UNIVERSITY FOR DEVELOPMENT STUDIES

THE EXTENT AND DETERMINANTS OF CLIMATE-SMART AGRICULTURE PRACTICE ADOPTION AND PRIORITIZATION IN NORTHERN GHANA

OBED KWAKU MAHAMA

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BY

OBED KWAKU MAHAMA

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

SEPTEMBER, 2022

DECLARATION

STUDENT

I hereby declare that this thesis is a result of my original work and that no part of it has been presented for another degree in this University or elsewhere:

CANDIDATE:

Signature;…………………………. Date;…………………………………..

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We hereby declare that the preparation and presentation of this thesis was supervised following the guidelines on supervision of thesis laid down by the University for Development Studies.

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ABSTRACT

Climate-smart agriculture (CSA) has become a touchy subject among all stakeholders in developing countries such as Ghana. Despite all efforts to promote the CSA in order to achieve sustainable yields, boost food and nutrition security, and adapt to and mitigate climate change, the farmers adoption is low. Stakeholders and other value chain actors, such as credit and service providers, are withdrawing in large numbers as a result of the agriculture risk trend. This study therefore seeks to suggest that beyond the adoption of CSA practices, farmers have to express their prioritization of the adopted CSA practices. Stakeholders can therefore focus on adopted practices that are prioritized by the farmers to ensure increases and sustainable adoption of these CSAs. Descriptive statistics was used to examine the extent of CSA practice adopted and prioritized. Multivariate Probit and the multinomial Probit model were used to examine determining factors for CSA practice adopted and prioritized respectively. The adoption and prioritization of the practices were low for all the practices. It was discovered that the determinants of CSA practices are best observed when the practices are prioritized. The study also revealed that not all adopted practices were prioritized. Five CSA practices were adopted and prioritized (Enhancing access to climate information, legumes crop as a previous crop, organic amendment to improve soil health, promotion of disease and pest-tolerant varieties, and promotion of stress-tolerance varieties). It was also concluded that, the farmers participation in CSA practice formulation enhances the prioritization of the practice.

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DEDICATION

I dedicate this work to my beloved mother, Asibi Ayenisah, and to my family.

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ACRONYMS AND ABBREVIATIONS

Climate Smart Villages	CSVs
Climate Smart Agriculture	CSA
Coefficient of Variation	CV
Food and Agricultural Organisation	FAO
Gross Domestic Product	GDP
Ghana Living Standard Survey	GLSS
Greenhouse Gas	GHS
Government of Ghana	GoG
Ghana Statistical Service	GSS
Intergovernmental Panel on Climate Change	IPCC
Provisional National Defense Council	PNDC
Inverse-Probability-Weighted Regression Adjustment	IPWRA
Metropolitan, Municipal, and District Assemblies	MMDAs
Ministry of Food and Agriculture	MoFA
Ministry of Finance and Economic Planning	MOFEP
Organizations for Economic and Co-operation Development	OECD
Population and Housing Census	PHC
Sub-Sahara African	SSA
Sustainable Development Goals	SDGs
Weather and Climate Information Services	WCIS
World Food Programme	WFP
World Health Organization	WHO

CHAPTER ONE

INTRODUCTION

1.1 Background

There has been a sharp rise in the global population over the centuries, and the largest proportionate increase is from developing countries (UN DESA, 2021). According to the World Bank report (2021), Sub-Saharan Africa and low-income countries had as high as 2.6 and 2.7 percent annual population growth respectively for the year 2020. Ghana was not of exception as it recorded a 2.1 percent growth in population. This population growth, together with urbanization and economic development, has resulted in a massive increase in food, energy, and water demand, putting pressure on the environment (Fukase & Martin, 2020; Molotoks et al., 2018). Satisfying these demands of the growing population, Crist et al (2017) asserted that, our natural world would be undermined. The scale of the human population and the current rate of its growth will significantly cause a loss in biodiversity and increase greenhouse gases emission. The rising food demand for the global population has led to predictions that, demand for food will be growing at a stable rate while global food production will not march the global food demand growth rate. The difference between food demand and supply will eventually widen (Tian et al., 2021).

Ghana is an agrarian economy with a subsistence agriculture system, with about 90% of farms less than 2 ha (MoFA, 2015). The agriculture sector is heavily dependent on rainfall, with limited access to credit, low level of mechanization, climate variation and change, high post-harvest losses, and among others have been major problem in the sector. Ghana's per capita GHG emission is ranks 151st out of 188 nations, accounting for only 0.07 percent of global emissions. According to the world resources institute climate analysis indicators tools, Ghana contributed 0.133 percent of the global emission in 2011with 59Mt CO_2 with 2.3 Mt CO_2 per capita (Winkler et al., 2018). Agriculture emissions increased by 32% between 1990 and 2011 (USAID, 2016), with the increase due to regular biomass burning in land preparation and an increase cattle production (MESTI, 2015). In 2012, the leading source of emissions were the agriculture sector, forestry sector, and other land use (AFOLU), accounting for 45.1 percent of the total net emissions thus 15.17 MtCO2e (MESTI, 2015). Ghana is noted to be a hotspot and extremely sensitive to climate change, the country is ranked the 101th of 181 most vulnerable nations. Ghana is 68th in most vulnerable country and the 85th least prepared, indicating that it is both vulnerable to and moderately prepared to handling the effects of climate change (MFAGG, 2019). The northern parts of Ghana have been highlighted highly vulnerable to climate variability and change relative to the other parts of the country and been indicated that there are variations in the rainfall pattern and an increase in the temperature in parts of the northern region (Klutse et al., 2021; Baffour-Ata, 2021).

The Medium-Term Agriculture Sector Investment Plan (METASIP), from 2011 to 2015 was developed through a large-scale participatory process and was based on FASDEP II objectives, with a target of at least 6% annual growth of GDP in the agriculture sector and at 10% of national budget was earmarked for government expenditure during the planning stage. These goal are in line with the Ghana Shared Growth and Development Agenda (GSGDA), ECOWAS'

ECOWAP, and NEPAD's CAADP, and are intended to contribute considerably to the UN's Millennium Development Goals (MoFA, 2015).

In light of the challenges imposed by climate change, the idea of climate smart agriculture conceptualized with three core aims, which are: increasing agriculture productivity to enhance food security, adapting to climate variability and change, and the reduction of greenhouse gas emission (Lipper & Zilberman, 2018). The Agricultural subsectors such as crop and animal production, fisheries, aquaculture, forestry, land and water resource management, and various stages of food value chains all confront unique issues relating to CSA's three goals, but they are all interconnected (Matteoli et al., 2020).

Climate change is a global constraint that requires an intensive effort by all nations. The National Climate Change Policy of Ghana is an integrated response to climate change. It was prepared and designed within the context of national sustainable development priorities. It provides a well-defined pathway for dealing with negative impacts of climate change and variation within the socio-economic of Ghana and looks to taping the opportunities and benefits of a green economy. The National Climate Change Policy directs and coordinates how Ghana responding to the challenges of climate change, effective adaptation, mitigation, and social development are the three goals the policy. Four subject areas have been selected to address Ghana's adaptation difficulties thus infrastructure and energy, natural resources management, food and agricultural security, and disaster planning and response (Ministry of Environment, Science, 2013) (Aggarwal, Jarvis, Campbell, Zougmoré, Khatri-chhetri, et al., 2018; Asumadu-Sarkodie & Owusu, 2017).

Again, Ghana's Ministry of Agriculture (MoFA) in 2019 created the Climate-Smart Agriculture Investment Plan (CSAIP) to execute the Agricultural and Food Security component of the National Climate Change Policy. The government, together with cooperating bodies, has implemented several climate-smart agricultural practices across the nation (MoFA, 2020).

According to Noellemeyer et al, (2018), Climate-Smart Agriculture (CSA) practice prioritization involves the selection and ranking of various CSA practices based on their suitability for a specific region or context. The process involves identifying and evaluating the potential benefits and challenges of different (CSA) practices in addressing the impacts of climate change on agriculture, including enhancing food security, increasing productivity, improving resilience to climate variability, and reducing greenhouse gas emissions.

1.2 Problem statement

Agricultural productivity in several developing nations has been declining. This is attributed to population growth and climate change variations (Robinson, 2020). Given changing climatic conditions in agriculture, there is a risk of inefficiently supplying the agricultural needs of a growing global population in the future (Martinez et al., 2018; Zhang et al., 2018).

The variation in climate conditions like rainfall, temperature, and extreme weather events like floods, droughts and soil erosion has led to decline in crop yield and increased pest infestation (Wossen et al., 2018). Sullo et al. (2020) studied the indigenous knowledge indicators in determining the changes in climate and reported that climate variability has become a serious problem for rural farmers in Ghana due to its effects on components important for agricultural production.

Frimpong et al. (2020) determined how vulnerable smallholder farmers were to heat stress by measuring their heat exposure. Farmers may experience different effects from heat exposure and have a variety of coping mechanisms, but these are inefficient at protecting them from heat-related mortality and morbidity at both the farm and household levels. This suggests that there should be some improvements made to the current heat exposure prevention strategies at the household level.

According to a study conducted by Asante et al. (2021) in Northern Ghana, the majority (95.9 percent) of smallholder farmers have observed climate change in their local environment, including prolonged drought (95.9 percent), unpredictable rainfall patterns (94.2 percent), high temperatures (99.2 percent), strong winds (66.9 percent), and frequent flood events (99.2 percent). Smallholder farmers have discovered that variations in rainfall patterns (97.5 percent) and temperature (99.2 percent) lead to a decline in agricultural output.

Klutse et al. (2020) stated that minimum air temperatures are expected to rise by 0.5 °C under RCP 2.6 and 2.5 °C under RCP 8.5, respectively, over northern Ghana. By the year 2080, maximum air temperatures are probably going to rise by 1 °C under RCP 2.6 and 2 °C under RCP 8.5. The stations' yearly warming rates show that the lowest temperatures are warming more quickly than the maximum temperatures. The minimum temperatures and heat waves are closely correlated. Without the implementation of measures like irrigation and appropriate crop selection, smallholder food crop farming systems are likely to be significantly impacted, with a direct risk of low crop production. This, among others, triggers welfare reduction through increased crop yield gaps, making people vulnerable to food insecurity and poverty traps (Boadi et al., 2017; Puplampu & Essegbey, 2020).

File and Derbile, (2020), assessed climate change sensitivity in north western Ghana, concentrating on temperature, sunshine, and wind as climate components. According to the findings, smallholder farmers in the present generation are more vulnerable to climate change than those in the grandparents' generation were. As a result, farmers now are exposed to more intense sunlight, heat, and wind than they were in the past. As a result, these climate threats have a particularly negative impact on their way of life.

The attempt to address this effect of climate change and climate variation requires large-scale investment in climate-change agriculture systems or practices (Karanja et al., 2021; Rosenstock et al., 2015). A strong collaboration between the government and private sector happens to be a promising way to create business opportunities for private entities to upscale CSA practices (Casey et al., 2021; Totin et al., 2018). There happens to be a higher risk associated with agriculture with which Ndamani and Watanabe (2017) reported that about 97 percent of these risks are climate-induced and the rest are unknown in the rural Ghanaian setup. This has weakened the private sector’s role in Ghanaian’s agricultural development in general and has led to weak CSA practices prioritization, which are often seen as undesirable business practices (Totin et al., 2018).

Research on CSA has been growing in diverse ways to help address climate change and much literatures are found on CSA technologies and practices, CSA adoption, and determinants of CSA adoption but less literature are found on the determinants of CSA practice prioritization. It is shown to have been studied by (Zakari et al., 2019) in Niger but not in the Ghanaian context. Damba, Kizito, et al. (2021) have done closely related studies in Ghana but did not capture the determining factors of the prioritization of the CSA practices.

According to Nkonya et al. (2016), adoption of CSA in northern Ghana is hindered by the lack of technical capacity and financial resources. Therefore, there is a need to prioritize the most effective and feasible CSA practices that can be implemented with limited resources.

1.3 Justification of the study

Climate change poses a significant threat to farmers that are resource constrained all over the world. However, the situation happens to be more intense in SSA and Ghana, where the three northern areas are thought to be the most vulnerable to climate change's harmful effects. This study will show the conversant way of dealing with the effect of climate change among farmers in the study area. There are several research conducted on CSA practice, CSA practice adoption, CSA practice prioritization, and determinants of CSA adoption, and not much has been done on the determinants of CSA practice prioritization by farmers. This study was focused on CSA practices that were prioritized for determinants to influence policy directions. The determinants of these prioritized practices are more representative because they select the best utility maximization practice from the ones they adopted. This will reflect the targeted areas on which policies should focus in promoting specific CSA practices.

The extent of CSA practice adoption and prioritization is ideal to know how these CSA practices are likely to contribute to achieving the CSA goals (increase productivity, mitigation, adaptation to climate, and reduction of greenhouse gas emissions). How well farmers in northern Ghana use these CSA practices and the kinds of practices that are very important to their production are very important. This will guide the stakeholders towards the kinds of CSA practices that, when promoted, will have the maximum impact on the farmers, the climate, and the value chain and protect their investment. This study will also add to the literature on the determinants of CSA practices prioritization among farmers in northern Ghana and the best approach to help reduce the risk of promoting climate-smart agriculture through the reduction in dis-adoption.

1.4 Research Questions

What is the extent and determinants of CSA practice adoption and prioritization in Northern Ghana?

Specific Questions

1. What is the extent of CSA practice adopted and prioritized in Northern Ghana?
2. What are the factors influencing CSA practice adoption in Northern Ghana?
3. What are the factors influencing CSA practice Prioritization in Northern Ghana?

1.5 Research Objectives

The main objective of this research is to examine the extent and determinants of CSA practice prioritization and adoption in Northern Ghana.

Specific objectives

1. To determine the extent to which farmers have prioritized and adopted CSA practices in Northern Ghana
2. To identify the factors influencing CSA practice adoption in Northern Ghana
3. To identify the factors influencing CSA practice Prioritization in Northern Ghana

1.6 The organisation of the study

This thesis is done in five main chapters with sub-chapters. The first chapter presents the introduction of the thesis and sub sectioned the background, problem statement, and justification. It continued with the main and specific research questions the study addressed, stated the main and specific objectives, and ended the chapter with the scope of the study.

Literature review of the study was captured in the second chapter of the study.

The third chapter of this study is for methodology of the thesis, it captured the study area, design of the research, conceptual and theoretical framework, and the models to achieve the stated objectives of the study. The chapter four displays the results and discussion of the outcome of the study.

The last chapter (Chapter five) shows the summaries of the findings, conclusion, and policy recommendation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature on topics related to this research. The concepts employed in this research are also explained in this chapter. Section 2.1 discussed the climate change village approach, and sections 2.3 and 2.4 discussed climate change and the effect of the climate change on agriculture. Climate smart agriculture, climate smart agriculture adoption, and climate smart agriculture prioritization were reviewed in sections 2.5 to 2.7 and section 2.8 reviewed an empirical study of determinants of CSA adoption and prioritization.

2.2 The climate change village approach

Researchers, local partners, and farmers cooperate to analyse and maximize interactions across a portfolio of climate-smart agricultural interventions in climate-smart villages. Researchers, local partners, farmer organizations, and policymakers collaborate to identify the most effective technology and institutional interventions to improve productivity, increase incomes, achieve climate resilience, and enable climate mitigation based on global knowledge and local realities. This is accomplished by enhancing farming communities' capabilities through the use of targeted agricultural technologies, climate information services, and collaboration with institutions and policymakers. These villages are set up in areas recognized as climate change hotspots in Asia, Africa, and Latin America, with the primary purpose of focusing on long-term agricultural development (Aggarwal, Jarvis, Campbell, Zougmoré, Khatri-

Chhetri, et al 2018; Jules Bayala et al., 2016; Hariharan et al., 2020; Tuan et al., 2016).

