms more likely to engage with programs that offer additional support and resources (Kassie and Wale, 2022). This aligns with the literature suggesting that diversified farming systems are more adaptable and open to innovation (Van *et al*., 2014)

Land ownership emerged as a significant (at 1%) positive coefficient of 1.278. The marginal effect indicated that owning land increased the probability of GASIP participation by 11.5%. Land ownership is often a prerequisite for participating in agricultural programs, as it provides the security and resources needed to make long-term investments (Holden and Ghebru, 2016).

Moreover, landowners are more likely to perceive the benefits of programs like GASIP as directly impacting their primary asset, which is their land. This perception increases their motivation to participate, as they can see tangible improvements in land productivity, sustainability, and economic returns. In the context of GASIP, this is particularly relevant, as the program focuses on enhancing agricultural productivity through Climate-Smart Agricultural Practices (CSAPs) and infrastructure development, which directly benefit landowners.

Access to credit was another crucial determinant of participation, with a coefficient of 0.601 (significant at 5%) and a marginal effect of 0.054. Credit accessible households were 5.4% more likely to engage in GASIP than those without access. This finding underscores the importance of financial inclusion in enabling farmers to commit to inputs and technologies that boost productivity, which are often necessary for successful participation in agricultural programs (Karlan and Osei, 2014). Credit access reduces liquidity constraints, allowing farmers to fully leverage the opportunities offered by programs like GASIP.

The negative coefficient for radio ownership (-0.449) presents an intriguing paradox, as one would generally expect access to information via radio to facilitate increased participation in programs like the Ghana Agricultural Sector Investment Program (GASIP). The observed marginal effect of -0.040 suggests that households with access to radios were 4.0% less likelihood to participate in GASIP, a finding that is significant at the 10% level. Several explanations can account for this unexpected result. First, the nature of the information disseminated through radio could play a crucial role. If the content primarily focuses on alternative agricultural practices or emphasizes challenges in the agricultural sector rather than promoting the specific benefits of GASIP, it may inadvertently dissuade participation. For instance, if radio programs prioritize topics such as market fluctuations or climatic challenges without emphasizing the support offered by GASIP, potential participants may feel that the program does not address their needs or concerns.

Additionally, socio-economic dynamics linked to radio ownership might further illuminate this negative association. Households that possess radios may be more economically stable or engaged in diverse income-generating activities, leading them to rely less on agricultural programs like GASIP. In this scenario, the availability of alternative information channels might cultivate a sense of self-sufficiency, thereby diminishing the perceived necessity to engage with GASIP.

Furthermore, radio ownership might also provide access to diverse viewpoints and sources of information, potentially creating confusion or skepticism regarding the advantages of program participation. For example, if these households receive competing narratives that highlight the risks or inefficiencies of participating in government programs, it could deter them from enrolling in GASIP.

This finding aligns with Aker's (2011) assertion that access to information does not always equate to improved outcomes; rather, the relevance and alignment of that information with the program's goals are crucial for effective participation. Consequently, this negative relationship underscores the importance of ensuring that information communicated through mass media aligns with the objectives of agricultural programs, reinforcing their perceived value and encouraging participation. Further research could explore the specific content of radio programming and its impact on farmers' decision-making processes regarding participation in initiatives like GASIP, thereby providing deeper insights into how information dissemination affects agricultural engagement.

Similarly, mobile phone ownership had a negative coefficient (-0.733), with a marginal effect of -0.066 which was statistically significant at 5%. This indicated that mobile phone owners were 6.6% less likely to participate. This result could be explained by the nature of the information exchanged via mobile phones or the possibility that mobile phones are used for purposes that compete with participation in agricultural programs (Muto and Yamano, 2009). Alternatively, it might reflect the socio-economic status of mobile phone owners, who could have different needs or priorities.

The non-significance of farm experience, household size, farm size, and bicycle ownership suggested that while they might have some intuitive or theoretical relevance, they did not statistically explain the variation in GASIP participation in this dataset. Thus, awareness, education, land ownership, and access to credit, were more critical in influencing participation decisions.

The pseudo-R-squared value of 0.7602 indicates that the model explains a substantial portion (76%) of the variation in GASIP participation, which is quite high for a probit model. The chi-square statistic of 113.27 with a p-value less than 0.01 confirms that the model is highly significant overall, meaning that the independent variables collectively have a strong explanatory power regarding participation.

4.3 Adoption of CSAPs

The table 4,3 outlines the extent to which smallholder farmers have adopted different Climate-Smart Agricultural Practices (CSAPs) aimed at improving resilience and sustainability in agriculture. These practices are designed to enhance productivity, adapt to changing climatic conditions, and mitigate the environmental impact of farming activities. Adoption rates vary significantly across practices, reflecting farmers' preferences, resources, and the perceived benefits or challenges associated with each practice. By identifying which CSAPs are more widely implemented, the results offer valuable insights into farmers' willingness to embrace innovations that promote sustainable farming, and highlights areas where further extension services or interventions may be needed to boost adoption of less popular practices.

Table 4.3: Adoption of CSAPs

CSAPs	Number of farmers	Proportion adopted (%)
Agroforestry	180	43.90%
Mulching	253	61.71%
Mixed Cropping	370	90.24%
Mixed Farming	283	69.02%
Improved Seed Varieties	263	64.15%
Irrigation Management	195	47.56%
Changing Planting Time	277	67.56%
More Efficient Use of Fertilizer	263	64.15%
The Integrated Pest Management	240	58.54%
Leaving Crop Residue	363	88.54%
Minimum Tillage	243	59.27%

Source: Field Survey, 2024

From Table 4.3, about 90% of farmers practised mixed cropping which involved the cultivation of multiple crops on the same plot within the same cultivation season. By optimizing land use and promoting agro-biodiversity, it enhances ecosystem resilience and reduces the risk of total crop failures. Research by Wenda and Synowiec (2021) showed that mixed cropping resulted in higher yields compared to monoculture systems. Their study further indicated that mixed cropping systems can produce more yield than pure stands of crops, particularly in tropical regions where environmental conditions can be challenging. Mixed cropping systems can increase overall productivity, particularly in resource-constrained environments. Moreover, finding by Okunlola (2009) indicate that, mixed cropping can contribute to pest and disease management by disrupting monoculture conditions, thereby reducing reliance on chemical inputs.

Crop residue retention which was practised by 88.54% of farmers is a cornerstone of soil health management. By returning crop residues to the soil, farmers improve soil structure, organic matter content, and water infiltration. Recent finding by Shah and Modi, (2021) shows that the practice is crucial for mitigating erosion, enhancing nutrient cycling, and sequestering carbon. The benefits are particularly pronounced in regions susceptible to drought or heavy rainfall, where soil conservation is paramount.

Mixed farming, which involves the integration of crop cultivation and livestock rearing, was moderately adopted among farmers, with 69.02% embracing this practice. This approach optimizes resource utilization, enhances resilience, and diversifies income streams, making it a valuable strategy for sustainable agriculture. However, the successful implementation of mixed farming requires a broader skill set, higher labor inputs, and often greater initial investments compared to traditional monocropping systems. These challenges are highlighted by Thornton, (2014) who noted that while mixed farming systems are beneficial, they demand significant management expertise and resource allocation.

In order to adjust to the difficulties brought forth by climate change, a significant number of farmers have adjusted their planting times, with 67.56% of them adopting this strategy. This approach demonstrates a proactive step to reduce the dangers associated with unpredictable weather patterns. By optimizing planting dates, farmers can improve crop yields and reduce the likelihood of crop failures. As highlighted by (Singh *et al*., 2024) and supported by (Makate

.(2019), the effectiveness of this strategy depends on access to accurate climate information, a deep understanding of crop phenology, and the flexibility to adapt to changing weather conditions. Without these critical resources, the benefits of adjusting planting times may be limited, underscoring the need for enhanced climate services and agricultural support.

The adoption of better seed types had a 64.15% adoption rate among farmers due to their potential to boost yields, enhance crop quality, and improve resistance to pests and diseases. While these benefits are well-recognized, the widespread adoption of improved seeds is shaped by factors such as seed costs, availability, and the compatibility of new varieties with existing farming systems. Moreover, as Mugo (2020) and Kassie (2018) indicated, farmers often require technical assistance and training to fully realize the benefits of these seeds, highlighting the need for supportive agricultural extension services to facilitate their effective use.

Efficient fertilizer management was used by 64.15% 0f farmers to achieve optimal crop yields while minimizing environmental impacts. Pretty and Bharucha (2015) found that farmers have implemented practices to optimize fertilizer use, such as applying fertilizers based on soil test results and adopting precision agriculture technologies. However, the widespread adoption of efficient fertilizer management is hindered by factors such as access to soil testing services, the availability of affordable fertilizers, and the knowledge and skills required for precision agriculture. About 61.71% of farmers practised mulching It entails applying organic or inorganic elements to the soil's surface. Pretty and Bharucha (2015) explained that Mulching benefits soil by retaining moisture, hindering weed growth, and boosting fertility. However, Sims and Corsi (2018) argued that the availability of suitable mulching materials, the labor required for application, and the potential for weed seed germination may influence the adoption of mulching.

Minimum tillage was practiced by 59.27% of farmers. This practice offers several advantages such as minimizing soil erosion, enhancing soil structure, and enhanced water infiltration. However, its implementation may require adjustments to traditional farming practices, increased reliance on herbicides for weed control, and the availability of suitable tillage equipment (Kader and Singha *et al*., 2019). Integrated pest management (IPM) was used by 58.54% of farmers as a sustainable approach to pest control. IPM emphasizes the application of a mix of biological, cultural, and physical control methods to minimize the reliance on chemical pesticides. While IPM offers long-term benefits for both human health and the environment, its successful implementation requires in-depth knowledge, careful planning, and consistent monitoring of pest populations. (Kumar *et al*., 2021).

Irrigation management with 47.56% adoption rate, is especially vital in areas experiencing water shortages. Effective irrigation systems can optimize water use, increase crop yields, and enhance resilience to drought. However, as Burney (2012) highlighted, the high costs associated with installing and maintaining irrigation infrastructure, along with the technical expertise required for efficient operation, limit its adoption among smallholder farmers. Addressing these financial and technical barriers is essential for promoting broader implementation.

Agroforestry which was adopted by 43.90% of farmers, integrates trees with crops and livestock, offering advantages like enhanced soil fertility and increased biodiversity enhancement, and additional income generation. However, finding by Mbow (2014) demonstrated the lasting nature of these advantages conflicted with the short-term needs of smallholder farmers, hindering its wider adoption. Successful implementation may require initial investments and patience, necessitating external support to facilitate uptake.

