INCLUSIVITY OF VEGETABLE COOPERATIVES AND EFFECT ON ADOPTION OF WATER-RELATED CLIMATE SMART PRACTICES AMONG VEGETABLE FARMERS IN SOUTHERN GHANA

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DECLARATION

DECLARATION

I, JERRY AYUURETOLIYA AKANWAKE, do hereby declare that except for the references cited, which have been duly acknowledged, this work, "**Inclusivity of Vegetable Cooperatives and Effect on Adoption of Water-Related Climate Smart Practices among Vegetable Farmers in Southern Ghana,**" is the result of my research. It has never been presented either in whole or in part for any other degree at the university or elsewhere.

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DEDICATION

I dedicate this thesis to God, my Chief, Naba John Akanwake A-ille II, the Akanwake's family, Mount Sinai, and all my friends and lovers.

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ABSTRACT

Water smart agriculture practices have the potential to ensure water availability for vegetable farmers through practices such as irrigation, water harvesting, drought-resistant crops, mulching, conservation tillage, and cover cropping. There is a concern for inclusivity within cooperatives operated by vegetable farmers in southern Ghana. Limiting participation of vegetable farmers in cooperatives has consequences for adopting water-related climate smart practices. The major objective of this study is to assess how the inclusive cooperative business model (ICBM) influences the adoption of water-related climate smart practices (WCP) among vegetable farmers. The specific objectives are to: (1) determine the extent to which vegetable cooperatives in Ghana apply the IBM, (2) identify the factors that influence participation in vegetable cooperatives that employ IBM, (3) determine the extent to which vegetable cooperatives that employ IBM are effective in farmer adoption of WCP and (4) measure the impacts of WCP adoption on vegetable farmers' output and income. The study used descriptive statistics, logit, ordered probit, and propensity score matching models to analyse the four objectives respectively. The study collected data from 561 randomly selected vegetable farmers in the Greater Accra, Central and Eastern regions of Ghana. The results showed that cooperatives in Ghana inculcated inclusivity in their operations, but at a low level. They overlook support that reduces resource poverty. The logit results showed that market access, access to credit, training and development, perceived contribution to the environment and community, and access to climate change information were positively significant. The ordered probit results showed that, cooperative play a critical role in influencing the number of WCP adoption by vegetable farmers. The PSM results showed that vegetable farmers who join cooperatives earn more and had more output than those who are not in cooperatives. The study suggests the implementation of infrastructure development that will ease quick access to the market for vegetable farmers in IBM cooperatives to trade their produce. ADB Bank, other financial institutions, and investors with interest in agriculture should invest in vegetable farmers in IBM cooperatives through low-interest rate loans and credit. Extension officers and climate change agents should make information on climate change available to vegetable cooperatives. Vegetable farmers are encouraged to join IBM cooperatives because they will be empowered resulting in increased output and income levels.

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BMC	Business Model Canvas
CAP	Climate Smart Agriculture Practices
CCDR	Country and Climate Development Report
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organisation
FBOs	Farmer Based Organizations
GIDA	Ghana Irrigation Development Authority
IBM	Inclusive Business Model
ICA	International Cooperative Alliance
ICBM	Inclusive Cooperative Business Model
ND-GAIN	Notre Dame Global Adaptation Initiative
NGO	Non-Governmental Organisation
OPM	Ordered Probit Model
PSM	Propensity Scores Matching
UNFCC	United Nations Framework Convention on Climate Change
WCP	Water-Related Climate Smart Practice

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The global agricultural sector faces imminent threats owing to climate change, with adverse consequences for food security and livelihoods. Thus, the issue of climate change and its impact on the global, African, and Ghanaian economies have become a pressing concern in recent years. Climate change can be defined as a change in the average of different climatic characteristics over a longer period and a wider geographic area, including temperature, precipitation, relative humidity, and the composition of atmospheric gases (National Geographic, 2022). Current weather extremes are already affecting millions of people globally, endangering supply chains for agriculture, many coastal towns, and the security of food and water.

Climate change poses a substantial threat to the environment, agricultural practices, and economic sustainability (Adzawla et al., 2020). A specific area of concern is the impact of climate change on water resources, which is integral to the success of agricultural activities, particularly in Ghana. Unpredictable and increasingly irregular patterns of rainfall in Ghana have been linked to climate change, making water management a pivotal issue for the country's agricultural sector (National Geographic, 2022). The effects of climate change, particularly in the context of water-related challenges, have the potential to undermine food security and economic stability, not only in Ghana, but also across the African continent and the global stage (Porter et al., 2019).

Water scarcity and variability in water availability have direct implications for agricultural practices, particularly for vegetable farmers in Ghana. Farmers rely heavily on water resources for irrigation and other climate-smart practices (Asante et al., 2012). Vegetable crops rely heavily on water resources and are susceptible to climate change, especially rising temperatures, which can have a negative impact on their productivity. Heat stress in plants is a direct result of dryness and high temperatures caused by climate change and negatively affects plant development and health. (Payen et al., 2015, Abdul-Razak & Kruse, 2017, Porter et al., 2019, Dumitru et al., 2023, Saeed et al., 2023).

Irregularities in rainfall patterns and increasing instances of drought have hampered farmers' efforts to sustainably produce (Fagariba et al., 2018). Furthermore, the unpredictability of climate change-related weather patterns can lead to crop failure and reduced outputs, ultimately impacting food production and economic sustainability (World Bank 2021). Therefore, this problem needs to be addressed by promoting climate-smart practices that optimize water-use efficiency for vegetable farmers (Aryal et al., 2020).

With the rise of these concerns, Climate Smart Agriculture (CSA) has been suggested as an intervention to help mitigate climate change (World Bank 2021; FAO 2013). The FAO defines CSA as a farming technique that transforms agricultural food systems into green and climate-resilient practices. This includes on-farm actions such as planting varieties that are high-output and tolerant to biotic and abiotic cues, using innovative agricultural technologies that improve crop growth and physiology, encouraging farming practices such as cover cropping, crop rotation, mixed cropping, increased use of organic fertilizers and manure, and effective irrigation.

Climate Smart Agriculture Practices (CAPs) are essential in boosting farmers' ability to adapt to rising climate change, lower greenhouse gas emission and increase productivity and food security sustainably (Zhou et al., 2024). According to Antwi-Agyei and Amanor (2023), Climate Smart Agriculture Practices are grouped into seven dimensions (which includes water smart practices, energy smart practices, nutrient smart practices, carbon smart practices, weather smart practices, planting smart practices, and knowledge smart practices and these dimensions have about 31 different practices.

Previous studies have revealed that Climate Smart Agriculture Practices positively affect farmers' resilience to climate change. According to Zizinga et al., (2022), in rain-fed agricultural systems in Uganda, the implementation of CAPs (mulching, halfmoon pits, and permanent planting basins) enhances maize grain output by 28–66%, 38–57%, and 8–56% in seasons one, two and three. Ishakku and Abdulai (2020) noted that CAPs, such as crop choice and soil and water conservation practices, increase diary diversity and income of rural households by 15.2% and 12.4%, respectively, and lower food and nutrition insecurity of CAPs adopters by 35%.

Despite the successful contribution of CAPs, other studies have revealed that the adoption of CAPs, especially water smart practices, is still low, especially in the agricultural transitional zone and developing countries where West Africa and Ghana are a part (Westermann et al., 2018; Kangogo et al., 2021; Tambet & Stopnitzky, 2021). Some researchers have revealed that the low adoption rate is a result of low knowledge and perceptions about the benefits of CAPs, few incentives and constraints to influence farmers to adopt CPAs, individual households, and plot-level characteristics, such as age, sex, education, household size, plot size, plot fertility, and topography (Malhi et al., 2021; Owusu et al., 2021; Waaswa et al., 2022).

In response to these concerns of low adoption of CAPs, there has been a growing interest in adopting inclusive cooperative business models as a means of mitigating the impact of climate change on vegetable farming. These cooperative models seek to promote collective action and resource sharing among farmers, encouraging the use of climate-smart practices and sustainable management of water resources (Abdul-Razak & Kruse, 2017). By pooling resources and knowledge, farmers can better adapt to changing weather patterns and water scarcity, thereby reducing their vulnerability to climate change.

Inclusivity is the deliberate technique of making sure that everyone feels appreciated, accepted, and able to engage completely regardless of background or identity. Making sure that everyone has equal access to opportunities, resources, and participation regardless of traits like gender, age, ethnicity, or location is known as inclusivity. By lowering obstacles that keep some groups from participating in or profiting from societal activities or resources, it seeks to advance social justice and equality (Sutherland et al., 2020). Ensuring fair access to resources, decision-making involvement, and customised assistance for underserved populations, including women, young people, and smallholder farmers, are all components of inclusivity in agriculture (Christian et al., 2024). In this study, inclusivity is defined as the inclusion of IBM in the running the affairs of a registered cooperative.

Several studies have examined farmer-based organizations (FBOs), for example, cooperatives in promoting the adoption of climate-smart practices and sustainable water management among vegetable farmers. These studies have revealed promising results, showing that cooperatives can lead to increased access to resources, technical knowledge, and financial support, all of which are crucial for implementing water-related climate smart practices (Kiptot and Franzel, 2012; Abdul-Rahaman and Abdulai, 2020; Zhou et al., 2023). For instance, Kiptot and Franzel (2012) found that cooperative-based approaches significantly increased the adoption of agroforestry practices among farmers in Kenya, improving water retention and overall sustainability.

Additionally, a study by Abdul-Rahaman and Abdulai, (2020) in Ghana explored farmer groups, collective marketing and small farmers performance. Their research demonstrated that cooperatives play a critical role in enhancing farmers' access to training and technical support in climate-smart practices, such as water-efficient irrigation techniques and/or the use of drought-resistant crop varieties, ultimately leading to increased crop output and income stability.

Furthermore, research conducted by Liu et al., (2021) in China has investigated cooperative efforts in water resource management among vegetable farmers facing water scarcity. The study highlighted that these cooperative approaches facilitated better water allocation and utilization, reduced water wastage, and improved the overall water efficiency. As a result, these farmers were better equipped to adapt to changing climatic conditions and safeguard their livelihoods.

While these studies collectively provide insights into the potential benefits of cooperatives for vegetable farmers in various contexts, there is still a need for more comprehensive research to examine the effectiveness of the inclusive cooperative business model in influencing the adoption of water-related smart practices among vegetable farmers. Furthermore, comparative studies across different regions, including Ghana, will help determine the generalizability of cooperative approaches for promoting water-related climate-smart practices and addressing the unique challenges faced by vegetable farmers across diverse agricultural landscapes. Furthermore, the global and African contexts present unique challenges and opportunities for cooperative approaches that require specific attention in research and policy formulation. Hence, addressing challenges related to water scarcity and climate change is crucial.

Thus, by investigating the inclusivity of vegetable cooperatives and the effects on the adoption of climate-smart practices among vegetable farmers, this study aims to contribute to the on-going discourse on sustainable agriculture, food security, building resilience to climate change, and economic resilience in Ghana. To fill the gap in the existing literature, this study seeks to address how effective inclusive cooperative business models influence the adoption of water-related climate-smart practices among vegetable farmers, the key factors in the success of inclusive cooperatives in promoting climate-smart practices within the vegetable farming sector, and what socio-economic and environmental impacts can be attributed to increased adoption of climate-smart practices through inclusive cooperatives.

1.2 Problem Statement of the Study

West Africa has been labelled a climate change hotspot, where crop outputs and production are anticipated to decrease due to climate change, with subsequent effects on food security (IPCC, 2014). According to the IPCC (2014), African nations that already have a long history of poverty and food insecurity face serious threats from the effects of climate change and its linked events on food production and food security. World Bank's Country and Climate Development Report (CCDR) for Ghana, at least one million more people may become poor due to climate-related disasters, and the income of poor households may decrease by as much as 40% by 2050 if urgent climate action is not implemented (World Bank Group, 2022).

At the local level, particularly within communities and at the company level, economic concerns revolving around climate change and its impact on agriculture are becoming increasingly pressing. Vegetable farming, which often serves as a vital source of livelihood and income for local communities and small-scale enterprises, is notably susceptible to the challenges posed by climate change. Erratic rainfall patterns, droughts, and water scarcity are among the predominant issues faced by these stakeholders as they undermine the reliability and sustainability of vegetable farming (FAO, 2015). Ghana's agricultural sector is significantly impacted by climate change, leading to unpredictable rainfall patterns and increased drought conditions that threaten food security and farmer livelihoods (Adzawla et al., 2020; Fagariba et al., 2018).

CSA practices (CAPs), specifically water smart practices such as solar powered irrigation, drip, and sprinkler irrigation, which have been prospected as a strategy to help build farmers' resilience to climate change impacts on water scarcity, have been adopted and practiced (Westermann et al., 2 018; Kangogo et al., 2021; Owusu, 2021; Tambet & Stopnitzky, 2021).

There is growing interest in the potential of inclusive cooperative business models. These models are viewed as mechanisms to address the challenges faced by vegetable farmers and small-scale enterprises. They offer a platform for collective action, shared resources, and mutual support, with the goal of enhancing the adoption of water-related climate smart practices (Owusu, 2021). While inclusive cooperatives are designed to facilitate collective action among farmers, empirical evidence indicates that their effectiveness in promoting the adoption of WCPs is not well-documented. However, amidst this growing interest and optimism surrounding inclusive cooperative business models, a pivotal and overarching question emerges as the focal point: To what extent does inclusivity within cooperative influence the adoption of water-related climate-smart practices among vegetable farmers in Southern Ghana?

Empirical studies have indicated that cooperative approaches have the potential to enhance resource access and knowledge sharing among vegetable farmers and small-scale enterprises, as well as influencing smallholder farmers to adopt water-related smart practices (irrigation) (Abate et al., 2014; Owusu, 2021). Despite these positive findings, several gaps still exist in creating a cooperative inclusive business model. Studies have shown that many cooperatives operate at a low level of inclusivity, failing to adequately support marginalized farmers who are most vulnerable to climate impacts (Abdul-Rahaman & Abdulai, 2020; Owusu et al., 2021).

In Ghana, Ankrah et al. (2021) noted that peer influence, chronic diseases, ethnicity, institutions, infrastructure accessibility, and income level influence the selection of farmers' cooperative members, making it biased and exclusive.

Whether vegetable cooperatives are effective and inclusive in influencing the adoption of water-related climate smart practices in Ghana remains understudied. Hence, a comprehensive investigation is needed to assess the effectiveness of these inclusive business models in influencing the adoption of water-related climate smart practices, particularly in vegetable farmers and small-scale enterprises in local communities. Furthermore, understanding the broader economic implications of inclusive cooperative business models and their contributions to local economic resilience is essential for formulating evidence-based strategies and policies. This study aims to address these concerns, offers an understanding of the effectiveness of inclusive cooperative business models, and provides a foundation for potential solutions to local and company-level economic concerns associated with climate change and vegetable farming.

The following specific questions are raised:

1. To what extent do vegetable cooperatives in Southern Ghana apply inclusive business models?
2. What factors influence participation in vegetable cooperatives that employ IBM?
3. How effective are vegetable cooperatives employing IBM in the adoption of water-related climate-smart practices (WCP)?
4. What is the impact of cooperative membership on the output and income of vegetable farmers?

1.3 Objectives of the Study

The major objective of the study is to assess how inclusive cooperative business model (ICBM) influence adoption of water-related climate smart practices (WCP) among vegetable farmers in Southern Ghana. The specific objectives are to:

1. Determine the extent to which vegetable cooperatives in Southern Ghana apply inclusive business model (IBM),
2. Identify the factors that influence participation in vegetable cooperatives that apply IBM,
3. Determine the level to which vegetable cooperatives that apply IBM are effective in the adoption of WCP and
4. Measure the impact of IBM cooperative membership on output and income of vegetable farmers.

1.4 Relevance of the Study

The study titled 'Inclusivity of Vegetable Cooperatives and Effect on Adoption of Water-Related Climate Smart Practices among Vegetable Farmers in South Ghana' holds significant relevance in addressing critical issues related to climate change, agricultural sustainability, and economic resilience. By investigating how inclusive cooperative business models (ICBM) influence the adoption of water-related climate-smart practices (WCP), this study provides valuable insights for various stakeholders, including farmers, policymakers, and agricultural organizations.

This study contributes to meeting the objectives of Ghana's Food and Agriculture Sector development Policy II (FASDEP II), which aims reflect

1. Food security and emergency preparedness.

2. Sustainable management of land and environment in the face of the climate change challenge; and
3. Improved growth in incomes of vegetable farmers.

The agricultural sector, particularly vegetable farming, is profoundly affected by climate change, which manifests as erratic rainfall patterns, prolonged droughts, and increased water scarcity. As noted by the Intergovernmental Panel on Climate Change (IPCC, 2014), West Africa is identified as a climate change hotspot where crop yields are expected to decline, exacerbating food insecurity. This study explored the potential of inclusive cooperatives to facilitate the adoption of WCP, which can enhance the resilience of vegetable farmers. By promoting practices, such as efficient irrigation and water harvesting, cooperatives can help mitigate the impacts of climate change and ensure sustainable food production and security. According to Aryal et al., (2020), the adoption of climate-smart practices is essential for optimizing water-use efficiency among farmers. Additionally, the World Bank (2021) emphasized that climate-smart agriculture can play a critical role in reducing vulnerability to climate-related shocks.

The adoption of Climate Smart Agriculture (CSA) practices, especially water-smart practices, is essential for improving water-use efficiency and ensuring sustainable vegetable production. This study highlights the potential for cooperatives to facilitate the dissemination of these practices among farmers. Previous research indicates that cooperatives can significantly enhance access to resources, technical knowledge, and financial support (Kiptot & Franzel, 2012; Liu et al., 2021).

Understanding the extent to which vegetable cooperatives apply inclusive business models is essential for identifying gaps and opportunities for improvement. Cooperative leaders can utilize these findings to enhance inclusivity in their operations, ensuring that all members benefit from resources and support. This could lead to increased member engagement and improved cooperative performance. According to Abdul-Rahaman and Abdulai (2020), cooperatives that effectively implement inclusive business models can better support their members in accessing resources and training, ultimately leading to improved agricultural practices.

Identifying the factors that influence participation in inclusive cooperatives is crucial in designing effective outreach and engagement strategies. Policymakers and agricultural organizations can use this information to develop targeted programs that encourage participation among marginalized groups, thereby strengthening cooperative membership and collective action. Abdul-Rahaman and Abdulai (2020) found that socio-economic characteristics significantly affect participation rates in cooperatives, indicating the need for tailored outreach efforts to engage diverse farmer populations.

Evaluating the effectiveness of cooperatives in promoting WCP adoption provides insights into the mechanisms that facilitate sustainable practices. Farmers can benefit from the enhanced training and support provided by cooperatives, leading to improved agricultural practices and increased resilience to climate change. Additionally, cooperative leaders can leverage these findings to attract more members by showcasing successful WCP adoption. Liu et al., (2021) emphasized that cooperative approaches facilitated better water management among farmers, highlighting the effectiveness of cooperatives in promoting sustainable practices that are critical for enhancing agricultural productivity.

Measuring the impact of cooperative membership on the output and income of vegetable farmers is essential to understand the broader benefits of cooperative membership. These findings can inform policymakers about the economic advantages of supporting cooperatives, leading to increased investment in cooperative development. Additionally, cooperative members can use evidence of increased income and output to advocate for further resources and support. The World Bank (2022) underscores the importance of cooperative membership in enhancing smallholder farmers' economic resilience, which aligns with the findings of this study.

The relevance of this study lies in its potential to address critical issues related to climate change, sustainable agricultural practices, economic resilience and cooperative development. By focusing on the inclusivity of vegetable cooperatives and their role in promoting water-related climate-smart practices, this study aims to contribute to the ongoing efforts to enhance food security and resilience among smallholder farmers in South Ghana. These findings will benefit various stakeholders, including farmers, policymakers, and agricultural organizations, by providing evidence-based insights and recommendations for promoting sustainable agriculture in the face of climate change.

1.5 Organization of the Report

The study is organised into five chapters. Apart from the Introduction, Chapter Two presents the literature review, with subsections on climate change, climate smart agriculture (CSA), topology of water-related climate smart practices, cooperatives, cooperative mandate and alternative business model, vegetable farming, and empirical literature review on the major and specific objectives. Chapter Three describes the methodology of the study, including theoretical framework, conceptual framework, method of data analysis, method of data collection, scope, and limitations of the study. In Chapter Four the results are presented and discussed with subsections on background of study respondents, extent of application of IBM by vegetable cooperatives in Ghana, factors that influence participation in vegetable cooperatives that apply IBM, level of vegetable cooperative influence on farmers adoption of water-related climate smart practices and impact of WCP adoption on income and output of vegetable farmers. The summary, conclusions and recommendations are presented in the final chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter explore existing literature on climate change and climate smart agriculture practices most especially in relation to cooperative and vegetable farming.

2.2 Climate Change

Climate change continues to be an alarming subject for discussion because it remains a threat to humanity especially in the 21st century (Asante et al., 2012 & Adzawla et al., 2020). Climate change can be defined as a change in the average of different climatic characteristics over a longer period and a wider geographic area, including temperature, precipitation, relative humidity, and the composition of atmospheric gases (National Geographic, 2022). Climate change means a 'change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods' (United Nations Framework Convention on Climate Change (UNFCCC, 2011). The past few decades show that increased human activity that changed the composition of the Earth's atmosphere was the cause of major changes in the global climate. These activities have led to the release of carbon dioxide and other greenhouse gas such as CO_2, methane, and nitrous oxide, as well as other substances) into the atmosphere which cause the depletion of the ozone layer resulting to global warming (Malhi et al., 2021). Higher temperatures and sea levels, a rise in greenhouse gas emissions, and irregular, unexpected, unreliable rainfall patterns and seasons are all signs of climate change (Asare-Nuamah & Botchway, 2019). Higher temperature and heat increase extreme weather events such as heat waves, wildfires, heavy rains and flooding, drought and change in rainfall pattern are all because of climate change (Montzka et al., 2011, Camelia, & Carmen, 2012).