The Climate-Smart Villages (CSV) is to strategically; Understand the efficacy of several CSA alternatives (technologies, practices, services, policies and programs) not only for increasing productivity and rising incomes, but also for building climate resilience, reducing GHG emission, increasing adaptive capacity wherever possible; developing (non-regrettable) solutions in consideration of the future effects of climate change; Recognize the gender, socioeconomic, and biophysical barriers to adoption as well as the enablers; identify and test promising adoption incentives, institutional arrangements, financial options and scaling up methods while ensuring alignment with institutions, local and national knowledge and development strategies (Aggarwal et al., 2018; Jules Bayala et al., 2016; CCAFS, 2017; Gates, 2015; Sanogo et al., 2020; Sunil & Rameti, 2017).

Bayala et al 2021 used the CSV approach to implement research activities in the following areas, Burkina Faso's Tibtenga (Yatenga); Ghana's Doggoh (Jirapa), and Bompari (Lawra); Mali's Ngakoro and Tongo (Cinzana); Niger's Kampa Zarma (Kollo); and Senegal's Ngouye and Daga Birame (Kaffrine). Except for the Senegal sites (15m to 50m asl), which are located at a significantly lower altitude than the others, all of these locations are between 180 and 350 meters above sea level (asl) and are located at a much lower altitude compared to the others.

The CSVs in Ghana have climate-smart interventions such as; Weather-smart activities, this intervention or portfolio comprises climate informed agriculture advisories, weather updates, weather insurance, climate analogies as a tool for forwarding planning, maladaptation prevention techniques. Seed-Smart or breed smart portfolio comprises adopted varieties and breeds, seed banks including community based initiatives; Water-smart practices portfolio comprises aquifer recharging, rainwater harvesting, laser-land levelling, community water management, raised bed planting, micro irrigation, and solar pumps; Carbon or nutrient smart practices portfolio entails agroforestry, minimum tillage, livestock management, integrated nutrient management, land use systems and biofuels; and market/institutional smart activities portfolio entail cross sectional links; local institutions, including learning platforms and local institution, contingency planning, market information, financial services, gender equitable approaches, and off farm risk management strategies (Aggarwal, Jarvis, Campbell, Zougmoré, Khatri-Chhetri, et al., 2018).

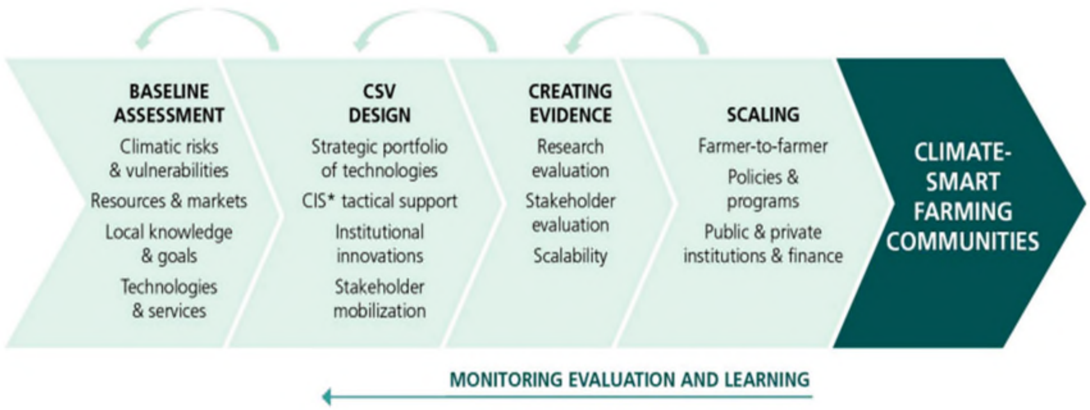

Figure 2.1: Steps for CSV AR4D approach implementation

Source: (CCAFS, 2017)

Figure 2.1 shows the process of establishing the CSV AG4D site. In establishing a CSV AR4D site, the first and most important phase is to establish trust and relationships among various stakeholders and obtain agreement and buy-in to a common strategy. The primary procedures then follow once partners have opted to build a CSV site.

2.3 Climate change

Over the immediate past decades, the International Panel on Climate Change (IPCC) statements on the human role in recent global warming have become increasingly evident in the Second Assessment Report (Houghton, 1996) thus from “a measurable human influence on the global climate” to “human impact has been the primary source of observed global warming since the mid-twentieth century” in the Fifth Assemble Report (Dahe et al.,2014).

Climate change is likely to progressively mount pressure on global and food access in vulnerable regions, which affects food and nutrition security.

Floods, droughts, and heatwaves will become more frequent, severe, and intense and persistent sea level rise will raise the risks of food security in marginalized regions from a moderate to high (high confidence) between 1.5^{o}C and 2^{o}C of global warming with little or no level of adaption (medium confidence). Food security threats from climate variations and changes will be more intense in the mid-term if global warming is greater than or 2^{o}C. resulting in malnutrition and micronutrient deficiencies, especially in the Sub-Saharan Africa, Central and South America, South Asia, and small islands.

In the long term, areas vulnerable to climate-related hazards would grow significantly if global warming rises to 3°C or greater (high confidence), aggravating regional disparities in food security concerns (IPCC, 2022).

2.4 Effect of climate change on agriculture

Climate change effects on agriculture are largely shrouded in mystery. Climate change on the other hand, is predicted to have a negative impact and has highly challenged production in agriculture due to changes in climate variations and change, precipitation, temperature, longer dry periods, and carbon dioxide fertilization (Karimi et al., 2018; Mutunga et al., 2017).

According to Komives et al., (2019), agriculture has been and is arguably among the most vulnerable sectors to climate change. The agricultural and food industries contribute significantly to climate change, but they are also particularly vulnerable to the consequential outcome. Technological advancements are targeting at mitigating the effects of climate change, making it more imperative than ever to recruit, retain, and develop qualified personnel in this sector (Frona et al., 2021).

Chemura et al., (2020) studied the Impacts of climate change on the agro-climatic suitability of major food crops in Ghana, and the study modelled the climatic suitability for sorghum, maize, groundnut, and cassava using obtained yield and agronomic variables. It was shown that, under climate projected conditions, three crops out of the four had decreasing optimal suitability areas except for groundnut.

In current climatic conditions, 18 percent of Ghana's land is suitable for two crops. Regions with optimal suitability for two and three crops will drop by 12% under forecasted climatic conditions, whereas areas with moderate suitability for multiple crops will expand.

A study by Baffour-Ata et al. (2021) asserting climate variabilities effect on yield asserted that, the reduction in annual rainfall and rise in the annual temperature led to decrease in crop yields. The variability in the onset, length of rain days, cessation of rain, and the number of dry days has resulted in variations in the yields of rice, maize, millet, sorghum, and groundnut at a magnitude of 14%, 25%, 30%, 32%, and 43% respectfully. Their study results generally showed that climate change significantly affects agriculture in northern Ghana.

The farming system selection in Ghana has been impacted by climate change as studied by Etwire, (2020). Farmers are adjusting their practices in response to climate change. They are switching farm types that are changing from a climate-vulnerable system of farming to a more resilient one. Based on this study, the farmers were likely moving from specialized tree based plantation and crop farming to specialized integrated food crop and livestock farms. It was also noted that the aggregated volume of agricultural output and value will reduce since plantations are the most profitable farm venture currently. This is because of climate-induced agroecological shifts thus desertification and shortened rainy days for growing in a season have led to declined tree-based farms.

According to a study by Nyuor et al. (2016), climate change has a considerable economic influence on agriculture in Ghana, particularly cereals. High temperatures throughout the growing season, particularly in the early and late seasons, could explain the negative association between temperature and net revenue. The estimates revealed that the net revenue per hectare of maize and sorghum in Northern Ghana was considerably impacted by temperature and precipitation. Given present levels, increasing precipitation (by 1 mm) and decreasing temperature (by 1 °C) would affect net revenue, although differently across seasons and crops. The net revenue for both crops declined as a result of temperature levels during all seasons.

Bikwibili et al. (2021) examined the effects of flood disasters, climate change and food security in northern Ghana. Flood disasters are one of the consequences of climate change, which influence food production negatively and as a result, food security.

Further research indicates that there is a chance that both the frequency of floods and their effects will rise in the future. Floods submerge crops and farm, cattle and pastures, potentially reducing crop yield and animal output. In addition to destroying physical infrastructure, floods can interrupt socioeconomic activity connected to the agricultural sector and may have an impact on food production. The potential to affect agricultural productivity and food security in northern Ghana is suggested by evidence from the literature that flood episodes caused by the spill of the Bagre dam is related to climate change (Alhassan, 2020).

2.5 Climate-smart agriculture

Climate Smart Agriculture is an initiative for guiding agriculture operations in the face of climate variation and changes.

This concept was introduced in 2010 by the Food and Agriculture Organization of the United Nations. and it has from that time being improving based on the inputs and synchronal involvement of several parties in its implementation and development. The Climate Smart Agriculture's goal is to develop internationally executable principles for managing agriculture sustainably in the rising climate change issues, this serve as the bases for policy support and recommendations from several multilateral institutions like the UN's FAO (Lipper & Zilberman, 2018).

CSA is a term coined by the Food and Agriculture Organization (FAO) of the United Nations (UN) to describe agricultural practices that increase productivity, contributes to increased resilience (adaptation), and decrease greenhouse gas emission (mitigation) where there is a possibility, while also assisting in the attainment of food security and developmental goals (FAO, 2021; IPCC, 2021).

It was asserted by Zougmoré et al., (2019) Climate Smart Agriculture has been initiated to cover all components of agriculture, through field events or practices to the food supply chain, and enabling CSA across all levels of demands a significant initiative to execute its policies, safety, capacity building and economic matters (Sarker et al., 2019).

2.6 Climate -smart agriculture adoption

Climate Smart Agriculture is an approach that aims to address the challenges of climate change in agriculture while enhancing sustainable development of agriculture to improve food security. Adoption of CSA practices is critical for the success of this approach, and several studies have examined the determining factors of CSA adoption in different contexts.

Socio-economic factors, like access to finance, land tenure, and market access, have been identified as critical factors of CSA adoption. For example, a study by Amoah et al. (2020) found that access to credit predicted the adoption of CSA practice among rural farmer in Ghana was significant. In contrast, a lack of access to credit was identified as a significant barrier to the adoption of access to credit was identified as an important barrier to the adoption of CSA practices. A different study by Kilic et al. (2020) showed that access to finance and credit played a significant role in promoting the adoption CSA practices among farmer in Turkey.

Institutional factors, such as policy frameworks, institutional support, and stakeholder engagement, also play a critical role in promoting CSA adoption. A study by Brempong et al. (2020) found that policy frameworks that promote the adoption of CSA practices and stakeholder engagement that incorporates the perspectives of various actors were critical in promoting the adoption of CSA practices in Ghana. On the other hand, a lack of institutional support was identified as a significant barrier for CSA adoption in several studies (Kueper etal., 2021; Wanjiku et al., 2021).

Individual factors, like the farmers knowledge, attitudes, and perceptions of CSA practices, also influence CSA adoption. A study by Donkoh et al. (2020) found that farmers' knowledge of CSA practices and their perceptions of their efficacy significantly predicted their adoption of these practices in Ghana. Research has also shown that farmer-to-farmer extension services are an effective way to promote the adoption of CSA practices in several contexts (Kueper et al., 2021; Wanjiku et al., 2021).

Contextual factors, such as climatic conditions and socio-cultural practices, also play a role in CSA adoption. A study by Kombat et al. (2021) found that farmers' perceptions of the impact of climate change on their agricultural practices significantly predicted their adoption of CSA practices in northern Ghana. Similarly, a study by Kilic et al. (2021) found that farmers' perceptions of the risks and benefits of CSA practices were critical in promoting their adoption in Turkey.

In conclusion, the adoption of CSA practices is influenced by a range of factors, including socio-economic factors, institutional factors, individual factors, and contextual factors. Access to finance, policy frameworks, institutional support, farmers' knowledge, attitudes, and perceptions of CSA practices, and contextual factors such as climatic conditions and socio-cultural practices are critical determinants of CSA adoption. Understanding these determinants can help policymakers and practitioners to develop effective strategies for promoting the adoption of CSA practices and addressing the challenges of climate change in agriculture.

2.7 Climate-smart agriculture prioritization

According to the definition provided by FAO, (2013), Climate smart agriculture (CSA) practice prioritization is the process of selecting and ranking different CSA practices based on their suitability for a specific region or context.

Literature also defines Climate-Smart Agriculture (CSA) practice prioritization involves the selection and ranking of various CSA practices based on their suitability for a specific region or context (Seyoum, 2019).

Creating an investment portfolio across various agro-ecological zones, the identification and prioritization of CSA technologies enable climate change adaptation strategy in agriculture. One must take into account adaption solutions that are thoroughly assessed and prioritized by local farmers in connection to the significant climatic hazards in that location when defining CSA implementation plans at the farm level (Khatri-Chhetri et al., 2017).

AICCRA-Ghana project revealed that Ghana's Northern, North-East, and Savanna regions indicated low tillage, mucuna pruriens, or cowpea/maize intercropping-yam rotation as soil builders. Carbon stocks, leguminous crops as a preceding crop, organic amendment for increasing soil health, and promotion of stress-tolerant enhanced maize, cowpea, yam, and potato types were highlighted. Climate Smart Villages put a lot of emphasis on legumes as crops that come before cereals and on promoting seed varieties that are resistant to disease and pests. They used end-user friendliness, the ability to achieve one-health, gender and social inclusion, and the climate-smart pillars (productivity, mitigation, and adaptation) as criteria for ranking the practices, working with the stakeholders in the area, and the specifics of the products (Damba et al., 2021).

In a 2017 study, Khatri-Chhetri et al (2017) used a participatory assessment method to determine how much farmers in various rainfall zones would be willing to pay for certain CSA practices and technologies. Weather-based crop agro advisories, crop insurance, rainwater collection, contingency crop planning, site specific integrated nutrient management, and laser land levelling were the technologies that the rural farmers appreciated the most. This research demonstrates the potential of adopting a participatory CSA prioritizing technique to disseminate innovations on local planning for climate change adaptation.

Mwongera et al. (2017) employed methodologies aimed at identifying and prioritizing locally acceptable climate-smart agriculture (CSA) solutions required to meet the context-specific multidimensional complexity in agricultural systems. They described the Climate Smart Agriculture Rapid Appraisal (CSA-RA) in the article and showed how to use it to discover and rank locally acceptable CSA initiatives. According to their research, all of the priority techniques are related to raising food production and adaptability, but only mulching, agroforestry, and better animal breeds have the potential to additionally provide climate mitigation co-benefits.

In a paper published in 2019, Khatri-Chhetri et al provided some framework for prioritizing locally appropriate climate-smart agriculture initiatives and conducting implementation appropriateness analyses with key stakeholders. Prioritizing the right actions for the situation at hand is needed to help stakeholders make strategic decisions and improve the adaptability and efficiency of the agriculture production system in the face of climate change and uncertainty. Their criteria for prioritization were based on productivity, income, resilience, and emissions. Stakeholders gave top priority to ICT-based meteorological and agro-advisory services; farm insurance against climatic hazards; and technologies for managing water and nutrients.

2.8 Empirical study of determinants of CSA practice adoption

Akrofi-Atitianti et al. (2018) evaluated CSA practices adoption and its drivers in Ghana and used the binary logistic to estimate variables influencing farmers' use of agroecology practices. According to the findings of their study, farm tenure, farmer age, locality (district), residential status, and availability of extension services were the key determining factors impacting Agroecological practices.