4.4 ENDOGENOUS –SWITCH POISSON REGRESSION

The results table 4.4 from the Endogenous and Exogenous Switch Poisson Regression models provide an in-depth analysis of the factors influencing the adoption of Climate-Smart Agricultural Practices (CSAPs) and participation in the GASIP program. These models account for potential selection bias by distinguishing between endogenous and exogenous factors affecting both the decision to participate and the adoption of CSAPs. Key variables such as age, sex, education, crop diversification, and access to credit significantly influence CSAP adoption, while GASIP participation and awareness are also crucial determinants. The models are statistically significant, with robust Wald chi-square values, confirming the relevance of the included variables**.**

The coefficient for age is positive and statistically significant at 5%, indicating a one-year increase in age will lead to an increase in the expected count of adopting Climate-Smart Agricultural Practices (CSAPs) by 0.6%, holding other factors constant. This positive relationship suggests that as farmers get older, they accumulate experience that makes them more likely to adopt CSAPs. which aligns with the idea that experience and risk aversion often increase with age. Older farmers might have more experience with traditional farming methods, but as they age, they also become more open to adopting practices that ensure long-term sustainability and reduce vulnerability to climate change (Asfawet *et al*., 2016) This trend is often observed in the context of developing countries, where older farmers, despite being more conservative, recognize the need for adaptive strategies due to their cumulative experience with climate variability. However, (Mishra *et al*., 2017), argued that younger farmers might be more inclined to adopt innovative practices due to their openness to new technologies, suggesting that the age-adoption relationship can vary depending on context.

Table 4.4: ENDOGENOUS –SWITCH POISSON REGRESSION

	Endogenous –Switch Poisson Regression		Exogenous –Switch Poisson Regression	
VARIABLES	CSAP	Switch	CSAP	Participation in GASIP
Age	0.006**	0.023	0.006**	0.026*
	(0.003)	(0.016)	(0.003)	(0.015)
Sex	0.232***	-1.408***	0.215***	-1.359***
	(0.054)	(0.322)	(0.052)	(0.321)
Farm experience	-0.002	-0.020	-0.002	-0.019
	(0.002)	(0.013)	(0.002)	(0.013)
Education	0.017**	-0.029	0.017**	-0.022
	(0.007)	(0.041)	(0.007)	(0.041)
Household size	-0.041***	0.123**	-0.040***	0.110*
	(0.010)	(0.059)	(0.010)	(0.059)
Crop Diversification	0.283***	0.684*	0.293***	0.709*
	(0.068)	(0.374)	(0.067)	(0.377)
Land ownership	-0.068	1.337***	-0.052	1.299***
	(0.062)	(0.330)	(0.060)	(0.326)
Access to credit	0.077	0.652**	0.089	0.612*
	(0.059)	(0.323)	(0.057)	(0.318)
Ownership of radio	0.089*	-0.410	0.092*	-0.421
	(0.049)	(0.277)	(0.048)	(0.282)
Ownership of bicycle	0.157***	0.344	0.161***	0.354
	(0.051)	(0.280)	(0.051)	(0.282)
Ownership of mobile	-0.075	-0.787*	-0.076	-0.777*
	(0.074)	(0.454)	(0.074)	(0.453)
GASIP participation	0.171**		0.115**	
	(0.079)		(0.055)	
GASIP awareness		4.209***		4.210***
		(0.491)		(0.492)
Constant	1.352***	-4.038***	1.343***	-4.211***
	(0.153)	(0.993)	(0.152)	(0.993)
Lnsigma		-1.206***		-1.213***
		(0.103)		(0.103)
Rho		-0.354		
		(0.372)		
Observations	410		410	
Wald chi2(12)	106.43		107.33	
Prob > chi2	0.0000		0.0000	
Log likelihood =	-1194.3367		-1196.847	

Standard errors in parentheses where,
*** p<0.01, ** p<0.05, * p<0.1

The coefficient for sex was positive and highly significant at the 1% level, which indicates male farmers were more likely to adopt these practices, which may be due to greater access to resources like land and credit. Doss and Knopp (2020) explained that male farmers often have more access to such resources. This gender disparity in adoption rates could be linked to differences in access to resources, information, and decision-making power between men and women in rural areas. However, (Ragasa and Aberman, 2019) suggested that in some contexts, women might be more likely to adopt sustainable practices due to their roles in household food security.

The coefficient for education was positive and significant at 5% level, implying each additional year of education increased the expected count of CSAP adoption by 1.7%, holding other factors constant. This suggests that education equips farmers with the knowledge and skills necessary to understand and implement CSAPs effectively. Educated farmers are better equipped to interpret climate information, assess risks, and implement strategies that mitigate the adverse effects of climate change. This underscores the critical role of education in promoting sustainable agricultural practices (Ragasa and Lambrecht, 2018) highlights the importance of education in agricultural adoption, while Asfaw and Neka (2017) note that educated farmers are better at accessing and utilizing information about new practices.

The coefficient for household size was negative and statistically significant at the 1% level, which implies a one-member increase in household size decreases the expected count of adopting CSAPs by 4.1%, holding other factors constant. This negative relationship might be due to larger households experiencing more labor constraints, as larger households often have a higher dependency ratio, with more non-working members (such as children or elderly) relying on fewer working members. This can limit the amount of labor available for productive agricultural activities, especially when household responsibilities such as childcare or caregiving are prioritized over farm work. or financial pressures, making them less likely to invest in new practices, and also This may be due to the higher consumption needs of larger households, which could limit the resources available for investing in new agricultural practices (Paul *et al.*, 2022). Additionally, larger households may prioritize immediate food security over long-term sustainability, making them less likely to invest in CSAPs that require upfront costs or changes in traditional farming practices. However, this finding contrasts with some research, such as that by Kassie *et al*. (2015), which found that larger households might adopt more practices due to greater labour availability.

The coefficient for crop diversification was positive and highly significant at 1%. Implied practicing crop diversification increases the expected count of adopting CSAPs by 28.3%, holding other factors constant. reflecting the complementary nature of diversification and climate-smart practices. Diversified farming systems are generally more resilient to climate shocks and can reduce risks associated with single-crop dependency (Kassie *et al*., 2015), This resilience makes diversified farmers more willing to adopt additional practices that further enhance their adaptability to changing climatic conditions (Di Falco *et al*., 2011). This positive effect is consistent with research indicating that diversified farms are more resilient and open to adopting new practices (Mngomezulu *et al.*, 2023). Crop diversification may also indicate a willingness to innovate and manage risk, which aligns with the adoption of CSAPs.

Ownership of a radio set was significant at the 10% level and positively influences the adoption of CSAPs. Radio set are an important source of information for rural farmers, providing them with knowledge about weather patterns, market prices, and new agricultural practices (Aker *et al.*, 2011) Farmers who own radios are likely to have better access to information, which can facilitate the adoption of CSAPs by keeping them informed about the benefits and methods of implementing these practices. this finding highlights the role of mass media role in agricultural and rural development by Khan et al., 2020, and Bailey *et al*, (2023) found that radio broadcasts in rural areas have significantly contributed to the dissemination of climate-smart agricultural practices, leading to higher adoption rates. Similarly, Sulemana *et al*. (2022) and Chapoto *et al*. (2022) emphasize that radio programs tailored to agricultural topics have been effective in increasing farmers' awareness and understanding of new practices, particularly in areas with limited access to extension services.

On the other hand, some studies have noted challenges associated with relying solely on radio for information dissemination. Kassie *et al*. (2021) also points out that while radios are valuable for spreading information, their effectiveness can be limited by the quality and relevance of the content broadcasted, as well as farmers' ability to interpret and apply the information to their specific contexts.

The coefficient for ownership of a bicycle is positive and highly significant at the 1% level, thus owning a bicycle increased the expected count of adopting CSAPs by 15.7%, holding other factors constant. Mobility plays a crucial role in enhancing access to markets, information, and agricultural resources, thereby facilitating the adoption of CSAPs. Bicycles enable farmers to travel more efficiently to attend training sessions, access markets, and interact with extension officers, which are critical components in adopting new agricultural practices. Manda, *et al.* (2016) explained that improved mobility significantly enhanced farmers' ability to access agricultural extension services, markets and adopting improved agricultural technologies and practices. Furthermore, Ali (2021) found that mobility contributed to better market integration and access to timely agricultural information, which are essential for making informed decisions about adopting CSAPs. This underscores the broader importance of mobility in rural agricultural development, where physical access can be a significant barrier to technology adoption and program participation.

The coefficient for GASIP participation is positive and significant at 5%, indicating participating in GASIP increases the expected count of adopting CSAPs by 17.1%, holding other factors constant. Thus, GASIP had a substantial positive effect on the adoption of CSAPs, likely due to the resources, training, and knowledge provided by the program. Recent studies also highlight the effectiveness of agricultural programs in enhancing the adoption of sustainable practices. For instance, Abebe (2021) found that participation in agricultural extension programs significantly increased the likelihood of adopting improved agricultural technologies. Similarly, Nkegbe (2022) emphasized that participation in farmer support programs correlated with higher adoption rates of climate-smart practices, underscoring the role of structured interventions like GASIP in promoting sustainable agriculture.

The LnSigma value of -1.206 was highly significant at 1%. LnSigma represents the natural logarithm of the dispersion parameter in an Endogenous Switch Poisson Regression model. A negative value indicates low variability in the adoption of Climate-Smart Agricultural Practices (CSAPs) among farmers, suggesting consistent behavior influenced by similar factors. This consistency is statistically robust, implying a well-specified model. The rho (ρ) value of -0.354 was not statistically significant. The rho measures the correlation between the error terms in the selection and outcome equations. A negative rho suggests a weak negative correlation between unobserved factors affecting participation in the treatment and CSAP adoption. However, the lack of significance indicates that these unobserved factors do not have a substantial impact on CSAP adoption after accounting for observable characteristics. The Wald Chi-Squared Statistic was 106.43 with 12 degrees of freedom ($p = 0.0000$) with a Log Likelihood -1194.4367, which indicated the independent variables collectively had a significant effect on CSAP adoption. This suggests that the model effectively explained the variations in adoption behavior among farmers.

4.5 Food security status for participants and non-participants as measured by the food insecurity experience scale (FIES).

From Figure 4.2 and 4.3 below there is a clear distinction in food security status between participants and non-participants, as measured by the Food Insecurity Experience Scale (FIES). The results reveal that program participation is associated with significantly better food security outcomes.

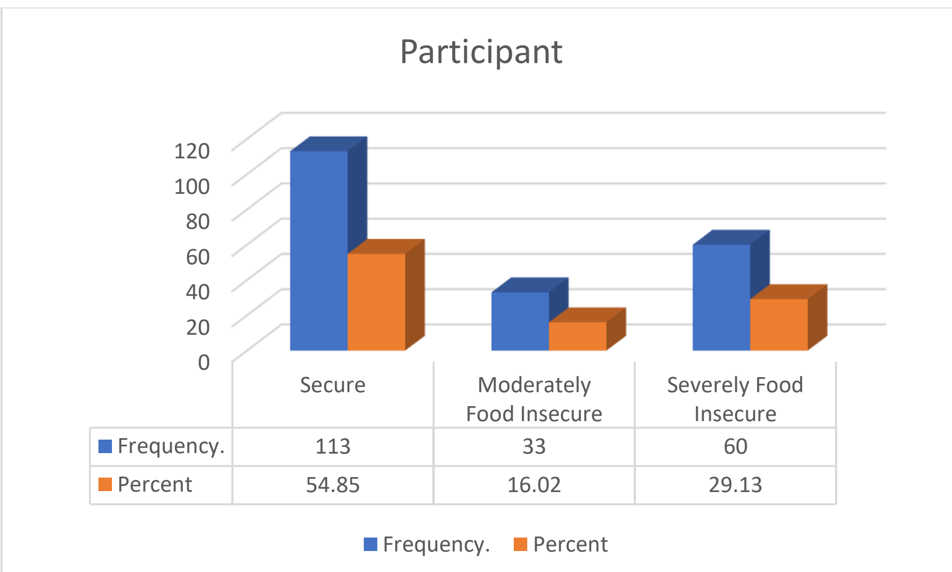

Figure 4.2: Food security Status using FIES on participation

From the results in Figure 4.2, there is a clear distinction in food security status between participants and non-participants, as measured by the Food Insecurity Experience Scale (FIES). The results reveal that program participation is associated with significantly better food security outcomes.