According to the United Nations (2023), human activities such as generating power by burning fossil fuels, manufacturing goods, deforestations, using transportation, producing food, powering building by using electricity and poor waste management release greenhouse gas and are among the major contributed to the causes of climate change. Since 1750, there has been a 150% increase in the concentration of greenhouse gases such as methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O), respectively (IPCC, 2014). Past research shows that, the primary greenhouse gas in the atmosphere is CO_2, which comes from industrial operations and fossil fuels at a rate of 65%, forestry, and other land uses at 11%, and other sources include methane (16%), nitrous oxide (6%), and fluorinated gases (2%) (IPCC, 2014).

Europe is the biggest contributor of CO_2 emissions with around 514 billion metric tonnes of CO_2 emissions. Asia and the continent of North America come next, with a combined CO_2 emissions record of 457 billion metric tonnes apiece. China has contributed 200 billion metric tonnes of CO_2 emissions, but the United States contributes 399 billion metric tonnes, or 25% of all historical emissions since 1751. Twenty-eight nations that form the European Union (EU-28) and set cooperative goals have contributed twenty-two percent (22%) of the total historical CO_2 emissions. Due to its low per-capita emissions, Africa only contributes 3% of the world's cumulative CO_2 emissions (Malhi et al., 2021). Though crop fertilisation increases when atmospheric CO_2 levels rise, and warmth causes a reduction in crop energy requirements, climate change has negatively affected water resources (Malhi et al., 2021).

Methane and nitrous oxide are the main emissions from the agriculture sector, accounting for 15% of all emissions (Malhi et al., 2021). Land-use changes, forestry practises, and agricultural land management all have a significant impact on atmospheric GHG concentration. The two main human-caused sources of greenhouse gas emissions from agriculture are land management and energy consumption in agriculture, which includes the production and use of farm equipment and inputs. A substantial contributor to global CH_4 emissions in the agriculture sector is the world's cattle population as well as rice fields, in addition to CO_2 emissions from burning crop and animal waste (Lenka et al., 2015).

A wide range of variables, including output, area under cultivation, and the rate at which fertiliser and organic manure are applied, affect the direct and indirect emissions GHGs from agricultural soil. Sources of direct emissions include crop residues, N fertilisers, and the mineralization of soil organic matter. Leaching, run-off, and atmospheric deposition are examples of indirect sources. The amount of N_2O released by the soil makes for around 50% of all agricultural emissions. The soil spontaneously releases greenhouse gases, even in the absence of cultivation (Lenka et al., 2015).

According to (IPCC, 2014), African nations already have a long history of poverty and food insecurity, and they face a serious threat from the effects of climate change and its linked events on food production and food security. According to the World Bank's most recent Country and Climate Development Report (CCDR) for Ghana, at least one million more people may become poor due to climate-related disasters, and the income of poor households may decrease by as much as 40% by 2050 if urgent climate action is not implemented (World Bank Group, 2022).

A major thread to agricultural livelihoods, especially in sub-Saharan Africa (SSA), is the occurrence of extreme weather events including floods, droughts, heatwaves, and windstorms brought on by rising temperatures and greenhouse gas concentrations (Agba et al., 2017).

2.2.1 Climate Change in Ghana

Since the 1960s, temperatures have been rising, and Ghana is currently experiencing the driest climate (since 1901) (Abbam et al., 2018). Climate change continues to show itself in Ghana as poor rainfall patterns and high temperatures, resulting in poor crop outputs, low productivity, and food security concerns for rural households (File & Nhamo, 2023). Climate change has primarily negative effects on Ghana's overall economic growth. The Notre Dame Global Adaptation Initiative (ND-GAIN) Index assesses 181 nations based on a score that accounts for the nation's vulnerability to climate change and other global issues, as well as its readiness to increase resilience. Ghana has been identified as vulnerable to the effects of climate change, ranking 108 out of 181 nations in the 2021 ND-GAIN Index (ND-GAIN, 2021). In the state of vulnerability, Ghana is particularly concerned with improving its resilience through the development of sustainable land use practices such as food security, climate-proof infrastructure, energy security, sustainable forest management, and urban waste management (World Bank Group, 2021).

2.2.2 History and Trends

Annual rainfall in Ghana ranges from 1,100mm in the north to around 2,100mm in the southwest. The northern part of the country has one rainy season that lasts from May to September, while the southern part has two rainy seasons, one from April to July and the other from September to November. The dry season (December to March) brings arid and dusty harmattan winds from the Sahara Desert, as well as low humidity, hot days (T >25°C) and cool nights (T<20°C). The average annual temperature is around 27°C, with greater temperatures often seen in the north and during the country's dry season (World Bank Group, 2021). According to the data from the Climate Change Knowledge Portal (CCKP, 2021) of the World

Bank Group, we can observe historical information for the period of 1901 to 2020. In terms of Ghana, the average mean temperature for the entire year is 27.3°C. However, the monthly average temperatures fluctuate, with temperatures ranging between 25°C and 26°C from June to September, and between 28°C and 29°C from February to April. As for the average annual precipitation, it amounts to 1,189.9 mm. The highest amount of rainfall occurs between May and September, while the period from November to January experiences extremely low levels of precipitation. These findings are based on the most recent climatology data from the years 1991 to 2020. Ghana's mean temperatures are expected to rise by 1.0°C to 3.0°C by mid-century, and by 2.3°C to 5.3°C by the end of the century (World Bank Group, 2021). As a result of this, there is a growing need for smallholder agriculture to adopt climate smart practices to boost production, improve food security, enhance resilience to climate shocks, and reduce greenhouse gas emissions (Taylor, 2018).

2.3 Climate Smart Agriculture (CSA)

The connection between agriculture and climate change adaptation and mitigation makes Climate Smart Agriculture (CSA) especially helpful (FAO, 2016). The FAO created climate-smart agriculture (CSA) as an integrated approach to address the challenges posed by climate change. In a background document created for The Hague Conference on Agriculture, Food Security, and Climate Change in 2010, FAO introduced the idea of CSA for the first time (FAO, 2016). The CSA helps ensure that agricultural advances in ways that preserve and conserve natural resources, making it a valuable method for addressing the effects of climate change on agriculture in the continent (FAO, 2016). Especially for communities whose livelihoods depend on both agriculture and limited natural resources, climate smart agriculture (CSA) is essential in ensuring sustainable agriculture (Sommer et al., 2018). Climate-smart agriculture (CSA) has been proven to be a revolutionary strategy that tackles poverty, food insecurity, climate change, and environmental degradation all at once. Agricultural mitigation and adaptation approaches can be integrated to attain food security with the help of the CSA strategy. It merges traditional and innovative techniques with context-specific services for climate change and variability adaptation to boost productivity sustainably while lowering greenhouse gas emissions (Khatri-Chhetr et al. 2017).

To support increased incomes, food security, and development, CSA seeks to accomplish three goals: (i) sustainably increase agricultural productivity; (ii) adapt and build resilience to climate change from the farm to the national level; and (iii) reduce greenhouse gas emissions and increase carbon sinks from agriculture in comparison to historical trends (Sikka et al., 2017).

Smallholder farmers continue to rely on their own skills, expertise, creativity, and resourcefulness to boost household food crop output and strengthen local resilience (Adusei, 2021). Indigenous knowledge is the collectively owned knowledge and experiences of smallholder farmers. It consists of mental inventories of the traits of the local flora and fauna, animal breeds, crops, and tree species, as well as belief systems that improve people's quality of life and environmental protection (File and Nhamo, 2023). Smallholder farmers typically suffer the burden of climate change since they have to already manage destroyed lands and lack the resources to modify their production strategies to account for variability and climate change (Adusei, 2021).

It is well acknowledged that indigenous knowledge may significantly reduce smallholder farmers' vulnerability to climate change through its contributions and applications in climate change adaptation (File &Nhamo, 2023 and Fentie et al., 2019). According to Anang and Asante (2020), smallholder farmers are primarily unable to adopt climate-smart agriculture practices because they cannot afford to purchase farm implements, improved seeds, credit, or weather information services, among other climate-smart practices. Moreover, a lot of climate-smart methods haven't been made acceptable by contextualising them inside the framework of indigenous smallholder farmers' practices, beliefs, and values (Dumenu & Obeng, 2016). According to Adusei (2021), CSA is contextual specific thus, CSA is not specific technology or well design practice that is universally recognised or applied.

According to FAO (2013), Climate-smart agriculture (CSA) is an 'approach that helps guide actions to transform agri-food systems towards green and climate resilient practices. Climate smart agriculture (CSA) aims to direct agricultural management in the face of climate change with the goal to establish internationally applicable guidelines for managing agriculture for food security in the face of climate change. These guidelines may serve as the foundation for recommendations and policy assistance (Tekeste, 2021). Khatri-Chhetri, (2020) defines climate smart agriculture practices as a collection of technologies, methods, and services aim to mitigate the impact of climate change on agriculture. Modifying crop management procedures to entirely modifying agricultural production systems to adapt to new climatic conditions in a specific location are examples of practices (Tadesse & Ahmed, 2023). In addition to enhancing farmers' ability to adapt to and resist climate change, CSA increases productivity and raising agricultural output in response to climate change (Fentie & Beyene, 2019).

Climate Smart Agriculture (CSA) refers to any agricultural technique that improves national food security and development goals while reducing or eliminating greenhouse gas emissions, building resilience to climate change (adaptation), and increasing food production in a sustainable manner (FAO, 2010). This definition addresses food security, ecosystem management, and climate change issues together, so integrating all three dimensions of sustainable development—economic, social, and environmental. According to a different definition provided by the Department for International Development (DfID, 2012), CSA encompasses the following programmes:

I. bolster smallholder farmers' livelihoods and prosperity.
II. produce food that farmers and consumers need.
III. improve people's nutrition, particularly that of women and children.
IV. assist farmers in adapting to current and future climate risks.
V. sustains the health of the land and increases its productivity.
VI. reduce greenhouse gas emissions from agriculture and store carbon in the soil.

According to the definitions given above, CSA is a way to support GHG-free, sustainable agriculture. Three "pillars" that underpin CSA include: i) boosting agricultural output sustainably for food and nutrition security; ii) climate change adaptation with the aim of decreasing exposure to short-term risks while addressing long-term climate changes; and iii) decreasing and/or eliminating greenhouse gas emissions wherever practicable (Thornton et al.,2018). Under some circumstances, CSA can result in triple-win outcomes: lower emissions of greenhouse gases, reduced impacts on climate risks and shocks, and enhanced production. However, putting CSA into practice frequently entails addressing trade-offs between the three pillars and assessing the advantages and disadvantages of various solutions in light of the goals of stakeholders (Antwi-Agyei et al., 2023; Thornton et al., 2018).

Research by Adusei, (2021) discover that, CSA practices that farmers in Ashanti region adopts includes: crop rotation, improved crop variety, mulching, compost application, agroforestry, irrigation, manure management and rain harvesting. The results indicated that, irrigation had a 100% adoption rate in the study area, water harvesting and mulching had 8.3% rate of adoption.

Tadesse and Ahmed (2023) systematically reviewed literature and discover that, Agronomic practices (improved seed varieties, crop rotation, cover cropping, and cover cropping), Integrated soil fertility management (composting, organic fertilizer and efficient use of inorganic fertilizer), Conservation agriculture (CA) (residue management, crop diversification and soil and water conservation), Irrigation (water management, bunds, terracing, contouring, and water harvesting), Integrated pest management (biological (protect, enhance or import enemies of pest), mechanical control (cultivation, trapping, pest exclusion) and chemical control (insect growth regulators, pheromones, biological/chemical pesticides) are some of the water smart agriculture practices.

2.3.1 Typologies of Climate Smart Agriculture (CSA)

According to Antwi-Agyei and Amanor (2023), their discovered seven (7) typologies of Climate Smart Agriculture (CSA) which include: water-smart practices, energy-smart practices, nutrient-smart practices, carbon-smart practices, weather-smart practice, planting-smart practices, and knowledge-smart practices.

According to the World Bank Group (2020), Nutrients-smart practices is defined as “Nutrition smart agriculture is a set of agriculture and agro-processing technologies and practices that contribute to the improvement of nutrition and increase of the farm and agribusiness-level productivity and revenue”. This means Nutrients Smart agriculture practices are geared towards nutrient use efficiency and some of these practices include legume planting among crops to increase the supply of nitrogen; applying fertilisers made of decomposed plant remains; covering the soil to promote plant development; mixed farming to ensure feed and biomass supply; and efficient land management to enable soil nutrient recovery (Antwi-Agyei and Amanor, 2023). Planting Smart Agriculture involves using techniques to increase produce quality and output. Adequate crop spacing techniques, cover crops, crop diversity, mixed crops, and crop rotation are some of these practices.

Energy Smart Agriculture focuses on practices that are specifically designed to ensure energy efficiency. These practices include utilising bullocks for tillage, reducing the amount of energy used in land preparation through zero or minimum tillage, utilising appropriate methods to ensure sustainability through conservation agriculture, building ridges of compacted earth to control soil erosion through earth bunding, and constructing stone bunds to form a barrier that slows down water runoff.

The goal of carbon smart agriculture practices is to reduce pollution overall. These methods include using good pest management techniques to limit the need for pesticides; not burning biomass leftovers on farms to minimise pollution; and integrating agriculture and trees through agroforestry and woodlot initiatives. Weather Smart Agriculture refers to methods designed to provide stable income throughout the year. These methods include using climate reports and climate information services to direct planting and harvesting operations, as well as purchasing crop (livestock) insurance strategies to mitigate revenue risk.

Knowledge-smart agriculture refers to methods that minimise danger of loss by utilising experience and science. The following are examples of knowledge-smart agriculture practices: planting pest-resistant plant varieties, planting early maturing crop varieties, using appropriate fertiliser to reduce chemical use, planting seed and fodder banks to store seeds for the following season, planting early to prevent loss due to short rainy season, using indigenous agro-ecological knowledge for adaptation purposes, and timely, proper harvesting and storing of produce (Antwi-Agyei and Amanor, 2023).

2.3.2 Water Smart Agriculture

Water smart agriculture (WSA) is an adaptive approach to agricultural practices that aims to optimize water use efficiency while enhancing productivity and sustainability. The significance of WSA is underscored by the increasing threats posed by climate change, particularly in regions like West Africa where erratic rainfall and droughts are common. Studies indicate that adopting WSA practices can lead to improved resilience against climate impacts, ensuring food security and sustainable livelihoods for farmers (Adzawla et al., 2020; Porter et al., 2019).

There are two categories of water resources: surface water and groundwater. Rivers, lakes, and other bodies of surface water are readily available and heavily relied upon for a variety of purposes, both industrial and household (Coleridge 2008). Aquifers hold groundwater, but their accessibility is influenced by local geology as well as other elements (Owusu et al., 2017). Humans depend on water for multiple facets of their lives, including home (domestic), industrial, agricultural, hydropower production, transportation and municipal settings. Water is, in fact, one of the most important natural resources for the survival of both human and animal life. Additionally, it is used for household chores like washing, cooking, and consumption. Rainfall is one of the most significant sources of water, especially in underdeveloped nations (Asare-Nuamah & Botchway 2019).

However, the amount of water available for those specific purposes is reduced because of shifting water-related environmental conditions and, to some extent, rising water demands (Subagyono & Pawitan, 2007). The demand for water to meet human requirements and the population's rapid increase have put pressure on the amount of water that is accessible. Pumping groundwater has grown in popularity, which has caused the groundwater table to drop and opened the door for seawater intrusion. Additionally, because the water in canal is running out, farmers in irrigated areas are having trouble getting irrigation water (Subagyono & Susanti, 2012). Climate change has added more pressure on water resources and caused unprecedented events including drought, floods affecting both lives and agriculture. Recently, there was an excessive flooding in the North Tongu districts caused by heavy rains which resulted in the spillage of the Akosombo and Kpong Dams. This spillage has caused negative effects on lives of humans and livestock and well as agriculture in general. At the same period of flooding, farmers in the Northern part of Ghana were lacking rain that will softest the grounds for them to harvest their groundnuts, and other root crops. It is encouraged that communities adopt water harvesting strategies to deal with water scarcity and flooding-related disasters (Subagyono & Susanti, 2012).

In Ghana, out of the entire land area, 41% is made up of forest regions and 69% is agricultural land with merely 0.2% of all agricultural land being irrigated land (World Bank, 2018). Ghana adopted Water Smart Agriculture (WaSA) in 2016 as a strategy to manage water efficiently and equitably to minimise climate hazards like dry spells and increase farmer resilience (CARE, 2020). The concept of WaSA is not new in terms of approaches. It incorporates proven techniques including climate-smart agriculture, conservation, and sustainable farming (CARE, 2020). Though WaSA was adopted in 2016, irrigation was first implemented in the early 1960s by the Ministry of Agriculture's Land Planning and Soil Conservation Unit. By virtue of SMC Decree 85, the Irrigation Development Authority (IDA) was established in 1977.

The Authority has built twenty-two (22) irrigation projects across the nation, totalling 6,505 hectares (ha). Furthermore, six schemes have been built under the Small Farms Irrigation Project (SFIP) and 22 schemes have been built under the Small-Scale Irrigation Development Project (SSIDP). Apart from the Tono and Kpong Irrigation Projects, which are overdeveloped and have a size of roughly 2,500 hectares, all these projects are smaller than 1,000 ha (MoFA, 2023). WaSA concentrates on improving soil moisture absorption and storage, rainwater collecting and storage, wastewater reuse, and small-scale irrigation as means of securing availability to water for agricultural purposes (CARE, 2020).

According to Haileslassie et al., (2022), water-smart crop farming is a strategy that maximises the use of water resources while also boosting crop resilience and output. Water-smart cropping solutions include a wide range of techniques, such as the development of drought-tolerant maize varieties, cover crops, cover cropping of legumes with food crops, system rice intensification, alternate wetting and drying, and farmer-led reduced irrigation. It is noted in literature that, the most used practices include irrigation, mulching, water harvesting, drought tolerant crops, conservation tillage and cover cropping. These practices help smallholder farmers outcome the challenges of water scarcity, climate change effect on rainfall by efficiently utilising water to increase productivity.

2.4 Typology of Water-Related Climate Smart Practices (WCP)

2.4.1 Irrigation

Irrigation has a significant impact on terrestrial water and hydrological cycles since it is responsible for an astounding 70% of freshwater withdrawals and 90% of freshwater usage globally (Guillaumot et al., 2022; Scanlon et al., 2023). The proportion of all renewable water resources in Ghana out of its total water resources is 1.8%, of which 66.4% is reportedly used for irrigation. Ghana's potential for irrigation, including its valley bottoms and floodplains, is estimated to be between 0.36 and 2.9 million hectares (Mha) (Namara et al., 2011).

Irrigation is the artificial application of water to the soil to ensure moisture that is important for the plant. There is difference method of irrigation which include drip irrigation, sprinkler irrigation, solid-set sprinkler irrigation, surface irrigation, Hand-move sprinkler irrigation, subsurface irrigation (Griffiths & Lecler, 2001; Ranjan et al., 2022). Reddy (2019), further break surface irrigation into; furrow irrigation, basin irrigation and border irrigation.

There are 22 irrigation projects administered and managed by the Ghana Irrigation Development Authority (GIDA)/Irrigation Company of Upper East Region (ICOUR) and these projects are the most common examples of Ghana's irrigation sector, which is typically compared to public or communal surface irrigation schemes (MoFA, 2023 & Namara et al., 2011). There are three (3) categories of irrigation system in Ghana which includes.

1. Informal (smallholder) irrigation,
2. Formal irrigation, and
3. Large Scale Commercial Irrigation

These Irrigation systems are broadly classified into two classes: conventional and developing systems (Diitoh 2020; Namara et al., 2011).

Informal irrigation is irrigation carried out by individuals who cultivate an area of up to 0.5 hectares or more, using basic buildings and equipment for the distribution, storage, and conveyance of water. The cultivation of roughly 2,000 hectares of shallots along Ghana's southeast coast, informal irrigation surrounding the hundreds of small reservoirs in the north, cultivation by informal irrigators in inland valleys, groundwater irrigation, such as that which occurs near Bawku, and irrigated urban and per urban agriculture are examples of traditional and community-initiated schemes that make up informal irrigation. Water is often fetched by hand using buckets and watering cans, while motorised pumps and hoses are also utilised near streams and reservoirs (Lamptey et al., 2011).

This subsector depends on private individuals who invest little with the support or non-support from government and or NGOs of which the sector depends on seasonal patterns and non-permanent infrastructures. Thus, little investment is needed to acquire assets and to some extent, these assets are mostly not fixed and long term structured.

An irrigation system that is dependent on a permanent system that is supported by public funds is known as formal irrigation. In Ghana, formal irrigation programmes began to take shape in the 1960s. This programme included the implementation of irrigation scheme and facilities at

Komenda and Asutsuare for the production of sugar. Other irrigation schemes and facilities are at Dawhenya and Ashaiman, Afife, Mankessim, Okyereko, Tono, and Vea which are some of the examples of formal irrigation (Lamptey et al., 2011).

The large-scale commercial irrigation is included in both formal and informal sub-sectors. This calls for a collaboration of many stakeholders most especially, government and the private individual with supports from NGOs and other bodies. According to Lamptey et al., (2011), they stated that "Large-scale commercial irrigation is formal when the government provides the primary headwork, conveyance, and distribution, while the private investor provides secondary distribution, water application, and equipment".