Abegunde et al. (2019) conducted a study to investigate the factors influencing adoption of CSA methods by small-scale farming households. The Generalized Ordered Logit Regression model was used to identify the variables affecting the sampled small-scale farming households' level of CSA used in the study area.

The composite score was utilized in this article to measure the farmers' level of use of CSA techniques. According to this study, there are several significant determinants of CSA ad scale farmers, including farm income, education, income from non-farm sources, contact with agricultural extension agents, distance from home to the farmstead, marital status, media exposure, membership in an agricultural-related groups, production activity, and perception of the impact of climate change.

To determine the treatment effect of CSA adoption on participation in emission practices, the study by Israel et al. (2020) used the Weighted Regression Adjustment (IPWRA) estimator for its estimations. From their findings, they concluded that FBO membership, credit access, extension services, and CSA training are the institutional indicator expected to expected to influence farm household engagement in emission activities. It is thought that involvement in GHG emission practices is influenced by the respondents' membership in farmer groups focused on any aspect of agricultural production. They also anticipate that farmers that belong to such an association will be more inclined to adopt CSA or sustainable farming techniques, which will reduce their participation in GHG emission practices.

Also, a study on whether CSA adoption improves the crop income of farmers and determinant assessments by Sardar et al. (2022), applied multinomial logistic regression model to investigate the factors that influence the adoption of a single to a bundle or full set of CSA practices. The study made some discoveries and showed that institutional variables, size of land holdings, financial resources, and the educational level attained by the farmers account for the majority of the single adoption to the bundled or full adoption methods. In the same way, farmers who had been hurt by climate shocks were more likely to use CSA methods.

Negera et al. (2022) estimated the multivariate probit model for factors influencing the adoption of multiple CSA practices. The outcome showed that most of the practices were significantly influenced by farmers' awareness of climate change, extension contacts, and the perception of climate changes impact on farmers. Land size and farmers' volume of assets also had a significant effect on farmer adoption but fewer practices.

Weniga Anuga et al. (2019) also employed the binary logistic regression model to estimate the determinants of CSA adoption by smallholder crop farmers in Techiman, Ghana. Results that came out from this study indicated that majority of the farmers were using personal experience in predicting the weather events and they adopted minimum tillage, through television or radio to access weather information, afforestation, and the application of organic manure as CSA practices. CSA adoption was also impacted by institutional, socio-cultural, economic, and environmental factors.

Similarly, Mwungu et al. (2018) estimated a multivariate probit to determine factors affecting CSA adoption, which allows for interdependence and trade-offs between practices. The practices that were taken into account were improved crop varieties, agroforestry, manure, minimum tillage, and irrigation. The amount of organic soil carbon, mean temperature, slope of the plot, food security status, and mean precipitation influenced the CSA adoption decision of the farmers. Other variables like credit, asset endowment, literacy rate, access to agricultural extension, and livestock ownership influenced adoption.

2.9 Empirical study of determinants of CSA practice prioritization

Climate change poses significant challenges to agriculture in Ghana, which has prompted the adoption of Climate Smart Agriculture (CSA) practices to help mitigate its impact. CSA practice prioritization is crucial for the successful implementation of these practices. This empirical review aims to examine the determinants of CSA practice prioritization in Ghana and their impact.

Several studies have explored the factors that influence CSA practice prioritization in Ghana, including socio-economic factors, institutional factors, individual factors, and contextual factors. Socio-economic factors include access to finance, land tenure, and market access, while institutional factors include policy frameworks, institutional support, and stakeholder engagement. Individual factors include farmers' knowledge, attitudes, and perceptions of CSA practices, while contextual factors include climatic conditions, ecological systems, and socio-cultural practices.

Research has shown that access to finance is a critical determinant of CSA practice prioritization in Ghana. For example, a study by Amoah et al. (2020) found that access to credit significantly predicted the adoption of CSA practices among smallholder farmers in Ghana. In contrast, a lack of access to credit was identified as a significant barrier to the adoption of CSA practices. Institutional factors, such as policy frameworks and stakeholder engagement, also play a crucial role in CSA practice prioritization in Ghana. A study by Brempong et al. (2020) found that policy frameworks that promote the adoption of CSA practices and stakeholder engagement that incorporates the perspectives of various actors were critical in promoting the adoption of CSA practices. On the other hand, a lack of institutional support was identified as a significant barrier to CSA practice prioritization in Ghana.

Individual factors, such as farmers' knowledge, attitudes, and perceptions of CSA practices, also influence CSA practice prioritization in Ghana. A study by Donkoh et al. (2020) found that farmers' knowledge of CSA practices and their perceptions of their efficacy significantly predicted their adoption of these practices. Research has also shown that farmer-to-farmer extension services are an effective way to promote the adoption of CSA practices in Ghana (Kueper et al., 2021).

Contextual factors, such as climatic conditions and socio-cultural practices, also play a role in CSA practice prioritization in Ghana. A study by Kombat et al. (2021) found that farmers' perceptions of the impact of climate change on their agricultural practices significantly predicted their adoption of CSA practices in northern Ghana.

In conclusion, CSA practice prioritization in Ghana is influenced by a range of factors, including socio-economic factors, institutional factors, individual factors, and contextual factors. Access to finance, policy frameworks, stakeholder engagement, farmers' knowledge, attitudes, and perceptions of CSA practices, and contextual factors such as climatic conditions and socio-cultural practices are critical determinants of CSA practice prioritization in Ghana. Understanding these determinants can help policymakers and practitioners to develop effective strategies for prioritizing CSA practices and addressing the challenges of climate change in agriculture in Ghana.

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1 Introduction

This chapter discusses the study area, the research design, and analytical tools employed to achieve the specific objectives of the study. A detailed discussion of the population, economic activities, and geography of the study areas is represented in section 3.2. Section 3.3 presents a detailed research design describing the data and source of data, sample technique and size, and others. In Section 3.4: Pictorial presentation and discussion of the concept of the study, and in Sections 3.5 to 3.8, the methods of analysing the data are discussed in detail.

3.2 The study area

This study was conducted in northern Ghana. Specifically, Tolon District (communities: Nyankpala, Woribog, Yizeigu) in the Northern Region, Kasena Nankana District (Tampola) and Bongo District (Yidongo) in the Upper East Region, and Lawra (Boompari, Dzuuri), Jirapa Municipal Assembly (Doggoh) in the Upper West Region.

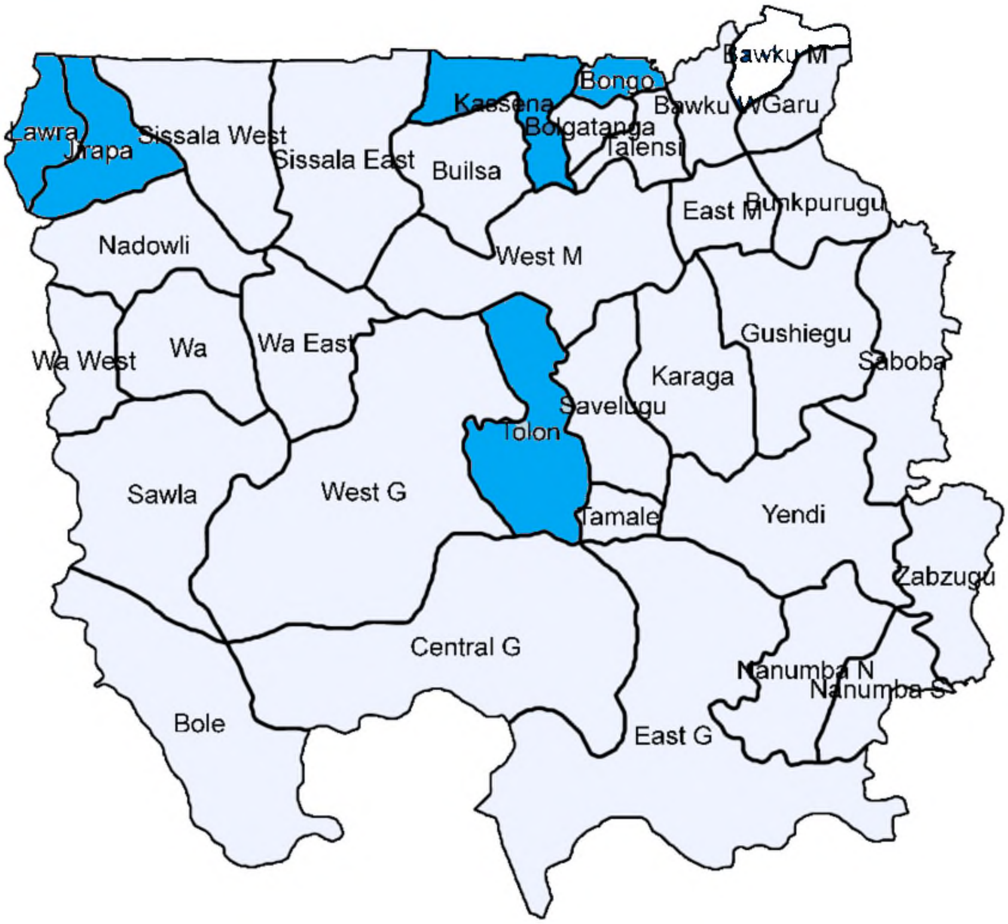

Figure 3.1: Map of the study areas

3.2.1 Profile of Northern Ghana

Northern Ghana is a region located in the northern part of Ghana, bordered to the north by Burkina Faso, to the east by Togo, to the west by Côte d'Ivoire, and to the south by the Brong-Ahafo and Northern regions of Ghana. The region covers an area of approximately 70,384 square kilometers and has a population of over 5 million people (Ghana Statistical Service, 2021). The region is predominantly made up of three main ethnic groups: the Dagombas, the Mamprusis, and the Gonjas. The region is also home to other ethnic groups such as the Frafras, Kusasis, and the Waalas. The people of Northern Ghana are known for their rich culture, colorful festivals, and warm hospitality (Kwami, 2017). The region is characterized by a dry and hot climate, with temperatures ranging from 27°C to 43°C (Adjei, 2018). The region is divided into three ecological zones: the Guinea savanna, the Sudan savanna, and the Sahel savanna (Kwami & Mensah, 2015).

The region's geography is characterized by a tropical savanna climate, with a rainy season from April to October and a dry season from November to March. The region also has several rivers and water bodies, including the Black Volta River, the White Volta River, and the Oti River (Kwami & Mensah, 2015).

Agriculture is the main economic activity in Northern Ghana, employing over 80% of the population (Adjei, 2018). The region's fertile soil and favorable climate make it suitable for crop production, with crops such as maize, millet, sorghum, and yams being the main staple foods (Dzomeku, 2018). It is known for its production of crops such as maize, millet, sorghum, yams, and rice, which are the main staple foods (Dzomeku, 2018). The region is also known for its shea butter production, which significantly contribute to the economic development, with Northern Ghana accounting for over 90% of Ghana's total shea butter exports (Kpelle, 2019).

The agricultural sector in Northern Ghana faces several challenges, including limited access to irrigation, low mechanization, and inadequate storage facilities (Dzomeku, 2018). Additionally, the region is prone to droughts and erratic rainfall patterns, which negatively impact crop yields (Kwami & Mensah, 2015).

3.3 Research design

This research used a cross-sectional data to study the determinants of CSA practice adoption and prioritization in the study area. Semi-structured questionnaire was given to cross-sectional sampled farmers in the area for the study through personal interviews. A mixed-method approach of both quantitative and qualitative methods was used for the data collection and analysis. This research used descriptive analysis to determine the extent to which the respondents adopted and prioritized the CSA practices. Quantitative analysis was also used to identify the factors influencing or determining factors for both the CSA practice being adopted and being prioritized.

3.3.1 Data sources and type

The type of data that was used for this study was mainly primary data, and it was collected from a cross sectional farmers in AICCRA implementation centres in Northern Ghana. The data entailed variables that were measured on both a categorical scale and a continuous scale. The adoption and prioritization of climate smart agricultural practices were collected as a binary outcome (Yes or No). The study also picked up data of the respondent's demographic, socio-economic, institutional characteristics, technical factors and others.

3.3.2 Sampling and sample size

The study was done using two hundred and forty (240) farmers across the AICCRA implementation centres in Northern Ghana. The sampling technique for the selection of respondents for this study was the multi-staged sampling. The first stage of the sampling procedure was purposively done by including all the districts involved in the AICRA project in northern Ghana. Simple random sampling was used to select eight (8) communities in the second stage of the sampling from districts involved in the AICRA project in northern Ghana. In the third stage, simple random sampling was used to choose thirty (30) farmers in each of the communities, with which 15 farmers are participant and 15 farmers are non-participants. The respondents were selected from Nyankpala, Woribog, and Yizeigu in the Northern region; Tampola and Yidongo from the Upper East region; and Boompari, Dzuuri,and Doggoh from the Upper West region.

3.4 Conceptual framework

According to Kalaa et al. (1994) and Robson (2018), a conceptual framework is a system of ideas, presumptions, expectations, beliefs, and theories that underpins and directs one's research and is an essential component of the research design. A conceptual framework is also a written or visual product that "explains, either visually or in narrative form, the primary objects to be examined; the key factors, concepts, or variables; and the hypothesized relationships that exist among them (Gubbins et al., 2020; Kalaa et al., 1994). A conceptual framework in social research attempts to explain links between variables, typically progressing from a simple model to a complex model. This conceptual framework of Climate-Smart Agriculture (CSA) practice prioritization is a strategic and systematic process of selecting and ranking various CSA practices based on their potential benefits and challenges in addressing the impacts of climate change on agriculture. The prioritization of climate-smart agriculture practices will lead to a more effective and efficient approach to addressing the impacts of climate change on agriculture, resulting in enhanced food security, increased productivity, improved resilience, and reduced greenhouse gas emissions in the specific region or context." This hypothesis implies that prioritizing the most effective and feasible CSA practices will have positive impacts on agriculture and the environment in the study area.

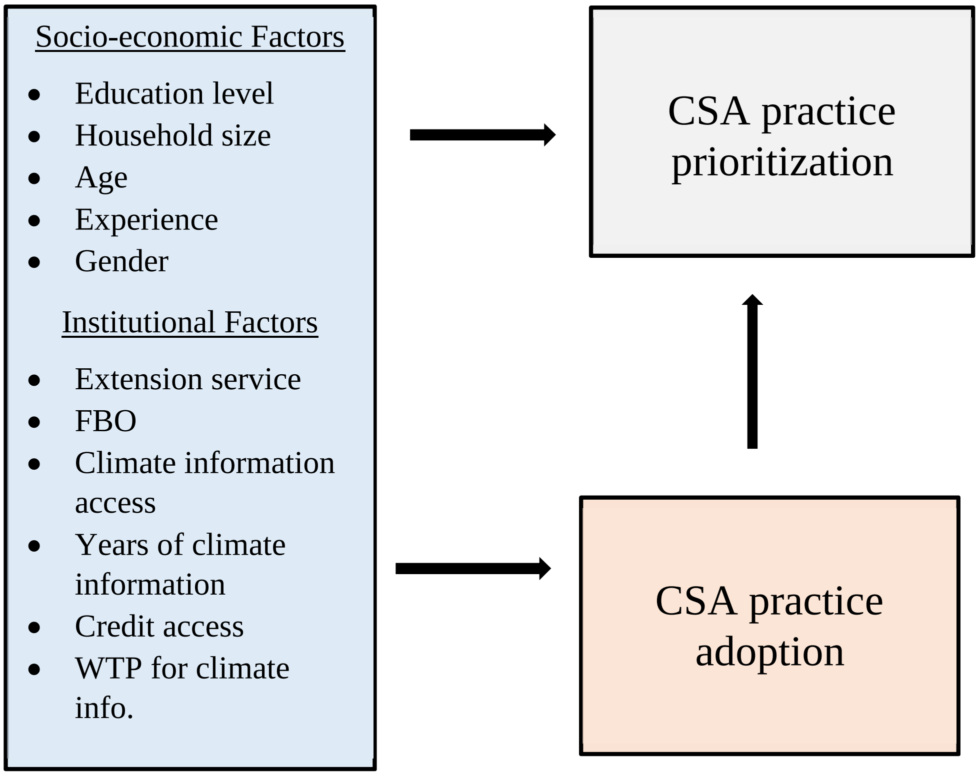

Figure 3.2: Conceptual framework

Source: Authors conceptualization

This conceptual framework depicts those socioeconomic factors (age, household size, educational level, and the like), institutional factors like farmer-based organization and extension services, climate information service, access to climate information, and willingness to pay for the services will influence CSA practice adoption and prioritization. The CSA practices adopted also influence the prioritized practices in that the farmers prioritize or select the best practice that they gain a lot from. In this study, the practice would have to be adopted before it could be prioritized. It is conceptualized that farmers can adopt a practice even if the utility is low or not properly observed when other external factors are present and play important role in adoption. The determinant of such adopted practice will be less informative, so this study lets the farmers prioritize one of the adopted practices. The practice, which is then selected, is the one from which they get the maximum utility. Then, the well-researched indicators that lead farmers to adopt CSA practices are listed in order of how important they are.