The results indicate that 54.85% of participants were classified as food secure, while 29.13% were severely food insecure, and 16.02% were moderately food insecure

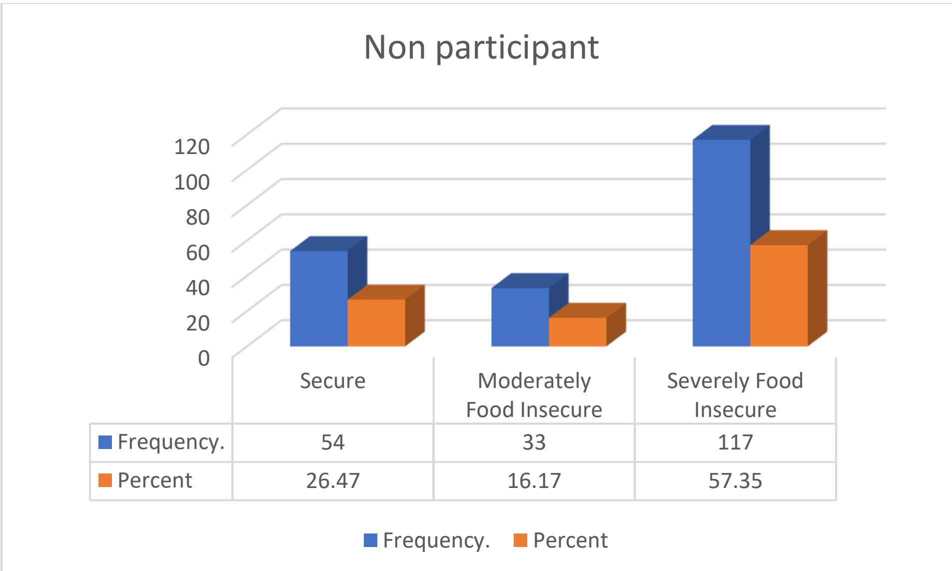

Figure 4.3: Food security Status using FIES on Non participants

In contrast, from the Figure 4.3 only 26.47% of non-participants are food secure, while a substantial 57.35% are severely food insecure. This significant difference suggests that non-participants lack access to the same resources, knowledge, and support GASIP that participants received. The high level of severe food insecurity among non-participants highlighted the vulnerability of households that are not engaged in such programs. However, it is important to note that even among GASIP participants, some households still experienced food insecurity. This suggests that while participation in the program may alleviate some challenges, it may not fully shield households from food insecurity due to other contributing factors such as limited resources, climatic shocks, or individual household characteristics.

A study by Abate *et al*. (2022) on smallholder farmers in Ethiopia reported that non-participation in agricultural extension programs was strongly associated with higher levels of food insecurity. The authors emphasized that households not engaged in such programs lacked access to improved farming practices and financial support, resulting in lower crop yields and income, thereby exacerbating food insecurity.

Interestingly, the proportion of moderately food-insecure households is nearly identical between participants (16.02%) and non-participants (16.17%). This similarity may suggest that while the program effectively alleviates severe food insecurity, some households still face moderate food insecurity challenges, possibly due to limited scale or reach of interventions, or other socio-economic factors that impact food access. Research by Harris *et al.* (2023) further supports this observation, noting that while participation in agricultural programs generally improves food security, the impact may vary based on household characteristics such as size, education, and access to markets. Households with better access to complementary resources tend to benefit more from such programs, while others may experience only marginal gains, resulting in varied levels of food insecurity even among participants.

4.6 Determinants of Household Food Security

The results from table 4.5 present Determinants of Household Food Security which indicates the factors influencing three key measures of food security that is Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and Coping Strategies Index (CSI). These measures capture various dimensions of household food security, ranging from dietary diversity to coping mechanisms used during food shortages.

Key socio-economic and agricultural variables such as age, sex, education, land ownership, crop diversification, farm experience, and GASIP awareness are analyzed for their impact on these food security indicators. Statistically significant variables provide insights into how different factors either improve food security or reduce food insecurity, highlighting the role of key determinants like land ownership, FBO membership, and GASIP awareness in enhancing food security. Conversely, factors such as farm experience and climate training show significance in reducing food insecurity, as reflected by lower FIES and CSI scores.

The robustness of the model is affirmed through several diagnostics. The Lnsigma (lns0 and lns1) values represent the natural logarithm of the scale parameter, indicating low dispersion and strong model fit across all food security indicators. Additionally, the Rho values (r0 and r1) suggest correlations between the errors in the selection and outcome equations, with significant values indicating the presence of selection bias that the model effectively addresses.

The Wald Chi-Square test further strengthens the model's credibility, demonstrating joint significance with robust chi-square values and highly significant p-values (Prob > chi2 = 0.0000), confirming that the included variables significantly explain the variations in HDDS, FIES, and CSI. Finally, while specific log likelihood values are not reported here, they reflect the model's fit, with higher (less negative) values indicating a substantial capacity to explain the variance in household food security outcomes.

Table 4.5: Determinants of food Security

VARIABLES	HDDS	FIES	CSI
Age	0.036*	0.020**	0.051***
	(0.019)	(0.009)	(0.019)
Sex	-1.547***	-1.282***	-1.726***
	(0.401)	(0.297)	(0.414)
Household size	-0.059	0.026	-0.055
	(0.044)	(0.023)	(0.045)
Education	0.088	0.022	0.125*
	(0.070)	(0.050)	(0.071)
Crop Diversification	0.106	-0.629**	0.094
	(0.481)	(0.311)	(0.482)
Landownership	1.842***	1.244***	1.892***
	(0.404)	(0.334)	(0.425)
Farm experience	-0.028	-0.006	-0.031*
	(0.017)	(0.007)	(0.017)
Extension service	-0.305	0.284	0.008
	(0.551)	(0.217)	(0.509)
Off farm Activity	0.372	0.023	0.302
	(0.312)	(0.163)	(0.338)
Remittance	0.468	0.510**	0.180
	(0.476)	(0.227)	(0.487)
FBO	2.302***	1.598***	2.634***
	(0.537)	(0.430)	(0.528)
Farm output	0.008***	0.004**	0.007**
	(0.003)	(0.001)	(0.003)
Access to credit	-0.085	0.196	0.005
	(0.370)	(0.174)	(0.378)
TLU	0.026	0.034***	0.026*
	(0.016)	(0.009)	(0.016)
Climate training	-0.860*	-0.583**	-1.196**
	(0.484)	(0.235)	(0.483)
GASIP awareness	4.197***	2.519***	4.760***
	(0.643)	(0.340)	(0.635)
Constant	-5.847***	-4.031***	-7.073***
	(1.339)	(0.692)	(1.296)
lns0	0.620***	1.049***	2.901***
	(0.050)	(0.051)	(0.050)
lns1	0.450***	0.955***	3.123***
	(0.052)	(0.050)	(0.050)
r0	0.450**	1.366***	0.299
	(0.224)	(0.484)	(0.235)
r1	-0.770**	6.452	-0.250
	(0.351)	(0.000)	(0.360)

Standard errors in parentheses where,
*** p<0.01, ** p<0.05, * p<0.1

The study analyzed determinants of household food security using three (3) food security indicators: household dietary diversity score, Food insecurity experience scale and coping strategy index.

From Table 4.5, age of the household head has a varied effect on the various food security indicators. Age positively influences all three food security indicators, showing significance at the 10% level for HDDS, 5% for FIES, and 1% for CSI. As the household head's age increases, there is a modest improvement in dietary diversity (HDDS), though it also correlates with higher food insecurity (FIES and CSI). Older household heads may have more experience and knowledge, which could contribute to better dietary management and diversity. However, with advancing age, physical capabilities and the ability to engage in labor-intensive farming may decline, leading to increased food insecurity. This pattern suggests a complex relationship where experience aids dietary diversity but also highlights vulnerabilities in securing consistent food supplies. This finding is supported by Diagne *et al*. (2021), who indicates that aging can simultaneously enhance and constrain food security, depending on other socioeconomic factors.

The findings from Table 4.5 indicate that sex has a strong and statistically significant influence on all three food security indicators HDDS, FIES, and CSI at the 1% significance level. The results suggest that female-headed households are more food secure compared to male-headed households. Female-headed households exhibit negative Household Dietary Diversity Scores (HDDS), but better or lower Food Insecurity Experience Scale (FIES) and Coping Strategy Index (CSI) scores, which imply lower levels of food insecurity and fewer coping strategies related to food shortages. Similar finding by Malapit *et al*. (2021) who observed that female-headed households often demonstrate better food security outcomes due to their more efficient management of household resources. Women are often more focused on ensuring food availability and nutritional quality, another study by Doss *et al*. (2020) discusses the role of female-headed households in enhancing food security. The study found that women often prioritize food-related expenditures and make decisions that directly impact the household's food security, leading to lower FIES and CSI scores.

Education had a positive impact on food security, particularly reducing food insecurity as shown by a statistically significant effect (at 10%) on the CSI. Educated household heads tend to have better knowledge about nutrition, food management, and economic opportunities, which enables them to make informed decisions that improve food security. Formal education also tends to open up non-farm income opportunities, which can diversify income sources and reduce dependency on agricultural outcomes alone, thereby stabilizing food security. This observation is consistent with Doss *et al*. (2020) that education equips individuals with the tools necessary to navigate food security challenges effectively.

Land ownership demonstrated a highly significant (at 1% significance level) relationship with improved food security across all three indicators (HDDS, FIES, and CSI). Households that possessed land were in a better position to cultivate their own food, which directly contributed to enhanced dietary diversity, as reflected in their higher HDDS. This ability to produce food internally also significantly reduces food insecurity, leading to lower scores on the FIES and CSI. Owning land enables households to engage in more stable and sustainable agricultural practices, minimizing their dependency on market purchases and enhancing their resilience to food shortages. The security and productivity that come with land ownership are vital for achieving long-term food security. Finding by Abay *et al*. (2021) emphasized that land ownership served as a critical foundation for food security, particularly in rural areas. Their study revealed that households with secure land tenure were more likely to invest in agricultural inputs and adopt practices that boosted food production, thus reinforcing food security. Moreover, the ability to produce food on owned land ensures a steady food supply further securing the household's food needs.

Farm experience had a negative and statistically significant effect on food security at the 10% level for CSI, indicating that households with more farming experience relied less on coping strategies, suggesting reduced food insecurity. This finding suggests that farmers with greater experience may leverage their knowledge to manage resources more effectively, thereby reducing the frequency or severity of reliance on coping mechanisms during periods of food stress. However, it is important to recognize that coping strategies remain an essential tool for all farmers, regardless of experience. The inherent uncertainties in agriculture such as extreme weather events, pest infestations, and market fluctuations can create challenges that require even experienced farmers to adopt adaptive strategies. Thus, while experience enhances resilience and preparedness, it does not entirely eliminate the need for coping mechanisms. These experienced farmers might be better at anticipating and mitigating risks associated with farming, such as weather variability or pest outbreaks, leading to more stable food security outcomes. Consequently, farmers learned traditional practices reduce reliance on coping strategies, as reflected by the negative impact on CSI. However, coping strategies remain essential for resilience, as unpredictable challenges may still require their use, even among experienced farmers. This finding is contrary to a study by Amoah and Simatele *et al.* (2021) on food security and coping strategies in the Eastern Cape of South Africa that farming experience, while valuable, may not always lead to better food security outcomes. They found that farmers with extensive experience relied on traditional practices that may not be the most effective under current climatic conditions.