The conventional systems are either created over many years by communities or people or are primarily established and promoted by the Ghanaian government and nongovernmental organisations (NGOs). Specific typologies under conventional systems include shallow groundwater irrigation in the coastal regions of south-eastern Ghana, small reservoirs, wastewater irrigation, public surface irrigation systems, recession agriculture, or residual moisture irrigation, and shallow groundwater irrigation based on traditional lifting technologies (Namara et al., 2011).

Emerging irrigation systems are those that are usually started by farmers and private entrepreneurs, either independently or with minimal assistance from NGOs and/or the government (Namara et al., 2011). Emerging irrigation systems are predicated on having access to flexible, mobile pumps that run on a variety of energy sources, including solar, diesel, petrol, wind, and grid-based electricity (Baldwin & Stwalley, 2022).

The irrigation system in Ghana is summarized in a table 2.1

Table 2.1: Ghana Irrigation System Classification

Type of system	Water source	Classification
	River	**Conventional (C)/Emerging (E)**
	Run-of-river diversion-based gravity-fed irrigation systems	C
	River-pumping-based gravity-fed irrigation systems	C
	Run-of-the-river-pumping-based sprinkler irrigation systems	C
	Reservoir	C
	Reservoir or storage-based gravity-fed irrigation systems	C
	Reservoir-pumping-based gravity-fed irrigation systems	C
Formal	Reservoir-pumping-based sprinkler irrigation systems	C
	Small reservoir-based communal irrigation systems	
	Lake	
	Lake pumping-based sprinkler irrigation systems	C
	Groundwater	
	Traditional shallow groundwater irrigation	
	River	
	Private smallholder systems	E
	Group or communal smallholder systems	E
	Reservoirs	
	Small reservoirs/dugout-based private irrigation systems	E
	Groundwater	
	Seasonal shallow groundwater irrigation systems	E
Informal	In-field seasonal shallow-well irrigation systems	E
	Informal Riverine shallow-well systems	E
	Permanent well irrigation	E
	Shallow-tube well irrigation systems	E
	Borehole irrigation systems	E
	Domestic wastewater and storm water	C
	Water capture	
	Recession agriculture or residual moisture irrigation	C
	Lowland/inland valley rice water capture systems	E
Large-scale commercial	Large-scale or commercial systems	E
	commercial Public-private partnership-based commercial irrigation systems	E

Source: Adopted from, Regassa et al., 2010.

Type of Irrigations System.

The types of irrigation system are based on International Water Management Institute (IWMI) classification of irrigation (Namara et al., 2010)

Conventional Irrigation Systems:

Public Surface Irrigation Systems:

I. *Run-of-river Diversion-based Gravity-fed Irrigation Systems***:** Water is diverted by a weir I into the main canal, which then flows gravitationally to the fields mostly paddy fields.

II. *Reservoir or Storage-based Gravity-fed Irrigation Systems***:** In this system, intake structures and canal systems use gravity to direct water from an earth dam or reservoir system to the fields.

III. *Lake–pumping-based Sprinkler Irrigation Systems:* this system has different configurations depending on the mobility of the pump thus whether the pump is fixed or moveable and whether there is a need for an intermediary storage reservoir between the lake's intake and the field's actual watering.

IV. *Run-of-the-river-pumping-based Sprinkler Irrigation Systems:* In these systems, a sprinkler system irrigates the fields by sending stored water, drawn by pumps from a concrete weir.

V. *Reservoir-pumping-based Sprinkler Irrigation Systems:* The foundation of the system is an earth-filled dam intended to be used with spray irrigation and gravity. Sprinkler systems receive irrigation water from pumps and water the fields.

VI. *Reservoir-pumping-based Gravity-fed Irrigation Systems:* In such schemes, an electric pumping system feeds water from a main dam into a night storage reservoir. The water is then gravity-fed into the paddy fields via a network of canals.

VII. *River-pumping-based Gravity-fed Irrigation Systems:* These systems involve pumping water from a river into a reservoir via subterranean pipes or canals over a distance. The water then flows under gravity through main canal systems to irrigate primarily paddy crops.

VIII. *Small Reservoir-based Communal Irrigation Systems***:** These are reservoir imitated and financed by donors and constructed by GIDA or private constructor with little contribution from the community. Small Reservoir are classified into two; thus, dams and dugouts. The main differentiating attributes are size, priority of water use, structural details and their management system.

Dugouts are smaller in surface area, the volume of water they impound and the number of beneficiaries. The waterbed of dugouts is scooped to create more depth and to impound more water. Unlike the small dams, dugouts have no intake structures, canals and laterals. Dugouts usually serve one to two villages and are planned primarily for domestic and livestock with limited use for irrigation. They are constructed mainly with the help of the District Assembly in locations where other forms of domestic water supply are non-existent or where appropriate dams cannot be constructed due to topographic unsuitability.

I. Domestic Wastewater and Storm Water Irrigation:

II. Recession Agriculture or Residual Moisture Irrigation

III. Traditional Shallow Groundwater Irrigation

Emerging Irrigation Systems

I. Groundwater Irrigation Systems

II. Seasonal Shallow Groundwater Irrigation Systems

III. In-field Seasonal Shallow-well Irrigation Systems

IV. Riverine Shallow-well Systems

V. Permanent Well Irrigation

VI. Shallow-tube well Irrigation Systems

VII. Borehole Irrigation Systems

VIII. River Lift Irrigation Systems

IX. Private Smallholder Systems

X. Group or Communal Smallholder Systems

Types of Irrigation Methods

There are different types of methods use to supply the fields with water to ensure that crops get the optimal amount of water needed from the growth and development. These methods can be categorised into two (2) which includes, surface and subsurface irrigations.

Surface Irrigation

This is a method of irrigation whereby the water is applied to the crop by the action of gravity or mechanical action or even by human application of simple watering cans and buckets. The water is applied to the top of the crop or field, pumping the water to the channels so it occupies the field. Some of the methods used under surface irrigation includes, flood irrigation, furrow methods and contour method. It is mostly called flood irrigation when the irrigation results in flooding or near flooding of the cultivated land. Historically, this has been the most common method of irrigating agricultural land and still is in most parts of the world Reddy (2019).

Subsurface irrigation

Subsurface irrigation is an efficient agricultural practice that involves delivering water directly to the root zone of plants through buried pipes or tubes. This method minimizes evaporation and runoff, making it particularly effective in arid and semi-arid regions where water scarcity is a significant concern. Subsurface irrigation can take various forms, including drip irrigation, which uses a network of tubes with emitters placed at specific intervals to supply water slowly and evenly.

Subsurface irrigation systems allow for precise water application, which significantly reduces water loss compared to traditional surface irrigation methods. This is particularly important in arid regions where every drop of water count (Kang et al., 2018). Since water is supplied below the surface, it limits moisture availability on the soil surface, which helps suppress weed growth and reduces competition for nutrients and water among crops (Zhou et al., 2024). Maintaining consistent moisture levels in the root zone promotes better root development and overall plant health. This can lead to enhanced nutrient uptake and improved crop resilience against stress conditions (Payen et al., 2015). Subsurface irrigation systems can be integrated with fertigation, allowing for the simultaneous application of fertilizers through the irrigation system. This leads to more efficient nutrient delivery directly to the plants (Abdul-Razak & Kruse, 2017).

2.4.2 Mulching

Mulching is the technique of covering the soil surface around the plants with an organic or synthetic mulch to create favourable conditions for the plant growth and efficient crop production (Chakraborty et al., 2008; Kader et al., 2017). Mulching is defined as a coating material spread over the soil surface (Kasirajan & Ngouajio 2012). Conserving soil moisture through mulching may be an effective option to save water as well as rising production in dry land farming (Kader et al., 2017). Mulches come in two varieties: biodegradable or organic mulches composed of organic materials, and inorganic mulches mostly composed of plastic-based materials (Kader et al., 2017). One effective method of conserving soil is the use of mulch. It improves soil moisture, soil nutrients, regulates soil temperature and saves water thereby being beneficial to the crops.

The major benefits of mulching include reduced soil water loss, soil erosion, the effect of water droplets striking the soil surface, weed growth, and competition for water and nutrients from nearby fields (Kader et al., 2017). Mulches are useful in the heat of the season because they stop water loss from soil evaporation. Mulch can aid with soil structure and nutrient cycling because it allows earthworms to migrate across the soil (Qin et al., 2018). It also reduces the pH of the soil, increasing the availability of nutrients (Kader et.al., 2019). This means mulching is important for vegetable production most especially at arid and semi-arid regions because vegetable crops depend heavenly on water. Mulching using waste from their produce is cost effective practice which would conserve water, moderate soil temperature, reduce waste and improve the soil health.

Mulches are used as a soil covering, for a variety of reasons:

I. Soil moisture retention
II. Heat trapping
III. Reduce runoff losses
IV. Increases germination percentage
V. It improves soil structure
VI. Weed prevention and control
VII. Protecting roots from fluctuating and extreme temperatures
VIII. To help control soil erosion (Telkar et al., 2017).

Types of materials use for mulching.

There are two (2) categories of materials used for mulching thus, organic and plastic (inorganic) materials.

Organic materials

These are mulch materials made from plants and animals. This type of materials is effective in minimizing nitrate leaching, boosting soil physical qualities, enhancing biological activity, balancing the nitrogen cycle, providing organic matter, controlling temperature and water retention, and reducing erosion (El-Beltagi et al., 2022). Some of the materials include.

I. *Straw mulching materials:* Paddy and wheat straw and other crop residues like stubbles, groundnut shells, cotton shells and many other crop residues; are the commonest mulching materials used as mulches on soil surface for moisture conservation (Telkar et al., 2017; El-Beltagi et al., 2022).

II. *Bark mulches:* these are mulches mostly used for vegetable and landscaping, and it is effective mulch because its pro-long water availability and retention for the crop (El-Beltagi et al., 2022). When it rains little, the bark chips will release the water they have been holding, providing plants with water even in dry times (Telkar et al., 2017).

III. *Wood chips:* Reprocessed wood and a variety of tree species are used to make wood chips. Because wood chip mulches have a high Carbon: Nitrogen ratio (C: N ratio), they may restrict the availability of soil nitrogen available for plant absorption while they decompose (El-Beltagi et al., 2022).

IV. *Sawdust:* these are mulch from the finishing of wood and furniture works and it contains poor nutrients compared to straw since it has half of the nutrient’s straw contains. It is advisable not to use sawdust most especially at areas where the pH in soil is low because of its acidic content. Regardless, it retains water for an extended period of time.

V. *Compost:* Compost is an excellent mulch and soil conditioner that can be easily made at home using a variety of waste items such as leaves, straw, grass, plant wastes, and animal waste, among others. It increases microbial population, improves the soil health and adds some nutrients to the soil (Telkar et al., 2017; El-Beltagi et al., 2022).

VI. *Newspapers***:** it is a cost-effective method of reducing weeds since it prevents of germination of fallen weed seeds in the previous year. Newspapers are also biodegradable hence adds nutrients to the soil.

Inorganic material

These are materials which are not made from the waste of plants and animals. Thought these materials retains water in the soil and prevents water evaporation, it does not add nutrients to the soil. It does not discompose as compared to the organic mulch. The most popular materials include plastic much and gravel (El-Beltagi et al., 2022), pebbles and crushed stones (Telkar et al., 2017).

Plastic materials: it comprises most of the mulch used in commercial crop cultivation and polyvinyl chloride, or polyethylene films are the plastic materials used as mulch (El-Beltagi et al., 2022). Plastic films mulch is effective in controlling evaporation whether black or transparent polyethylene and during winter and cooler seasons, it can raise the temperature around the crop due to its higher permeability to long-wave radiation (El-Beltagi et al., 2022). Fresh vegetables are progressively being produced through a practice known as "plastic culture", which involves using plastic as mulch in farming (Serrano-Ruiz et al., 2021).

Types of plastic mulch materials.

I. *Photo-degradable plastic mulch:* type of plastic mulch material is easily destroyed by sun light in a shorter period.

II. *Bio-degradable plastic mulch*: This type of plastic mulch film is easily degraded in the soil over a period of time.

III. *Colour of film:* Films are available in variety of colours including black, transparent, white, silver etc. But the selection of the colour of plastic mulch film depends on specific targets (Telkar et al., 2017).

IV. *Gravel, Pebbles and Crushed stones:* These materials are used successful for dry land fruit crops. Small rock or stone layer of 3-4 cm place on soil surface to provides good weed control, reduced evaporation and facilitate infiltration of rainwater into the soil (Telkar et al., 2017).

2.4.3 Water harvesting

Rainwater is a nature water resource that can be harvest and utilize for many purposes including domestic and agricultural purposes. Water harvesting can save 12%-100% of water depending on the surface of the infrastructure, precipitation and this contribute to water conservation (Şahina & Manioğlu, 2019). Water harvesting techniques (WHTs) have played a key role in improving the efficient use of rainwater and have increased the sustainability and reliability of rain-fed agriculture (Biazin et al., 2012). This water harvested can be used domestically as drinking water after treatment. On a larger scale, cooperative initiatives can improve the management of shared water resources and increase the sustainability of agricultural methods (Frimpong et al., 2023).

2.4.4 Drought tolerant crops

The ability of drought-tolerant crops to withstand water stress is being encouraged. In addition to these basic advantages, they have low eating habits and low nutritional requirements, which dictate the essential management measures. Numerous regions with irregular and low rainfall, where crop water stress is prevalent, have been found through studies to also be nutrient-deficient. Often, this insufficiency is the second most important soil constraint. Nutrient availability and soil water availability are frequently influenced by one another. This means that crop drought resilience and soil water uptake are both impacted by nutrient availability (Katusiime, 2015).

A plant that is resistant to drought is the result of a variety of drought tolerance and avoidance techniques working together. Changing the number of stomata and/or the size of these openings is one way that drought avoidance methods try to limit the consequences of drought. Another is by minimising water loss. To stop water loss, other characteristics include applying more cuticle wax, rolling leaves to minimise their surface area, and altering the direction of the leaves. Conversely, drought tolerance is more about the plant's ability to withstand the consequences of the drought, especially at the cellular level. This frequently entails the synthesis of chemicals and hormones that regulate the flow of water into and out of cells and preserve the integrity of the cell membrane (Williams, 2020). Alternatively referred to as "osmotic adjustment," a plant can regulate the flow of water through the concentration of solutes within its cells, even at extremely small levels. This maintains plant tissue healthy and prevents necrosis, which is commonly referred to as "browning," by assisting in the maintenance of a healthy cell membrane and the proper internal pressure within the cell (Williams, 2020).

2.4.5 Conservational tillage

The primary goals of tillage in agricultural fields are to improve soil health by managing crop residues and manure, controlling weeds, improving infiltration, which increases soil moisture storage, and lowering runoff and erosion (Steiner, 2002). Crop residues can be either tilted (adding the residue to the soil) or left as a mulch (no-tillage). According to Oorts et al., (2007), conventional tillage is known to accelerate the decomposition of soil organic matter by causing it to break down and/or expose.

2.4.6 Cover cropping technique

The term "cover crops" refers to plants that are grown to cover the surface of the land (Sharma et al., 2018). Cover cropping can also be defined as planting alongside the main crop, called 'companion cropping' or 'cover cropping' (Hughes et al., 2023). The purpose of planting cover crops in between primary crops is to increase agricultural productivity and output. Cover crops are classified as grasses, legumes, brassicas, and non-legumes. Legumes are the main component of cover crops; they are grown to cover the soil's surface and contribute to the improvement of the physical, chemical, and biological qualities of the soil. The perfect cover crop should be fast to germinate and emerge, resilient to extreme climate conditions, capable of fixing atmospheric nitrogen from the air, able to absorb nutrients from the soil by growing deep roots, able to produce a larger amount of biomass in a shorter amount of time, easy to work and cultivate, not compete with the primary crop, resistant to diseases and insect pests, able to suppress weeds, and inexpensive to cultivate (Reddy, 2018).

Cover crops have benefits for both the soil and the plant, and the practice of cover cropping helps mitigate climate change (Kaye & Quemada, 2017). Covering soil with crops alongside with complex crop rotations, high Nitrogen (N) inputs, and decreased tillage all increase soil carbon (Kaye & Quemada, 2017). Research indicates that farmers can preserve or enhance soil carbon stocks in their fields by using cover crops, although the effectiveness of this practice varies depending on several environmental and managerial factors (Hughes et al., 2023). Cover cropping increase social carbon, decrease soil erosions, reduce the flux of nitrogen oxide from soil to the atmosphere through the reduction of water and nitrate concentration from the soil, reduce synthetic Nitrogen fertilizer use (Kaye & Quemada, 2017), increasing nutrient efficiency, suppressing weeds, and improving soil physical properties (Bahatsi, 2023).

Cover cropping improves soil moisture and retains water. Cover crops aid in preserving soil moisture from irrigation and rainfall, lowering soil surface evaporation, and enhancing soil moisture availability for succeeding crops. At water potentials corresponding to field capacity and plant accessible water, cover crops increased soil water retention by 10%–11% and 21%–22%, respectively (Sharma et al., 2018). Cover crops function as a barrier between the soil's surface and precipitation, particularly rainfall, which helps to lessen the amount of precipitation that hits the land. Water slowly seeps into the ground through soil pores, which are created by soil macro fauna and strengthened by the root development of cover crops (Sharma et al., 2018). Despise the benefits, farmers perceive that cover cropping is labour intensive, time consuming, selection of the type of species to use and high cost of practicing cover cropping (Plastina et al., 2020).

2.5 Cooperatives, Mandate and Alternative Business Models

2.5.1 Definition and typology

Cooperatives have long fostered inclusive and sustainable approaches to economic and social development at the local level. It is in keeping with this focus that cooperative is expanding their development efforts creatively into areas such as environmental sustainability and carbon neutrality, as communities around the world are struggling to adapt to climate change and strengthen their resilience against its impacts.' (Secretary General Ban Ki Moon Message on the International Day of Co-operatives, 3 July 2008).

The International Cooperative Alliance (ICA) defines a cooperative as "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned and democratically controlled enterprise" (ICA, 2015). Cooperatives is a crucial aspect of human society most especially, the agricultural sector. Cooperatives act as economic enterprises as well as self-help organizations can uplift the ultra-poor and uplift their socio-economic condition (Bhandari & Shrestha, 2020). According to a United Nations (2009) report, cooperatives are meant to be highly democratic, self-governing businesses that rely on accountability and self-help to achieve social, cultural, environmental, and economic objectives. The goals of cooperatives are to reduce poverty and promote social cohesion.

The International Cooperative Alliance (ICA) commission on cooperative principles (2009) states that the following guidelines are essential to acceptable and successful cooperative practice:

1. Open membership: Everyone should be allowed to join cooperatives voluntarily and enjoy the services without any limitations.
2. Democratic structure: The members of the cooperative should maintain ultimate authority. Regardless of their shareholding amount or level of trade with the cooperative, all members should have equal access to voting and decision-making rights.
3. Members are entitled to savings or surpluses from the society's activities based on transactions. The cooperative's primary goal is to serve members, not to earn a profit. Nevertheless, as a business, it may have extra money that should be distributed as dividends to members.

4. Cooperative societies ought to provide for its members' education.
5. Cooperatives should cooperate with one another.
6. The cooperative organization ought to be independent and self-governing.
7. Community development should be a priority for cooperative institutions.

Cooperatives are the only type of business organisation that fully addresses the economic, democratic, and social components of poverty reduction at the same time, claims OCDC (2007). Agricultural cooperatives are widely regarded as an essential foundation that can assist smallholder farmers in overcoming the obstacles that prevent them from capitalising on their business. This is because they empower economically disadvantaged farmers by strengthening their collective bargaining power, which lowers the risks that these farmers face in the market (Woldu et al., 2013). Farmers 'group formation and collective marketing are increasingly taking the attention of governments, nongovernment organizations (NGOs) and researchers as a tool to overcome the problems facing farmers and development in low-income countries where agriculture remains the employer of the larger population (Zakari et al., 2021).

Agricultural cooperatives generate value through a variety of group action strategies, including negotiating lower prices, forming partnerships with other organizations and farmers, raising and investing cash, and luring outside assistance from public or private entities. These mechanisms can result in the delivery of basic services to farmers, including credit and savings plans; input supply and agricultural extension; access to more lucrative markets (pre-payments, premium payments, and stable contracts); value chain upgrades; income diversification; and improved supply chain organization (Dafni, 2022).

Farmers in many African countries have a long tradition of performing certain agricultural productive activities as a group rather as individuals (Onumah et al., 2007). Previous studies discovered that, farmers in Ghana engaged in collective activities long before the introduction of formal farmer groups and cooperatives. According to (deGraft-Johnson 1958; Onumah et al., 2007), collective activities among farmers are traced back to the pre-colonial period during which neighbouring farmers (usually relatives and friends) provided each other with reciprocal labour support on their fields, especially weeding. Dadson (1998) described the ‘’nnoboa’’ (an informal cooperative among the Akan’s in Ghana) as a traditional form of cooperation in Ghana involving group action and mutual aid based on social, ethnic and family factors in the area. In the late 1920s, the British colonial administration in Ghana introduced formal farmer organizations in the form of cooperatives to improve the quality and marketing of cocoa as well as provide loan facilities to farmers (deGraft- Johnson 1958; Wanyama et al. 2008).

Cooperative enterprise was first introduced in the cocoa industry around 1928, cocoa being the country's main export crop and economic backbone. The Department of Agriculture organized farmers into groups to teach them improved ways of fermenting cocoa for higher-quality beans. Early success stimulated a rapid expansion of cooperatives in cocoa and other crops, and this enhanced other functions as well (e.g., thrift and credit, and farm input supply). By 1937, there were over 400 cooperative societies. In 1944, a Department of Cooperatives was created specifically for cooperative development. By 1960, the cooperative movement had grown considerably and had become an economic and political force in its own right. The state-sponsored farmers’ organization, the United Ghana Farmers’ Cooperative Council (UGFCC), was given sole responsibility for cooperative development and it became the apex of the movement.