3.5 Theoretical Framework

This research was done in the AICCRA implementation centres/villages in Northern Ghana and focused on the determinants of CSA practice adoption and prioritization. The farmer's adoption and prioritization of these practices are dependent on several factors, and the ultimate is the perceived benefit that will be gained in the end. This indicates that this research is based on the utility maximization theory. The study outlined fourteen (14) CSA practices that were practiced in Northern Ghana. These practices were; cowpea/maize intercropping; contour stone bunds/contour tillage with tied ridges (minimal/zero rate of water run-off and soil erosion; minimum tillage for cowpea, maize, and vegetables production, dual purpose cowpea promotion(fodder and grain); promotion of pest and disease resistant maize and cowpea varieties (early maturing, drought, low N and striga); seedbed options-ridging as an alternative for mounding for yam cultivation; promotion of seed yam using mini-sett, aeroponic and hydroponic techniques; staking option trellis/minimum staking for deforestation reduction; promotion of stress tolerant varieties; enhancing biopesticide usage in cowpea and maize systems (Neem, wood ash etc.); using organic amendment for improving soil health; planting leguminous crop as previous crop (Farmyard manure, bagged compost; leguminous crop as the previous crop; Enhancing access to climate information (Seasonal calendar). Each of these CSA practices has a perceived utility or gain to the farmer.

The utility here is the suspected sustainable increase in yield related to each practice. If a farmer perceives a CSA practice will improve his/her yield, their level of adopting and prioritizing that practice will be high compared to the other practices.

Following Tetteh et al. (2020), the utility function is defined as the perceived utility/gain (U) that a farmer will derive from choosing a CSA practice given as;

$U_{nj}; Y_{ij} = b_i x_i + e_i$ Where, (j= 1, 2… 14; n=1, 2, 3… n) (1)

The farmer chooses the CSA practice (j) that provides the maximum utility or gains. Giving rise to the behavioural model:

$Choose\ alternative\ (i)\ if\ and\ only\ if\ U_{ni} > U_{nj}\ for\ j \neq i$ (2)

The farmer's decision to choose alternative i over j shows that the farmer's utility is maximized with option i. The farmer can also get higher benefits by adopting multiple CSA practices since they come with attached benefits and some are complementary in practice.

The farmers are faced with fourteen (14) CSA practices that will help improve their operations and well-being. The fourteen (14) CSA practices to be adopted are binary outcomes in nature. A farmer that adopts two CSA practices is assumed to have higher utility relative to a farmer that adopts one or nothing. This, therefore, implies that every additional CSA practice adopted brings an additional utility. The farmer that opts to adopt more will have high utility relative to those that adopt less.

3.6 The models

3.6.1 Analysis of determinants of CSA practice adoption

Addressing the effects of climate change on agriculture and farmers which come in diverse ways requires diverse or multiple approaches. Given this, the farmers decide the number of CSA practices they will adopt to improve their conditions. To analyse the adoption decision by the farmers, a Multivariate Probit model was estimated. This model is also based on the random utility model framework. The farmers are faced with the CSA practice adoption option which presents a choice problem. This study asked the farmers to choose from the fourteen (14) CSA practices, the ones they adopted. these practices included Cowpea /maize intercropping; Contour stone bunds or contour tillage with tied ridges (Zero or minimal rates of rainfall run-off and soil erosion; Promotion of dual-purpose cowpea (grain and fodder); Minimum tillage for maize, cowpea, and vegetable production (Planters/dibblers, herbicide, slasher); Promotion of disease and pest tolerant maize & cowpea varieties (early maturing, drought, and low N) tolerant improved cowpea and maize varieties; seedbed options-ridging as an alternative to mounding for yam production; promotion of seed yam with mini-sett, aeroponic and hydroponic technologies; staking option trellis/minimum staking for deforestation reduction; promotion of stress; Enhanced biopesticide use in maize and cowpea systems (Neem, wood ash); Organic amendment for improving soil health/leguminous crops as the previous crop (Farmyard manure, bagged compost; leguminous crop as the previous crop; Enhancing access to climate information (Seasonal calendar). This gave rise to fourteen (14) dependent binary outcome variables which seven (7) were included in the analysis for the determinants of CSA practice adoption. This was due to the non-adoption of some of the practices resulting from the farmer's liberty to select the practices of their choice. They select the practices that they perceive to gain more from. The decision to adopt a practice is not independent because a farmer may choose multiple practices, and the usage of one will lead to the adoption of the other. This suggests a possible correlation due to possible dependent variables' interdependency.

For binary outcome estimations, the Probit model could be estimated seven times to find the determinants. The individual Probit model for each practice is highly possible of generating bias and inconsistent results because of the possible correlation. A model that allows for correlation between dependent binary outcomes will be needed to produce unbiased and consistent determinants of adopting the CSA practices. The Multivariate Probit (MVP) estimator is a perfect estimator that will fit solving drawbacks of the individual Probit models.

3.6.2 Econometric modelling of the determinants of CSA practices adoption

The general expression of the Multivariate Probit (MVP) model by Mulwa et al (2017) is given as;

$$Y_{im}^{*} = \beta_{m}' X_{im} + \varepsilon_{im} \quad (3)$$

Where;

X_{im} is the predictor or explanatory variable for each CSA practice adoption. b_m are the coefficients of the predictors or vector unknown parameters, $\varepsilon_{im}, m = 1, \ldots, 7$ denotes the error term of the multivariate normal distribution with a zero mean and each variance is constant thus 1.

$Y_{im} = (m = 1, 2, \ldots, 7)$, represents the seven (7) CSA practices that the farmers choose from. X_{im} is the farmer's observed characteristics vector that is regressed against the vector of unknown parameter (adoption decision), this is a stochastic parameter. A multiple of Binary Probit models for each CSA practice adoption can be used to empirically estimate Equation 3.

The multivariate Probit (MVP) model is estimated using maximum likelihood (ML). This study estimated the parameters using the maximum likelihood procedure with the multivariate normality assumption.

The likelihood function probabilities and their derivatives for the maximum likelihood (ML) estimation are computed using the Geweke-Hajivassilioukeane (GHK) simulation process. This produces approximations to the m-fold multivariate integrals:

$$\int_{-\infty_m}^{S_m} \ldots.. \int_{-\infty}^{S_1} \rho(S_1, \ldots, S_m)\partial S_m, \ldots, \partial S_m \qquad (4)$$

Where;

$\rho(\cdot)$ represents the multivariate normal density. The likelihood of the observed outcomes logs is then used to calculate the log-likelihood model and it is defined as:

$$\Pr\left(\frac{pM_1,\ldots,pM_1}{s_1,\ldots,S_m}\right) = MNV(Tz, TRT) \qquad (5)$$

Where; Z is a vector defined from $Z = S_m'\aleph$, R is the correlation matrix, T is the diagonal matrix $t_{mm} = 2y_m - 1$, and MNV is the normality density of the Multivariate.

The marginal effects of a multivariate probit estimation depict how the independent variables affect the tendency of choosing one CSA practice, conditioned by the other practices being available.

The marginal of the distribution above, according to Mulwa et al (2017) is calculated as;

$$\frac{\partial E_1}{\partial S} = \sum_{j=1}^{m} \left[\frac{1}{P_2,m}\frac{\partial P_1}{\partial z_m}\right] \sigma_m - E_1 \times \sum_{j=2}^{m} \left[\frac{1}{P_2,m}\frac{\partial P_2}{\partial z_m}\right] \sigma_m{}' \quad (6)$$

Where S is the union of all the repressors used in the model

σ_m is defined as;

$$Z_m = \aleph' S_m = \sigma' S_m \quad (7)$$

Following Kariuki et al (2016), the empirical model of the Multivariate Probit with seven (7) CSA practices is given as:

$$\begin{Bmatrix} Y_1^* = x_1'\beta_1 + \epsilon_1, y_1 = 1 \; if \; Y_1^* > 0, 0 \; if \; otherwise \\ Y_2^* = x_2'\beta_2 + \epsilon_2, y_2 = 1 \; if \; Y_2^* > 0, 0 \; if \; otherwise \\ Y_3^* = x_3'\beta_3 + \epsilon_3, y_3 = 1 \; if \; Y_3^* > 0, 0 \; if \; otherwise \\ Y_4^* = x_4'\beta_4 + \epsilon_4, y_4 = 1 \; if \; Y_4^* > 0, 0 \; if \; otherwise \\ Y_5^* = x_5'\beta_5 + \epsilon_5, y_5 = 1 \; if \; Y_5^* > 0, 0 \; if \; otherwise \\ Y_6^* = x_6'\beta_6 + \epsilon_6, y_6 = 1 \; if \; Y_6^* > 0, 0 \; if \; otherwise \\ Y_7^* = x_7'\beta_7 + \epsilon_7, y_7 = 1 \; if \; Y_7^* > 0, 0 \; if \; otherwise \end{Bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The Equations 8 constitutes seven (7) of CSA practices, which each have latent variable, $Y_1^*, \ldots, Y_7^*$ which were unobserved variables but depend on the explanatory variable X_i. The error term assuming a standard normal has the structure below:

$$E \; \epsilon_i | x_1, \ldots, x_M = 0, Var \; \epsilon_i | x_1, \ldots, x_M = 1 \; and \; \epsilon, \epsilon_i | x_1, \ldots, x_M = \rho_{ij} \quad (9)$$

The repressors that relate to the latent variables in Equation 8 are represented by Y_i and take a binary outcome: $Y_{im} = 1$ if $Y_{im}^* > 0$ otherwise.

Where, $Y_1 = 1$ if farmer adopted organic amendment to improve soil health, 0 if otherwise, $Y_2 = 1$, if farmer adopted enhancing access to climate information, 0 if otherwise, $Y_3 = 1$, if farmer adopted the promotion of stress (drought, early maturing, striga, and low N) tolerant improves maize cowpea and potato, 0 if otherwise, $Y_4 = 1$, if farmer adopted the promotion of disease and pest-tolerant maize and cowpea varieties, 0 if otherwise, $Y_5 = 1$, if farmer adopted planting leguminous crop as the previous crop, 0 if otherwise, $Y_6 = 1$, if farmer adopted minimum tillage for maize, cowpea, and vegetable production, 0 if otherwise, $Y_7 = 1$, if farmer adopted water management (mulching), 0 if otherwise; X represents the vector o explanatory variables; $\beta_1 - \beta_7$ are the parameters of the vectors and $\epsilon_1 - \epsilon_7$ are the random errors with a mean of zero, constant variance, and n*n correlation matrix.

3.7 Variables, definitions, and a priori expectations

Access to climate information service CIS (X_1)

Accessing climate information services is the number of climate information a farmer indicates he gets in a production season. This is expected to be significant and positive to be a determining factor of CSA practice prioritization among farmers. The higher the number of CIS, the higher the farmer's understanding of how the CSA practice functions. Climate information service is a complimentary service needed for CSA practices to achieve its intended purpose.

Extension services (X_2)

These variable measures the number of extension service agent visits the farmers get during a production season. It is a numerical (continuous) measure. It is previewed to be significant and positive determinant factor that influences farmers' prioritization of CSA practices. The farmers' contact hours with the extension agents increase their exposure to new practices that will likely enhance their activities. The farmers will get to know these CSA practices in detail and eventually the number of CSA practices to be adopted will increase.

Farmer-Based Organizations FBO membership (X_3)

A farmer who belongs to a farmer-based organization was coded as 1 and those who are not were coded as 0. The respondents who happen to be part of these organizations are more probable to benefit from some CSA practices or had been enlightened by some members who had ever used these practices on how beneficial it is and works. This gives the farmers head-up knowledge of CSA practices and this guards their prioritization. With this, the farmer being a member of FBO is expected to have a positive and significant influence on determining CSA practice prioritization.

Years of farming (X_4)

This represents the years a responding farmer have been producing the research crop (cowpea and maize). The longer the years, the varying practices that had been used by the farmer in his/her production. Farming years expect that it should be a positive and significant determinant factor influencing the prioritization of CSA practices.

Years of education (X_5)

The number of years the responding farmer has attained formal education. This variable is expected to be a positive determinant of CSA practice prioritization. Formal education increases the capacity of the farmers able to read, understand, and write. This ability will position the farmer to better understand vital information despite how they are presented in respect of CSA practices. Formal education sometimes directly educate pupil on the benefit of these practices and this, in turn, will influence how these farmers prioritize the practices.

Gender (X_6)

This is the sex of the respondent and it is coded 0 for female and 1 for male. The gender expectation of determinant of CSA practice prioritization can go in any direction, either negative or positive. Before farmers will prioritize a practice, they depend on the information and or access to necessary resources to back their choices. In this case, because there is difficulty in achieving uniformity in the allocation of resources among male and female farmers, the direction can be positive (+) or negative (-)

Access to credit (X_7)

Farmers who have access to credit are coded 1, and those who did not were coded 0. This variable motivates the farmers in prioritizing CSA practices, it increases their financial capabilities to be able to access broad practices. The farmers who get credit to support their farming are more likely to prioritize the practice to the farmers who has less or no credit access, all things being equal. This suggests that access to credit as a variable has a positive coefficient after the analysis.

Occupation (X_8)

The major occupation of the respondent is coded 1 for being a crop farmer and 0 for other occupations (animal rearing, service/trade, artisan …). The farmers are motivated to do more or pay attention to where they generate their income. For their income stability, farmers go the extra mile to learn new ways to improve or at least maintain current activities (crop farming). The desire for farmers whose main occupation is crop farming is to improve their productivity despite the effect of climate change. Given this, the farmer's main occupation can positively or negatively influence CSA practice prioritization.

Age (X_9)

The age of the farmers is a continuous variable. The direction of age as a variable to influence CSA practice prioritization is indeterminate. This means, that positive or negative significant coefficients could be expected. Older farmers are more likely to have gone through several practices which directly or indirectly match the CSA practices. As the farmer's age increases, they get more experienced, connected, information gathered to influence the prioritization of CSA practices.

Household size (X_{10})

This variable is a continuous variable. The direction of influence by this variable is indeterminate. This means, that positive or negative significant coefficients could be expected. If the number of people in the household increase, the number of hands to help in production and dependency ratio of the household might all come to play and it will affect the adoption CSA practice.

Land ownership (X_{11})

Land ownership was coded as 1 for being customary land, 2 for being personal or purchased land, and 3 for being rented land. When important decisions must be made, all of these types of ownership come with varying levels of control and access to the land. Farming on some rented land most often experience unannounced evacuation. The form of land ownership is a complementarity to sustainable farming and is expected to significantly influence how the farmers prioritize the CSA practice. The sign of influence is indecisive, it can be positive or negative.