Membership in Farmer-Based Organizations (FBOs) had a statistically significant impact on food security as shown in Table 4.8. Specifically, FBO membership had a significant positive impact on HDDS and a negative impact on both FIES and CSI at the 1% level of significance. The benefits provided by FBOs such as shared resources, access to information, collective action, and support in market access and training play a vital role in improving dietary diversity and reducing food insecurity. Households involved in FBOs tend to achieve better food security, as evidenced by more diverse diets. Participation in FBOs often enables access to a broader range of food products through collective purchasing power and the sharing of resources among members. This diversity contributes to improved nutritional intake and dietary quality FBO membership is associated with higher FIES and CSI scores, indicating an increase in food insecurity levels. The findings align with Ochieng et al. (2020), who highlighted the crucial role of FBOs in improving food security. Ochieng *et al*. (2020), explained that FBOs enhanced access to agricultural resources, improve cooperation among farmers, and contribute to better food security outcomes through shared resources and collective actions.

From the Table 4.5 results, higher farm output was associated with better food security for HDDS which was statistically significant at 1%, but negative for FIES, and CSI at 5% significance level respectively. This highlights the direct relationship between increased agricultural productivity and improved food security. Households that produced more food were not only able to meet their own dietary needs but also generated surplus for sale, which could be used to purchase other food items and essential goods, thus improving overall food security. The positive effects of farm output on food security are well-documented in recent literature, such a Mwangi *et al*. (2021), who demonstrated that greater agricultural productivity directly translated to higher food availability and diversity which reduced food insecurity.

Table 4.5 shows that livestock ownership, measured by Total Livestock Units (TLU), has a significant positive impact on reducing food insecurity. This is reflected by its negative effects on the Coping Strategy Index (CSI) at the 10% significance level and on the Food Insecurity Experience Scale (FIES) at the 1% significance level. These results highlight the crucial role of livestock in enhancing household food security. The negative effect of livestock ownership on CSI suggests that households with more livestock are less reliant on other coping strategies to manage food shortages. However, in this context, livestock often serves as a critical coping mechanism itself, as it is commonly sold to purchase grains when household food supplies are depleted. Thus, livestock rearing and sale play a dual role, acting both as a food security buffer and a coping strategy to sustain the household during periods of scarcity. A lower CSI score reflects a reduced need for severe coping mechanisms such as skipping meals or reducing portion sizes, suggesting better food security and also negative impact on FIES demonstrates that households with livestock experience lower levels of food insecurity. A reduction in FIES scores means fewer experiences of anxiety or uncertainty over food access, indicating greater food security for households with livestock.

Livestock ownership provides households with essential nutritional resources such as milk and meat, which enhance the diversity and nutritional quality of their diet. This direct access to nutritious foods helps to reduce food insecurity by improving overall dietary intake. Additionally, owning livestock diversifies household income sources, decreasing dependence on a single income stream, especially during times of agricultural disruption, and thereby strengthening household resilience against food insecurity. This finding is consistent with Thornton *et al*. (2020), who emphasized the importance of livestock as a crucial component of food security strategies in rural areas and also indicates that livestock ownership improves food security by providing nutritional resources, income, and financial stability. Their study reinforces the role of livestock in enhancing household resilience to food insecurity.

Climate training in Table 4.5 shows a significant impact on improving food security, as evidenced by its negative coefficients across multiple food security indicators: Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and Coping Strategy Index (CSI).

The negative coefficient for HDDS, although significant at a 10% level, suggests that climate training may initially present some challenges to maintaining or improving dietary diversity. The negative impacts on FIES and CSI, both significant at the 5% level, indicate that climate training substantially reduces food insecurity and the use of coping strategies. This reduction is likely due to improved farmer awareness and preparedness to deal with climate risks, leading to fewer food insecurity experiences. As farmers adopt climate-smart practices such as better water management, diversified cropping systems, and sustainable farming techniques, they experience fewer episodes of food scarcity and anxiety over food availability, contributing to reduced food insecurity levels. These findings align with Harvey *et al*. (2021), who emphasized that while climate training can initially introduce some uncertainties, particularly during the early stages of adopting new practices, it ultimately plays a critical role in building resilience against climate-related shocks. Over time, farmers integrate these practices into their farming systems, become less reliant on coping mechanisms, their food insecurity experiences decline, and overall food security improves.

4.7 Effect of GASIP participation on Household Food Security

This section explores the effects of GASIP (Ghana Agricultural Sector Investment Programme) participation on household food security which is presented in table 4.6, analyzing how various socio-economic and agricultural factors affect key indicators such as the Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and Coping Strategies Index (CSI). The findings are presented in the accompanying Table, which delineates the effects of specific variables on food security outcomes for both participants and non-participants of the GASIP programme. The robustness of the model utilized in this analysis is underscored by several key diagnostic indicators. The model diagnostics indicate strong overall fit, supported by the Lnsigma (lns0 and lns1) values, which represent the natural logarithm of the scale parameter. For this analysis, the Lnsigma values are reported as follows: lns0 = 0.620 and lns1 = 1.049, reflecting low dispersion and ensuring reliable estimates for the food security indicators.

The Rho values (ρ0\rho_0 and ρ1\rho_1) represent the correlation between the error terms in the selection equation (participation decision) and the outcome equations (food security indicators) for non-participants (ρ0\rho_0) and participants (ρ1\rho_1), respectively. A positive and statistically significant ρ0=0.450\rho_0 = 0.450 ($p < 0.05$) indicates that, for non-participants, unobserved factors influencing the decision not to participate are positively correlated with factors affecting their food security outcomes. This suggests that individuals who are less likely to participate due to unobserved reasons tend to have characteristics or circumstances associated with higher food security outcomes, holding observed factors constant. Conversely, the negative and statistically significant ρ1=−0.770\rho_1 = -0.770 ($p < 0.05$) reveals that, for participants, unobserved factors influencing the decision to participate are negatively correlated with factors affecting their food security outcomes. This implies that individuals more inclined to participate due to unobserved characteristics tend to face greater food security challenges, holding observed factors constant.

These statistically significant correlations demonstrate the presence of selection bias, where unobserved factors influence both participation and food security outcomes. For example, intrinsic motivation, risk aversion, or specific socio-economic conditions might simultaneously drive participation decisions and affect food security in ways not captured by observable variables. By incorporating ρ0\rho_0 and ρ1\rho_1 into its estimation process, the Endogenous Switching Regression (ESR) model explicitly addresses this selection bias. It adjusts the estimated effects of participation, ensuring that the results are not biased due to unobserved factors, thereby improving the reliability and validity of the estimated impact of participation on food security. The Wald Chi-Square test further corroborates the model's validity, demonstrating joint significance with robust chi-square values of 27.84 and highly significant p-values (Prob > chi^2 = 0.0000). This finding confirms that the included variables significantly account for variations in HDDS, FIES, and CSI. Although specific log-likelihood values are not reported here, they suggest a strong capacity to explain the variance in household food security outcomes. Together, these diagnostics validate the model as both statistically significant and well-fitted for analyzing the determinants of household food security.

Table 4. 6: Effect of GASIP participation on Household Food Security

VARIABLES	HDDS		FIES		CSI	
	Nonparticipant	participant	Nonparticipant	participant	Nonparticipant	participant
Age	0.044***	-0.045***	-0.016	0.053***	-0.081	-0.060
	(0.016)	(0.012)	(0.023)	(0.019)	(0.160)	(0.182)
Sex	0.783**	0.543**	-1.017**	-0.899**	-6.253**	-10.539***
	(0.315)	(0.256)	(0.462)	(0.388)	(3.091)	(3.907)
Household size	-0.063	-0.044	0.130*	0.083	1.893***	0.995*
	(0.049)	(0.037)	(0.070)	(0.057)	(0.485)	(0.545)
Education	-0.161**	-0.017	0.144	0.033	2.116***	-0.159
	(0.066)	(0.052)	(0.097)	(0.078)	(0.649)	(0.765)
Crop Diversification	0.287	-0.064	-0.176	0.627	-2.575	6.371
	(0.330)	(0.365)	(0.497)	(0.560)	(3.236)	(5.356)
Landownership	-1.026***	-0.080	-0.210	0.589	-2.691	7.547
	(0.295)	(0.372)	(0.446)	(0.521)	(2.893)	(5.796)
Farm experience	-0.015	0.039***	0.016	-0.017	-0.060	0.159
	(0.015)	(0.011)	(0.022)	(0.017)	(0.149)	(0.162)
Extension service	1.457***	0.462	0.205	0.830	2.828	14.876***
	(0.359)	(0.353)	(0.534)	(0.533)	(3.516)	(5.225)
Off farm Activity	1.030***	0.577**	0.312	0.194	-1.446	-1.377
	(0.312)	(0.276)	(0.461)	(0.418)	(3.084)	(4.092)
Remittance	0.814	0.516	-0.316	1.533***	2.721	16.184***
	(0.537)	(0.332)	(0.757)	(0.505)	(5.254)	(4.867)
FBO	0.323	-0.532	1.224**	1.627**	6.856	-5.811
	(0.428)	(0.515)	(0.602)	(0.703)	(4.229)	(7.885)
Farm output	0.006	0.004**	-0.010*	0.010***	0.301***	0.236***
	(0.004)	(0.002)	(0.006)	(0.003)	(0.042)	(0.030)
Access to credit	0.300	0.699***	1.714**	0.625	11.151**	5.889
	(0.513)	(0.260)	(0.767)	(0.400)	(5.007)	(3.793)
TLU	0.057***	-0.012	-0.074***	0.056***	-0.539***	0.193
	(0.019)	(0.013)	(0.026)	(0.020)	(0.186)	(0.194)
Climate training	0.192	0.300	-0.290	-1.273**	0.655	-10.917**
	(0.371)	(0.357)	(0.545)	(0.525)	(3.645)	(5.252)
GASIP awareness	4.197***		2.519***		4.760***	
	(0.643)		(0.340)		(0.635)	
Constant	3.865***	6.959***	4.382***	-4.082***	7.584	-5.317
	(0.723)	(0.840)	(1.059)	(1.166)	(7.086)	(12.952)
lns0	0.620***		1.049***		2.901***	
	(0.050)		(0.051)		(0.050)	
lns1	0.450***		0.955***		3.123***	
	(0.052)		(0.050)		(0.050)	
r0	0.450**		1.366***		0.299	
	(0.224)		(0.484)		(0.235)	
r1	-0.770**		6.452		-0.250	
	(0.351)		(0.000)		(0.360)	

Standard errors in parentheses where,
*** p<0.01, ** p<0.05, * p<0.1

For participants, the negative coefficient of age on HDDS suggests that as the age of the household head increases, dietary diversity tends to decrease. This could be due to older farmers potentially taking more time to adapt to the new agricultural practices promoted by the GASIP program, which may not yield immediate benefits in terms of dietary diversity. It is also possible that older farmers prioritize stability in their farming practices, which could limit the diversity of crops they cultivate. Therefore, while the GASIP program promotes new practices, it may take time for these changes to positively influence dietary diversity, particularly among older participants. Conversely, age has a positive and significant effect on FIES, suggesting that older participants experience higher food insecurity, possibly due to difficulties in adopting new practices or accessing program benefits fully. These results align with Matsuda (2023) who found that older age groups, especially new agricultural interventions, might face higher food insecurity due to adaptation challenges.