After the Nkrumah regime, the new Government allowed the old cooperatives to re-establish themselves, with their own democratic institutions and structures. Succeeding governments have retained a permissive and liberal approach to the development of cooperatives, allowing other types of rural and farmers self-help organizations for income-generating activities to be formed, e.g., “nnoboa’’ groups (traditional associations), crop associations, commodity credit groups (sponsored by banks), community farms, women's groups, and external donor-assisted rural peoples' participatory organizations. Often loosely called cooperatives, these types are sometimes regarded as pre-cooperatives in the cooperative development process.

Farmers can find a route out of poverty and helplessness by working together to address these issues and gain a collective strength that they do not have individually (Birchall and Simmons, 2009). In addition to their combined strength, farmers join agricultural cooperatives in order to gain access to government assistance, markets both domestically and internationally, credits, training, and input supply (Tefera et al., 2016). Agricultural cooperatives have been conducting business in a way now being recommended as the most effective route to transformational development. In Cameroon, the government is promoting cooperatives in order to facilitate producers' access to inputs, improve agricultural productivity and producers' living conditions (Tumenta et al., 2021). They can be single or multiple purpose cooperatives, agricultural input supply cooperatives, marketing cooperatives, agricultural credit cooperatives, machinery cooperatives, land acquisition cooperatives, livestock producers’ cooperatives, fishermen cooperative society, vegetable cooperative, oil mill cooperatives, rice mill cooperatives, among others (Wassie et al., 2019).

2.5.2 Cooperative mandate

The model of business operation that these cooperatives adopted seek to empower them to be more productive and competitive. The executives of the cooperative were asked about their core mandate of existence. These cooperatives were not having one exact core mandate but rather a range of mandates. The core mandate has similarities across the eleven (11) cooperatives. The vision and mission are enlisted below.

Their vision emphasizes:

Empowerment of Smallholders: To enhance the livelihoods of smallholder farmers through collective action, enabling them to access markets, resources, and information.

Inclusivity: To foster an inclusive environment where vulnerable groups, including women and youth, are actively involved in decision-making processes and benefit from cooperative activities.

Sustainability: To promote sustainable agricultural practices that ensure long-term productivity and environmental stewardship.

The mission of the cooperative can be articulated as follows:

Facilitating Market Access: To provide members with improved access to markets by leveraging collective bargaining power and establishing partnerships with buyers.

Providing Support Services: To offer training, technical assistance, and resources that enhance members' agricultural practices, business skills, and overall productivity.

Promoting Fair Trade Practices: To ensure that all members receive fair prices for their products while maintaining transparency in pricing mechanisms.

Building Capacity: To strengthen the negotiation power of members through skills development, collective bargaining, and access to financial services.

Enhancing Community Development: To contribute to local economic development by supporting community initiatives and fostering collaboration among members as well contributing to the community environment and social wellbeing.

Resource access: Access to quality seeds, fertilizers, access to irrigation water, input and equipment, land access and other agricultural inputs. These cooperatives seek to facilitate bulk purchasing of these inputs, reducing costs for individual farmers resources.

The mission and vison of the cooperative aligns with the principles of IBM.

2.5.3 Business models and cooperative operations
Business models:

According to FAO (2015), a business model "describes the rationale of how a business creates, delivers, and captures value". Schaltegger et al., (2016), further expand the definition of business model as such a system that "helps describing, analysing, managing and communicating (i) a company's sustainable value proposition to its customers and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social and economic capital beyond its organizational boundaries."

Business model set a guidance for the firm performance and the future activities. The business model encompasses every facet of an organization's strategy for creating a lucrative product and distributing it to its intended market. This entails figuring out who the target market is, comprehending what they need, choosing what goods or services to provide them, providing those goods or services, and figuring out how to turn a profit (Nooh, 2019). Being the blueprint, when the business encounters any problem, the immediate response is the business model. Cooperative which is form of business model do serve this purpose as well.

Every business model has factors that contribute to its success and that is also so for cooperatives as well. In Malaysia for example, research shows eight essential success factors for cooperatives which includes, resource management, internal control systems, good leadership, being aware of opportunities, having a clear vision and mission, member support and involvement, an entrepreneurial culture, and effective communication (Nooh, 2019).

2.5.4 The Business Model Canvas (BMC)

Alex Osterwalder developed the Business Model Canvas (BMC), a tool for strategic management that aids in the definition, creation, and analysis of business models for enterprises. There are nine building blocks for BMC which includes Customer Segment, Value Propositions, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partnerships and Cost Structure. The key element of the BMC aims at creating value for the customer and in creating that value, involves cost component and revenue components. The BMC can help business study customers hence creating competitive advantage and better users' beneficial experience.

2.5.5 Inclusive Business Models (IBM)

The private sector is said to be more successful and efficient than organisations in the public and civil society at generating investment capital and achieving objectives (Hall et al., 2017). Therefore, putting the private sector in the lead in achieving societal goals requires companies to adopt perspectives that extend beyond their short-term financial interests. As a result, inclusive business models have emerged, which are methods of conducting business that assist the underprivileged as suppliers or customers (Likoko & Kini, 2017).

Donor nations aggressively encourage businesses to use inclusive business models, which involve involving smallholders and communities in company operations. By including smallholders in commercial value chains and giving them access to markets, inputs, and services like financing and training in ways that are profitable for them, inclusive business seeks to enhance the livelihoods of smallholders in the agricultural sector (Woodhill et al, 2016, Kelly et al., 2015).

The United Nations' Sustainable Development Goals (SDGs) formulated slogan in 2016, 'leaving no one behind', is believed to be the year inclusion took a flight. Social inclusion, according to the UN, is "a process of improving the terms of participation in society through enhancing opportunities, access to resources, voice and respect for rights, particularly for disadvantaged people" (United Nations, 2016). Inclusion has become central to development policy and the standard of development intervention financed by public money (Gupta & Pouw, 2017; Otsuki & Helvoirt, 2017).

There is no worldwide policy document that fully captures the global agreement on inclusive business (German et al., 2020) since the private sector a role to play in adding smallholders' producers and enterprise into their business operation. A private sector strategy aimed at or including those at the base of the economic pyramid (such as: poor, disable, marginalised, women) by integrating them as suppliers, distributors, retailers, or customers into a company's main business value chain is known as inclusive business (FAO, 2015; World bank, 2018). According to Sopov et al. (2014), inclusive business models are activities implemented by companies that include marginalised and low-income groups into their core operations to create a mutually beneficial partnership. Through "productive" integration into the market economy, inclusive business models seek to ameliorate the circumstances of marginalised and vulnerable individuals (German et al., 2020).

An inclusive business model differs from all other business models in that it is "part of the company's core processes." Governments, NGOs, donors, and top agri-food corporations have enthusiastically embraced the notion of "inclusive business," which has emerged as a crucial framework for attempts to improve the compatibility between agribusiness expansion and rural livelihoods (Chamberlain & Anseeuw, 2019; German et al., 2020). The majority of assessment frameworks use variables like farm income and productivity, the number of smallholder farmers they contact, and the quantity of training they provide to estimate impact at the outcome level (Mangnus, 2019).

The six principles of an inclusive business model, as outlined by the Food and Agriculture Organization (FAO) provide a framework for developing inclusive business models that not only aim for economic viability but also prioritize social equity and environmental sustainability. The principles include.

1. *Providing a living wage:* Inclusive business models should ensure that vulnerable groups, such as smallholders and women-run enterprises, receive a living wage. This principle emphasizes fair compensation that meets the basic needs of these groups while also allowing buyers to profit. By prioritizing fair wages, businesses can contribute to poverty alleviation and improve the livelihoods of marginalized populations.
2. *Flexible trading arrangements*: Inclusive business models should incorporate flexible trading arrangements that facilitate easier participation for smallholders and micro or small enterprises (MSEs). This includes practices such as cash-on-delivery payments, accepting small consignments, and providing reliable and regular orders. Flexibility in trading helps lower barriers to entry for small producers and enhances their ability to engage in the market.
3. *Strengthening negotiation power:* Supporting farmers and small enterprises in establishing a stronger negotiation position is crucial. This can be achieved through skills development, collective bargaining, and access to market information and financial services. By enhancing their negotiation power, smallholders can secure better terms in their transactions, leading to improved economic outcomes.

4. *Building on existing market players:* Inclusive business models should build on the skills and expertise of existing market players, including traders and processors. Promoting value chain collaboration, transparency in pricing mechanisms, and risk-sharing arrangements can enhance the overall efficiency and effectiveness of the agricultural value chain. This principle encourages leveraging local knowledge and networks to strengthen market linkages.
5. *Scalability:* An inclusive business model should be scalable in the medium term, allowing for an increase in the number of small actors involved or the replication of the business model in other value chains or sectors. Scalability ensures that successful practices can be expanded, benefiting more participants and enhancing overall impact.
6. *Diversified income streams:* Finally, inclusive business models should allow for diversified income streams in the long term. This principle helps avoid overdependence on any single buyer or market outlet, thereby enhancing the resilience of smallholders. Diversification can include exploring new markets, products, or services, which can lead to more stable income sources.

2.5.6 Inclusive cooperatives

Inclusiveness is a key element of member's willingness to join cooperatives. Inclusive cooperatives are defined as organizations that actively engage marginalized groups, such as smallholders, women, and youth, in their operations and decision-making processes (Abdul-Rahaman & Abdulai, 2020). The inclusiveness of these cooperatives is crucial for enhancing the livelihoods of their members and promoting sustainable agricultural practices (Kelly et al., 2015). Empirical research done in Ethiopia noted, the low participation in agriculture cooperatives is a result of less inclusiveness and effectiveness of cooperatives (Wassie et al. 2019).

Empirical results from research shows that, there are many factors that influence farmers' participation in cooperatives. Some of these factors have positive and negative relationship with farmers 'participation. Some of the factors include age, family size, education, land size, credit service, traders and input suppliers (Wassie et al. 2019). When sub-systems of agribusiness which include: (i) agro inputs and agricultural equipment sub-system; (ii) on-farm sub-system; (iii) processing subsystem; (iv) marketing sub-system; and (v) supporting sub-system interrelate, it brings inclusiveness (Sedana & Astawa, 2019).

Access to resources, including financial support, training, and market opportunities, is fundamental for inclusivity. Cooperatives that provide equitable access empower all members, particularly those from marginalized backgrounds. For instance, Popoola et al. (2024) highlight that, cooperatives often facilitate access to credit and inputs, which are essential for smallholder productivity. Training programs that enhance the skills of cooperative members are critical for promoting inclusiveness. These programs can cover topics such as sustainable agricultural practices, financial literacy, and cooperative management. Kassa et al. (2024) found that cooperatives offering capacity-building initiatives significantly increase member engagement and productivity.

Improving market access is one of the primary goals of inclusive cooperatives. By pooling resources and negotiating collectively, cooperatives can secure better prices for their members' products. Abebaw & Haile, (2013), note that cooperatives enhance market access for smallholders and vulnerable groups by providing them with the necessary support to meet buyer requirements. An inclusive cooperative actively supports vulnerable groups by addressing barriers that may prevent their full participation. This includes providing targeted training programs, creating childcare facilities, or implementing mentorship programs for women and youth. It is importance to address gender disparities to ensure women can fully participate in agricultural cooperatives. Kassa et al. (2024), highlights the importance of cooperatives in providing support to vulnerable groups, particularly women and youth. The authors emphasize that inclusive cooperatives must actively address barriers faced by these groups to enhance their participation and benefits.

2.6 Vegetable Farming

Given that traditional methods of agriculture were established in anticipation of a predictable rainy season, this will probably threaten farming livelihoods. It is anticipated that subsistence farmers in the Sudanian zone will experience a rise in food insecurity due to their dependence on rainfed agriculture (Wood et al., 2021).

Globally, vegetable production has experienced substantial growth, with the Food and Agriculture Organization (FAO) reporting approximately 1.1 billion tons of vegetables produced in 2020 (FAO, 2021). This growth reflects the increasing demand for vegetables due to rising populations and changing dietary preferences. In Africa, vegetable production is also significant, with the continent producing around 30 million tons of vegetables annually (FAO, 2021). Countries like Egypt, Nigeria, and Ghana are among the leading producers in the region. In Ghana, vegetable farming has been a vital source of income and nutrition, with the country producing about 1.2 million tons of vegetables in 2020 (FAO, 2021). Major vegetable crops cultivated in Ghana include tomatoes, onions, peppers, and leafy greens, which are essential for both domestic consumption and export.

The output of vegetable crops in Ghana varies significantly based on several factors, including access to resources, farming practices, social belonging to groups and environmental conditions. According to Asante et al. (2012), the average output for tomatoes in Ghana is approximately 10-15 tons per hectare, while onions can output around 8-12 tons per hectare under optimal conditions.

However, the unpredictability of weather conditions, inadequate water supply, poor soil fertility, and pest infestations has led to reduced outputs and increased crop failures (Fagariba et al., 2018). Climate change poses a significant threat to vegetable farming in Ghana, primarily through altered rainfall patterns and increased temperatures. The World Bank (2021) reports that climate-related shocks could reduce agricultural productivity by up to 30% by 2050 if no adaptive measures are taken. This is particularly concerning for vegetable farmers, who rely heavily on consistent water supply for irrigation.

2.7 Empirical studies: Inclusivity of Vegetable Cooperatives and adoption of WCP

The major objective of this study is to assess how the inclusivity of vegetable cooperatives influence the adoption of water-related climate-smart practices (WCP) among vegetable farmers in Ghana. Inclusive cooperative business models play a crucial role in promoting the adoption of water-related climate-smart practices among vegetable farmers. By pooling resources, knowledge, and collective action, cooperatives can help farmers overcome barriers such as limited access to financial resources, training, and technical support. This collaborative approach has been shown to significantly impact farmers' productivity and income levels. For instance, studies indicate that participation in cooperatives can lead to a 15% to 35% increase in crop yields due to enhanced access to training and climate-smart practices (Abdul-Rahaman & Abdulai, 2020). Additionally, farmers involved in cooperatives often experience up to a 20% increase in income stability, as they benefit from shared resources and collective marketing efforts (Kiptot & Franzel, 2012). These impacts highlight the critical role those inclusive cooperatives play in improving the livelihoods of farmers, particularly in the face of climate-related challenges. When cooperatives are inclusive and engage marginalized farmers effectively, they are better equipped to facilitate the adoption of sustainable agricultural practices.

Several factors influence the inclusivity of vegetable cooperatives in Ghana. Owusu et al. (2021) found that many cooperatives struggle with low levels of member engagement and participation, which hampers their ability to fully implement inclusive practices. The authors argue that a lack of awareness among farmers about the benefits of cooperative membership contributes to this low engagement. Similarly, Abdul-Razak and Kruse (2017) highlight that limited access to resources, such as financial support and training, restricts the effectiveness of cooperatives in promoting inclusivity.

The inclusivity of vegetable cooperatives directly influences the adoption of water-related climate-smart practices among farmers. Liu et al. (2024) demonstrated that inclusive cooperative approaches facilitated better water resource management, leading to improved water efficiency and crop outputs. Specifically, their findings indicated that farmers participating in inclusive cooperatives experienced a 25% increase in water-use efficiency and a 30% rise in overall crop yields due to enhanced collective resource management strategies. Similarly, Ishakku and Abdulai (2020) reported that cooperative membership significantly increased the adoption of climate-smart practices, such as water-smart irrigation techniques, resulting in an average increase of 20% in agricultural productivity among cooperative members compared to non-members. These empirical findings underscore the critical role those inclusive cooperatives play in promoting sustainable agricultural practices and improving farmers' resilience to climate change.

The adoption of water-related climate-smart practices through inclusive cooperatives can lead to significant socio-economic benefits for vegetable farmers. Zizinga et al. (2022) found that farmers who adopted WCP experienced increased outputs and income stability, providing them with a more secure financial base to invest in their farms. Specifically, the study reported that cooperative members who implemented WCP saw an average increase in crop yields of 20% and a 15% improvement in income stability compared to those who did not participate in cooperatives.

Despite the positive impacts of inclusive cooperatives, barriers to the adoption of water-related climate-smart practices persist. Limited knowledge about climate-smart practices, financial constraints, and socio-cultural factors as key barriers hindering broader adoption. Inclusive cooperatives can play a vital role in addressing these barriers by providing access to training, financial resources, and facilitating the dissemination of knowledge about sustainable agricultural practices (Abdul-Rahaman & Abdulai, 2020).

2.7.1 Extent of vegetable cooperatives Inclusiveness

The application of inclusivity in vegetable cooperatives is essential for enhancing the livelihoods of smallholder farmers and promoting sustainable agricultural practices.

Global Context of inclusivity in Cooperatives

Globally, inclusive business models have been recognized as a means to integrate marginalized populations into the economic mainstream. The United Nations Development Programme (UNDP, 2019) emphasizes that inclusive business models can help alleviate poverty by providing access to markets, resources, and services for low-income communities. Studies have shown that cooperatives employing inclusivity can facilitate access to financial services, training, and technology for smallholder farmers, thereby enhancing their productivity and income (Zhou et al., 2024). Specifically, research indicates that farmers who participate in inclusive cooperatives experience a 20% to 40% increase in productivity due to improved access to resources and training opportunities. Additionally, these farmers report an average income increase of 15% to 25%, enabling them to invest further in their agricultural practices and enhance their overall livelihoods. These quantitative improvements highlight the significant impact that inclusive cooperatives can have on smallholder farmers' economic stability and productivity. For instance, Kiptot and Franzel (2012) found that cooperatives in Kenya significantly improved farmers' access to agroforestry practices by about 30%, which enhanced sustainability and resource management.

African Context of Inclusivity in Cooperatives

In Africa, the application of inclusivity in agricultural cooperatives has gained traction as a strategy to address food security and poverty alleviation. Abdul-Razak and Kruse (2017) highlighted that, inclusive cooperatives in various African countries have been instrumental in promoting climate-smart agricultural practices among smallholder farmers. The authors argue that by fostering collective action, cooperatives can enhance resource-sharing and knowledge dissemination, which are crucial for adopting sustainable practices in the face of climate change. However, the overall implementation of inclusivity in African cooperatives remains inconsistent, often hindered by factors such as limited access to financial resources, inadequate training, and socio-cultural barriers (Brown et al., 2020).

Inclusivity in Cooperatives in Ghana

In Ghana, the extent to which vegetable cooperatives apply inclusive business models is still developing. Owusu et al., (2021) found that while some cooperatives have made efforts to incorporate inclusivity, the overall application of inclusivity remains low. Many cooperatives struggle with low levels of member engagement and participation, which hampers their ability to fully implement inclusive practices. The authors argue that a lack of awareness among farmers about the benefits of cooperative membership contributes to this low engagement. Moreover, the research by Abdul-Rahaman and Abdulai (2020) indicates that limited access to resources, such as financial support and training, restricts the effectiveness of cooperatives in promoting inclusivity. This is particularly concerning in the context of vegetable farming, where access to water and climate-smart practices is critical for productivity and sustainability.

The application of inclusivity in vegetable cooperatives in Ghana is critical for enhancing the livelihoods of smallholder farmers and promoting sustainable agricultural practices. Inclusivity aims to integrate marginalized groups into the value chain, allowing them to benefit from economic opportunities and resources that would otherwise be inaccessible. This section reviews the empirical literature on the extent to which vegetable cooperatives in Ghana have adopted these inclusive models.

The barriers to effective implementation of inclusivity in vegetable cooperatives is multifaceted. According to Kiptot and Franzel (2012), one of the primary challenges is the lack of access to credit and financial resources, which prevents smallholder farmers from investing in necessary agricultural inputs and technologies. This financial constraint is compounded by limited training opportunities, as noted by Abdul-Rahaman and Abdulai (2020), who found that cooperatives that do not provide adequate training on climate-smart practices fail to engage their members effectively. Moreover, socio-cultural factors also play a significant role in limiting participation in cooperatives. Many farmers may be hesitant to join cooperatives due to mistrust or previous negative experiences (Brown et al., 2020). This mistrust can hinder the formation of strong cooperative networks that are essential for implementing inclusive business models.

Despite these challenges, there are positive outcomes associated with the application of inclusivity in vegetable cooperatives. Liu et al., (2021) demonstrated that cooperatives can enhance farmers' access to resources and technical knowledge, which are crucial for adopting water-related climate-smart practices. This access not only improves agricultural productivity but also contributes to increased income stability among cooperative members. Furthermore, Zizinga et al., (2022) found that cooperatives that employ inclusive practices can significantly improve the resilience of farmers to climate change, as they provide a platform for resource-sharing and collective action.

To enhance inclusivity in vegetable cooperatives, several recommendations can be drawn from the literature. First, it is essential to implement awareness campaigns that educate farmers about the benefits of cooperative membership and the inclusive practices that can be adopted (Owusu et al., 2021). Second, cooperatives should focus on improving access to financial resources by partnering with financial institutions to offer tailored financial products that meet the needs of smallholder farmers (Kiptot and Franzel, 2012). Additionally, providing comprehensive training programs on climate-smart practices will empower cooperative members and increase their participation (Abdul-Rahaman and Abdulai, 2020). Finally, fostering a culture of trust and collaboration within cooperatives will be vital for overcoming socio-cultural barriers and enhancing member engagement.

Vegetable cooperatives in Ghana have made efforts to apply inclusive business models, the overall extent of inclusivity remains low. Barriers such as limited access to resources, training, and socio-cultural factors hinder the effectiveness of these cooperatives in promoting IBM. Addressing these challenges through targeted interventions can enhance the inclusivity of cooperatives, ultimately leading to improved adoption of water-related climate-smart practices and greater resilience among vegetable farmers in the face of climate change.