Land size and labour ($X_{12} - X_{13}$)

These variables are continuous. The land size is the total area that the respondent cultivated during the past growing season. Labour is also the people available for undertaking an agricultural activity. The more people help in production the easier it is to consider or prioritize labour-intensive CSA practice. They are both projected to have either negative or positive outcome.

3.8 Econometric analysis for the determinants of CSA practice prioritization

This study used the Multinomial Logistic model to identify the factors that determine CSA practice prioritization. This is because the multinomial logic model allows for one practice to be selected from the multiple and in the prioritization of the CSA practices, only one can be selected. The binary probit or logistic model was not appropriate for the analysis because it is limited to only two possible choices, but this specific objective have seven possible CSA practices to prioritize. The multivariate Probit model was also defeated because the dependent variables in this specific objective were mutually exclusive and the multivariate Probit model gives room for more than one Practices to be selected. The farmers were asked to prioritize one out of the CSA practices that they adopted. Out of the seven (7) CSA practices that were adopted by the farmers in the study area, only five (5) were prioritized by at least one farmer. The five practices featured in the Multinomial Logistic Regression were; Enhancing access to climate information; Leguminous crop as the previous crop; Organic amendment to improve soil health; Promotion of disease and pest tolerant maize and cowpea varieties; Promotion of stress (drought, early maturing, striga and low N) tolerant Improved maize and cowpea which did not follow any natural order or anything in that form. The dependent variables were based on several explanatory variables X's (age of farmer, education in years, household size, sex, land ownership, extension service, credit access, WTP for climate information service, and perception of climate information)

The Multinomial Logistic model was estimated by making the group of farmers who did not prioritize any of the five CSA practices the base category. This resulted in six (6) outcomes. Their structural function which included the error term; $j = 1, 2, .., 6$.

In this model, the coefficient $(b^1, b^2, \dots, b^6)$ for each corresponding outcome was estimated. the predicted probabilities are given in the equations following (Etwire, 2020; Sadiq et al., 2019).

$$\Pr(Y_i = j) = \frac{e^{X_i b'_j}}{\sum_{m=1}^{6} e^{X_i b'_m}} \quad j = 1,2, \dots ,6. \qquad (10)$$

This is expanded as;

$$\left\{\begin{array}{l} \Pr(Y_i = 1) = \dfrac{e^{Xb(1)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + e^{Xb(6)}} \\ \Pr(Y_i = 2) = \dfrac{e^{Xb(2)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + e^{Xb(6)}} \\ \Pr(Y_i = 3) = \dfrac{e^{Xb(3)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + e^{Xb(6)}} \\ \Pr(Y_i = 4) = \dfrac{e^{Xb(4)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + e^{Xb(6)}} \\ \Pr(Y_i = 5) = \dfrac{e^{Xb(5)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + e^{Xb(6)}} \\ \Pr(Y_i = 6) = \dfrac{e^{Xb(6)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + e^{Xb(6)}} \end{array}\right\} \dots\dots\dots (11)$$

Equation 10 above is not identified meaning each of the practices will have the same probabilities because there are multiple solutions for the coefficients $(b^1, b^2, \ldots, b^6)$. The model was then identified by setting the sixth category (no practice prioritized) as the reference or base group. The model now looks like this;

$$P_j \equiv \Pr(Y_i = j) = \frac{e^{X_i b_j'}}{\sum_{m=1}^{5} e^{X_i b_m'} + 1} \quad j = 1,2, \ldots ,5. \qquad (12)$$

Expanded as;

$$\left\{\begin{array}{l} \Pr(Y_i = 1) = \dfrac{e^{Xb(1)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + 1} \\ \Pr(Y_i = 2) = \dfrac{e^{Xb(2)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + 1} \\ \Pr(Y_i = 3) = \dfrac{e^{Xb(3)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + 1} \\ \Pr(Y_i = 4) = \dfrac{e^{Xb(4)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + 1} \\ \Pr(Y_i = 5) = \dfrac{e^{Xb(5)}}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + 1} \\ \Pr(Y_i = 6) = \dfrac{1}{e^{Xb(1)} + e^{Xb(2)} + e^{Xb(3)} + e^{Xb(4)} + e^{Xb(5)} + 1} \end{array}\right\} \ldots\ldots\ldots . (13)$$

After setting the sixth category (no practice prioritized) $Y_i = 6$ as the base outcome, the relative probabilities also known as relative risk ratio (RRR) are generated. The relative probability for $Y_i = 1$ is given as;

$$RRR_1 = \frac{\Pr(Y_i=1)}{\Pr(Y_i=6)} = \frac{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+1}{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+1} * \frac{e^{Xb(1)}}{1} \qquad (14)$$

$$RRR_1 = \frac{\Pr(Y_i=1)}{\Pr(Y_i=6)} = e^{Xb(1)} \qquad (15)$$

The relative probability for $Y_i = 2$ is given as;

$$RRR_2 = \frac{\Pr(Y_i=2)}{\Pr(Y_i=6)} = \frac{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+1}{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+1} * \frac{e^{Xb(2)}}{1} = e^{Xb(2)} \qquad (16)$$

The relative probability for $Y_i = n$ is given as;

$$RRR_n = \frac{\Pr(Y_i=n)}{\Pr(Y_i=6)} = \frac{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+1}{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+1} * \frac{e^{Xb(n)}}{1} = e^{Xb(n)} \quad (17)$$

The X is a vector that is accompanied by explanatory variables $(x_1, x_2, \dots, x_n)$ and $b(n)$ by $(b_1, b_2, \dots, b_n)$. If there is a unit change x_i, the effect on the outcome (CSA practice) variable can be obtained from;

$$\frac{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+e^{Xb(6)}}{e^{Xb(1)}+e^{Xb(2)}+e^{Xb(3)}+e^{Xb(4)}+e^{Xb(5)}+e^{Xb(6)}} = e^{b(n)} \quad (18)$$

The results from the Multinomial logit model only give the direction of the effect of the explanatory variables on the outcome variables when estimated. This study wanted to interpret the coefficients, so it estimated the average marginal effects. The average marginal effects help attain the actual magnitude change in probability.

Table 3.1: Explanatory variables and measurements

IV	Variables	Measurement
X_1	Age	years of farmers
X_2	Education	Years of education
X_3	Gender	1 if male; 0 if female
X_4	WTP for climate information	1 if yes; 0 if not/otherwise
X_5	Land ownership	1 if self-owned; 0 if not/otherwise
X_6	Extension service access	1 if yes; 0 if not/otherwise
X_7	Climate information usefulness	1 if yes; 0 if not/otherwise
X_8	Household size	Number of people in the household
X_9	Farmer Based Organizations	1 if yes; 0 if not/otherwise

X_{10}	Credit access	1 if yes; 0 if not or otherwise
X_{11}	Years of climate information	Number of years of receiving climate information

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter shows the findings from the data obtained and discusses the results. Section 4.2 represents socio-demographic characteristics and section 4.3 represents the years and level of education attained. Section 4.4 discusses Extension and credit access, as well as FBO membership; Section 4.5 discusses access and perception of climate information; Section 4.6 discusses the extent of CSA practice adoption by farmers, and Section 4.7 discusses the extent of CSA practice prioritization.

Summary statistics of explanatory variables in the models were represented in section 4.8. The section 4.9 presented the correlation between CSA practices adopted, section 4.10 presented the determinants of CSA practice adoption from the Multivariate Probit (MVP) model, and section 4.11 presented the determinants of CSA practice prioritization.

Descriptive results

4.2 Socio-demographic characteristics

4.2.1 Sex, age, marital status, and household size

This study in Table 4.1 reports that out of the 216 respondents (farmers) sampled from the study areas in Northern Ghana, female farmers were the minority, representing about 39.35%, and this is in line with the results of Yokying & Lambrecht (2020). The male farmers numbered 131, representing 60.65%. Farming in this area is dominated by males. This is because of the labour-intensive nature of the agriculture sector, land tenure issues, traditions, and others (Partey et al., 2020).

Amongst the respondents, Table 4.1 showed 197 (90.74%) were married, about 2.78% were not married, 12 (5.56%) had also lost their partner through death, and about 0.93 lost their partner through separation or divorce. This is usually common among farming communities, they have a lot of people getting married to increase the labour availability in their households (GSS, 2021a).

The average age of a respondent given in Table 4.1 is about 45 years old, with the minimum years being 17 years and the maximum years being 83 years, having standard deviation of 5.33. The mean age of 45years plus standard deviation years 5.55 suggests that the majority of the respondents fall below 52years. This shows that a lot of young people work in agriculture, or more specifically, in the crop sector.

Table 4.1: Distribution of sex, marital status, age, and household size

Variable	Frequency	Percentage	Mean	Min	Max
Sex			0.61	0	1
Female	85	39.35			
Male	131	60.65			
Total	***216***	***100.00***			
Marital status			1.23	1	4
Married	196	90.74			
Separated/Divorced	2	0.93			
Single	6	2,78			
Widowed	12	5.56			
Total	***216***	***100.00***			
Age			45.10 (5.33)	17	83
Household size			8.29 (4.72)	2	30

In the account of household size in Table 4.1, the respondent whose household had the most people had 30 people. The minimum number of people recorded in a household was 2. The households recorded average number of 8 people. This shows how likely it is that a farmer will be able to get help or labour to increase production per household.

4.2.2 Educational level and years of education

Education has been a vital pillar in technology adoption and upscaling (Ammentorp et al., 2021; Amri et al., 2022). In this view, this research captured the extent to which a farmer has gotten to in formal education. The outcome, as shown in **Table 4.2,** stated that 111 farmers had no formal education, which represents about 51.39%, and the rest had at least a year of formal education.

Table 4.2: Distribution of educational level and years

Education level	Frequency	Percentage	Mean	Min	Max
No formal	111	51.39			
Basic	76	35.19			
Secondary	18	8.33			
Tertiary	11	5.09			
Total	***216***	***100.00***			
Years of education			3.02	0	21

About 35.19% of the respondents had basic education, about 8.33% had secondary education, and the least was tertiary education, which was about 5.09% with only 11 farmers. The average years of formal education attained by a farmer are about 3 years, with the minimum being not having formal education (no) and the maximum is 21 years of education. More than half of the people who answered the survey did not have any form of formal education. This suggests the farmers have a very low level of formal education.

4.2.3 Extension and credit access, and FBO membership

According to Table 4.3, the majority of farmers, or approximately 70.37%, had access to extension services, while the remaining 29.63% did not. Given the financial capacity of these farmers, a lot of support in diverse forms is needed to improve their production. Hence, increasing food availability and security. But it was noted that a large proportion, about 51.39%, of the farmers did not get access to credit in any form, and only about 48.61% had access to credit. Credit facilitators in the era of climate change and variations deem supporting agriculture to be too risky. Interest rates are too high among the few that will make credit available because the demand is high and such credits are not for farmers alone.

Table 4.3: Distribution of extension and credit access, and FBO membership

Variable	Frequency	Percentage
Extension access		
No	64	29.63
Yes	152	70.37
Total	***216***	***100.00***
Credit access		
No	111	51.39
Yes	105	48.61
Total	***216***	***100.00***
FBO membership		
No	98	45.37
Yes	118	54.63
Total	***216***	***100.00***

4.3 Access and perception of climate information

Access to climate information is very important in keeping the future posted on major climate variations. The findings in Table 4.4 showed that 89.81% of the farmers had access to climate information, and 10.19% did not have access to the information. The usefulness of the information as perceived by the respondents is recorded and shown in Table 4.4. About 66.20% perceived the information to be very useful, 6.49% said it was useful, and 27.31% said it was not useful. From Table 4.4, the 59 farmers that recorded the information that is not useful were inflated by the 22 farmers that did not get access to the information. This means that 37 (17.12%) farmers said the climate information is not useful. They did not see the effect of the information on their activities or output.

Table 4.4: Access and perception of climate information

Variable	Frequency	Percentage
Access climate info.		
No	22	10.19
Yes	194	89.81
Total	***216***	***100.00***
Climate info usefulness		
Not useful	59	27.31
Useful	14	6.49
Very useful	143	66.20
Total	***216***	***100.00***

4.4 Extent of CSA practice adoption by farmers

The extent of adoption was measured by the number of farmers that adopted a practice. Table 4.5 below shows the extent to which each of the seven CSA practices was adopted.

It showed that cultivating leguminous crops as the previous crop was adopted by almost 39.81% of farmers (86). This is not surprising given that farmers prefer technologies that are based on their local ecological knowledge, as Mensah et al (2021) discovered, and several studies have revealed that this same practice is being adopted (Abdul Rahman et al., 2021; Mensah et al., 2021a). They might have been practicing it already or practicing something related to it. The second most adopted practice was enhancing access to climate information. It was adopted by 83 farmers or about 38.43% of the respondents. This has led the farmers to enquire to have information that will help in their production by reducing the risk of climate change to production. Promotion of stress (drought, early maturing, striga, and low N) tolerant varieties to improve maize, cowpea, and potatoes were adopted by 53 (24.54%) farmers, making it the third most adopted practice. Organic amendments to improve soil health were adopted by 51(23.61%) farmers, making it the fourth most adopted CSApractice among the farmers in the study area. It was also shown that minimum tillage for maize, cowpea, and vegetable production was adopted as the fifth practice by 48 (22.22%) farmers. The promotion of disease and pest-tolerant maize and cowpea varieties was adopted by 37 farmers, representing about 17.13% of the farmers, and lastly, water management (mulching) was adopted by 20 farmers, also representing about 20.83%.

Table 4.5: Extent of CSA practice Adoption by farmers

CSA Practices Adoption	Frequency	Percentage
Leguminous crop as the previous crop	86	39.81
Enhancing access to climate information	83	38.43

Promotion of stress (drought, early maturing, striga, and low N) tolerant to improve maize, cowpea, and potato	53	24.54
Organic amendment to improve soil health	51	23.61
Minimum tillage for maize, cowpea, and vegetable production	48	22.22
Promotion of disease and pest-tolerant maize and cowpea varieties	37	17.13
Water management (mulching)	20	9.26

4.5 Extent of CSA practice prioritization by farmers

This study defined prioritization as a practice that is selected from the number of practices a farmer has adopted. It was shown as presented in Table 4.6 that the most prioritized CSA practice by farmers in the study area was enhancing access to climate information, and it was prioritized by about 25.46% of the total 216 farmers interviewed. This CSA practice being the most prioritized practice shows that the farmers have gotten substantial knowledge of the harm caused by climate change and variation. Since not much can be done about the climate, climate variations predictions can be used by farmers to sustain their production and reduce their shocks.

Cultivating leguminous crops as the previous crop was prioritized by 28 (12.96%) of the farmers, being the second most prioritized practice. Farmers have used this practice in a variety of ways, the most common of which is intercropping (Ouédraogo et al., 2018; Peterson, 2014). The practice is a cheap way to revamp soil nitrogen composition and farmers are limited with supporting funds (Fosu-Mensah & Mensah, 2016). They opt for this practice to improve soil health for a better future yield.

Table 4.6 also revealed that organic amendment to improve soil health was the same as cultivating leguminous crops as the previous crop by 28 (12.96%) of the farmers. This practice does not require a lot of external input to achieve, if not none at all. It uses locally available organic materials. Several studies have shown that it is a cost-effective practice that greatly aids farmers in the sustainability of their production (Martey, 2018; Omari et al., 2018).

Lastly, in the prioritized practices, Table 4.6 shows that the promotion of disease and pest-tolerant maize and cowpea varieties was the fourth practice prioritized by 22(10.19%), and the promotion of stress (drought, early maturing, striga, and low N) tolerant to improve maize, cowpea, and potatoes as the fifth practice, 10(4.63%) prioritizing it.