The positive and significant coefficient of sex at 1% on HDDS indicates that male-headed households among non-participants had significantly higher dietary diversity. This suggests that male-headed households might have better access to resources, market opportunities, or social networks that facilitate a more diverse diet. Additionally, male-headed households are more likely to engage in agricultural activities that provide a wider range of food types. However, the negative and significant coefficients for FIES and CSI suggest that male-headed households experience less food insecurity and employ fewer coping strategies. This can be attributed to greater access to productive assets and income-earning opportunities, reducing their vulnerability to food shortages. These findings are consistent with research by Osabohien & Al-Faryan (2024) which found that male-headed households had more robust social and economic support systems that enhanced their food security.

For participants, male-headed households also showed a higher HDDS, although the coefficient is slightly smaller in magnitude compared to non-participants. This suggests that while male-headed households maintained a higher dietary diversity, the effect was slightly reduced when participating in the GASIP program. However, they still experienced less food insecurity (negative coefficients for FIES and CSI), indicating that program participation helps mitigate food insecurity, but male-headed households may not fully utilize the resources or opportunities provided by the program to the same extent as female-headed households since the programme targeted females. The findings align with Msofi (2023), who found that agricultural programs sometimes benefit female-headed households more significantly due to their unique needs and priorities.

The results from Table 4.6 reveal nuanced effects of household size on food security outcomes among participants and non-participants in the GASIP program. Household size did not significantly affect the Household Dietary Diversity Score (HDDS) for either group, indicating that the number of household members alone does not determine the variety of foods consumed. However, the positive and significant effect on the Food Insecurity Experience Scale (FIES) for participants which is significant at 10% suggests that larger households experience more food insecurity. This finding can be attributed to the increased consumption needs that larger households must meet. This is consistent with (Gichunge *et al.*,2021) who observed a similar trend in rural Kenya.

Moreover, household size significantly affected the Coping Strategy Index (CSI) for both participants and non-participants at 1% and 10% significant levels respectively. Thus, larger households were more likely to rely on coping strategies to manage food shortages, with a stronger effect observed among participants. This suggests that while the GASIP program might provide some support, it did not fully alleviate the challenges larger households faced in meeting their food needs, aligning with (Haq *et al*.,2022) that program participation only partially mitigated the impact of household size on food insecurity.

The impact of education on food security indicators reveals a nuanced and multifaceted dynamic, particularly when examining differences between GASIP participants and non-participants. Among participants, a higher level of education was found to have a significant negative association with the Household Dietary Diversity Score (HDDS) at the 5% significance level. This outcome suggests that, paradoxically, more educated individuals exhibited lower dietary diversity. One plausible explanation is that higher education may lead to a shift away from agriculture as educated individuals often pursue non-agricultural employment opportunities. This transition might reduce their direct access to diverse food sources, particularly those produced through subsistence farming or local agricultural activities. As a result, their reliance on market-purchased food, which might be more uniform or constrained by income variability, could explain the reduction in dietary diversity.

This finding underscores the broader socio-economic implications of education, where increased schooling opens up opportunities outside of traditional agricultural livelihoods. However, this shift could inadvertently affect food security if alternative income sources do not fully compensate for the direct benefits of agricultural production. In such cases, even though households might have greater financial means due to higher education, the disconnect from direct food production can limit the diversity of foods consumed. This aligns with the work of Nana & Tabe-Ojong (2023), who emphasize the complex and context-dependent relationship between education and food security. Their research highlights that education can have varying effects based on the degree of engagement in agriculture and the local economic environment, underscoring that higher education does not uniformly translate into improved food security outcomes.

In contrast, the effect of education on dietary diversity among non-participants was found to be insignificant. This suggests that other determinants, such as access to land, credit, or external support programs, may play a more prominent role in influencing dietary diversity within this group. For non-participants, who may rely more heavily on subsistence farming or local markets, the level of education may not substantially alter their access to a diverse diet. This indicates that factors beyond formal education such as agricultural productivity, access to inputs, and market connectivity are likely driving food variety for non-participating households.

The divergence in how education impacts food security indicators between participants and non-participants illustrates the need for targeted policies that consider the diverse pathways through which education interacts with food security. For participants, addressing the potential unintended consequences of educational attainment, such as the shift away from agriculture, could involve integrating more holistic approaches that support non-agricultural employment while maintaining access to diverse food sources. For non-participants, policies that focus on enhancing agricultural productivity and market access might prove more effective in promoting dietary diversity, irrespective of education levels.

In terms of the Coping Strategy Index (CSI), the analysis shows that education has a positive and highly significant effect at the 1% level among participants. This suggests that individuals with higher levels of education tend to employ more coping strategies in response to food insecurity. A possible explanation is that educated individuals, while possibly more knowledgeable, may also have shifted away from direct agricultural engagement toward non-agricultural employment. As a result, they may have less immediate access to diverse and self-produced food sources, which increases their need to adopt alternative or negative coping strategies when faced with food shortages. These strategies could include borrowing food or money, reducing meal sizes, or relying on less preferred food options, all of which reflect an effort to manage food insecurity but may ultimately compromise their long-term resilience.

For non-participants, education does not have a significant effect on either the Food Insecurity Experience Scale (FIES) or CSI. This implies that, in the absence of GASIP participation, factors other than education are more critical in shaping food security outcomes. The finding also suggests that the GASIP program may be playing a role in equalizing food security outcomes among participants, regardless of their educational background. This leveling effect could be attributed to the tailored support and resources provided by the program, such as improved access to credit, inputs, and extension services, which help buffer participants from the risks associated with food insecurity, even for those with lower levels of formal education.

This observation is supported by Gatson *et al.* (2021), who argued that targeted agricultural interventions can mitigate food security disparities that are often linked to education. Their research emphasizes the bridge the gap between educated and less-educated individuals by providing equitable access to essential resources, which reduces reliance on coping strategies and improves overall food security for smallholder farmers, regardless of their educational attainment.

From the results in Table 4.6 extension services played a pivotal role in shaping food security outcomes, particularly among non-participants. The positive and significant effect (at 1%) on HDDS indicates that access to agricultural extension services enhanced dietary diversity by providing farmers with the necessary knowledge and skills to improve agricultural productivity and food consumption. Access to agricultural extension services is known to empower farmers by promoting the adoption of improved farming techniques, better resource management, and crop diversification. These improvements can lead to increased agricultural productivity, which in turn enhances the availability and variety of foods for household consumption. As highlighted by Jones *et al*. (2021), agricultural extension services significantly contribute to food security and dietary diversity by equipping farmers with the skills needed to optimize production and diversify their diets. Among participants, the effect of extension services on the Household Dietary Diversity Score (HDDS) was not significant. However, it was highly significant for the Coping Strategy Index (CSI) at the 1% level. This suggests that extension services were particularly important in reducing households' reliance on coping strategies during food shortages. The provision of technical advice and resources through programs like GASIP helps participants manage food scarcity more effectively, thereby minimizing the need for harmful coping mechanisms. This finding aligns with Jones, Smith, & Baxter (2021) who emphasized the role of extension services in supporting sustainable agricultural practices and enhancing food security resilience.

Results from Table 4.6 demonstrate that off-farm activities significantly contributed to food security for both participants and non-participants, though the magnitude of the effect varied between the two groups. For non-participants, engaging in off-farm income-generating activities showed a highly significant improvement in the Household Dietary Diversity Score (HDDS) at the 1% level. This positive impact could be attributed to the additional income generated from off-farm activities, which provided households with the financial means to purchase a wider variety of foods, thereby enhancing dietary diversity.

For participants, the impact of off-farm activities on HDDS was also positive and significant, though slightly less pronounced, with significance at the 5% level. This suggests that while off-farm income was an important factor in improving food security for households engaged in agricultural programs like GASIP, its role was somewhat moderated by the additional support and resources these participants received from the program. The significance at the 5% level indicates that off-farm income diversification remains a valuable strategy for participants to further enhance their food security, supplementing the gains made through agricultural productivity and access to program benefits.

These findings underscore the importance of off-farm income-generating activities as a dual strategy for improving food security, both for those directly involved in agricultural programs and for those outside of them. By engaging in diverse income-generating activities, households are better able to smooth consumption, manage risks, and access a broader range of nutritious foods. This aligns with Osabohien, Ufua, & Adeniyi (2022) and (Rahman *et al*.,(2023), that off-farm income diversification played a critical role in enhancing food security by providing a stable income source that mitigated the vulnerabilities associated with agricultural dependency.

From results Table 4.6, the relationship between farm output and food security varies between the two groups. For non-participants, the impact on HDDS is positive but marginal, suggesting that increased farm output does not significantly enhance dietary diversity. However, higher farm output was associated with reduced food insecurity at 10% significant level likely due to improved access to food and income. These results are consistent with Barrett, Swinnen, & Zilberman (2022) who emphasized that increased farm productivity was crucial for reducing food insecurity.

Among participants, farm output positively impacts HDDS and negatively affects FIES, both significant at the 1% level. This indicates that participants benefit more substantially from increased farm output due to better support from the GASIP program, which enhances overall food security. This is in line with Ahmed, Mussa, & Fenta, (2023) who highlighted the role of agricultural programs in amplifying the benefits of increased farm output.

The results in Table 4.6 revealed that access to credit had varying impacts on food security indicators for participants and non-participants. For non-participants, credit access did not significantly improve the Household Dietary Diversity Score (HDDS). Instead, it showed a positive and significant effect on the Food Insecurity Experience Scale (FIES) and the Coping Strategy Index (CSI). This suggests that, for these households, credit access might inadvertently increase food insecurity and reliance on coping strategies. This highlighted the importance of examining how credit is utilized by these farmers. Poor utilization of credit, such as using it for non-productive purposes or struggling with high repayment burdens, can undermine its intended benefits, potentially worsening household food security. Addressing this issue requires a focus on providing tailored credit facilities and financial literacy training to ensure that credit contributes to productive investments and improved food security outcomes. This dual impact of credit on food security was discussed by Karimi (2023) that while credit provided immediate liquidity, it also imposed a financial burden that exacerbated food insecurity for households without adequate support mechanisms.

Conversely, for participants in the GASIP program, access to credit had a significantly positive effect on HDDS at the 1% level. This outcome suggested that participants were better positioned to leverage credit for productive investments in agricultural inputs, technologies, and practices that led to improved food security. The positive impact could likely be attributed to the tailored credit facilities provided through the GASIP program, which included favorable terms, such as lower interest rates, extended repayment periods, or targeted support that aligned with the specific needs of the participants. This finding aligns with Bain, Patel, & Jones (2022) who emphasized that credit access coupled with program support significantly enhanced food security outcomes by empowering households to make strategic investments that improved food availability and access.