2.7.2 Factors influencing participation in inclusive cooperatives

The participation of vegetable farmers in cooperatives that inclusive is influenced by a variety of factors. Understanding these factors is essential for enhancing cooperative engagement and promoting sustainable agricultural practices. Some of the factors includes.

Access to Financial Resources

Access to financial resources is a significant determinant of participation in vegetable cooperatives. Kiptot and Franzel (2012) found that farmers with improved access to credit were more likely to join cooperatives, as financial support enables them to invest in necessary agricultural inputs and technologies. This finding is echoed by Abdul-Razak and Kruse (2017), who emphasized that the availability of financial resources significantly enhances the ability of farmers to participate in cooperatives, as it reduces the financial barriers that often prevent smallholder farmers from joining collective organizations.

Training and Capacity Building

Training and capacity-building initiatives are crucial in influencing farmers' participation in cooperatives. Abdul-Rahaman and Abdulai (2020) highlighted that cooperative providing training on climate-smart practices significantly enhance farmers' willingness to join. When farmers receive education and technical support, they are more likely to perceive the cooperative as a valuable resource that can improve their farming practices and overall productivity. This aligns with the findings of Owusu et al., (2021), who noted that training programs focused on sustainable agricultural practices foster greater engagement and participation among cooperative members. Their research found that the implementation of such training programs led to a 40% increase in member participation in cooperative activities.

Market Access

Market access is another significant factor influencing participation in vegetable cooperatives. Liu et al., (2021) found that farmers who perceive that, cooperatives can provide better market opportunities are more likely to join. Cooperatives facilitate improved market access for their members by providing collective marketing strategies, which enhance their bargaining power and reduce transaction costs. This is particularly important in the context of vegetable farming, where market volatility can significantly impact income stability. Zizinga et al., (2022) also support this notion, indicating that cooperatives that enhance market access contribute to increased participation among farmers seeking to secure better prices for their produce. Their findings revealed that cooperatives facilitating improved market access led to a 35% increase in farmer participation in cooperative activities.

Community Support and Social Networks

The role of community support and social networks in influencing participation in cooperatives is significant. Brown et al. (2018) found that farmers who are part of supportive community networks are more likely to engage with cooperatives. Specifically, their research indicated that the presence of strong social capital, characterized by trust and mutual support among community members, can lead to a 25% increase in cooperative membership. This social dynamic is crucial for the success of cooperatives, as it enhances member engagement and commitment to cooperative activities. When farmers feel supported by their community, they are more inclined to participate actively, which ultimately contributes to the cooperative's effectiveness and sustainability.

Perceived benefits of Membership

Farmers' perceptions of the benefits associated with cooperative membership significantly influence their decision to participate. Abdul-Rahaman and Abdulai (2020) noted that when farmers recognize the potential advantages of joining a cooperative such as improved access to resources, training, and market opportunities they are more inclined to engage. This perception is often shaped by previous experiences with cooperatives or the success stories of other members within the community. Owusu et al., (2021) further emphasized that clear communication of the benefits of cooperative membership is essential for attracting new members and retaining existing ones.

Access to Climate Change Information

Access to information regarding climate change and its impacts is another factor influencing participation in vegetable cooperatives. Farmers who are informed about climate change issues and the adaptive practices available are more likely to engage in cooperatives that promote climate-smart agriculture. The study by Abdul-Razak and Kruse (2017) highlighted that information dissemination through cooperatives can empower farmers to make informed decisions regarding their agricultural practices, thereby enhancing their willingness to participate.

Socio-Demographic Factors

Socio-demographic factors, including age, education level, and household size, also play a role in influencing participation in cooperatives. For instance, younger farmers and those with higher education levels are often more inclined to join cooperatives due to their openness to new ideas and practices (Mashi et al., 2022; Tadesse & Ahmed, 2023). Additionally, larger household sizes may provide more labour resources, making cooperative participation more feasible for some families.

The factors influencing participation in vegetable cooperatives employing Inclusive Business Models in Ghana are crucial. Access to financial resources, training and capacity building, market access, community support, perceived benefits, access to climate change information, and socio-demographic factors all play critical roles in shaping farmers' decisions to engage with cooperatives. Addressing these factors through targeted interventions can enhance participation rates and improve the effectiveness of cooperatives in promoting sustainable agricultural practices.

2.7.3 Influence of inclusive vegetable cooperatives on adoption of WCP

The adoption of water-related climate-smart practices (WCP) among vegetable farmers is critical for enhancing agricultural sustainability and resilience to climate change. The extent to which vegetable cooperatives that employ inclusive influence the level of WCP adoption, categorized into "no adoption," "low adoption," "moderate adoption," and "high adoption." The review draws on empirical studies at the global, African, and Ghanaian levels, including recent findings from Njogu et al., (2024) and Nyambu et al., (2024).

Global Context of ICBM and WCP Adoption

Globally, cooperatives employing inclusive business models have been recognized for their potential to enhance the adoption of sustainable agricultural practices. The International Cooperative Alliance (ICA, 2021) emphasizes that cooperatives empower farmers by providing access to resources, markets, and services essential for implementing climate-smart practices. For instance, Kiptot and Franzel (2012) found that inclusive cooperatives in Kenya significantly improved farmers' access to agroforestry practices, which enhanced water management and overall sustainability. This access is critical for increasing the likelihood of higher adoption rates of WCP, allowing farmers to transition from "no adoption" or "low adoption" to "moderate" or "high adoption" levels.

African Context of ICBM and WCP Adoption

In Africa, the application of inclusiveness in agricultural cooperatives has gained traction as a strategy to address water scarcity and promote the adoption of climate-smart practices. Abdul-Razak and Kruse (2017) highlighted that, inclusive cooperatives in various African countries have been instrumental in enhancing farmers' resilience to climate change by facilitating the adoption of water-related climate-smart practices. They argue that by fostering collective action, cooperatives can enhance resource-sharing and knowledge dissemination, which are crucial for adopting sustainable practices. However, the overall implementation of inclusivity in African cooperatives remains inconsistent, often hindered by factors such as limited access to financial resources, inadequate training, and socio-cultural barriers (Brown et al., 2020).

The Situation in Ghana

In Ghana, the extent to which inclusive vegetable cooperatives influence the adoption of WCP is still an emerging area of research. Owusu et al., (2021) found that while some cooperatives have made efforts to incorporate inclusivity, the overall application of inclusivity remains low. Many cooperatives struggle with low levels of member engagement and participation, which hampers their ability to fully implement inclusive practices and promote the adoption of WCP. The study indicated that market access, access to credit, training and development, perceived contributions to the environment, and access to climate change information were positively significant factors influencing WCP adoption levels among cooperative members.

Inclusive Cooperative Business Models (ICBM) have emerged as a significant strategy in promoting sustainable agricultural practices, particularly in the context of climate change. These models aim to empower smallholder farmers by enhancing their access to resources, knowledge, and markets, thereby facilitating the adoption of water-related climate-smart practices (WCP):

1. *Access to Financial Resources:* Access to credit is crucial for farmers to invest in necessary agricultural inputs and technologies. Njogu et al., (2024) found that cooperative membership significantly increased farmers' access to financial resources, enabling them to adopt water-efficient technologies. This access is vital for transitioning from "no adoption" to "moderate" or "high adoption" levels of WCP.

2. *Training and Capacity Building:* Training initiatives provided by cooperatives are essential for enhancing the adoption of WCP. Nyambu et al., (2024) emphasized that cooperatives that offer education on climate-smart practices significantly increase farmers' willingness to adopt these practices. The study indicated that farmers who participated in training were more likely to move from "low adoption" to "moderate" or "high adoption" levels of WCP.

3. *Market Access:* Improved market access through cooperatives incentivizes farmers to adopt WCP. Liu et al., (2021) found that farmers who perceive that, cooperatives can provide better market opportunities are more likely to engage in WCP. This economic incentive is particularly important for achieving "moderate" to "high adoption" levels, as it directly impacts farmers' income stability.

4. *Community Support and Social Networks:* The presence of supportive community networks within cooperatives fosters a sense of belonging and encourages collective action. Brown et al., (2018) found that social capital enhances member engagement and commitment to adopting

climate-smart practices. This community support can lead to increased adoption rates, facilitating movement from "no adoption" to higher adoption levels.

5. *Perceived Benefits of Membership*: Farmers' perceptions of the benefits associated with cooperative membership significantly influence their decision to participate and adopt WCP. Owusu et al., (2021) noted that when farmers recognize the advantages of joining a cooperative such as improved access to resources and training, they are more inclined to adopt WCP. This perception is critical for achieving higher adoption levels.

6. *Access to Climate Change Information:* Access to information regarding climate change and its impacts is crucial for encouraging the level of adoption of WCP. Njogu et al., (2024) highlighted that, farmers who are informed about climate change issues and the adaptive practices available are more likely to engage in cooperatives that promote climate-smart agriculture.

7. *Socio-Demographic Factors:* Socio-demographic factors, including age, education level, and household size, also play a role in influencing the adoption of WCP. Mashi et al., (2022) found that younger, more educated farmers and those with larger households are often more inclined to adopt these practices.

The empirical literature indicates that inclusive cooperatives significantly influence the level of adoption of water-related climate-smart practices among vegetable farmers. By providing access to resources, training, market opportunities, and community support, cooperatives enhance farmers' capacity to implement sustainable agricultural practices.

2.7.4 Impact of cooperative membership on output and income of vegetable farmers

The impact of cooperative membership on the output and income of vegetable farmers is a critical area of research, particularly in the context of climate change and sustainable agricultural practices.

Cooperative Membership and Output

Cooperative membership has been shown to positively influence the output of vegetable farmers. Liu et al., (2023) found that cooperative-based approaches significantly improved water resource management among vegetable farmers, leading to enhanced crop outputs, specifically, their study reported an average increase in crop yields of 30% among farmers who adopted these cooperative practices. The study highlighted that, farmers who were members of cooperatives had access to better irrigation techniques and shared resources, which contributed to increased productivity. Similarly, Ishakku and Abdulai (2020) reported that cooperative membership was associated with higher outputs due to improved access to training and technical support on climate-smart practices. Their research indicated that farmers who participated in cooperatives adopted water-efficient irrigation techniques, which directly contributed to output improvements.

Income stability and Cooperative Membership

The relationship between cooperative membership and income stability among vegetable farmers is well-documented. Abdul-Rahaman and Abdulai (2020) demonstrated that cooperative members experienced higher incomes compared to non-members, primarily due to better market access and collective marketing strategies. The study emphasized that cooperatives enhance farmers' bargaining power, allowing them to secure better prices for their produce. This finding aligns with Zizinga et al., (2022), who noted that cooperative membership significantly increased the income of vegetable farmers, providing them with a more stable financial base to invest in their farms. The results showed that members of cooperative have an average income increase of 20% to 30% compared to non-members

Whiles literature portrait positive results for cooperative membership, there exist factors that are influencing income and output of vegetable farmers. These factors are.

1. *Access to Financial Resources:* Access to credit and financial resources is crucial for farmers to invest in necessary agricultural inputs and technologies. Kiptot and Franzel (2012) found that farmers with improved access to credit through cooperatives were more likely to invest in necessary inputs, leading to increased outputs. This financial support allows farmers to adopt modern farming techniques and technologies, which are essential for enhancing productivity.

2. *Training and Capacity Building:* Training initiatives provided by cooperatives are vital for enhancing the output and income of vegetable farmers. Zho et al (2022) found that cooperative members who received training on water-efficient practices saw a significant increase in their vegetable yields and income compared to non-members. Also, Abdul-Rahaman and Abdulai (2020) found that access to these resources through cooperatives led to improved agricultural practices, which enhanced crop yields and income stability for participating farmers.

3. *Market Access:* Market access is another significant factor influencing the impact of cooperative membership on income and output. Owusu et al. (2021) found that cooperatives enhance members' ability to access larger markets and better prices for their products, resulting in improved income levels. The study emphasizes the importance of market access as a key benefit of cooperative membership.

4. *Community Support and Social Networks*: The role of community support and social networks in enhancing the impact of cooperative membership on output and income is significant.

Owusu et al. (2021) found that cooperative members benefit from shared experiences and resources, which significantly contribute to increased productivity and income levels. The research highlights that social cohesion within cooperatives fosters a supportive environment for adopting new agricultural practices.

5. *Perceived Benefits of Membership*: Farmers' perceptions of the benefits associated with cooperative membership significantly influence their decision to participate and the subsequent impact on output and income.

6. *Socio-Demographic Factors:* Socio-demographic factors, including age, education level, and household size, also play a role in influencing the impact of cooperative membership on output and income. Malhi et al. (2021) in their study explores various socio-demographic factors influencing the adoption of climate-smart practices among farmers. They found that age and education level significantly impact the likelihood of adopting these practices through cooperative membership, suggesting that younger and more educated farmers are more inclined to engage with cooperatives and implement innovative agricultural techniques.

The empirical literature indicates that cooperative membership has a positive impact on the output and income of vegetable farmers. Factors such as access to financial resources, training and capacity building, market access, community support, and perceived benefits all play critical roles in shaping the effectiveness of cooperatives in enhancing agricultural productivity and economic viability.

2.8 Summary and Identification of Knowledge Gap

There is limited research on the extent to which vegetable cooperatives in Ghana apply inclusivity. While some cooperatives have made efforts to incorporate inclusivity, the overall application of inclusive remains low and requires further investigation. The literature highlights that many cooperatives struggle with low levels of member engagement and participation, which hampers their ability to fully implement inclusive practices (Abdul-Rahaman & Abdulai, 2020). More research is needed to understand the current state of inclusive adoption among vegetable cooperatives in Ghana.

Lack of comprehensive understanding of the factors influencing participation in vegetable cooperatives employing inclusive. The literature identifies factors like access to resources, training, and market opportunities as influencing cooperative participation. However, a more detailed examination of the dynamics of farmer participation in inclusive cooperatives is lacking. Understanding the motivations, barriers, and determinants of membership is crucial for promoting greater inclusivity (Owusu et al. 2021; Abdul-Rahaman & Abdulai ,2020; Fagariba et al., 2018).

Insufficient evidence on the effectiveness of vegetable cooperatives employing IBM in influencing the adoption of water-related climate-smart practices (WCP). While studies suggest positive impacts of cooperatives on WCP adoption, the extent to which inclusive cooperatives influence adoption remains an emerging area of research. More rigorous analysis is needed to quantify the influence of inclusive cooperatives on the adoption of practices like irrigation, water harvesting, drought-resistant crops, mulching, conservation tillage, and cover cropping. Comparative studies across different regions could provide valuable insights (Zhou et al. 2023; Kangogo et al. 2021; Westermann et al. 2018).

Inadequate research measuring the impacts of cooperative membership on output and income of vegetable farmers. The literature points to increased outputs and incomes associated with cooperative membership but lacks a comprehensive assessment of the socio-economic benefits of adopting WCP via ICBM. More detailed analysis is required to understand the impact pathways and magnitude of benefits, including changes in productivity, income, food security, and resilience to climate change. By addressing these knowledge gaps through empirical analysis, this study aims to contribute to the ongoing discourse on the role of inclusive cooperatives in enhancing the adoption of water-related climate-smart practices and improving the livelihoods of vegetable farmers in Ghana. The findings could inform policy decisions and guide the development of effective strategies for promoting water smart practices in the face of climate change (Mashi et al. 2022; Owusu et al. 2021).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter focuses on the research methodology. The chapter goes into the types, sources, and methods for data collection as well as the research approach and design for the quantitative and qualitative investigations. Additionally covered are the sampling procedure, target population, sampling technique, sample size, and data analysis. Research methodology, which lays out guidelines and directions that order the researcher to find and present solutions to research problems with careful consideration for the reliability and validity issues to be raised by those who participate, is the driving force behind every research project (William, 2011). According to Richard (2004, P. 1229) research methodology is "the aspect of a research that is dedicated to describe the actions to be taken to investigate a research problem and the rationale for the application of the specific procedures or techniques used to identify, select, process and analyse information applied to understanding the problem, thereby, allowing the reader to critically evaluate a study's overall validity and reliability". There are three types of research strategies namely, quantitative, qualitative and mixed research method (Creswell, 2014) and this research will use the mixed research method. According to Creswell (2012), a mixed method is a process for gathering, assessing, and "mixing" quantitative and qualitative research and methodologies in a single study to better understand a research subject. Creswell (2011) asserts that combining qualitative and quantitative data outputs a greater grasp of a study problem than either type alone.

3.2 Theoretical Framework of the Study

The major objective of this study is to assess how inclusive cooperative business model (ICBM) influence adoption of water-related climate smart practices (WCP) among vegetable farmers in southern Ghana. To address this objective, the study adopts a theoretical framework rooted in economic and adoption theory. Specifically, the study draws upon the utility theory, which emphasizes the role of institutions and cooperative satisfaction in shaping economic behaviour. The study links this theoretical perspective to the research design, which focuses on inclusive cooperative models within the agricultural sector.

3.2.1 Diffusion of innovation theory

One of the theories that this research based on is the Diffusion of Innovation Theory popularized by Everett Rogers in 1962. Adekoya and Tologbonse (2011) define adoption as the decision to fully utilize an innovation or technology as the best available course of action. An innovation can be adopted when a person or organization decides to put it to use. An innovation is an idea, practice or object that is perceived as new by an individual or a group. Thus, if the idea is new to the individual or group, it is perceived as innovation. The newness nature of the innovation may be an expression in terms of knowledge, persuasion or a decision to adopt (Rogers et al.2014).

According to Rogers (1985) Diffusion is defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system". A process where individuals or groups create and share ideas to reach mutual understanding is called communication. Diffusion is therefore implying that; information and ideas reaches the target audience through a channel that create understanding. Thus, diffusion is a type of communication that deals with reaching target audience with new ideas and the newness of the idea gives the content of the communication. Communication helps clear uncertainties through the sharing of information (Rogers, 1985). When considering new technology, most farmers went through a number of logical problem-solving steps known as the adoption process.

The diffusion of innovation theory, developed by Everett Rogers in 1962, provides a framework for understanding how new ideas, practices, or technologies spread through a social system over time. The theory posits that the adoption of an innovation is influenced by five key factors: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 1962).

Relative Advantage

Relative advantage refers to the degree to which an innovation is perceived as better than the idea, practice, or technology it supersedes. In the context of this study, the adoption of water-related climate-smart practices (WCP) through inclusive cooperative business models (ICBM) must be perceived by vegetable farmers as providing a clear advantage over their current practices. This is mostly measured in economic terms, but social-prestige factors, convenience and satisfaction are also important. The more the idea is advantageous, the greater the rate of adoption. Meaning, when vegetable farmers perceive that, joining cooperatives which are inclusive helps them to have access to resources and knowledge that will aid them to adopt to water related climate smart agriculture practices, the greater the rate of joining such cooperatives and vice versa

Compatibility

Compatibility is the degree of an innovation being consistent with existing values, experience and needs of potential adopters. Many farmers have values, traditions and experience of innovation that may or may not be consistent with what they know and believe. For example, in some part of Ghana, farmers believe that there are certain day(s) in the week whereby a farmer is not supposed to visit the farm. Bringing innovation of practice that is not consistent with this believe will mean that, those farmers in that geographical area will not adopt the innovation. Needs of the potential adopters need to be considered when introducing an innovation. Thus, water smart agriculture practices that are not consistent with the needs, values of the members could result to low adoption and when these practices are compatible with members, it will result in high adoptions. For WCP to be readily adopted, they must align with the cultural, social, and economic contexts of vegetable farmers in Ghana.

Complexity

Complexity is the degree to which an innovation is perceived as difficult to understand and use. Innovations vary in terms of their ease of being understood and used by members in a social system (cooperatives). Some are easy to be understood and use whiles others are difficulty to be understood and used. When members perceive that a particular water smart agriculture practice is difficulty to be understood and use in terms of ease of funding, labour intensiveness, ease of market for both inputs and output, they turn not to adopt such practices and vice versa. For that matter, communication and simplified education and training needs to deploy to members for easy understanding and usage. If WCP are seen as too complex or challenging to implement, farmers may be less likely to adopt them. Cooperatives can play a role in reducing complexity by providing training and support.

Trialability

Trialability is the degree to which an innovation can be experimented with on a limited basis. The degree to which an innovation may be experimented with on a limited basis before fully deployed. This basis could be in small instalment, or with a small group of people. This means that farmers in cooperatives will be adopt practices in instalment basis in the sense that, they would like try water smart practices in small piece of land and gradually increase to the whole farmland. This is important for them to make a decision to adopt those practices that works for them. The ability to trial WCP on a small scale can help reduce the perceived risk associated with adoption and encourage more farmers to try the practices. Cooperatives also play an important role here by having and demonstration farmers where these water smart practices are tried before diffusing the practice to the entire members.

Observability

Observability is the degree to which the results of an innovation are visible to others. When farmers can see the benefits of WCP adoption, such as increased outputs or income, they are more likely to adopt the practices themselves.

The diffusion of innovation theory is closely linked to the conceptual framework of this study. The factors that influence the adoption of WCP through inclusive cooperatives, such as access to resources, training, and market opportunities, can be understood through the lens of the diffusion of innovation theory. For example, the relative advantage of WCP adoption by farmers in cooperatives may be increased outputs and income, as suggested by the literature (Abdul-Rahaman & Abdulai, 2020; Zizinga et al., 2022). The compatibility of WCP with existing farming practices and values will influence their adoption, as highlighted by the importance of socio-demographic factors (Mashi et al., 2022). The complexity of WCP can be reduced through training and capacity building provided by cooperatives, as emphasized in the conceptual framework. The trialability of WCP may be enhanced by cooperatives offering small-scale trials or demonstrations, while the observability of results can be improved through effective feedback mechanisms.