Table 4.6: Extent of CSA practice prioritization by farmers

CSA Practices prioritized	Frequency	Percentage
Enhancing access to climate information	55	25.46
Leguminous crop as the previous crop	28	12.96
Organic amendment to improve soil health	28	12.96
Promotion of disease and pest-tolerant maize and cowpea varieties	22	10.19
Promotion of stress (drought, early maturing, striga, and low N) tolerant to improve maize, cowpea, and potato	10	4.63

None prioritized	73	33.80
Total	216	100

4.6 Summary statistics of explanatory variables in the models

Tables present the summary statistics of explanatory variables used in the multivariate Probit and the multinomial logit models.

Table 4.7: Summary statistics of explanatory variables in the models

IV	Variables	Measurement	Mean	Min.	Max.
X_1	Age	years of farmers	45.10	17	83
X_2	Education	Years of education	3.018	0	21
X_3	Gender	1 if male; 0 if female	0.606	0	1
X_4	Land ownership	1 if self-owned; 0 if not/otherwise	0.537	0	1
X_5	Extension service access	1 if yes; 0 if not/otherwise	0.703	0	1
X_6	Climate information usefulness	1 if yes; 0 if not/otherwise	0.662	0	1
X_7	Household size	Number of people in the household	8.287	2	30
X_8	Farmer Based Organizations	1 if yes; 0 if not/otherwise	0.546	0	1
X_9	Credit access	1 if yes; 0 if not/otherwise	0 .486	0	1
X_{10}	Years of climate information	Number of years of receiving climate information	3.861	0	30

Empirical results

4.7 Correlation of CSA practices adoption

The estimated correlation among the error terms of the CSA practices was generated using the multivariate probit MVP model. The likelihood ratio test reported in Table 4.8 chi2 (21) = 73.8245 Prob > chi2 = 0.000 suggests the empirical rejection of the independency of error terms in the individual equations. This implies that the error term of a farmer adopting various CSA practices is not independent of the others. The existing correlation in the error terms justified the use of the MVP model to analyse the data rather than running seven separate binary models. The results in Table 4.8 below shows significant correlation between some CSA practices but some did not meet expected results. The positive and significant practices indicate the practices complements each other and the best outcome is obtained if they are used together. The complementary CSA practices were stress-tolerant maize, cowpea, and potato varieties, the organic amendment to improve soil health, water management (mulching), and promotion of disease and pest-tolerant maize and cowpea varieties, and water management (mulching) and minimum tillage for maize, cowpea, and vegetable production.

The significant negative correlation coefficients indicate that the practices are substitutes, implying that one practice can be used in place of the other and they have high potential of achieving same results. The substitute CSA practices were water management (mulching) and an organic amendment to improve soil health, water management (mulching) and Enhancing access to climate information, water management and Promotion of stress-tolerant to improve maize, cowpea, and potato. Enhancing access to climate information and Promotion of disease and pest-tolerant maize and cowpea varieties, Minimum tillage for maize, cowpea, and vegetable production, and Promotion of stress-tolerant to improve maize, cowpea, and potato.

This shows that there are external, uncontrollable factors that affect CSA practice adoption. The model outcome with a wild chi-square of 282.67 and statistically significant at 1% suggests the fact that the explanatory variables contribute to explaining farmers' CSA practice adoption decisions.

Table 4.8: Correlation coefficients of CSA practice adoption

CSA practices	Correlation coefficients	Standard error
ENH vs ORG	-0.08	0.132
PS vs ORG	0.355***	0.133
PD vs ORG	-0.679***	0.241
LEG vs ORG	-0.04	0.111
MIN vs ORG	-0.159	0.121
WTM vs ORG	-0.682***	0.161
PS vs ENH	0.08	0.141
PD vs ENH	-0.414**	0.184
LEG vs ENH	0.166	0.131
MIN vs ENH	0.061	0.133
WTM vs ENH	-0.278*	0.151
PD vs PS	-0.076	0.162
LEG vs PS	-0.07	0.110
MIN vs PS	-0.343**	0.142
WTM vs PS	-0.265*	0.145
LEG vs PD	-0.043	0.104
MIN vs PD	0.023	0.139
WTM vs PD	0.575***	0.168
MIN vs LEG	-0.235**	0.111
WTM vs LEG	-0.063	0.120
WTM vs MIN	0.285**	0.142

Joint significant test of the independent equations: chi2 (21) = 73.825 Prob > chi2 = 0.000

****p < 0.001*

*Note: ***, ** and * represents the significant level at 1%, 5% and 10% respectively.*

ORG = Organic amendment to improve soil health; ENH = Enhancing access to climate information; PS = Promotion of stress (drought, early maturing, striga, and low N) tolerant to improve maize, cowpea, and potato; PD = Promotion of disease and pest tolerant maize and cowpea varieties; LEG = Leguminous crop as the previous crop; MIN = Minimum tillage for maize, cowpea and vegetable production; WTM = Water management (mulching).

Source: Field survey, 2022

4.8 The determinants of CSA practice adoption

The adoption of technologies is based on several determining factors (Adams et al., 2021), including the adoption of CSA practices. This study employed the Multivariate Probit (MVP) model to estimate the determining factor for CSA practice adoption and the outcome is represented in Table 4.9. The results are discussed on a variable basis below.

The results show that the age of a farmer influences the adoption of CSA practices as researched by Akrofi-Atitianti et al., (2018) and Djido et al., (2021b). The outcome in Table 4.9 implies that the aging farmer is less likely to adopt the organic amendment to improve soil health at a 5% significant level. This is because age is a decreasing function of the ability to perform labour-intensive activities. In the same way, aging farmers were more likely to adopt the promotion of disease and pest-tolerant maize and cowpea varieties at a 10% significant level. This is because they want to eliminate the extra effort required to control pests and diseases on their farms.

Education, as researched by many, has been proven to be a positive and significant determining factor for technology adoption and prioritization (Bilaliib Udimal et al., 2017; Dagunga et al., 2020). In this study in Table 4.9, an increase in a farmer's years of education influences positively the likelihood of adopting enhancing access to climate information, promotion of stress-tolerant improved maize, cowpea, and potato, promotion of disease and pest tolerant maize and cowpea varieties, and water management (mulching). But it was also found that education decreases the probability of a farmer adopting organic amendments to improve soil health. This could be accounted for because when most farmers get educated, they tend to spend more time in their acquired formal sector jobs. They now have less time for organic amendment.

Table 4.9 shows that female farmers are more likely to adopt enhancing access to climate information at a 5% level of significance, minimum tillage for maize, cowpea, and vegetable production at a 5% level of significance, and water management (mulching) at a 1% significant level. These practices require fewer resources than promoting disease- and pest-resistant maize and cowpea varieties, as well as cultivating leguminous crops as the previous crop, which the male farmer was more likely to adopt. The female farmers were less likely to adopt the practices than the male farmers were significantly more likely to adopt because they are capital and land-constrained. This is affirmed by Mensah et al. (2021b) and Sam et al. (2019).

Climate information for farmers is an important step toward strategically preparing for the effects of climate change. Therefore, the farmers who were willing to pay for climate information services were more likely to adopt improved access to climate information, organic amendments to improve soil health, and minimum tillage for maize, cowpea, and vegetable production as compared to their counterparts at a significant level of 1%, 10%, and 5% degrees of freedom. This is plausible because the information would motivate the farmers to start their activities in time to meet the required conditions for sustainability. It would also greatly reduce the stress of repeating or correcting a stressful soil organic amendment process. The farmers that were not willing to pay for the information were only more likely to adopt the promotion of disease and pest-tolerant maize and cowpea varieties. This is because this practice can have some negative climate-induced effects.

The findings also revealed that farmers who do not own their farmland were more likely to promote stress tolerance in maize, cowpea, and potato varieties to increase yield. Because the farmers were working on temporary land, this was ideal. Because continuous access to the land is not guaranteed and the owner can request it at any time, most owners are unwilling to invest in improving the land's performance. Those who owned farmland, on the other hand, were more likely to use enhanced access to climate information as compared to others.

Access to extension services reported in Table 4.9 shows that farmers with access are more likely to adopt enhancing access to climate information and promotion of disease and pest-tolerant maize and cowpea varieties at 1% and 10% significance levels, respectively. The farmers could have been linked to or trained by the extension agents on how to get the climate in formation and promotion of enhanced products the farmers are engaged in. Farmers in the study area predominantly engaged in maize and cowpea, hence the positive influence on this adoption. However, the farmers that did not have access to extension services were also more likely to adopt an organic amendment to improve soil health. This is plausible because, in the study area, most of the new strategies that help farmers cope with the negative effects of climate change are likely to be spread by the extension agents. Since they don't get access, they also rely on their traditional ecological knowledge of agriculture and adopt practices that will also help in their production in times of climatic effects. This results in a high adoption decision to promote disease and pest-resistant maize and cowpea varieties.

This study also shows that a farmer's being a member of a farmer-based organization is a determinant of adopting CSA practice just as studied by (Diallo et al., 2019; Israel et al., 2020). In Table 4.9, FBO members are highly positive significant at 1% to adopting the Promotion of disease and pest-tolerant maize and cowpea varieties, Minimum tillage for maize, cowpea, and vegetable production, and water management. This is because being a member of an organized group gives the farmers the leverage to get training from agricultural facilities or projects like AICCRA and to get inputs in all alternate forms. This findings is in line with Azumah et al., (2020).

Table 4.9: Determinants of CSA practices adoption from Multivariate Probit analysis

Practice / Variables	ENH	LEG	ORG	PD	PS	MIN	WTM
Age	0.004 (0.007)	-0.004 (0.007)	**-0.02** (0.008)**	**0.014* (0.008)**	0.001 (0.008)	-0.010 (-0.010)	0.001 (0.008)
Education	**0.035* (0.019)**	0.0173 (0.018)	**-0.036* (0.022)**	**0.0320* (0.017)**	**0.0450*** (0.018)**	-0.007 (0.018)	**0.013 (0.017)**
Gender	**-0.426** (0.206)**	**0.467** (0.195)**	0.202 (0.226)	**0.420* (0.229)**	0.0707 (0.216)	0.348 (0.220)	**0.503** (0.211)**
WTP for climate information	**0.563*** (0.203)**	-0.093 (0.192)	**0.344* (0.209)**	**-0.788*** (0.205)**	-0.130 (0.209)	-0.425 (0.209)	**-0.927*** (0.232)**
Land ownership	**0.337* (0.203)**	0.102 (0.191)	-0.180 (0.211)	-0.025 (0.206)	**-0.405** (0.198)**	**0.506** (0.219)**	-0.130 (0.206)
Extension service access	**0.681*** (0.242)**	0.083 (0.227)	**-0.620** (0.256)**	**0.473* (0.283)**	-0.334 (0.225)	-0.211 (0.267)	-0.028 (0.268)
Climate inform usefulness	0.164 (0.243)	-0.042 (0.235)	0.052 (0.262)	-0.435 (0.270)	-0.096 (0.138)	-0.243 (0.251)	0.143 (0.248)
Household size	0.025 (0.020)	0.001 (0.021)	0.021 (0.021)	-0.023 (0.035)	-0.010 (0.022)	0.005 (0.021)	**-0.058** (-0.058)**

Farmer Based Organizations	**-0.557**** **(0.228)**	-0.197 (0.215)	-0.054 (0.252)	**0.947***** **(0.305)**	-0.092 (0.212)	**0.894***** **(0.241)**	**1.051***** **(0.253)**
Credit access	0.256 (0.186)	0.133 (0.179)	-0.183 (0.195)	0.106 (0.192)	0.295 (0.197)	-0.009 (0.197)	-0.050 (0.192)
Years of climate information	**0.056**** **(0.026)**	0.000 (0.025)	-0.040 (0.035)	-0.032 (0.033)	**0.046*** **(0.027)**	0.024 (0.024)	0.002 (0.030)

Joint significant test: Wild chi2 (77) = 282.67 *Prob > chi2 = 0.000, ***p < 0.001*
*Note: ***, ** and * represents the significant level at 1%, 5% and 10% respectively.*
ORG = Organic amendment to improve soil health; ENH = Enhancing access to climate information; PS = Promotion of stress (drought, early maturing, striga, and low N) tolerant to improve maize, cowpea, and potato; PD = Promotion of disease and pest tolerant maize and cowpea varieties; LEG = Leguminous crop as the previous crop; MIN = Minimum tillage for maize, cowpea and vegetable production; WTM = Water management (mulching).

Then farmers who were not members of FBOs were also more likely to adopt enhancing access to climate information. Their inability to source information from a group does not limit them from getting information for their production. The media for the dissemination of information are open to everybody; the radio, TV, text, voice, and face-to-face. Those who have no other source are more likely to use this to protect production decisions.

The final variable reported in Table 4.9, the years a farmer has been receiving climate information, was observed to be positively significant in influencing the adoption decision of the farmer. The years of receiving the climate information was significant in adopting enhancing access to climate information and promotion of stress tolerance to improve maize, cowpea, and potato at 5% and 10%, respectively. As the years increase, their knowledge of how the information helps their production increases, and they will opt to adopt more practices.

4.9 Determinants CSA prioritization

The explanatory variable approach is used to report marginal effects from the multinomial logit, which variables influence the prioritization of the CSA practice, and by what magnitude. Results from Table 4.10 show that farmers' years of education have a positive significant impact on prioritizing access to climate information, an organic amendment to improve soil health, and the promotion of disease and pest-tolerant maize and cowpea varieties. That is, if a farmer's years of formal education increased by one, the farmer has about an 8.48%, 10%, and 1.5%* chance of prioritizing enhancing access to climate information, an organic amendment to improve soil health; and the promotion of disease and pest tolerant maize and cowpea varieties, respectively. The farmers' average probability to prioritize the promotion of stress-tolerant crops to improve maize, cowpea and potatoes also decreased by 34.57%. Research by Curtis, (2022) and Sam et al., (2020) also showed that education is positively related to technology uptake. In that, the farmers become more exposed to knowledge about these practices and how beneficial they are. They inferred in their study that increasing education among farmers takes them off the farm and they get less time to operate, likewise prioritizing some practices.

From Table 4.10, being female increases the average probability of prioritizing enhancing access to climate information by about 2%. This means that male farmers are less likely to prioritize this practice. The females in the study area spend relatively less time on the farm because of their household duties. It brings them closer to the medium that enhances their knowledge of climate information. Drying and planting of seeds are predominantly female roles in the study area, and climate information is a very important part of executing this task (Gyan et al., 2020; Shee et al., 2019; Sugri et al., 2021).

Climate information availability and accessibility are said to be vital for climate-smart technology promotion (Khatri-Chhetri et al., 2017; Mwongera et al., 2017). This has replicated farmers' prioritizing enhanced access to climate information. Farmers who own their land are nearly 13.8% more likely to prioritize enhanced access to climate information than their counterparts who do not own any land. It is also observed that farmers without their lands are significantly more likely (at about 8.9%) to prioritize organic amendments to improve soil health than those that have land. This is because they have to sustain the small amount of food they get to farmers for continuous production. Research has also proven organic amendment is the best sustainable and cheapest option to enhance quality production (Hammad et al., 2020; Haque et al., 2021).

The farmers that had access to extension services were reported by Table 4.10 to be 21% significantly more likely to prioritize leguminous crops as their previous crop as compared to those who did not get access. Access to extension also had a negative influence of 12.45% and 6.99% on prioritizing the promotion of disease and pest-tolerant maize and cowpea varieties and the promotion of stress-tolerant to improve maize, cowpea, and potatoes, respectively, at a 5% significant level. This result did not meet the a priori expectation, which was supposed to be positive. However, Donkoh et al, (2019) predicted that some extension methods do not encourage cross-learning and experience-sharing among farmers from various homes and backgrounds, and this accounted for the negative effect.