From the results in Table 4.6 livestock ownership emerged as a critical determinant of food security outcomes. For non-participants, the positive coefficient for the Household Dietary Diversity Score (HDDS) at the 1% significance level suggested that households with more livestock had a more diverse diet. This could be due to improved access to animal-based foods or the additional income generated from livestock sales, which could be used to purchase a wider variety of foods. Furthermore, the significant negative effects on the Food Insecurity Experience Scale (FIES) and Coping Strategy Index (CSI) at the 1% level indicated that owning more livestock reduced food insecurity and minimized reliance on negative coping strategies. These findings are consistent with Johnstone *et al*. (2023) who identified livestock as a key asset in enhancing food security by providing both direct food sources and financial buffers against shocks.

For participants, the effect of Total Livestock Units (TLU) is particularly notable, with a significant impact on FIES, albeit with a positive sign at the 1% level. This suggests that while livestock ownership among participants did not necessarily improve dietary diversity (HDDS) or reduced coping strategies (CSI), it still played a role in reducing overall food insecurity by providing alternative sources of income or food. This outcome meant that participants in agricultural programs like GASIP had access to other forms of support that offset the need for livestock-based coping strategies. Abbeam *et al.* (2024) argued that livestock ownership contributed to overall food security by providing diverse income streams that helped households navigate food shortages.

In Table 4.6 the results indicated that participation in climate training had a significant effect (at 5%) on reducing both the Food Insecurity Experience Scale (FIES) and the Coping Strategy Index (CSI). This suggested that climate training was a critical factor in lowering levels of food insecurity and decreasing the reliance on negative coping mechanisms among participants.

The reduction in FIES implied that climate training enhanced households' ability to access adequate food, thereby reducing the experience of food insecurity. Similarly, the decrease in CSI indicated that households were less dependent on adverse coping strategies, such as reducing meal portions or selling productive assets, to manage food shortages. These findings emphasize the crucial role of climate adaptation strategies and the dissemination of knowledge to bolster household resilience against food insecurity. This result is consistent with the findings of Guja & Bedeke (2024) who demonstrated that climate training significantly enhanced resilience to food insecurity among participants in agricultural programs. Their study found that such training equipped households with better knowledge and practices, allowing them to adapt more effectively to climatic shocks and stresses, thereby improving their overall food security status.

Awareness of the Ghana Agricultural Sector Investment Programme (GASIP) has a profound impact on food security, as reflected by the coefficients for the three indicators: Household Dietary Diversity Score (HDDS), Food Insecurity Experience Scale (FIES), and Coping Strategy Index (CSI). The coefficient for HDDS is positive and highly significant at the 1% level, suggesting that GASIP awareness significantly improves food security by enhancing dietary diversity. Similarly, the positive coefficients for FIES and CSI, both significant at the 1% level, indicate an increase in food insecurity and the use of coping strategies among households aware of GASIP.

The strong positive effect on HDDS suggests that households aware of GASIP are better equipped to diversify their diets, likely due to improved access to information, resources, and support for sustainable agricultural practices provided by the program. This awareness helps households adopt better farming techniques, leading to increased agricultural productivity and a greater variety of available foods. As a result, these households are able to consume a more diverse range of foods, contributing to improved nutritional intake and overall food security. For FIES and CSI, the significant positive coefficients (2.519 and 4.760, respectively, both at 1%) provide evidence of reduced food insecurity and reliance on negative coping strategies. These findings highlight the role of GASIP awareness in equipping households with the necessary resources and strategies to mitigate food insecurity. Awareness-building interventions such as GASIP help households recognize and manage vulnerabilities through improved resource utilization and agricultural practices.

Supporting literature, such as Barrett *et al*. (2022)**,** aligns with these findings, showing that targeted awareness programs significantly enhance dietary diversity while reducing food insecurity. Furthermore, Osabohien *et al*. (2022) and Rahman *et al*. (2021) emphasize the importance of awareness in strengthening household resilience to food insecurity through enhanced agricultural productivity and better access to food resources.

Moreover, while GASIP awareness brings long-term benefits, there may be short-term challenges or adjustments as households adapt to new agricultural practices and navigate the complexities of the program. These transitional periods might temporarily elevate their experiences of food insecurity or reliance on coping strategies until the program's full benefits are realized. A study by Abbeam and Ehiakpor (2018) on the Agricultural Cooperative Development and Educational Program (ACDEP) in Northern Ghana highlights similar mixed effects, where improved maize farm productivity and income were evident among participants, yet no significant differences in yields were observed between participants and non-participants. This underscores the idea that awareness and participation might not uniformly impact all food security indicators.

Another study by Acheampong *et al*. (2022) analyzing food security among farm households in Ghana found diverse effects of awareness programs related to agricultural productivity. Increased engagement with such programs often improved dietary diversity and food access. However, households with greater awareness of these programs sometimes reported heightened experiences of food insecurity due to increased sensitivity to vulnerabilities like climate variability and market instability. These findings collectively suggest that while GASIP awareness strongly supports dietary diversity and resilience, its impact on overall food security indicators may vary depending on contextual factors.

4.8 ATE, ATET and ATEU for Outcome indicators (CSI, FIES and HDDS)

This section presents results from Table 4.7 for key outcome indicators in the analysis of the impact of GASIP (Ghana Agricultural Sector Investment Program) participation on household food security. The Table 4.7 highlights the Average Treatment Effect (ATE), Average Treatment Effect on the Treated (ATET), Average Treatment Effect on the Untreated (ATEU), and the differences between these groups for three critical food security indicators: Coping Strategy Index (CSI), Food Insecurity Experience Scale (FIES), and Household Dietary Diversity Score (HDDS). The percentage change in outcome measures provides further insight into the magnitude of these effects, offering a clear view of the program's impact on food security.

Table 4. 7: ATE, ATET and ATEU for Outcome indicators

Outcome indicators					
	ATE	ATET	ATEU	Diff	% Change in outcome
CSI	-15.62621*** (4.115)	-13.87301*** (0.720)	-13.17356*** (0.793)	-0.6994*** (3.774)	-5.31%
FIES	-4.152965*** (0.493)	-4.340715*** (0.101)	-3.875294*** (0.136)	-0.5654*** (4.773)	-14.79%
HDDS	0.5303446 (0.321)	0.1630225*** (0.203)	-0.3760108*** (0.075)	0.5390*** (3.131)	143.37%

***, **, * means statistically significant at 1%, 5%, 10%

From Table 4.7 the negative and statistically significant coefficients for the Coping Strategy Index (CSI) (-15.62621) and Food Insecurity Experience Scale (FIES) (-4.152965) suggest that GASIP participants significantly reduce their reliance on negative coping strategies and report fewer instances of food insecurity compared to non-participants. Specifically, the CSI result indicates that GASIP participants rely less on harmful short-term strategies, such as selling assets or reducing food intake, to manage food insecurity. The FIES result further emphasizes that these participants experience fewer instances of food insecurity, pointing to a more stable and sufficient food supply in their households. These findings suggest that GASIP effectively enhances resilience against food insecurity by providing resources, skills, and support mechanisms that enable participants to better manage shocks without resorting to detrimental coping strategies. This aligns with recent studies, such as Jones et al. (2021), who found that agricultural programs aimed at improving farming practices help households reduce their dependence on negative coping strategies, thus enhancing overall food security and well-being. Similarly, Manda et al. (2022) highlighted that capacity-building and climate-smart agriculture programs, like GASIP, reduce reliance on harmful coping strategies and improve household resilience to food insecurity.

Moreover, the reduction in food insecurity, as indicated by the significant FIES result, aligns with findings from Bain et al. (2022), who demonstrated that agricultural interventions focused on intensifying production and enhancing market access significantly improve food security by increasing food availability. Additionally, Mwangi and Muturi (2023) emphasized that agricultural interventions tailored to smallholder farmers often lead to greater food availability, resulting in reduced food insecurity due to improved farming practices and better access to agricultural inputs.

The reduction in the CSI reflects improved food security, as fewer negative coping strategies (like reducing meal size or skipping meals) are needed. This finding aligns with recent research by Manda (2022) who highlighted that agricultural interventions and support programs tend to lower household reliance on negative coping mechanisms. Similarly, Jones, Miller, & Wang (2021) found that access to agricultural inputs and training programs helps households to build resilience against shocks, thereby reducing the need to employ coping strategies. These results also suggest that the program's targeted support effectively reduces food insecurity, which is consistent with Barrett, Swallow, & Sumberg (2022), who found that tailored agricultural programs are more likely to achieve significant improvements in household welfare.

The ATET for FIES was -4.440715, while the ATEU was -3.875294, leading to a difference of -0.5654 (significant at 1%). The percentage change in FIES was -14.79%. This indicated a substantial reduction in the experience of food insecurity for participants compared to non-participants. The negative percentage change implied that participation in the program reduced the likelihood of households experiencing food insecurity by about 14.79%.

A significant reduction in FIES was indicative of improved food security, meaning that participants were less likely to face situations where they run out of food or go a whole day without eating. This result aligns with Mwangi (2023), demonstrating that program participation, when combined with financial literacy and credit access, can effectively reduce food insecurity experiences. Furthermore, Bain, Jones, & Smith (2022) found that participants in agricultural and financial intervention programs reported fewer incidences of food insecurity due to increased access to resources and information, which helped them manage their food needs more effectively.

The ATET for HDDS was 0.1630225, while the ATEU was -0.3760108, resulting in a difference of 0.5390 (significant at 1%). The percentage change in HDDS was 143.37%. This highly positive change indicated a significant improvement in dietary diversity for program participants compared to non-participants. A 143.37% increase suggested that households participating in the program consumed a wider variety of food groups, reflecting better nutrition and food security status.

The increase in HDDS indicated that participants benefited from greater access to diverse foods, possibly due to enhanced income, improved agricultural practices, or better market access. This finding aligns with Ahmed, Rashid, & Sarker (2023) who found that targeted agricultural programs significantly enhanced household dietary diversity by providing better access to nutritious foods. Barrett, Swallow & Sumberg (2022) also supports this conclusion, demonstrating that participation in programs promoting agricultural innovation correlates with improved dietary diversity. Additionally, Osabohien, Olayemi, & Afolabi, (2022) reported similar findings that intervention programs led to increased consumption of diverse food groups, improving overall nutritional outcomes.

The analysis of the outcome indicators revealed that participation in the program significantly enhanced food security among households. The negative changes in CSI and FIES suggest reduced food insecurity and lowered reliance on negative coping mechanisms. Meanwhile, the positive change in HDDS indicates improved dietary diversity, contributing to better nutritional outcomes. These findings align with recent literature by Jones *et al*. (2021) who demonstrated that tailored agricultural programs, particularly those focusing on extension services and credit access, significantly enhance food security and reduce reliance on harmful coping strategies. Similarly, Barrett *et al*. (2022) emphasizes that programs targeting smallholder farmers, when coupled with financial literacy and resource access, improve dietary diversity and overall household welfare.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents a summary of findings in section 5.1. Section 5.2 presents the conclusion drawn from the results of the study and section 5.3, the policy recommendations.