After these five (5) factors are satisfied by the farmer, another decision is authority Innovation decision and, in this decision, the choice to adopt or reject lines in the powers of individual who have power, status or technical expertise. The innovation decision process includes.

i. Knowledge
ii. Persuasion
iii. Decision
iv. Implementation
v. Confirmation

Rogers' model outlined the critical elements that affect an innovation's diffusion among a group of adopters. The model is based on the supposition that the population of possible adopters has been accurately identified previously. As a result, there is no theoretical basis for identifying an innovation's adopters in the technology diffusion paradigm (Kaine, 2003). A general description of the steps or procedures that people may take while deciding whether to accept an innovation may be found in Rogers' model and other models of decision-making about the adoption of innovations. These models merely show the procedures involved; they do not forecast how these decisions will turn out (Kaine, 2004).

All the different adoption behaviour models acknowledge that the degree to which an innovation can help the buyer's demands be better met is the primary element affecting the decision to adopt it. When it comes to agricultural innovations, this entails assessing how well an innovation can serve the needs of the primary producer in their capacity as an agricultural enterprise manager. Determining precisely what need an innovation can satisfy and under what conditions it is most likely to meet that need better than alternatives is the key to determining who would potentially embrace an agricultural innovation (Kaine, 2004).

3.2.2 Random Utility Theory

There are differences amongst consumers and hence consumers can decide to purchase whatever good that satisfy their need or want. Their economic situation will influence their decision-making in terms of tastes, price, availability of food, and budget. This study examines how vegetable farmers are implementing water-smart agriculture techniques through their cooperatives which is one possible way to lessen the harmful consequences of climate change. According to Carrer et al., (2017), the random utility framework highlights that the farmer's choice to adopt or not will depend on the utility they anticipate from the adoption. According to this idea, the farmer will consider their budget, the benefits of the chosen alternative and utility maximisation (Kurgat et al., 2020). These benefits include, increased profitability and productivity, a shorter crop growing season, better use of water and soil, and increased disease resistance (Davis et al., 2012).

A random utility framework can be used to assess a farmer's decision to participating in an inclusive cooperative. Let U_{tA} represent the utility received by a farmer upon participating in an inclusive cooperative $\mathbf{U_{tN}}$ represent the utility of non-members of cooperatives. Let $\mathcal{E}_t$ be the error term and Y_t be a vector of farm and family factors influencing decisions to pursue vegetable farming. The state of adoption for vegetable farmer's **t** utility will be.

$$\begin{cases} \mathbf{U_{tA} = fY_t + \mathcal{E}_{tA}} \\ \mathbf{U_{tN} = fY_t + \mathcal{E}_{tN}} \end{cases} \qquad (3.1)$$

Adopting the idea of participating in cooperative would only be chosen by a vegetable farmer if the utility gained from doing so outweighed the utility from not doing so: $U_{tA} > \mathbf{U_{tN}}$. Participating in an inclusive cooperative can provide benefits including food security, output, employment, income, fertile farmland and a decent standard of living. Since utilities are unobservable, it can be expressed in observable term below.

$$W^*_t = \beta Y_t + \varepsilon_t \quad (3.2)$$

With

$$\begin{cases} 1 \text{ } if \text{ } W^*_t > 0 \\ 0 \text{ } otherwise \end{cases} \quad (3.3)$$

Where W^*_t is a binary indicator variable that equals 1 if vegetable farmers adopt the choice of being part of a cooperative and zero if otherwise. B is a vector that shows the effects of the factors of $\boldsymbol{Y_t}$ adoption of cooperative.

According to Gujarati and Porter, (2008), Logit, Probit and linear probability models are normally used to evaluate factors that influence the probability that a choice will be made. Logit analysis is used to identify factors that affect or influence the decision-making status; factors that affect the adoption of an innovation or technology in this study, adoption of water smart agriculture.

When examining farmers' adoption choices, the Probit and Logit regression models are favoured above the linear probability model. Unrealistic values result from the linear probability model's inability to fit the expected values between 0 and 1, which is caused by heteroskedasticity. The farmer's adoption choices can be examined using the logit model. It is specified as:

$$P_r\left(Y = {}^{1}/_{X_1, X_{2,\dots\dots\dots} X_k}\right) = \Phi(\beta_0 + \beta_1 X_1 + \beta_2 X_3 + \beta_3 X_3 + \cdots + \beta_k X_k) \quad (3.3)$$

Where Y which is the dependent variable is binary and Φ is the cumulative standard normal distribution function. $X_1, X_{2,}$, etc., are the regressors. $\beta_0 \beta_1$ $etc.$, are the coefficients to be estimated. The logit model however is appropriate for only two alternative choices thus yes or no with may take the values (1 and 0).

$$P_i = \frac{e^{zi}}{1 + e^{zi}} \tag{3.4}$$

Where P_i is the probability of joining inclusive vegetable cooperatives, *e* represents the base of natural logarithms, and Z_i is a function of *n*-explanatory variables which is also expressed as:

$$Z_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + U_i \tag{3.5}$$

where $i = 1, 2, 3……n$; $\beta_0 =$ intercept $\beta_i =$ regression coefficients to be estimated, $U_i =$ a disturbance term, and X_i = a set of observable characteristics.

3.3 Conceptual Framework of the Study

The major objective of this study is to assess how the inclusivity of vegetable cooperative and measure effect on adoption of water-related climate smart practices (WCP) among vegetable farmers. To address this objective, the study adopts a theoretical framework rooted in economic theory. Specifically, the study draws upon the principles of institutional economics, which emphasize the role of institutions and cooperative arrangements in shaping economic behaviour. The study links this theoretical perspective to the research design, which focuses on inclusive cooperative models within the agricultural sector.

Vegetable farmers are being introduced to participating in inclusive cooperative which helps them to adopt to climate smart agriculture practice to help them adapt to the rising challenges of climate change. Water smart agriculture is one of these practices that has been encouraged to be used by vegetable farmers since these types of crops (vegetables) much on water resource.

These farmers ability to adopt to water smart practices depends on their ability to afford the cost of adoption of these practices. Individually, most of the farmers are unable to adopt to water smart practices due to the cost, lack of pull power and negotiations. Therefore, these farmers form groups that helps them to have a voice and a pull power. These groups seek to empower every farmer to have access to resource from government, donors and non-governmental organization.

Vegetable farmers engage in cooperative action that are in the form of inclusive business model in nature. Meaning, these farmers are not only interested in the income they get from their produce but foster environmental soundness community contribution as well. Inclusive Cooperatives empower members to have their voice heard, gives them negotiation power, empower the poor and vulnerable, and pull power that helps them to adopt water smart practices.

Vegetable farmers who are not formally registered are considered as non-inclusive. According to the literature, unregistered or informal groups lack formal mechanisms for inclusivity, such as democratic governance and open membership, whereas registered cooperatives frequently do, which results in the exclusion of underprivileged groups (Bijman & Wijers, 2019).

There are other factors that contribute to the adoption rate which include other institutional factors like access to credit, market, and irrigation water source which influence farmers' adoption or non-adoption of water smart practices. Farmers who have access to irrigation water facility turn to adopt to water smart practices like irrigation practices, water conservation practices. Access to market also influence farmers to adopt to water smart practices since after production, the farmers will have market for their products and hence reduces post-harvest loses. Many farmers lack adequate funding to buy inputs seasonal and out of season cultivation thereby they end cultivating once in a season. The conceptual framework is presented in a flow chat in figure 3.1

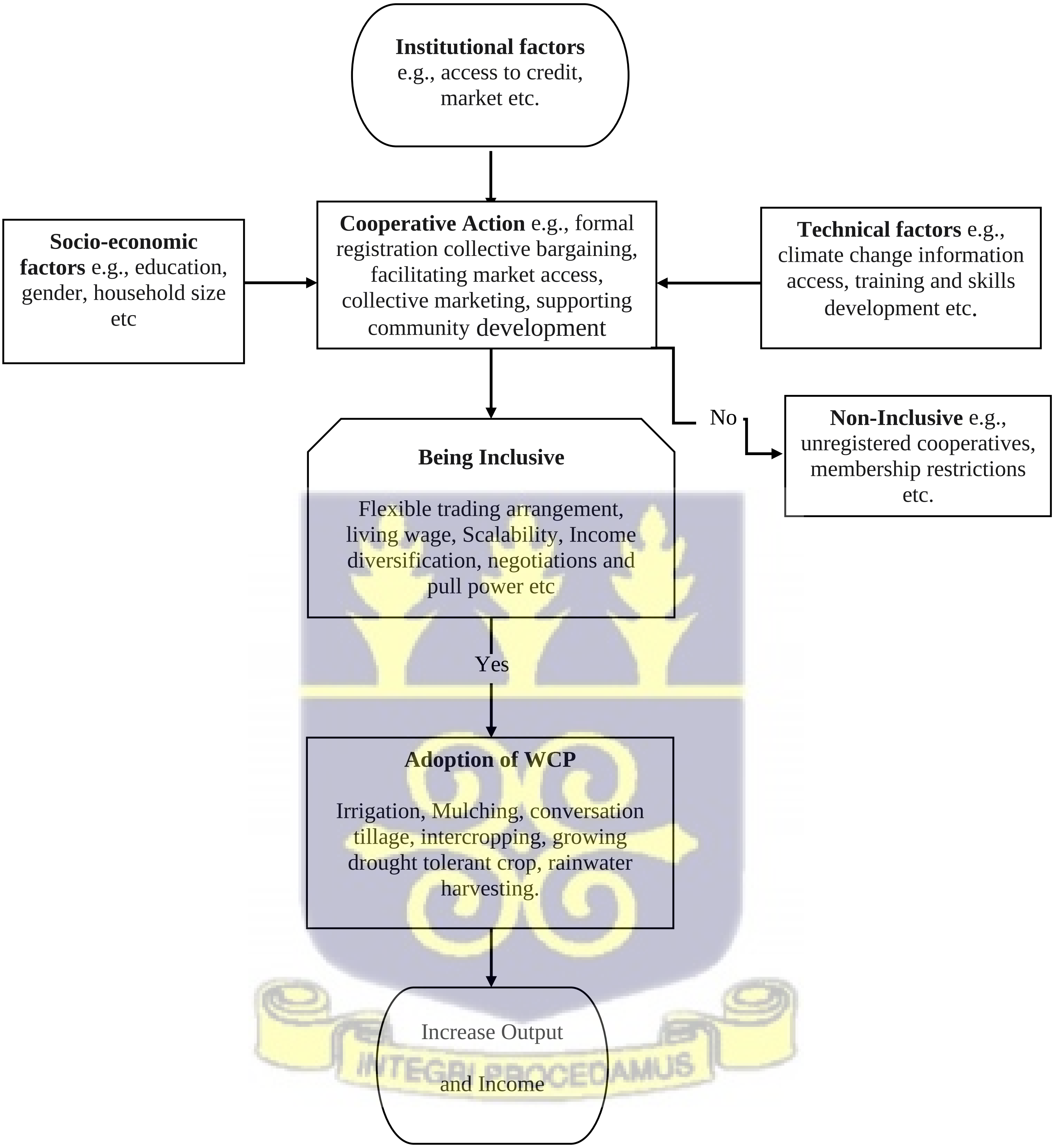

Figure 3.1: Conceptual framework: Linking ICBM to farm income

Source: Researcher's construct,2024

3.4 Method of Data Analysis

3.4.1 Determining the extent of inclusiveness of vegetable cooperatives in Southern Ghana.

Cooperative IBM application plays a vital role in ensuring that, farmers are empowered to increase their output and income. Nineteen (19) elements were used to measure the application of IBM by cooperatives in Ghana. These elements were selected from previous studies like (Mangnus, 2023; Vermeulen & Cotula, 2010; FAO, 2015). These 19 elements are categorised into four dimension which includes ownership, voice, risk and return (Vermeulen & Cotula, 2010; Baodu et al., 2024). This objective was analysed by asking the respondents (272 cooperative members) to rank their response on a five-point Likert scale of 1 - 5 with 1 being "strongly disagree" 2 being "disagree", 3 "neutral", 4 being "agree" and 5 being "strongly agree."

For each of the measuring element, the mean score and the median score were calculated. These scores were compared to determine whether the element is highly applied or lowly applied. Farmers who were not in any formal registered cooperative were considered as non-application of inclusivity. This classification is supported by previous studies (Mangnus, 2023; Vermeulen & Cotula, 2010).

The inclusion index was then calculated to determine the cooperatives' extent of application of Inclusion. The inclusion mean index was calculated by averaging the total inclusion application scores of the items used to measure inclusion. This is in conformity with Boadu et al., (2024), who used the Social Inclusion Index for their study on the topic, 'Social and solidarity economy, and social inclusion of cooperatives in the Assin Fosu Municipality, Ghana.' Similarly, Canada Mortgage and Housing Corporation (CMHC), (2021) used the Social Inclusion Index (SII) to measure the sense of belonging on five key dimensions.

Inclusivity mean score Index formula:

$$Inclusivity\ Mean\ Score\ Index\ = \frac{Total\ score\ of\ Inclusion\ elements\ per\ person}{Number\ of\ elments\ (19)} \quad (3.9)$$

In calculating for the inclusive scores for each element, formula (4.0) was used.

$$Inclusivity\ Mean\ Score\ Index\ = \frac{Total\ score\ of\ Inclusion\ of\ each\ elements}{Number\ of\ respondents\ (272)} \quad (3.10)$$

Low social inclusion was defined as a social inclusion score below the median inclusion index, while strong social inclusion was defined as a social inclusion score equal to or higher than the median (Boadu et al., 2024). This is applicable to inclusivity; hence, in this study, a low inclusivity application is when the inclusivity application mean score (inclusivity index) is below the median and strong/high when the inclusivity mean index score is equal to or greater than the median. Table 3.1 illustrate inclusivity measurements.

Table 3.1: Measurement of Inclusivity

Ownership Dimension
The cooperative is open and doesn't exclude vulnerable group
Doesn't discriminate members base on state of disability
Flexible trading arrangement
The cooperative helps land-poor
The cooperative give opportunity to the young farmers
Members have a sense of belonging
Voice Dimension
The cooperative is scalable in the medium term
Inclusive participation in decision making
The cooperative advocate and ensure suitable farming practices
The cooperative establishes strong negotiation power
The cooperative ensures gender equality and equity
Risk Dimension
The cooperative creates a living wage for assistance
The cooperative target poverty eviction
There is equal access to finance and credit facility
The cooperative provide access to cost effective inputs
The cooperative provides output aggregation
Reward Dimension
The cooperative allows diversified income streams
The cooperative build on existing skills and expertise of farmers
The cooperative provides training and capacity building
Median

Source: owner's computations 2024

3.4.2 Identifying the factors that influence participation in inclusive vegetable cooperatives

Vegetable farmers have a decision threshold of adopting the idea of joining to participate in an inclusive cooperative and this decision threshold is influence by various factors. When only one innovation is involved, probit/logit models are typically used to identify the factors influencing innovation adoption. Since vegetable farmers has the choice of selecting from joining a cooperative or not, the logit model is best for the analysis. According to Abebaw and Haile (2013), the logit model is appropriate for analysing the determinants of cooperative membership when farmers have the option to join or not join. Similarly, Verhofstadt and

Maertens (2014) utilized a logit model to examine the factors affecting smallholder participation in agricultural cooperatives in Rwanda.

The model is specified as:

$$P_i = \frac{e^{zi}}{1 + e^{zi}} \tag{3.11}$$

Where P_i is the probability of joining inclusive vegetable cooperatives, *e* represents the base of natural logarithms, and Z_i is a function of *n*-explanatory variables which is also expressed as:

$$Z_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + U_i \tag{3.12}$$

where $i = 1, 2, 3......n$; β_0 = intercept β_i = regression coefficients to be estimated, U_i = a disturbance term, and X_i = a set of observable characteristics.

From equation (3.11), the empirical model is specified as;

$Y^* = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 HHs + \beta_4 Edulev + \beta_5 VfExp + \beta_6 Region + \beta_7 Landsize$ *(acre)* + β_8*Exotic Vegetable* + β_9*Market access* + β_{10}*Credit access* + β_{11}*Contribution to community* + β_{12}*Irrigation water access* + β_{13}*Training and Skills Development* + β_{15}*Climate change information* + β_{16}*Perceived Income empowerment* + U_i

3.4.3 Determining vegetable cooperatives effectiveness on adoption of WCPs

This study assesses the degree to which a vegetable farmer has adopted climate-smart practices. The measure for the outcome variable is ordinal, ranging from "No adoption" to "High adoption". The ordered probit model was used to analyses the level of adoption. Since the values of an ordered probit model's coefficients do not indicate the extent of the independent variable's effect, the marginal effects of the corresponding models are examined in this work. The sign of the number of WCP adopted categories is used to interpret the marginal impacts.

A category's positive coefficient indicates that an increase in that variable will raise the chance of adopting more WCP, whilst a negative sign of any category would indicate that an increase in that variable will decrease the probability of being in that number of WCP adopted.

This study categorized six (6) type of WCP into no adoption category, low adoption category, moderate adoption and high adoption category. The no adoption category was specified as a category with zero (0) adoption of the listed WCP, low adoption was specified as farmers who adopted 1WCP, moderate adoption includes farmers who adopted 2-3 WCP and the high adoption category includes farmers who adopted 4-6 WCP. This categorification was in accordance with (Mwikamba et al., 2024).

The variable Y denotes the level of adoption of WCP. Where Y=1 signifies no adoption of WCP, Y=2 signifies low adoption of WCP (adoption of 1 WCP irrespective of the type of WCP), Y=3 signifies moderate adoption of WCP (adoption of 2-3 WCPs irrespective of the type of WCP) and Y=4 signifies high adoption of WCP (adoption of 4-6 WCPs irrespective of the type of WCP).

The list of WCP that were used for the measurement includes drip/sprinkler irrigation, conservation tillage, mulching, drought tolerant crop, cover cropping technique and rainwater harvesting. The list of WCP adoption include; Drip/sprinkler irrigation, conservation tillage, cover cropping technique, mulching, rainwater harvesting and drought tolerant crop. The econometric measure requires a model outside of the usage of binary choice econometric models, and as WCP adoption is ordinal and categorical, an ordered logit or probit model was found to be the most suited for the investigation. According to Greene (2002) even though the result is discrete, the multinomial probit or logit models are unable to account for the ordinal nature of the dependent variable. The error term is assumed to be normally distributed in the probit model and logistically distributed in the logit model. The most widely used model for ordered answer data in econometric studies is the ordered probit model, despite the fact that both produce the same findings, according to a study of the relevant literature. For this reason, the ordered probit model was used in this study to analyse the factors that influence the level of WCP adoption.

The ordered probit model as formulated by (McKelvey& Zavoina, 1975). is modelled on an unobservable latent random variable as follows.

$$Y * = X_i\beta_i + \varepsilon_i \text{ , } where\ i = 1,2 \ldots\ldots\ldots\ldots\ldots N \tag{3.13}$$

Where E $(\frac{\varepsilon_i}{x_i})$ = 0 and Var $(\frac{\varepsilon_i}{x_i})$) = 1. The observable variable,$Y^*{}_i$ is treated as an ordinal variable with J number of response categories and as a representation of the theoretical random variable, $Y^*{}_i$, and μ= μ−1 μ_0 $\mu_1 . . . \mu_j - 1\mu_j$ defined as a vector of unobservable threshold parameters, with the relation between the observable and the latent variable expressed as;

$$Y_i = j\ if\ \mu_{j-1} < Y^*{}_i \leq \mu_j, \quad j = 0, 1, 2, \ldots., J \tag{3.14}$$

Where $\mu_{j-1} = -\infty$, $\mu_0 = 0$, $\mu_j = \infty$ and $\mu{-1} < \mu_0 < \mu_i < \cdots < \mu_j$.

The probability can be written as.

$$Prob\,[\,Y_i = j] = Prob\left[\,\mu_{j-1} < Y^*{}_i \leq \mu_j\,\right] \tag{3.15}$$

$$= Prob\left[\,\mu_{j-1} - X_i\beta_i\right] < \varepsilon_i \leq \left[\,\mu_j - X_i\beta_i\right] \tag{3.16}$$

$$= \Phi\left(\mu_j - X_i\beta_i\right) - \Phi\left(\mu_{j-1} - X_i\beta_i\right) \tag{3.17}$$

Where J is the categories of responses to cooperative membership and Φ (.) is the standard normal cumulative distribution function.

$$\frac{\partial prob[Cellj]}{\partial X_i} \left[\Phi\left(\mu_j - X_i\beta_i\right) - \Phi\left(\mu_{j-1} - X_i\beta_i\right)\right] \times \beta \tag{3.18}$$

Where Φ (.) is the standard normal density function. Therefore, the empirical model for the analysis of this objective is specified as follows.

$$CM_{ij} = \alpha + \beta W_i + \delta Z_i + \mathcal{E}_i \tag{3.19}$$

The dependent variable, given as CM is the vegetable farmer cooperative membership status proxied by the number/level of WCP adoption. The subscript *i* characterises the i^{th}household, *j* (j = 0,1,2,3) and *j* (j = 0,1,2,) respectively represents, the four categories of the dependent variable indicated as; if vegetable farmers fall within no adoption, low adoption, moderate adoption and high adoption categories for WCP adoption.