This study revealed that the farmers who perceived climate information to be useful were 13.35% significantly more likely to prioritize enhancing access to climate information than those who tagged it as not useful. The farmers who said climate information is useful might have gotten a good result from accessing some of this information. Many researchers (Igberi et al., 2022; Mensah et al., 2021b) studied climate information on rainfall patterns, intensity, and temperature to protect farmers who adopted the information to adopt practices that will manage soil nutrients loss through mulching to preserve soil moisture and temperature. Those who had not gotten this information realized decreased productivity.

In this study, the number of people in a household, when increased by one, is reported to play a positive significant role in increasing the probability of prioritizing cultivating leguminous crops as preview crops by about 1% and a negative significant probability of about 1% in prioritizing promotion of stress-tolerant improved maize, cowpea, and potato varieties. This outcome fits the reality among farm households in the study area. Almost everyone pitched in to help with the farming activities. Improving the soil organically is a labour-intensive practice as compared to the use of fertilizer. So, the larger the household, the easier it is to achieve this aim. Practices that come with high implementation costs are less desirable among farmers in most developing countries (Williams et al., 2019). They spend more to feed their large households, and, mostly, not much will be left to source improved varieties. This explains the 0.008 lower likelihood of prioritizing the promotion of disease-tolerant varieties.

The decision to prioritize a CSA practice is also dependent on whether a farmer has access to credit or not. According to Table 4.10, a farmer who has access to credit is 0.0624 (6.24%) more likely than their colleagues who do not prioritize the promotion of disease and pest-tolerant maize and cowpea varieties. This practice is a cost-attached CSA practice; to adopt it, funds are needed. Climate information is a cross-cutting action in the development, adoption, and periodization of CSA practices (Damba et al., 2021).

The results in Table 4.10 show that the number of years a farmer has been receiving climate information influences their prioritization decision on some practices. The result shows that if the number of years a farmer receives climate information increases by one, there will be an increase in the average probability of prioritizing; enhancing access to climate information by about 0.016(1.6%), an organic amendment to improve soil health by about 0.014 (1.4%), and promotion of stress-tolerant to improve maize, cowpea, and potato yields by about 0.007 (0.7%), all with significance levels of 10%, 5%, and 10%, respectively.

Table 4.10: Determinants of CSA practices prioritization from multinomial analysis

Practice / Variables	ENH	LEG	ORG	PD	PS
Age	0.002	0.002	-0.000	0.001	0.000
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
Education	**0.085*** **	0.017	**0.101*** **	**0.015***	**-0.346*** **
	(0.029)	(0.012)	**(0.038)**	**(0.009)**	**(0.105)**
Gender	**-0.209*** **	0.028	0.058	0.046	0.001
	(0.054)	(0.043)	(0.048)	(0.047)	(0.040)
Land ownership	**0.138** **	-0.036	**-0.089** **	-0.057	0.0225
	(0.058)	(0.045)	**(0.041)**	(0.043)	(0.031)
Extension	0.011	**0.211** **	**-0.125** **	-0.020	**-0.070*** **
service access	(0.063)	**(0.088)**	**(0.057)**	(0.059)	**(0.022)**
Climate inform	**0.134***	0.008	0.071	-0.053	-0.031
usefulness	**(0.079)**	(0.060)	(0.054)	(0.058)	(0.031)
Household size	-0.002	-0.011	**0.008** **	**-0.009***	0.005
	(0.007)	(0.001)	**(0.004)**	**(0.004)**	(0.003)
Farmer Based	-0.085	0.024	-0.025	0.102	-0.042
Organizations	(0.059)	(0.060)	(0.067)	(0.064)	(0.031)
Credit access	-0.018	-0.010	-0.056	-0.011	**0.062***
	(0.054)	(0.045)	(0.044)	(0.040)	**(0.033)**
Years of climate	**0.016***	**0.014** **	-0.018	0.006	**0.007***
information	**(0.009)**	**(0.007)**	(0.011)	(0.006)	**(0.004)**

*Note: ***, ** and * represents the significant level at 1%, 5% and 10% respectively.*
ORG = Organic amendment to improve soil health; ENH = Enhancing access to climate information; PS = Promotion of stress (drought, early maturing, striga, and low N)

tolerant to improve maize, cowpea, and potato; PD = Promotion of disease and pest tolerant maize and cowpea varieties and LEG = Leguminous crop the previous crop.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

An overview of the research process and significant findings from the study are presented in this chapter. The study's major conclusions are summarized in Section 5.2 following the precise research objectives. Conclusions regarding the study's results are provided in section 5.3. The policy recommendations in section 5.4 were drawn from the conclusions in section 5.3, respectively.

5.2 Summary of findings

Climate change and variability have a negative impact on Ghana's agricultural sector, particularly on rural dwellers. Climate-smart agriculture has been recommended by many to be the way to address the effects. The attempts to address this have not been fully embraced by the stakeholders and facilitators. This necessitated the study to ascertain the extent and determinants of CSA practice adoption and prioritization in Northern Ghana.

1. Seven CSA practices were studied, and the extent of their adoption was approximately 39.81% for previous crop leguminous crops; 38.43% for improved climate information; 24.54% for stress-tolerant maize, cowpea, and potato varieties; 23.61% for organic amendment to improve soil health; 22.22% for minimum tillage for maize, cowpea, and vegetable production; 17.13% for disease and pest tolerant maize and cowpea varieties; and 9.26% for water management.

2. The study showed that only 5 of the practices were prioritized. Enhancing access to climate information was the most prioritized practice, with approximately 25.46% of farmers, followed by approximately 12.96% for legumes as a previous crop and organic amendment to improve soil health, 10.19% for the promotion of disease and pest-tolerant maize, and cowpea, and 4.63% for the promotion of stress-tolerant maize, cowpea, and potatoes.
3. Results from the multivariate probit model showed that the determinants of CSA practice adoption were age, years of formal education, gender of respondents, willingness to pay for climate information, land ownership, extension, household size, farmer-based organization membership, credit access, years of receiving climate information, and perception of the information. However, the determinants vary with each practice.
4. The multinomial logistic also showed the determining factors of prioritizing CSA practices to be years of formal education, land ownership, extension, household size, credit access, years of receiving climate information, and perception of the information. These determinants varied in the prioritization of each practice.

5.3 Conclusions

The main objective of this research was to examine the extent and determinants of CSA practice adoption and prioritization in Northern Ghana. The study revealed that the link between the determinants of a CSA practice's being adopted and being prioritized varies, and in some cases, has opposite effects on adoption and prioritization.

1. Generally, CSA practices adoption among farmers in the study area were low across all the seven practices.

2. Not all CSA practices adopted by farmers were prioritized by same farmers.
3. Improving access to climate information; leguminous crops as previous crops; an organic amendment to improve soil health; promotion of disease and pest-tolerant maize and cowpea varieties; and promotion of stress-tolerant improved maize and cowpea are CSA practices that were adopted and prioritized by the farmers.
4. Water management and minimum tillage were not prioritized, this pose risk on stakeholders if their resources are directed to these practices.
5. Organic amendment to improve soil health and promote stress-tolerant improved maize and cowpea varieties were significant and complementary practices that will yield the maximum benefit.
6. The study also showed that education and training (extension agent contacts) were the major drivers for effective usage of the CSA practices, that can help in achieving the CSA goals of AICCRA Ghana.

5.4 Recommendations

The recommendation below is made following the key finding of the study.

1. The governments and stakeholder (international institutions/bodies, NGO's, …) should enhance their action plans that targets improving CSA practices to reduce the effects of climate change and climate variation.
2. The farmer's (End-users) level of prioritizing CSA practices should be considered when formulating policies.

3. Projects, policies, or climate change interventions should promote or combine CSA practices that are complementary for the best outcome.
4. Climate-smart agriculture enablers or promotion units of government and other stakeholders should provide conducive environment and participatory approaches for farmers to learn new technologies.
5. The stakeholders should mimic the community participatory demonstrations by AICCRA to improve the adoption and prioritization of CSA practices.

Limitations

1. The measure of the CSA practice prioritization was not strong enough. Future research can look at the CSA prioritization by rating each practice the pillars of climate smart agriculture. Thus, how adaptive and mitigative a CSA practice to climate change and sustainably increase in agriculture yield.
2. Time constrained. The outcome variables were many and the time for research was also short for exhaustively studying all the CSA practices. Short time research like the MPhil thesis should limit the number of output variables to enhance proper scrutiny of the thesis.

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APPENDICES

Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) PROJECT
Ghana Cluster

BASELINE SURVEY: Questionnaire for Farmers

Enumerato e read this statement to respondent:

Dear Sir/Ma

We are conc a survey to collect baseline information before starting the implementation of the Project entitled: Accelerating Impacts of CGIAR Climate Research for (AICCRA). Your household was randomly selected to participate in the survey. Your responses to these questions will remain anonymous and will only be u purposes of the research. Taking part in this study is voluntary and should you choose not to take part, there will be no consequence.

Consent

Does the ho head/respondent consent to provide information? Yes /__/, No/__/ (If No, end the survey) [if the household head is not the respondent]

Does the res t consent to provide information? Yes /__/, No/__/

SECTION A. QUESTIONNAIRRE IDENTIFIER

A.1	Qu aire ID:	
A.2	Da	
A.3	St me:	
A.4	Er ie:	
A.5	Re	1. Upper West 2. Bono East 3. Northern 4. Central Region **5.** Upper East
A.6	Di	1. Lawra 2. Jirapa 3. Kintampo North 4. Kintampo South 5. Techiman North 6. Tolon 7. Cape Coast Municipal 8. Komenda Edina Eguafo Abirem 9. Navrongo 10. Other(s) Specify
A.7	Cc ty:	
A.8	Na numerator	
A.9	Se pondent	1.Male 0.Female
A.10	Cc umber of respondent	
A.11	Is lent the head of the Household?	1=Yes 0=No
A.12	If uestion A.10, what is the relationship of the respondent to isehold head?	1 = Wife; 2 = Husband; 3 = Adult child living at home; 4 = other (mentioned) *NB: (Interview should only be carried out with one of the three adult members of the household i.e. husband or wife or adult member is living in the household)*
A.13	GPS coordinates of residence (waypoint)	Latitude: [__________] Longitude: [_________] Elevation:

	(Please use your phone to capture the coordinates for hard copy)	[__________]
A.14	Commodity Value Chain	1. Maize 2. Cowpea 3. Yam 4. sweet potato **5.** Tomatoes

SECTION B. GENERAL HOUSEHOLD INFORMATION

No.	eral household information	Response	
B.1.1	the sex of the of household head?	1 = Male 0 = Female	
B.1.2	the age (years) of the of household head		
B.1.3.	the marital status of the household head *1 =*	*Single, 2= Married, 3=Widowed, 4=Separated/Divorced*	
B.1.4	the highest education level of household	*1 = No formal education, 2 = Primary education, 3 = Secondary education, 4 = Tertiary (beyond High school), 5 = Others (Please specify)*	
B.1.5.	the household size (number of members)?		
B.2	egory	Male	Female
B.2.1	r = to 14 years		
B.2.2	to 24years		
B.2.3	to 60years		
B.2.4	0 years		

B.2.5. Do you ; to any farming or community groups? 1.Yes 0. No

B.2.6. If yes, v of benefit do you gain from the farming group or community group?

(A) Train od agronomic practices
(B) Acce ate information
(C) Acce ing inputs
(D) Labo n farmers (Building social capital)
(E) Other y……………………………………………………………

SECTION C. LAND HOLDING STATUS

How much l[illegible] you have?

Ownership	**(Acres)**	**In whose name is the land owned/ shared/ rented**	**Distance from home to the land (km)**
C.1 Owned			
C.2 Rented [illegible] hers			
C.3 Rented [illegible] rs			
C.4 Sharecr[illegible]			
C.5 Tempo[illegible] r for cropping			
C.6 Commu[illegible]			
C.7 Other ([illegible]			

C.7 How ma[illegible] have you been farming on the land?.......................................

C.8 What is t[illegible] nce (km) from your house to the farm? ....

SECTION D. CLIMATE INFORMATION USAGE AND SERVICES

D.1 Do you h ess to climate information? 1. Yes 0. No

If ye f information? 1. Rainfall on-set 2. First cessation 3. Second cessation 4. Temperature 5. Humidity 6. Precipitation (rainfall) volume

7. Ar , please specify …

D.2 How use e Climate information you access?

(A) Very

(B) Som useful

(C) Not

D.3 Where d et this information from? 1. Radio 2. TV 3. Telephone 4. Neighbor 5. Extension Agents

6.Farm ed Organization 7. Community information centres 8. Other farmers 9. Any other, please specify …

D.4 In which you receive the information? 1. Voice 2. Text 3. Video 4. Word of mouth 5. Any other, please specify …

D.5 Which o tions above is most preferable? 1.Voice 2. Text 3. Video 4. Word of mouth 5. Other, please specify …

D.6.0 Have y untered any problems or challenges with the option chosen? 1. Yes 0. No

D.6.1 What a e challenges?...

D.6.2 Can th n be improved in either frequency of messaging or content? 1. Yes 0.No

D.6.3 How ca e improved?..

D.7.0 How lo rs) have you been receiving Climate Information (CI)?...........

D.7.1 Do you it? 1.Yes 0. No

D.7.2 If yes, ch per information? ……………………..

D.7.3 How fr is this paid? a.per day b.week c.month d.quarterly e.every 6 months f.every year

D.7.4 If some ovides climate information to you at GHS 5.0 per month will you be willing to pay?