5.1 Summary of findings

- This study examined the effects of participation in the Ghana Agricultural Sector Investment Programme (GASIP) on food security among smallholder farmers in the Upper East Region. Data for the study were collected during the 2024 cropping season A two-sampling procedure, purposive and simple random was employed in selecting the respondents due to the large population size, ensuring the analysis captures the most recent agricultural and food security dynamics. The primary aim was to understand how involvement in GASIP influenced key food security indicators, such as the Coping Strategy Index (CSI), Food Insecurity Experience Scale (FIES), and Household Dietary Diversity Score (HDDS).
- A Probit model was used to identify the determinants of GASIP participation, while an Endogenous Switching Poisson Regression model was applied to examine how participation influenced the adoption of CSAPs. Additionally, an Endogenous Switching Regression model was utilized to explore the effects of participation on food security outcomes as measured by HDDS, FIES, and CSI.
- The study found that GASIP awareness significantly increased the likelihood of participation, with households who were aware 37.9% more likely to participate. Other significant determinants included age, education, crop diversification, land ownership, and

access to credit which were all having positive effect on GASIP participation. Households practicing crop diversification were 7.5% more likely to participate, while landowners were 11.5% more likely to engage in the program.

- Interestingly, male farmers were less likely to participate compared to female farmers, possibly due to different roles and perceptions of agricultural programs. The study also highlighted that while age positively influenced participation, its effect was relatively low than other significant variables
- The adoption rates of various CSAPs among participants were substantial, with mixed cropping (90.24%), crop residue retention (88.54%), and mixed farming (69.02%) being the most prevalent practices. These practices were closely linked to improved sustainability and productivity of farming systems.
- Factors such as age, sex, education, and crop diversification were positively associated with the adoption of CSAPs. For example, male farmers were more likely to adopt CSAPs due to greater access to resources, while educated farmers had higher adoption rates due to better knowledge and skills.
- GASIP participation significantly improved food security outcomes. The study found a notable reduction in the Coping Strategy Index (CSI) by -5.31%, indicating a decrease in reliance on negative coping mechanisms such as reducing meal sizes or skipping meals.
- There was a significant decrease of -14.79% in the Food Insecurity Experience Scale (FIES) for participants, suggesting reduced experiences of food insecurity among program beneficiaries.
- The Household Dietary Diversity Score (HDDS) increased by 143.37% among participants, reflecting greater dietary diversity and improved nutritional intake,

attributable to better access to diverse food sources, increased income, and enhanced agricultural practices promoted by GASIP.

- The study revealed significant differences in food security outcomes between participants and non-participants. About 54.85% of participants were classified as food secure, compared to only 26.47% of non-participants. Conversely, a higher proportion of non-participants (57.35%) were severely food insecure compared to participants (29.13%). The analysis showed that GASIP participation reduced food insecurity and improved dietary diversity more effectively among participants than among non-participants, underscoring the importance of targeted agricultural programs.

5.2 Conclusion

The study revealed that participation in the Ghana Agricultural Sector Investment Programme (GASIP) significantly impacted smallholder farmers' food security and the adoption of Climate-Smart Agricultural Practices (CSAPs) in the Upper East Region of Ghana. Key determinants of participation such as awareness of GASIP, education, land ownership, and access to credit, were found to substantially influence farmers' likelihood of engaging in the program. The findings suggested that targeted efforts to increase awareness and access to resources were crucial for enhancing participation rates.

Moreover, the results indicated that the adoption of CSAPs was positively associated with factors such as age, sex, education, and crop diversification. Farmers who participated in GASIP were more likely to adopt these practices, which play a vital role in enhancing resilience against climate change and improving food security outcomes. Socio-demographic characteristics, such as age and sex, significantly affect food security outcomes, with older and female-headed households showing different effects on food security indicators.

GASIP participation had a differential impact on food security indicators. While participation in GASIP improved Household Dietary Diversity Score (HDDS) by increasing access to diverse food sources, it also influenced the Food Insecurity Experience Scale (FIES) and Coping Strategy Index (CSI) by reducing reliance on coping mechanisms and enhancing overall food security. However, the extent of these impacts varied among households, underlining the importance of targeted interventions that consider these diverse socio-economic backgrounds. The study emphasizes the critical role of program participation, education, land ownership, and access to financial services in improving food security among smallholder farmers.

5.3 Recommendations

Based on the findings and conclusions of this study regarding the effects of the Ghana Agricultural Sector Investment Programme (GASIP) on food security among smallholder farmers, the following policy recommendations are proposed for the Ministry of Food and Agriculture (MoFA), research institutions, and other stakeholders within the agricultural sector.

The MoFA, should prioritize enhancing awareness campaigns by utilizing local media, community meetings, and partnerships with farmer organizations to effectively communicate the benefits of agricultural programs. Although GASIP has concluded, this recommendation highlights the critical role of awareness in shaping the design and implementation of future initiatives. By adopting participatory approaches that actively engage farmers in the planning and execution of these campaigns, MoFA can ensure that future programs are inclusive, well-informed, and positioned for greater success.

Government through MoFA and donor agencies (IFAD) should prioritize education, capacity-building initiatives, and policy integration in future agricultural programs to promote the adoption of Climate-Smart Agricultural Practices (CSAPs). Lessons learned from the Ghana Agricultural Sector Investment Programme (GASIP) should guide the design of future initiatives, ensuring they address knowledge gaps and focus on sustainable farming practices. This can be achieved through comprehensive training programs that incorporate classroom learning, field demonstrations, mentorship, and access to educational resources, equipping farmers with the necessary skills to adopt innovative and climate-resilient agricultural methods.

In addition, fostering a culture of continuous learning through ongoing training and knowledge-sharing will empower farmers to make informed decisions and implement sustainable practices effectively. To ensure long-term food security and resilience to climate change, the government should integrate Climate-Smart Agriculture into national policies. Creating an enabling environment that incentivizes farmers to adopt sustainable practices will strengthen the agricultural sector's adaptability to climate challenges while promoting productivity and sustainability.

Government through MoFA and NGOs (IFAD) should develop gender-sensitive agricultural programs that support women's participation by providing them with access to resources, training, and decision-making opportunities. These efforts will foster an inclusive agricultural environment, empowering women and enhancing their contributions to the sector

Government and donor agencies (IFAD), in collaboration with the Ministry of Food and Agriculture (MoFA), should promote crop diversification initiatives and strengthen agricultural extension services to support smallholder farmers. Encouraging farmers to adopt high-nutrient and climate-resilient crop varieties through targeted extension services will enhance diverse cropping systems, improve dietary diversity, and reduce vulnerability to climate shocks.

To achieve this, MoFA should invest in training agricultural extension workers to address the diverse needs of smallholder farmers. This includes enhancing the dissemination of knowledge, resources, and tailored support for various demographic groups, ensuring all farmers receive the guidance necessary to adopt improved agricultural practices and boost productivity.

5.4 Limitations of the Study

Despite the robust analytical framework and empirical models employed in this study, a number of limitations should be acknowledged.

1. The study was geographically confined to three districts in the Upper East Region Bolgatanga Municipality, Bongo, and Builsa North. While these areas were purposively selected due to their active participation in GASIP interventions, the findings may not be generalizable to other regions of Ghana, particularly those with different agro-ecological, institutional, or market characteristics.
2. Due to logistical and financial constraints, the sample size was relatively small. This may reduce the statistical power of the study and limit the precision of the estimated effects, particularly in subgroup analyses.

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APPENDIX

UNIVERSITY FOR DEVELOPMENT STUDIES

FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES

DEPARTMENT OF AGRICULTURAL AND FOOD ECONOMICS

HOUSEHOLD SURVEY

TITLE: IMPACT OF PARTICIPATION IN GASIP PROGRAMME ON SMALLHOLDER FARMERS' WELFARE IN UPPER EAST REGION OF GHANA

This questionnaire is meant for data collection to address the above topic in partial fulfillment for the award of MPhil Agricultural Economics at the University for Development Studies. Your response to the questions would encourage the researcher to get appropriate information that will contribute to knowledge. Your confidentiality is assured.

District	Select from list of districts
Village/Community	Select from list of communities
GPS Coordinates of HH Compound	Latitude: |__|__|__||__|__|__||__|__|__||__| Longitude: |__|__|__||__|__|__||__|__|__||__|

SECTION A. DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

1. *Farmer basic characteristics*

Age of farmer	
Sex of farmer	(1) Male [ ] (2) Female [ ]
Marital status of farmer	(1) Married [ ] (2) Single [ ] (3) divorced [ ]
Household (HH) size	………………

Note: Household size includes all people, who usually eat from the same pot and sleep under the same roof. Include also members who are absent for less than two months!

2. *Educational status (human capital)*

Can the farmer (HHH) read, construct and write a simple sentence?	(1) Yes [ ] (2) No [ ]
Tick the highest level of education completed by the farmer	(1) Non-formal/Islamic education [ ] (4) Voc/Sec. Tech/SSS/SHS [ ] (2) Primary school [ ] (5) Teacher/Nursing Colleges [ ] (3) Middle school/JSS/JHS [ ] (6) Polytechnic/University [ ]

Number of years of schooling by farmer	…………………..

SECTION B: FARM CHARACTERISTICS AND HOUSEHOLD INCOME

1. *Farm Characteristics*

› you own the land you farm on?	(1) Yes [ ] (2) No [ ]
rming experience in years	

lease fill in the following table about the **crops grown** last year (in **kg/bags/crates/bowls**) where **1 bag = 100kg**

:rops	**Total land (acres)**	**Total production (kg or bags)**	**Sales (kg/bags)**	**Sales price (GH¢)**	**Savings/stored as seed (kg or bags)**	**Consumption (kg or bags)**
ɅIajor crop						
.. Maize						
:. Soyabean,						
:. Cowpea						
· others						
ɅIinor crop						
1. Pepper,						
2. Tomatoes,						
3. Okra						
4. Leafy Vegetables,						
5. others						

cost of inputs purchased

Crop	**Quantity (Seeds)kg**	**Unit price (Seed)** (GH₵)	**Quantity of Fertilizer bags**	**Unit price (Fertilizer)** (GH₵)	**Quantity of chemicals, (Herbicides)**	**Unit price (Herbicides)** (GH₵)	**Quantity of chemicals,** (pesticides)	**Unit price** (pesticide (GH₵)
1. Maize								
2. Soyabean,								
3. Cowpea								
4 others								
Minor crop								
1. Pepper,								
2. Tomatoes,								
3. Okra								

4. Leafy Vegetables,								
5. others								

2. *Household income (off farm)*

o you or any household member engage in off-farm income-enerating activities?	(1) Yes [ ] (2) No [ ]
yes, how much does your household earn on off farm for last ear?	Cedis
oes your household receive any other money from other relatives **emittance**)	(1) Yes [ ] (2) No [ ]
yes, how much does your household receives from relatives and iends for last year? (**Remittance**)	Cedis

2.1 AGRICULTURAL & HOUSEHOLD ASSETS: Livestock and Household asset owned and value

sset/Item	Do you have item? 0=No 1=Yes	If yes, how many?	unit cost (GHc)	total value GHc
tlass				
askets				
te sack				
otorize spraying machine				
andheld spraying achine				
adio				
elevision				
cycle				
otorcycle				
ar/Moto-King				
Mobile phone				
Refrigerator				
Computer				
House				
Cattle				
Sheep				
Goat				
Fowls				
Guinea fowls				
Ducks				
Pig				