The empirical model is specified as:

$Y^* = \beta_0 + \beta_1 Age + \beta_2 IBMCooperatives + \beta_3 \text{Vegetable Grown} +$

$\beta_4 \text{2023 vegetable income} + \beta_5 \text{ Land size} + \beta_6 \text{Cooperative implementation of WCP} +$

$\beta_7 \text{Credit} + \beta_8 Irrigation\ water\ access + \beta_9 Training\ and\ Skills\ Development +$

$\beta_{10}\ Climate\ change\ information + U_i$

Table 3.4: Variables, descriptions, unit of measurement and their expected outcomes (OPM)

Variables	Description	Unit of measurement	Apriori Expectation
Age	Age	Years	+/-
IBMCooperative	Cooperatives that apply IBM	Dummy (High=1, Low=0)	+/-
Vegtype	Type of vegetable	Local/exotic	+/-
EDU	Education level	Education level completed (years)	+
2023VegIncome	Income from vegetable in 2023	In (GHS)	+
FS	Farm size	In (acre)	+
Coo Imp. of WCP	Cooperative implementation of WCP	Ordinal values	+
Credit	Credit access	Dummy (yes=1, no=0)	+/-
IrrigaWater	Irrigation water access	Dummy (yes=1, no=0)	+/-
Training	Training and skills development	Dummy (yes=1, no=0)	+
ClimateAcces	Climate change information access	Dummy (yes=1, no=0)	

3.4.4 Measuring the impact of cooperative membership on output and income of vegetable farmers

The propensity scores matching (PSM) procedure was employed to measure the impact of cooperative membership on income and output. This variable gauge the economic benefits of inclusive cooperative membership in terms of income generated from vegetable farming and output of selected vegetable crops.

By conveniently summarising the conditional probability of a member given pre-treatment characteristics, the propensity score matching (PSM) technique matches each member unit to a non-member unit based on similar observable characteristics, thereby helping to adjust for initial differences between member and non-member groups (Rosenbaum and Rubin 1983). As a result, the propensity score is predicted using a logit model as the initial step in PSM and the results were used to predict the propensity scores. The scores give the likelihood of a vegetable farmer benefits from participating in an inclusive cooperative given its characteristics.

The next crucial step after estimating the propensity scores is to impose the common support region because only in this region can the average treatment effect be determined for both the treated and the population (Caliendo and Kopeinig 2008). The common support region is defined by excluding observations whose propensity scores are less than the minimum of the treated group and more than the maximum of the comparison groups. It is the area that falls between the minimum and maximum propensity scores of the treated (vegetable cooperative members) and comparison groups (non-members), respectively (Caliendo and Kopeinig 2008). Selecting an appropriate matching estimator comes after this stage. A number of matching estimators were listed by Caliendo and Kopeinig (2008). These included stratification, which compares the outcome within intervals/blocks of propensity scores, nearest neighbour, which selects an individual from a comparison group as a matching partner for a treated individual that is closest in terms of propensity score, radius matching, which selects an individual from the comparison group as a matching partner for a treated individual that lies within a given radius, and kernel, a non-parametric matching estimator that constructs the counterfactual outcome using weighted averages of all individuals in the control group.

The study used the Nearest Neighbour (NN) matching method, which matches each treatment unit to the comparison unit with the propensity score that is nearest to it. It is one of the most used matching techniques and one of the simplest to use. In order for the matched groups to be credibly counterfactual after matching, a covariate balancing test was necessary to make sure that the disparities in the covariates in the two groups of matched samples were eliminated.

There are two underlying assumptions to the PSM technique. The first assumption, known as unconfoundedness, maintains that program uptake depends only on characteristics that are observable (Rosenbaum & Rubin, 1983). A common support or overlap condition is assumed second assumptions. This requirement guarantees that comparison observations are close to the propensity score distribution for the treatment observations.

The matching quality check, which determines whether or not the matching process can balance the distribution of various variables, is the fourth crucial stage in the PSM process. If there are discrepancies, this suggests that the matching process was insufficient or unsatisfactory, and corrective measures should be taken (Caliendo and Kopeinig, 2008). The next stage is to determine whether the treatment changed the effect indicators if a good match with the expected household participation probabilities is obtained. The difference in mean outcome between matched cooperative members and non-members who have shared support, conditional on the propensity score, determines the average treatment effect on the treated (ATT). According to Pufahl and Weiss (2008), noted that, the most common evaluation parameter of interest in PSM is the mean impact of treatment on the treated (ATT).

Thus, the average effects of joining a veggie cooperative will be as follows:

$$ATT = Y\,(D_i = 1) - Y\,(D_i = 0) \tag{3.20}$$

$$= E\left(Y_i^1 - Y_i^0 \,\middle|\, P_i = 1\right) \tag{3.21}$$

$$= E\,[Y_i^1 \,|\, P_i = 1] - E\,[Y_i^0 \,|\, P_i = 1] \tag{3.22}$$

This answers the following question: ‘How much did farms participating in the water smart agriculture benefit compared to what they would have experienced without participating in the water smart agriculture?’

The variables, their descriptions, units of measurement and expected outcomes are shown in table 3.4

Table 3.5: Variables, descriptions, unit of measurement and their expected outcomes

Variables	Description	Unit of measurement	Apriori Expectation
Age	Age	Years	+/-
GEN	Gender	Dummy (Male=1, female=0)	+/-
HH	Household Size	Actual number of persons	+/-
EDU	Education level	Ears of education	+
AINCOME	Annual Income	In (GHS)	+
MS	Marital status		+/-
FarmExper	Vegetable farming experience		+/-
FS	Farm size	In (acre)	+
Region	Region		+/-
Vegtype	Type of vegetable	Local/exotic	+/-
Market	Market access	Dummy (yes=1, no=0)	+
Credit	Credit access	Dummy (yes=1, no=0)	+/-
Contrib	Community contribution	Dummy (yes=1, no=0)	+
IrrigaWater	Irrigation water access	Dummy (yes=1, no=0)	+/-
Training	Training and skills development	Dummy (yes=1, no=0)	+
ClimateAcces	Climate change information access	Dummy (yes=1, no=0)	
Income empowers	Perceived income empowerment	Dummy (yes=1, no=0)	+

Source: Author's

3.5 Method of Data Collection

3.5.1 Sources of data and instruments employed

The study employs multiple sources, including surveys, and interviews to collect data. Key informant interviews were conducted with officers from Soil Research Institute of CSIR, Water

Research Institute of CSIR, International Water Management Institute (IWMI), Ghana Irrigation Development Authority (GIDA), and Crop Research Institute of CSIR (see Appendix 3.1 for interview guide). Structured questionnaires served as the primary instrument for gathering data from individual vegetable farmers and cooperative members (see Appendix 3.2). Additionally, secondary data from government reports, agricultural organizations, and relevant literature were utilized.

3.5.2 Sampling procedure

The sampling procedure involves selecting a representative sample of vegetable farmers and cooperative members from various regions. The study first used multi-stage sampling technique which involves a series of sampling procedures. Purposive sampling was used to select the regions, districts and communities from the database of "Building Vegetable Farmers Resilience against Climate Change" project (University of Ghana). The study employed stratified random sampling to ensure the diversity of the sample in terms of geographical location and cooperative participation. A total of 561 vegetable farmers were randomly sampled from both the treatment and control groups. The sample size was based on the Slovins formula, which provides the sample size (n) using the known population size (N) and the acceptable error value (e). The formula is given below.

$$n = \frac{N}{(1 + Ne^2} \tag{3.23}$$

3.5.3 Interview procedure and ethical considerations

The survey was conducted as an in-depth interview with individual farmers face-to-face in the homes, farms and community centres. A few key informants, such as cooperative leaders and agricultural experts were also interviewed individually, to gain a deeper understanding of the dynamics within inclusive cooperative models and the adoption of water related climate-smart practices. Closed-ended questionnaires were administered to the individual vegetable farmers.

The researcher applied and utilised ethical considerations for the data collection in the study. The researcher ensured that all respondents were fully informed about the purpose of the study, the nature of their participation, and their rights. This included providing clear information about how their data would be used and ensuring they understood they could withdraw from the study at any time without penalty. The respondents were informed that, their identities would remain confidential, and data would be anonymized to protect personal information.

The researcher engaged with respondents respectfully, ensuring that their cultural norms and values were respected throughout the data collection process. This included being sensitive to local customs and practices when interacting with farmers. Also, Participation was strictly voluntary, with no coercion involved. Respondents were reminded that they could choose not to answer specific questions if they felt uncomfortable.

Measures were implemented to securely store collected data, ensuring that it was accessible only to authorized individuals. Finally, in disseminating results and findings, the researcher committed to presenting findings accurately and responsibly, avoiding any misrepresentation of participant contributions or experiences.

3.5.4 The Study Area

The study was conducted in Central, Greater Accra and Eastern Regions of Ghana, focusing on areas with a significant presence of vegetable farming and inclusive cooperative models as detailed below.

Central Region

In Central Region, two districts which are Gomoa East and Gomoa West Districts were selected for the study. These Districts were selected based on recommendation of earlier researchers of the same project.

Gomoa East District (Potsin)

The district, with Gomoa Potsin as its capital, was formed in 2018 as one of the 38 newly established and upgraded district assemblies, curving out of the Gomoa Central District Assembly (formerly Gomoa East). The boundaries of the Agona West Municipality, Effutu Municipality, Gomoa West District, Awutu Senya East Municipality, and the Awutu Senya West District are shared by the Gomoa East District. It is approximately 260.69 square kilometres in size. As per the 2021 population and housing census, the district has 308,697 residents, comprising 152,238 males and 156,459 females (Ghana Statistical Service,2021).

According to the Republic of Ghana Composite Budget For 2023-2026 Programme Based Budget Estimates For 2023 Gomoa East District Assembly, N.D., the estimated total area used for agriculture is 169.25 square meters, with the following crops been cultivated which including cassava, maize, sugar cane, pineapple, rice, pawpaw, vegetables, citrus, yam, and plantains is encouraged by the district's ecology. As a result, non-traditional crops including pineapple, chilly and birds-eye pepper, and Asian vegetables are now being grown. The major vegetable crops grown includes okro, green pepper, tomatoes, garden eggs, and onions (Ghana Statistical Service,2021).

Gomoa West (Okyereko)

Gomoa West District: Located in the eastern portion of Ghana's Central Region, the district has Apam as its administrative capital. Its latitudes range from 514 to 535 north, while its longitudes range from 0.22 to 054 west. The district is 465 square kilometres in total area on land. Gomoa West District borders Mfantseman Municipal to the west, Effutu Municipal to the east, and the Gulf of Guinea to the south. It also shares boundaries with Gomoa East District to the north (Ghana District, 2024). As per the 2021 population and housing census, the district has 129,512 residents, comprising 59,420 males and 70,092 females (GSS,2021).

Okyereko community was selected for the study. Okyereko has an irrigation facility where they have formed an organised Water User Association which allies with the study. The irrigation scheme covers about 81 hectares of farmland with more 130 farmers who engage in various agricultural activities including vegetable cultivation. The major vegetable grown at Okyereko includes okro, tomatoes, and garden eggs though rice and maize are the major crops grown at Okyereko.

Greater Accra Region

Ashaiman Municipal (Jericho)

The Ashaiman Municipality is roughly 30 kilometres from Accra, the Ghanaian capital, and 4 kilometres north of Tema. Ashaiman is located between Latitude 5° 42' North and Longitude 0° 01'west, whereas Tema is located on the Greenwich Meridian at Longitude 0 0. The Municipality borders Adenta Municipal to the north, La Nkwantanang Madina Municipal to the west, Tema Metropolitan to the east, and Ledzokuku Municipal to the south (Ghana District, 2024).

As per the 2021 population and housing census, the Municipality has 208,060 residents, comprising 103,410 males and 104,650 females (GSS, 2021).

The project covers about 150 hectares of which about 56 hectares are under irrigation. The crops cultivated at the site includes maize, rice and vegetables. The major vegetables include okro, tomatoes, green pepper, ayoyo, cabbage, lettuce, and alefu.

Ga East Municipal Assembly (Atomic)

Ga East Municipal (GEMA) is one of the 29 districts in Greater Accra region. Crop, poultry, and livestock production are the main agricultural activities. A variety of vegetables are grown, including peppers, tomatoes, cabbage, okra, and garden eggs among others.

The Ga East Municipal Assembly is situated in the Greater Accra Region's northern part. Abokobi serves as the Municipality's administrative capital. The Municipality borders the Accra Metropolitan to the south, the Akwapim South District to the north, the Ga West Municipal to the west, and the La Kwantanang Municipal to the east (Ghana District, 2024). As of the 2021 population and housing census, the Municipality has 283,379 residents, comprising 140,015 men and 143,364 women (GSS, 2021). GEMA has a land coverage of about 113 km^2.

The Atomic size was selected for the study as result of recommendation from an earlier researcher of the same project. The farmers at Atomic cultivate on the land of Ghana Atomic Energy Commission (GAEC)/BNARI. The land is leased to them with a yearly subscription of about GHS 2000.00. The size is also popular when it comes to vegetable production and with an established cooperative.

Ayawaso West Wuogon Municipal Assembly (AWMA)

The Ayawaso West Municipality covers 385 km² of land, which accounts for approximately 3.0% of the Greater Accra Regional land area. It is situated in latitude 00°06'W and longitude 05°35'N. The Municipality is surrounded by the following municipalities: La Nkwantanang Madina Municipal in the north; Adenta Municipal in the northeast; Ledzokuku Municipal in the east; La Dade Kotopon Municipal in the southeast; Ayawaso North Municipal in the south; Accra Metropolitan in the south-west; Okaikwei North Municipal in the west; and Ga East Municipal in the north-west (Ghana District,2024). According to the population and housing census conducted in 2021, there are 75,303 people living in the Municipality, including 38,164 men and 36,689 women (GSS, 2021).

Eastern Region

West Akim Municipal District

There are thirty-three (33) districts in Ghana's Eastern Region, including the West Akim Municipality. In 2008, the district gained municipal status, with Asamankese serving as the municipal capital. The West Akim Municipality is located between latitudes 500 40′ North and 600.0′ North and longitudes 00 25′ West and 00 47′ West. Its borders are shared by Suhum Municipal and Upper West Akim District to the east, Agona, Awutu-Efutu-Senya, and Ga Districts to the south, Denkyembour District to the north, and Birim South District to the west. An estimated 559 km2 make up the Municipality's total land area (Ghana District,2024). Asamankese, the municipal capital, located roughly 75 kilometres northwest of Accra.

Generally speaking, the ground is undulating, with elevations between 60 and 460 meters above sea level. The Atiwa Range, which lies between Pabi and Wawase, is the highest point. The moist semi-equatorial climate zone includes the municipality. The bi-modal rainfall ranges from 1,238 to 1,660 mm. The range of temperatures is 25.20C to 270C. Cocoa, coffee, citrus, oil palm, rubber, cassava, yam, plantain, maize, and non-traditional crops like tiger nuts, black pepper, ginger, and sweet berries can all be grown in the municipality's rich, well-drained soil. The soils are suitable for growing vegetables, rice, and sugar cane. About 52.1% of the working force is employed in agriculture, which is the district's main economic sector.

Nsawam-Adoagyire Municipal District

The Nsawam Adoagyiri Municipality is a part of the thirty-three (33) municipalities and districts in Ghana's eastern region, and it is one of the country's 261 metropolitan, municipal, and district assemblies. The Municipality's capital is Nsawam, and it is located in the southeast of the Eastern Region between latitudes 5'.45 N and 5'.58 N and longitudes 0.07'W and 0.27' W. Out of the Eastern Region's overall territory, the Municipal encompasses roughly 175 square kilometres. It is bordered to the east by Akwapim South District, to the north and west by Suhum Municipal, and to the south by Ga West Municipal. According to the 2021 population and housing census, there are 155,597 people living in the Municipality, comprising 76,417 men and 79180 women (Ghana Districts, 2024).

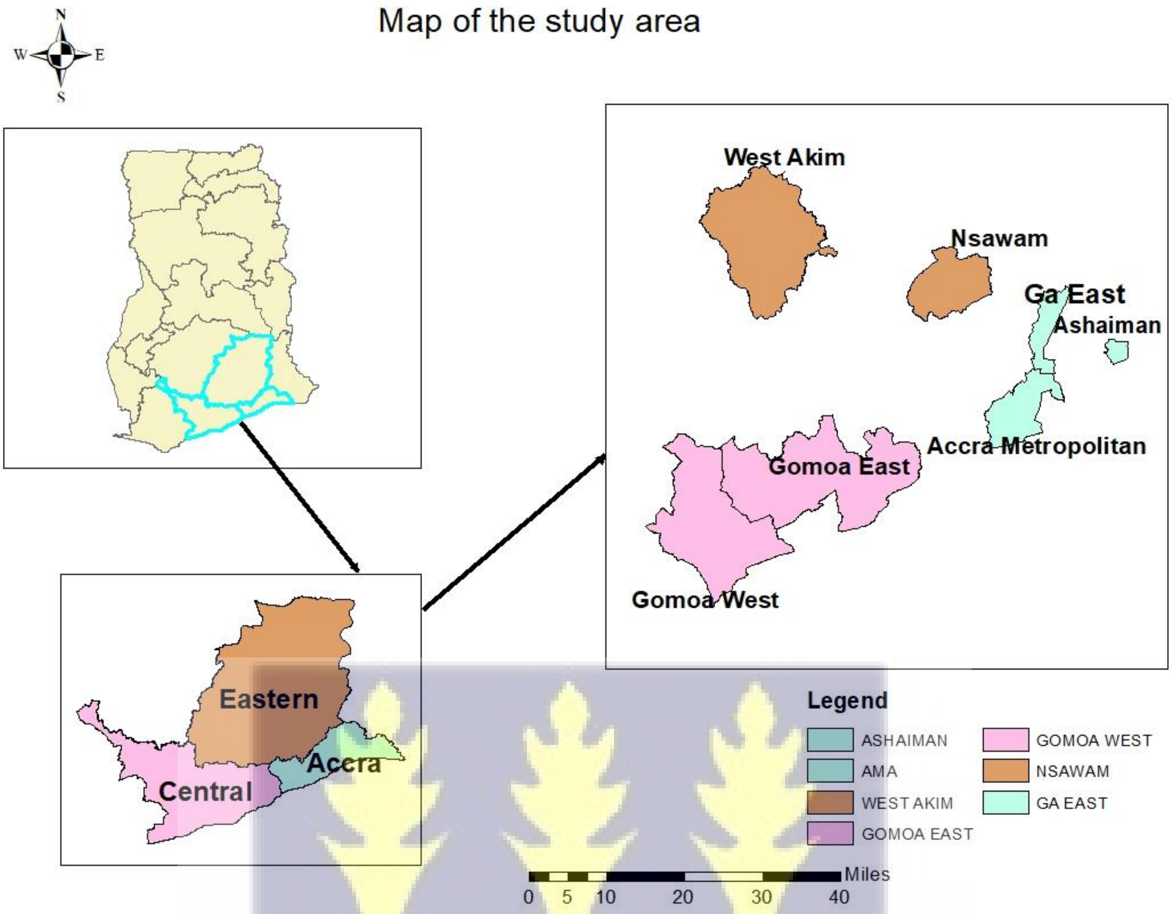

Figure 3.2: The Study area

Source: Author, 2024

3.6 Scope and Limitations of the Study

The study primarily focuses on evaluating the effectiveness of inclusive cooperative models in driving the adoption of water-related climate-smart practices among vegetable farmers at the local and company levels in selected regions of Ghana. The study concentrates on cooperative membership's impact on climate-smart practices, economic outcomes, and resource access, particularly in the context of local communities and small-scale enterprises engaged in vegetable farming. In relation, the findings may not fully represent the diverse agricultural practices and conditions across the entirety of Ghana. Again, data quality relies on surveys, interviews, and secondary sources, potentially influenced by respondent bias or recall errors.

The study again reflects data collected during a specific time frame, which may not capture long-term changes or seasonal variations.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results of the study. The first session discusses the background of the respondents. Then the results of each specific objective of the study are presented and discussed in the main and sub-sections.

4.2 Background of the Respondents

The background of the respondents comprises of the personal, household, farm and community characteristics of the respondents in the study area and these are explained with relative frequencies tables and figures.

4.2.1 Personal level characteristics of respondents

Age: The age distribution of the study is presented in Table 4.1. The mean age of the study is approximately 47 years with the youngest farmer being 15 years old and the oldest farmer being 85 years old. The mean age of 46 years mimics the national average age of farmers, which is estimated as greater than 40 years, implying dominance of aged rather than younger adults (https://mofa.gov.gh).

Table 4.1: Personal level characteristic of respondents

	G. Accra	Central	Eastern	Total	G.Accra	Central	Eastern	Total	G. Accra	Central	Eastern
Age	42.44	49.97	47.60	46.67	12.55	10.99	9.88	11.72	197	208	156
Vegetable Farming experience	14.41	16.95	19.64	16.81	9.67	10.97	12.36	11.13	197	208	156
Household size	4.49	5.53	6.16	5.34	2.25	2.07	2.75	2.43	197	208	156
Household dependent	2.76	4.22	4.88	3.89	1.95	1.97	2.69	2.35	197	208	156
Household labour on farm	2.58	2.71	2.51	2.61	1.19	1.04	0.91	1.06	197	208	156
Income from vegetable in 2023 (GHS)	14,308.33	8,199.86	7,594.23	10,176.49	12,085.77	6,252.71	6,181.69	9,244.79	197	208	156

Source: survey data, June 2024

Gender: The gender distribution shows that, there are more men involved in vegetable farming in the study area than women. With a frequency of 453 representing approximately 81%, males were the dominate vegetable farmers and with 108 female farmers representing approximately 19% in the study (Table 4.2). Empirical studies from Abdul-Razak and Kruse (2017), Adzawla et al. (2020) and Owusu et al. (2021) found that, vegetable farming is dominated by males in Southern Ghana.

Marital Status: Marital status influences farmers to increase productivity due to interest in high income to address family issues. From the results, majority of the respondents were married (thus, 473 respondents representing 84.31%). For the single, 40 of the respondents representing 7.13% are unmarried, 20 respondents representing 3.57% are divorced and 28 respondents representing 4.99% are widow/widower. This is shown in table 4.2.