1.Yes 0.No

SECTION E. USE OF CLIMATE SMART AGRICULTURAL PRACTICES

No.	Practices	(a) Are you aware of this Practice? Yes = 1 No = 0	(b) If aware, do you use this Practice Yes = 1 No = 0	(c) Source of information on the Practice? (see codes)	(d) When (Year) did you start using the Practice?	(e) Area covered by the Practice (Acres)	(f) Why do you prefer this Practice? (Use of CSA Prioritization Criteria) multi select with the indicators
E.1	o						
	ıotion of disease and pest ant maize and cowpea ties						
	mum tillage for maize and ɔea production						
	bed options-Ridging as an native to mounding for yam uction						
	er management (mulching)						
	ıotion of stress (drought, maturing, striga and low N erant Improved maize, ɔea varieties						
E.2	Central						
	Promotion of On-Farm Composting						

No.	CSA Practices	(a) Are you aware of this Practice? Yes = 1 No = 0	(b) If aware, do you use this Practice Yes = 1 No = 0	(c) Source of information on the Practice? (see codes)	(d) When (Year) did you start using the Practice?	(e) Area covered by the Practice (Acres)	(f) Why do you prefer this Practice? (Use of CSA Prioritization Criteria) multi select with the indicators
	nic amendment for oving soil health						
	nced biopesticide use in to systems						
	notion of disease and pest ant potato varieties						
	ncing access to climate mation						
E.3	**hern/Savanna/North East**						
	mum tillage for maize, pea and vegetable uction						
	una pruriens or cowpea ze intercropping-yam tion to build soil C stocks						
	minous crops as previous crop to yam						
	Organic amendment for improving soil health						
	Promotion of stress (drought,						

No.	CSA Practices	(a) Are you aware of this Practice? Yes = 1 No = 0	(b) If aware, do you use this Practice Yes = 1 No = 0	(c) Source of information on the Practice? (see codes)	(d) When (Year) did you start using the Practice?	(e) Area covered by the Practice (Acres)	(f) Why do you prefer this Practice? (Use of CSA Prioritization Criteria) multi select with the indicators
	' maturing, striga and low N erant Improved maize, ea varieties						
E.4	**er East/Upper West**						
	minous crops as previous to cereals						
	notion of disease and pest ant maize, cowpea, potato tomato varieties						
	mum tillage for maize, ea and vegetable uction						
	una pruriens or cowpea ze intercropping to build soil cks						
	nced biopesticide use in maize, cowpea, potato and vegetable systems						
	Water management (mulching)						

No.	CSA Practices	(a) Are you aware of this Practice? Yes = 1 No = 0	(b) If aware, do you use this Practice Yes = 1 No = 0	(c) Source of information on the Practice? (see codes)	(d) When (Year) did you start using the Practice?	(e) Area covered by the Practice (Acres)	(f) Why do you prefer this Practice? (Use of CSA Prioritization Criteria) multi select with the indicators
	notion of stress (drought, maturing, striga and low N erant Improved maize, pea varieties						
	notion of Phosphorous ent and Nitrogen fixing pea varieties						
Code	odes for source of information: 1 = Government Extension workers, 2 = Farmer Group members, 3 = NGO (specify),4 = Other farmers, 5 = Radio, 7 = onstration/research sites, 8.Community Information centre 9.Special broadcast on market days 99 = Other (specify) (f)**1.Climate Smartness** Productivity 1.b.Adaptation 1.c.Mitigation **2.Gender & Social Inclusion**(**2a**.Labour Requirement-2.a.1.Male,2.a.2Female **2b**.Youth Involvement-..Male,2.b.2.Female **2c**.Women Friendliness- 2.c.1.Lower associated Drudgery 2.c.2.Availability2.c.3.Accessibility2.c.4.Affordability 2.c.5.Socio-cultural ptability 2.c.6.Lower Implementation requirements **3.One-Health Achievement** 3.a.Reduces Pest Load 3.b.Addresses Nutrient Depletion 3.c.Addresses Water Adequacy 3.d.Addresses Soil-Water Pollution 3.e.Promotes crop livestock integration 3.f.Lower GHG emissions 3.g.Public Health Implications - ributes to lowering incidences of diseases to humans 3.h.Preserves Biodiversity **4.End-user friendliness** 4.a.Technical feasibility-4.a.1.Male, 4.a.2.Female 4.b.Lower Associated Cost (Cost-Effectiveness)-4.b.1.Male 4.b.2.Female						

SECTION F. COST OF CSA PRACTICES

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	o East						
	otion of disease and pest ınt maize and cowpea ties						
	ss						
	residue						
	or						
	ticide						
	ulant						
	oved seed of maize						
	oved seed of cowpea						
	ertilizer						
	Ammonia/Urea fertilizer						
	Sacks						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	num tillage for maize and ea production						
	ss						
	residue						
	or						
	r						
	ticide						
	ulant						
	oved seed of maize						
	oved seed of cowpea						
	ertilizer						
	onia/Urea fertilizer						
	Sacks						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	r management (mulching)						
	ss						
	residue						
	or						
	hene sheet						
	el						
	ncing access to climate mation						
	le phones						
	Community centres						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	ern/Savanna/North East						
	num tillage for maize, ea and vegetable uction						
	ss						
	residue						
	or						
	ticide						
	ulant						
	ved seed of maize						
	ved seed of cowpea						
	ved seed of tomato						
	ertilizer						
	Ammonia/Urea fertilizer						
	Sacks						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	una pruriens or cowpea ze intercropping-yam ion to build soil C stocks						
	ss						
	residue						
	or						
	ticide						
	ulant						
	oved seed of maize						
	oved seed of cowpea						
	na seed						
	ertilizer						
	Ammonia/Urea fertilizer						
	Sacks						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	minous crops as previous to yam						
	ss						
	residue						
	or						
	ticide						
	ulant						
	oved seed of cowpea						
	yam						
	ertilizer						
	onia/Urea fertilizer						
	Organic amendment for improving soil health						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	ss						
	residue						
	ıic fertilizer						
	otion of stress (drought, maturing, striga and low N rant Improved maize, ea varieties						
	ss						
	residue						
	or						
	Insecticide						
	Innoculant						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	ved seed of maize						
	ved seed of cowpea						
	ertilizer						
	onia/Urea fertilizer						
	r East/Upper West						
	ninous crops as previous to cereals						
	ss						
	residue						
	or						
	ticide						
	Innoculant						
	Improved seed of cowpea						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	oved seed of maize						
	ertilizer						
	onia/Urea fertilizer						
	otion of disease and pest ant maize, cowpea, potato omato varieties						
	ss						
	residue						
	or						
	ticide						
	ulant						
	Improved seed of maize						
	Improved seed of cowpea						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	oved tomato seed						
	ertilizer						
	onia/Urea fertilizer						
	oved sweetpotato vines						
	num tillage for maize, ea and vegetable uction						
	ss						
	residue						
	or						
	ticide						
	Innoculant						
	Improved seed of maize						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	oved seed of cowpea						
	oved seed of tomato						
	ertilizer						
	onia/Urea fertilizer						
	una pruriens or cowpea ze intercropping to build stocks						
	ss						
	residue						
	or						
	Insecticide						
	Innoculant						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	...oved seed of maize						
	...oved seed of cowpea						
	...na seed						
	...ertilizer						
	...onia/Urea fertilizer						
	...nced biopesticide use in ...e, cowpea, potato and ...able systems						
	...esticides						
	...ss						
	...residue						
	Tractor						
	Land						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	ticide						
	ulant						
	ved seed of maize						
	ved seed of cowpea						
	ved tomato seed						
	ertilizer						
	onia/Urea fertilizer						
	ved sweetpotato vines						
	r management (mulching)						
	Cutlass						
	Crop residue						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	or						
	hene sheet						
	l						
	otion of stress (drought, maturing, striga and low N rant Improved maize, ea varieties						
	ss						
	residue						
	or						
	ticide						
	ulant						
	Improved seed of maize						
	Improved seed of cowpea						

No.	Prioritized CSA practices (input)	(a) Common source	(b) Distance from house to the source (km)	(c) Average cost per unit GHS	(d) Unit	(e) Perception of cost	(f) Constraints to access
	ertilizer						
	onia/Urea fertilizer						
(a)	**ulture input seller in my community 2. Agriculture input seller in nearby community 3. Colleague farmer 4. Extension agent 5.Major city in my area r specify (e) 1. Expensive 2.Moderate 3.Low/Cheap**						

Region: Bono East

Commoditie ;, Cowpea, Yam

No.	**ific Commodity**	**Proposed Bundled CSA Practices**	**Tick for practices that you have combined in the last 5 years (multiple select option)**
Bundle 1	Yam	Biological soil and seed treatment (Application of neem leaf powder to treat soil and ash to treat seed yam before planting	
		Seedbed options-Ridging as an alternative to mounding for yam production	
		Staking Options-Trellis/Minimum staking to reduce deforestation in yam production	
		Promotion of Seed yam multiplication technologies (mini-sett technology; aeroponics and hydroponics technologies)	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	
Bundle 2	laize, Cowpea	Minimum tillage for maize and cowpea production-	
		Promotion of stress (drought, early maturing, striga and low N) tolerant Improved maize, cowpea varieties	
		Promotion of disease and pest tolerant maize and cowpea varieties	

No.	Specific Commodity	Proposed Bundled CSA Practices	Tick for practices that you have combined in the last 5 years (multiple select option)
		Enhanced biopesticide use in maize and cowpea systems	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	
		Enhancing access to climate information	

Region: Central

Commodities: Sweet Potato

No.	**pecific Commodity**	**Proposed Bundled CSA Practices**	**Tick for practices that you have combined in the last 5 years (multiple select option)**
Bundle 1	veet Potato	Vine technology (cutting and planting)	
		Promotion of vine multiplication technologies (aeroponics and hydroponics technologies)	
		Biocontrol of the sweet potato beetle	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	

Region: Northern

Commodities: Maize, Cowpea and Yam

No.	**c odity**	**Proposed Bundled CSA Practices**	**Tick for practices that you have combined in the last 5 years (multiple select option)**
Bundle 1	a, Potato	Minimum tillage for maize, cowpea and vegetable production	
		Promotion of stress (drought, early maturing, striga and low N) tolerant Improved maize, cowpea varieties	
		Promotion of disease and pest tolerant maize, cowpea, potato, and yam varieties	
		Enhanced biopesticide use in maize and cowpea systems	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	
Bundle 2		Biological soil and seed treatment (Application of neem leaf powder to treat soil and ash to treat seed yam before planting	
		Seedbed options-Ridging as an alternative to mounding for yam production	
		Staking Options-Trellis/Minimum staking to reduce deforestation in yam production -	
		Promotion of Seed yam multiplication technologies (mini-sett technology; aeroponics and hydroponics technologies)	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	

Bundle 3	Maize, Cowpea,	Mucuna pruriens or cowpea /maize intercropping-yam rotation to build soil C stocks	
		Promotion of dual-purpose cowpea (grain and fodder)	

Region: Upper West and Upper East

Commoditie e, Cowpea, Tomatoes

No.	**ific Commodity**	**Proposed Bundled CSA Practices**	**Tick for practices that you have combined in the last 5 years (multiple select option)**
Bundle 1	e, Cowpea,	Mucuna pruriens or cowpea /maize intercropping to build soil C stocks	
		Contour stone bunds or contour tillage with tied ridges (Zero or minimal rates of rainfall run-off and soil erosion)	
		Promotion of dual-purpose cowpea (grain and fodder)	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	
Bundle 2	e, Cowpea,	Minimum tillage for maize, cowpea and vegetable production	
		Promotion of disease and pest tolerant maize & cowpea varieties	
		Enhanced biopesticide use in maize and cowpea systems	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	
Bundle 3	atoes	Contour stone bunds or contour tillage with tied ridges (Zero or minimal rates of rainfall run-off and soil erosion)	
		Promotion of drip and sprinkler irrigation for vegetable farming	
		Organic amendment for improving soil health / Leguminous crops as previous crop	
		Enhancing access to climate information	

SECTION G. CROP PRODUCTION ESTIMATES (YIELD AND REVENUE)

G.1: What is ... al acreage(s) cultivated for……… in the last cropping season(major) 2020? _______________

G.2 What is t... l quantity of ……. harvested the last cropping season 2020? [in maxi bags (100kg) for maize, 100 tubers for, yam ,100 tubers for sweet potato, …….50 kg/cr... omatoes] __________________

G.3 What is t... l quantity of your harvested ……………sold the last cropping season (2020)? [in maxi bags (100kg) for maize, 100 tubers for, yam, 100 tubers for sweet potat... 0 kg/crate for tomatoes] __________________

G.4: What is ... rage price (specific Value chains) in the last cropping season in GHC? _______________

G.5: What is ... timated yield for 2021? [in maxi bags (100kg) for maize, 100 tubers for, yam ,100 tubers for sweet potato, …….50 kg/crate for tomatoes]

SECTION H: ALLOCATION OF CROP HARVEST

Please provi mation about the use of your Crop in the last cropping season

	ity med	Quantity kept for planting (seed)	Quantity used as payment for inputs	Quantity bartered or exchanged for goods and services	Quantity lost through Post-harvest losses	Quantity for other uses
H.1 Maize (100kg)						
H.2 Cowpea (100kg)						
H.3 Yam (100 tubers)						
H.4 Orange flesh Sweet Potato (100kg)						
H.5 Tomatoes (50 kg)						

SECTION I. SOURCES OF FINANCING CSA PRACTICES and GAPS

Please provi mation on your access to any of the following sources of CSA Financing

Row	Sou orrowed money	Amount requested in GHC (a)	Amount granted in the last 12 months (b)
I.1	Rel d friends		
I.2	Inf vings and credit group		
I.3	Mo der		
I.4	Go nt credit schemes		
I.5	NG h/Mosque		
I.6	Bar		
I.7	Mi nce institution		
I.8	Oth se specify		

SECTION J. ACCESS TO AND USE OF AGRICULTURAL EXTENSION SERVICES

J.1 How mar (per season) do you interact with Extension Agents? ………………..
J.2 Did anyo ur household visit an agricultural extension agent or an agricultural extension center during th 2 months to seek advice or assistance on growing crops? Yes = 1, No = 0 /____/
J.3 Who in y sehold met an agricultural extension agent? 1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify
J.4 If yes, ho times during the last 12 months did members of your household do this? /____/
J.5 Through edium do you receive extension services? 1. Face -to- Face(extension agents to farmer) 2. Digital/Electronic 3. Farmer -to- farmer
J.6 From wh ou receive extension services? 1. MOFA Extension 2. NGOs 3. Private 4. Research Institutions/universities
J.7 Do you p e extension services? 1. Yes 0=No
J.7.1 If yes, h ch (GHS) do pay for the services per season? GHS……….
J.7.2 Who in usehold pays for this service? 1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify

J.8 What kin sistance or information were requested? Tick where appropriate

Crop produ		Did you request (Yes =1 No=0)	*Perception on usefulness of assistance: 1= Not useful, 2= Somehow useful, 3= Useful, 4= Very useful*	*Timeliness of the assistance or information: 1= Untimely, 2= Always provided late, 3= Not always timely, 4= Timely*
J.8.1	f fertilizer			
J.8.2	f improved varieties			
J.8.3	and disease management			
J.8.4	nanagement			
J.8.5	her information			
J.8.6	Marketing advice			
J.8.7	t for crop production			
J.8.8	ral crop production advice			
J.8.9	Bush fire management			
J.8.10	Improved management of Livestock			
J.8.11	Farm management and record keeping			
J.8.12	Other			

J.9 During the past 12 months, did any agricultural extension agent visit your household? Yes=1 No = 0 /_____/

J.9.1 if yes to . nany times did any extension agent visit your household during the last 12 months? /_____/

J.9.2 Who did nsion agent talk to when they visited? 1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify

SECTION K. ACCESS TO CAPACITY BUILDING ON CSA

K.1 Have you member of this household participated in any agricultural research or extension training in the last 12 months? (Yes = 1, No = 0) /____/
K.1.1 If yes, ticipated? 1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify

Row	(a K Who p the t	(b) K.1.2 Topic	K.1.3 Did you or any of the other farmers ask for the training (Yes = 1 No = 0)	(c) K.1.4 Usefulness of the training	d) K.1.5 Timeliness of the training	e) If yes, who participated?
1						
2						
3						
4						
5						
Codes	*Research Institution/Universities=1, Government Agencies =2, NGO= 3, Private Sector= 4 other =5* *Topic of Training: 1= Crop management, 2 = Pest and disease control, 3= Livestock husbandry, 4= Specific agricultural technologies (specify………). 99= Other (specify)* *Perception on usefulness of training: 1= Not useful, 2= Somehow useful, 3= Useful, 4= Very useful* *Timeliness of the training: 1= Untimely, 2= Always provided late, 3= Not always timely, 4= Timely*					(e)1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify

SECTION M: ASSET OWNERSHIP OF THE HOUSEHOLD

M.1 Livestock	1 ber/Qty	M.1.2 Unit price (GHC)	M.2. Other assets	M.2.1 Number/Qty	M.2.2 Unit price (GHC)	M.3 Who owns this property 1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify	M.4Who decides to dispose off this property 1.Husband 2.Wife 3.Daughter 4.Son 5.Other(s) specify
Bulls			Car				
Cattle			Motorbike				
Goats			Bike				
Sheep			Television				
Poultry			Radio				
Pigs			Mobile phone				
Donkey			Refrigerator				
Other, specify			Tractor				
			Donkey cart				
			Plough				
			Water pump				
			Water tank				
			Hoe				
			Cutlass				

			Thresher/Sheller				
			Grain moisture meter				
			Postharvest drying area				
			Local granary for storage				
			Other, specify				

SECTION N: PERSONAL DETAILS OF THE RESPONDENT

N.1 Name of Respondent……………………………………………

N.2 Contact of Respondent…………………………………………………

END OF THE QUESTIONS

THANK YOU