2.3 *General questions*

Residential status	[ ] Indigene/native [ ] Settler [ ] Migrant
Do you have access to extension services?	[ ] Yes [ ] No
If yes, how many times last year?	
Are you a member of any farmers association?	[ ] Yes [ ] No
Do you use credit in production?	[ ] Yes [ ] No
If yes, what is the source of credit for your production?	[ ] Bank [ ] LBCs [ ] Cooperatives [ ] Friends/Family/Relative [ ] Moneylenders [ ] Mobile money
Have you ever participated in any training on climate change?	[ ] Yes [ ] No
Did you get access to fertilizer subsidy last year?	[ ] Yes [ ] No
Did you get access to mechanization/tractor services?	[ ] Yes [ ] No
Are you aware of crop insurance?	[ ] Yes [ ] No
Have you ever participated in crop insurance?	[ ] Yes [ ] No

SECTION C: Participation in GASIP

3. *Participation in GASIP*

re you aware of the GASIP program?	(1) Yes [ ]	(2) No [ ]
GASIP present in your community?	(1) Yes [ ]	(2) No [ ]
re you a GASIP participant?	(1) Yes [ ]	(2) No [ ]
o you have Knowledge of someone working at GASIP?	(1) Yes [ ]	(2) No [ ]
as any family member previously worked with GASIP?	(1) Yes [ ]	(2) No [ ]
ave you participated in similar projects before?	(1) Yes [ ]	(2) No [ ]
Did you receive training about GASIP?	(1) Yes [ ]	(2) No [ ]
How long have you been in GASIP?		
Is GASIP beneficial?	(1) Yes [ ]	(2) No [ ]
Do you have access to irrigation for your farm?	(1) Yes [ ]	(2) No [ ]
If yes was the irrigation supported/facilitated by GASIP?	(1) Yes [ ]	(2) No [ ]
Do you have access to inputs for your farm through GASIP?	(1) Yes [ ]	(2) No [ ]
If yes was the inputs supported/facilitated by GASIP?	(1) Yes [ ]	(2) No [ ]
Did you benefit from PFJ input program?	(1) Yes [ ]	(2) No [ ]
Did you received financial literacy from GASIP?	(1) Yes [ ]	(2) No [ ]
Did GASIP facilitate opening of a bank account for you?	(1) Yes [ ]	(2) No [ ]
Do you have access to credit for your farm facilitated by GASIP?	(1) Yes [ ]	(2) No [ ]
Do you have access to market information?	(1) Yes [ ]	(2) No [ ]
Do you have access to market for your farm?	(1) Yes [ ]	(2) No [ ]

What is the distance from your home to the agricultural extension office? ………….. km	
What is the distance from your home to the local market? …………….. km	
What is the distance from your home to the farm? km……………….	
Are you a member of a farmer- based organization (FBO)?	(1) Yes [ ] (2) No [ ]
Do you receive weather information?	(1) Yes [ ] (2) No [ ]
your opinion what have been the rainfall pattern for the previous ear?	(1)Low [ ] (2)High [ ]
your opinion what have been the temperature for the previous ear?	(1)Low [ ] (2)High [ ]

4. *Climate Smart Agriculture Practices*

SAP – which of the following do you practice?	
. Agroforestry	(1) Yes [ ] (2) No [ ]
. Mulching	(1) Yes [ ] (2) No [ ]
. Mixed Cropping	(1) Yes [ ] (2) No [ ]
. Mixed Farming	(1) Yes [ ] (2) No [ ]
. Crop Rotation	(1) Yes [ ] (2) No [ ]
. Improved Seed Varieties	(1) Yes [ ] (2) No [ ]
. Irrigation Management	(1) Yes [ ] (2) No [ ]
. Changing Planting Time	(1) Yes [ ] (2) No [ ]
. Proper fertilizer Application	(1) Yes [ ] (2) No [ ]
0. Integrated pest management	(1) Yes [ ] (2) No [ ]
1. Crop residue	(1) Yes [ ] (2) No [ ]
2. Minimum tillage /Zero tillage	(1) Yes [ ] (2) No [ ]
3. Manure / inorganic fertilizer	

5. *Food Insecurity Experience Scale Survey Module (FIES-SM)*

IES-SM Individual – 12 Months

Now I would like to ask you some questions about food.	
Q1. During the last 12 months, was there a time when you were worried you would not have enough food to eat because of a lack of money or other resources?	0 No 98 Don't Know 1 Yes 99 Refused
Q2. Still thinking about the last 12 months, was there a time when you were unable to eat healthy and nutritious food because of a lack of money or other resources?	0 No 98 Don't Know 1 Yes 99 Refused
Q3. During the last 12 months, was there a time when you ate only a few kinds of foods because of a lack of money or other resources?	0 No 98 Don't Know

	1 Yes 99 Refused
Q4. During the last 12 months, was there a time when you had to skip a meal because there was not enough money or other resources to get food?	0 No 98 Don't Know 1 Yes 99 Refused
Q5. Still thinking about the last 12 months, was there a time when you ate less than thought you should because of a lack of money or other resources?	0 No 98 Don't Know 1 Yes 99 Refused
In the past 12 months, was there a time when your household ran out of food ause of a lack of money or other resources?	0 No 98 Don't Know 1 Yes 99 Refused
In the past 12 months, was there a time when you were hungry but did not eat ause of a lack of money or other resources for food?	0 No 98 Don't Know 1 Yes 99 Refused
During the last 12 months, was there a time when you went without eating for a le day because of a lack of money or other resources?	0 No 98 Don't Know 1 Yes 99 Refused

6. Consumption Coping Strategy Responses (CSI) Behaviors:

aviors: In the past 7 days, if there have been times when you did not have ugh food or money to buy food, how many days has your household had to:	Frequency: Number of days out of the past seven: (Use numbers 0 – 7 to answer number of days; Use NA for not applicable)
ely on less preferred and less expensive foods?	
orrow food, or rely on help from a friend or relative?	
urchase food on credit? d. Gather wild food, hunt, or harvest immature crops?	
onsume seed stock held for next season?	
f. Send household members to eat elsewhere?	
g. Send household members to beg?	
h. Limit portion size at mealtimes?	
i. Restrict consumption by adults in order for small children to eat?	
j. Feed working members of HH at the expense of non-working members?	
k. Reduce number of meals eaten in a day?	
l. Skip entire days without eating?	

HOUSEHOLD CONSUMPTION AND NON-FOOD ITEMS EXPENDITURE AS A MEASURE OF WELFARE

Expenditure item		Amount per week (for food) and Amount per month for non-food items (GHC)
• Own-produced food (Cost incurred in agricultural production (crops and or animals)): Estimate cost of own produced food (assuming you are to buy in your local market) per week.		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
•		
• Purchased-Food: Estimate cost of food items (e.g., milk, meat, fish, oil, fruits, vegetables, salt, etc.) that you bought for the household per week.		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Food as gift: Estimate cost of food giving to you as gift by relatives and friends (assuming you are to buy them) per week		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Accommodation (Assume how much you will pay if you are in your own house/room; maintenance cost should be included)		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Clothing		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Education		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Health or medication		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Transportation		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Utility;	(a) Water	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
	(b) Electricity	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
	(c) Kerosene	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Communication (telephone, postal etc.)		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Sanitation		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Ceremonies;	(a) Funerals	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
	(b) Naming and outdooring ceremonies	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }

	(c) Parties/entertainments	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
	(d) Tithes and offerings	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
	(e) Gifts	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
	(f) Others………………………	1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Fuel/ Firewood		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Saving		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Maintenance of assets (e.g. TV, Motor bikes, Cars etc)		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }
• Others………………………………………..		1, 1 – 50 { } 2. 51 – 100 { } 3. 101 -150 { } 4. 151 – 200 { } 5 201 above { }

7. *Food Consumption Score and Food Consumption Score Nutrition*

This module will allow you to collect information needed to compute the FCS and the FCSN

How many days over the last 7 days, did most members of your household (50% +) eat the following food items, inside or outside the home? And what was their source? *(Use codes below, write 0 if not consumed in the last 7 days)*

Note for enumerator: Determine whether the consumption of fish, milk was only in small quantities.

	Foods	Number of days eaten in the past **7 days** *If 0 days, do not specify the main source.*		How was this food acquired? **Write the main source of food for the past 7 days**
1.	**Cereals, grains, roots and tubers, such as:** Rice, pasta, bread, sorghum, millet, maize, potato, yam, cassava, white sweet potato, plantain	|___|	FCSStap	|___|
2.	**Pulses/legumes, nuts and seeds, such as:** beans, cowpeas, lentils, soy, pigeon pea, peanuts, and/or other nuts	|___|	FCSPulse	|___|
3.	**Milk and other dairy products, such as:** milk, yoghurt, cheese, and other dairy products [Exclude margarine/butter or small amounts of milk for tea/coffee]	|___|	FCSDairy	|___|
4.	**Meat, fish and eggs, such as:** goat, beef, chicken, pork, fish, including canned tuna, insects, escargot, and/or other seafood, eggs (meat and fish consumed in large quantities and not as a condiment)	|___|	FCSPr	|___|
If 0 à skip to question 5				
4.1	**Flesh meat, such as:** beef, pork, lamb, goat, rabbit, chicken, duck, other birds, insects	|___|	FCSNPrMeatF	|___|
4.2	**Organ meat, such as:** liver, kidney, heart and/or other organ meats		FCSNPrMeatO	

4.3	**Fish/shellfish, such as:** fish, including canned tuna, escargot, and/or other seafood (fish in large quantities and not as a condiment)	|___|	FCSNPrFish	|___|
4.4	**Eggs**	|___|	FCSNPrEggs	|___|
5.	**Vegetables and leaves, such as:** spinach, onion, tomatoes, carrots, peppers, green beans, lettuce, etc	|___|	FCSVeg	|___|
If 0 à skip to question 6				
5.1	**Orange vegetables (vegetables rich in Vitamin A), such as:** carrot, red pepper, pumpkin, orange sweet potatoes	|___|	FCSNVegOrg	|___|
5.2	**Green leafy vegetables, such as:** spinach, broccoli, amaranth and/or other dark green leaves, cassava leaves	|___|	FCSNVegGre	|___|
6.	**Fruits, such as:** banana, apple, lemon, mango, papaya, apricot, peach, etc	|___|	FCSFruit	|___|
If 0 à skip to question 7				
6.1	**Orange fruits (Fruits rich in Vitamin A), such as:** mango, papaya, apricot, and peach [Exclude oranges]	|___|	FCSNFruiOrg	|___|
7.	**Oil/fat/butter, such as:** vegetable oil, palm oil, shea butter, margarine, and other fats/oil	|___|	FCSFat	|___|
8.	**Sugar, or sweet, such as:** sugar, honey, jam, candy, cookies, pastries, cakes and other sweet (sugary drinks)	|___|	FCSSugar	|___|
9.	**Condiments/spices, such as:** tea, coffee, cocoa powder, salt, garlic, spices, yeast, baking powder, tomato paste or sauce, and small amounts of meat, fish, milk or other food items consumed as a condiment	|___|	FCSCond	|___|
Codebook list name: SRf		**Food acquisition codes** 1= Own production (crops, animal) 2 = Fishing / Hunting		

	3 = Gathering 4 = Loan 5 = Market (purchase with cash) 6 = Market (purchase on credit) 7 = Begging for food 8 = Exchange labor or items for food 9 = Gift (food) from family relatives or friends 10 = Other 11 = Food aid from civil society, NGOs, government, WFP etc.