Household size: the household size of respondents which could be a contributing factor of family labour ranges from a minimum of one (1) to a maximum of 25 including the respondents. The mean of 5 is slightly higher than the national average rural household size of 4 (https://dhsprogram.com).

Household dependents: the household dependents including spouses of the respondents show that, the minimum dependents are zero (0) the maximum dependent is 17 persons. This indicates that, aside the farmer, almost all the household members are dependent on the activities of the respondents for their daily needs.

Household labour: About three household dependents work on the farm. A maximum 8 dependents work on the farms of the respondents. Of course, there are older people among the respondents who might not have enough strength and energy required to engage in farming activities, the dependents help them at the farm.

Table 4.2: Personal level characteristic of respondents

Variable	Frequency	Percent
Gender		
Female	108	19.25
Male	453	80.75
Marital status		
Unmarried	28	4.99
Married	473	84.31
Divorced	40	7.13
Widow(er)	20	3.57
Education level		
No formal education	112	19.96
Basic education	330	58.82
Secondary education	110	19.61
Undergraduate degree	7	1.25
Master's degree	2	0.36
Main occupation		
Farmer	532	94.83
Trader	17	3.03
Teacher	2	0.36
Security	6	1.07
Others	4	0.71

Residential status		
Indigent	367	65.42
Migrant	189	33.69
Foreigner	5	0.89

Source: survey data, June 2024

Education level: Education is key to success in every society. Education paves the way for the wellbeing of society. It makes people adopt innovation and technology easily. Education also plays an important role in peoples decision making process especially in terms of trying new technology or innovation in agriculture. The results of the study showed that 330 respondents representing approximately 59% had basic education (primary and junior high school). 110 respondents representing approximately 20% had secondary education, 112 respondents representing 2% had no formal education, and the rest obtained tertiary level education. These results show that there are more farmers in the sample that had formal education. Having a form of formal education puts the farmers in an advantage of having the ability to make well informed decision regarding current trends, challenges and innovative technologies that help boost productivity. Several studies have documented the relationship between education and the adoption of agricultural innovations in Southern Ghana. For instance, Abdul-Razak and Kruse (2017) found that educated farmers are more likely to adopt climate-smart agricultural practices, as they possess better comprehension of the benefits these practices offer. This aligns with findings from Adzawla et al. (2020) study conducted in South Tongu and Zabzugu districts of Ghana, which demonstrated that higher educational levels correlate with increased engagement in water-related climate-smart practices among vegetable farmers.

Vegetable farming experience: one crucial variable that was measured was the years of experience of vegetable farmers. The results show that, the minimum year of experience is one (1) year, and the maximum years is 56 years. This year of experience is important since cooperative shares information and knowledge among members. The mean year of experience is approximately 17 years. This means the sample vegetable farmers understand their practices and challenges and can make informed decisions in respect of cooperation.

Income from vegetable in 2023: the respondents were asked about the income generated for the whole farming seasons of 2023. The average income from vegetable farming (up to three seasons) was GHS10, 641.12; the maximum income was GHS 76,100.00.

Religion: Religion is a free choice of communicating with God. In Ghana, there are three major religions which include Christianity, Islam and Traditional. Majority (75%) of the respondents were Christians, and the rest were of Islam (23%) and Traditional (9%) religion.

Main occupation: Occupation is source of income for the working class. There are many sectors in Ghana, but the notable sectors include agriculture and service sectors. In the agricultural sector, there are inputs supply, production, trading and agro-processing sub-sectors. The results showed that, majority (94%) were farmers; there were few traders (4%), teachers and security persons.

The GSS regularly publishes reports on employment and economic activities in Ghana. Their 2021 Population and Housing Census indicated that agriculture remains a primary source of livelihood in many regions, including Central, Eastern, and Greater Accra. The census data show a 42.5% of households engaged in agricultural activities, reflecting the importance of farming as a major occupation. Adzawla et al. (2020) examined the impact of climate change on vegetable production in Southern Ghana and highlighted that a large proportion of farmers in the Central and Eastern regions relied on farming as their main source of income. The authors noted that vegetable farming is particularly prevalent due to favourable climatic conditions and market demand in these areas.

Residential status: The results show that, 367 respondents representing 65.42% were indigenes, 189 respondents representing 33.70% were migrants from Ghana and 5 respondents representing 0.89% were foreigners.

4.2.2 Farm level characteristic of respondents

Land Ownership: Land ownership is key in farmers decision in long term investment on the farm in terms of fixed assets which includes irrigation equipment like pipes, dugout, and underground water drilling. Results from the study show that approximately 35 of the respondents owned the land the used for their farming activities and 65% do not own the land they use for the farming activities (Table 4.3).

Land Acquisition: Farmers sometimes acquire lands for their farming activities when they do not own a title for themselves. The results from the study indicated that 4% of the respondents acquired the land from friends, 39% acquired the land from the government, 43% rented the land from private persons and 14% acquired the land from cooperative land.

Total Land Size: the minimum land size of the respondents was 0.2 acres; the maximum land size is 65 acres and mean land size is 2.38 acres (approx. 1Ha), suggesting small holdings.

Table 4.3: Farm level characteristic of respondents

Variable	Mean	Std. Dev.	Min	Max
Total land size	2.6	4.2	0.2	65
Land under vegetable irrigation	1.4	2.7	0.0	55
Variable	**Frequency**			**Percentage**
Land ownership				
Not own land	366			65.24
Own land	195			34.76
How did you get the land				
Friend's land	8			3.01
Government land	111			41.73
Rented land	94			35.34
Cooperative land	53			19.92

Source: survey data, June 2024

Land under irrigation: Irrigation is key for vegetable farming especially during the dry season and when there are irrigation water resources available. The results of the study showed that majority of the respondents use irrigation; the maximum land under irrigation is 11 acres. This could be as a result of the irrigation facilities system of land apportioning. At Ashaiman and

Okyereko irrigation facilities, each farmer is apportioned land of 1 acre to 2 acres. A total of 36 (6.42%) respondents had no land under irrigation. A total of 82% (460) respondents had their land ranging from 0.1-2.0 acres under irrigation. Also, 6.77% (38) respondents had their land ranging from 2.1-4.0 acres under irrigation. Ranging from 4.1-6.0, 3.21% (18) had their land was under irrigation. With a land ranging from 6.1-8.0 acres, 0.89% (5) respondents' land was under irrigation and with 0.71% (4) respondent had their land ranging from 10 acres and above under irrigation. Figure 4.1 shows the data of land that were used under vegetable irrigation during the study.

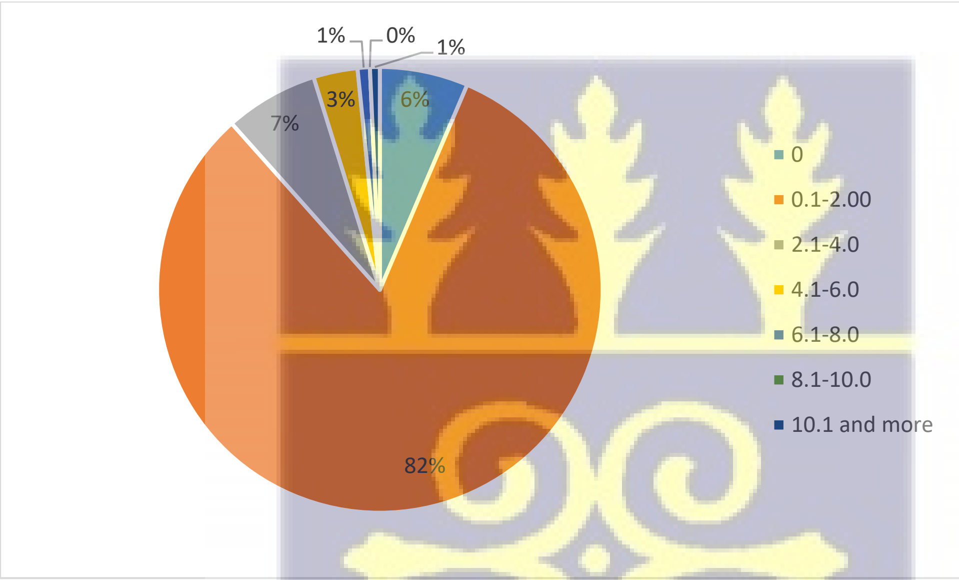

Figure 4.1: Land size under vegetable irrigation
Source: Field data (2024).

Types of vegetable: In the three regions, there were different vegetables cultivated though there were some vegetables that were common in all the regions. In terms of lettuces cultivation, 16.86% (68) respondents were cultivating lettuce. 18.20% (73) cultivated cabbage, 33% (133) of the respondents cultivated green pepper, 36.97% (149) respondents cultivated tomatoes, 18.61% (75) respondents cultivated cucumber, 84.37% (340) respondents farm other vegetables. The other vegetable includes 57.57% (232) of the respondents' farm okro, 9.68%

(39) farm onion, 17.62% (71) farm garden egg, 5.21% (21) farm ayoyo, 3.97% (16) farm alefu, 8.19% (33) farm pepper (sweet).

Table 4.4: Types of vegetables cultivated by respondents

Crop	Frequency	Percentage
Lettuce		
No	470	83.78
Yes	91	16.22
Cabbage		
No	464	82.71
Yes	97	17.29
Green pepper		
No	376	67.02
Yes	185	32.98
Tomatoes		
No	340	60.60
Yes	221	39.40
Cucumber		
No	466	83.07
Yes	95	16.93
Okro		
No	231	41.18
Yes	330	58.82
Onion		
No	519	92.51
Yes	42	7.49
Garden egg		
No	471	85.98
Yes	90	14.02
Ayoyo		
No	537	95.72
Yes	24	4.28
Crop	Frequency	Percentage
Alefu		
No	545	97.15
Yes	16	2.85
Pepper		
No	512	91.27
Yes	49	8.73
Other Vegetable		
No	128	22.82
Yes	433	77.18

Source: survey data, June 2024

4.2.3 Community level characteristics of respondents

Regions: In Ghana, the country has been divided into sixteen (16) regions with the aim of fostering decentralisation and development. In the study, three (3) regions were selected, which includes Greater Accra, Central, and Eastern Regions. Greater Accra Region represented 40.20% (162), Central Region, 34.74% (140) and Eastern region,25.06% (101) of the sample (Table 4.5).

Districts: Districts are localised administrative office for the government in geographical areas in Ghana. Ghana currently has 261 district which is made up of 109 municipal districts and 145 ordinary districts and 6 metropolitan districts. Greater Accra Region has 26 districts, Central Regions has 22 administrative districts, and Eastern Region has 33 districts. The study area was made up of three (3) districts from Greater Accra Region and two (2) each from Central and Eastern Regions. Eleven (11) communities were used for the study with Greater Accra made up of four (4) communities, two (2) communities from Central Region and five (5) communities from Eastern Region.

Table 4.5: Tabulation of Regions, districts and Communities

Region	Frequency	Percent	District	Community(ies)
Greater Accra	197	35.12	Ashaiman Municipal Assembly	Jericho
			Ayawaso West Municipal Assembly	Roman Ridge and CSIR
			Ga East Municipal Assembly	Atomic Energy
Central Region	208	37.08	Gomoa East District	Potsin
			Gomoa West District	Okyereko
Eastern Region	156	27.81	West Akim Municipal District	Ekorso
			Nsawam-Adoagyire Municipal District	Bronikrom Nyamebekereye Boukurom Duayede
Total	561	100		

Source: survey data, June 2024

Cooperative membership: Cooperative membership offers farmers opportunities and access to resources. Belonging offers training and learning opportunities to members, these training could be from within or organize by the cooperative. From the study, 48.57% (272) respondents belong to a cooperative and 51.43% (289) respondents did not belong to any cooperative.

Cooperative formal registration: cooperative in Ghana are supposed to register their cooperative at the office of Department of Cooperative. Formal registration makes the cooperative visible and legally recognised. 48.57% (272) respondents had their cooperative legally and formally registered at the office of Department of Cooperatives. This means, all those cooperatives that the respondents belong, are all registered.

Position in cooperative: Majority of the respondents (92.65%) were members and 7.35% of the respondents were executives.

Cooperative name: Name gives every person and objects a unique identity. Name makes identification easy and as a matter fact, groups, companies, business, places and organisation are given unique names. A cooperative name is given by the members of the cooperative which when fully and formally registered at the Department of cooperatives, make it unique and traceable. From Table 4.6, the results showed that the Abapa Farmer Group and Potsin were 19.12% (52), Adom Wo Vegetable Cooperative was 4.41% (12), Ashaiman Irrigation Farmers Association was 11.76% (32), Ashaiman Water Users Association was 8.09% (22), BNARI Land Vegetable Growers and Marketing Cooperative Society was 10.29% (28), Bisa Farmers Association was 5.15% (14), Bronikrom Vegetable Farmers Association was 1.47% (4), Okyereko Water Users Association was 23.53% (64), Potsin Rice and Abapa Farmers Association was 6.25% (17), Roman Ridge Vegetable Growers Association was 3.31% (9), and Trassaco Vegetable Farmers Association was 6.62% (18).

Table 4.6: Community level characteristics of respondents

Variable	Frequency	Percentage
Non-members	289	51.43
Members	272	48.57
Not Registered	289	32.51
Registered	272	67.49
Abapa Farmer Group, Potsin	52	19.12
Adom wo wio Vegetable Cooperative	12	4.41
Ashaiman Irrigation Farmers Association	32	11.76
Ashaiman Water Users Association	22	8.09
BNARI Land Vegetable Growers and Marketing Cooperative Society	28	10.29
Bisa Farmers Association	14	5.15
Bronikrom Vegetable Farmers Association	4	1.47
Okyereko Water Users Association	64	23.53
Potsin Rice and Abapa Farmers Association	17	6.25
Roman Ridge Vegetable Growers Association	9	3.31
Trassaco Vegetable Farmers Association	18	6.62

Source: Survey data, June 2024

In all the communities visited, there was electricity, local market (for input dealers and product sales), portable water, financial institutions (formal and informal) and motorable roads.

4.3 The Extent of inclusivity of Vegetable Cooperatives in Southern Ghana

The results from the study indicated that, cooperatives in the study area apply inclusive business model. The study first asked respondents concerning their perception about inclusion in their cooperative. The results indicated that, 93% (253) perceived that, their cooperative is inclusive and 6.99% (19) perceived their cooperative are non-inclusive . In terms of regional analysis, of the total 253 cooperative members who perceived their cooperative as inclusive, 6% are from the Eastern region, 46% from the Greater Accra region, and 48% from the Central region. Similarly, out of the 19 respondents who perceived their cooperative non-inclusive, 2.21% are from Greater Accra region and 4.78% are from Central region. This result is shown in figure 4.3.

Several empirical studies support this finding, for example, Abdul-Razak and Kruse (2017) found that cooperatives play a significant role in enhancing farmers' access to resources and information. The authors noted that cooperative models foster a sense of community and shared purpose, which contributes to a positive perception of inclusion among members.

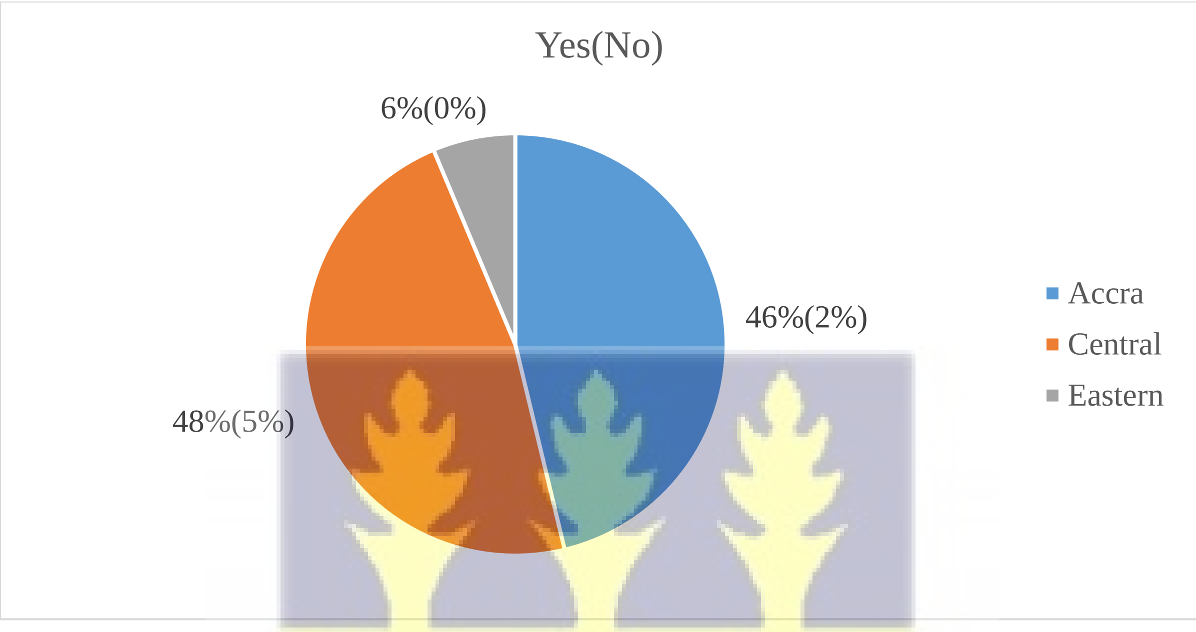

Figure 4.3 Perception of cooperative inclusion

Source : Field data (2024).

Also, Kiptot and Franzel (2012) found that cooperatives significantly enhance members' perceptions of inclusion by providing access to resources, training, and market opportunities. While this study was conducted in Kenya, its findings are relevant to understanding how similar cooperative structures can promote inclusivity in Ghana.

The results on the extent of IBM application study showed that approximately 50% of the respondents perceived the application by vegetable cooperatives as low level. In Ghana, cooperatives have yet to apply inclusive business models (IBMs) highly and very often, especially in rural areas. Studies show that although cooperatives, like the ones in the Assin Fosu Municipality, improve access to financial resources and thereby promote social inclusion, their interaction with IBMs is quite low (Boadu et al., 2024). A study conducted on smallholder rice farmers found that while joint venture models are preferred, IBMs are not widely used, with very few farmers expressing interest in them (Creppy et al., 2024).

In terms of the four (4) dimensions, risk dimension of IBM was low (all items which was used to measure risks were all low). Voice dimension had two (2) items which measure voice dimension low, ownership and reward dimensions had one (1) item being low.

The median score was 4.34, this median was compared with the mean score of each of the 19 items to ascertain the extent of each item's application in the various cooperatives. The results indicated that, when it comes to cooperatives helping land poor farmers who are members of the cooperative, it is low. This limitation can largely be attributed to the challenges associated with securing land, which remains scarce and difficult to obtain. The land tenure issues in Ghana are particularly concerning, complicating the ability of cooperatives to secure land for their members. Additionally, many cooperatives in Ghana face financial instability, which further hinders their capacity to acquire land on behalf of their members. In certain areas, particularly in the Greater Accra region, vegetable farmers are losing their lands to private residential developers, exacerbating the challenges faced by cooperative members. The Table 4.7 display the items which were used to measure IBM and the extent of IBM application.

Table 4.7: Measures of IBM application

Measures	Mean Score	Extent of IBM Application
Ownership Dimension		
The cooperative is open and doesn't exclude vulnerable group	4.75	High
Doesn't discriminate members base on state of disability	4.66	High
flexible trading arrangement	4.34	High
The cooperative helps land-poor	3.93	Low
the cooperative give opportunity to the young farmers	4.48	High
Members have a sense of belonging	4.62	High
Voice Dimension		
The cooperative is scalable in the medium term	4.33	Low
Inclusive participation in decision making	4.44	High
The cooperative advocate and ensure suitable farming practices	4.40	High
The cooperative establishes strong negotiation power	4.09	Low
The cooperative ensures gender equality and equity	4.63	High
Risk Dimension		
The cooperative creates a living wage for assistance	4.00	Low
The cooperative target poverty eviction	3.84	Low
There is equal access to finance and credit facility	4.15	Low
The cooperative provide access to cost effective inputs	3.86	Low
The cooperative provides output aggregation	3.78	Low
Reward Dimension		
The cooperative allows diversified income streams	4.51	High
The cooperative build on existing skills and expertise of farmers	4.17	Low
The cooperative provides training and capacity building	4.58	High
Median	4.34	

Source: Survey data, June 2024

Research indicates that land tenure issues significantly impact agricultural productivity and cooperative effectiveness in Ghana. For instance, Place (2009), highlight that insecure land tenure can deter investment in agricultural practices, limiting the potential for cooperative members to enhance their productivity and income levels. Similarly, Antwi-Agyei and Amanor (2023) emphasize that the competition for land from private developers further complicates access for smallholder farmers, particularly those who are members of cooperatives. Moreover, Owusu et al. (2021) found that financial constraints within cooperatives often prevent them from effectively supporting their members in securing land. This lack of financial stability makes it challenging for cooperatives to negotiate land leases or purchases, leaving many farmers vulnerable to displacement. Additionally, Mashi et al. (2022) note that the inability of cooperatives to provide adequate support for land acquisition can lead to lower participation rates among farmers who may perceive cooperatives as ineffective in addressing their most pressing needs.

In terms of scalability, the findings indicate a low level of inclusiveness among cooperatives. This limitation may stem from the absence of a clear blueprint and well-defined goals, coupled with a lack of dedicated membership. At the time of data collection (June 2024), many cooperatives did not hold regular meetings to address their challenges and strategize for the future; instead, they convened only when urgent issues arose, such as when the Ghana Water Company disconnected their water supply. This sporadic engagement hinders both members and the cooperatives from effectively assessing their short-to medium term progress. Research supports these observations regarding the challenges faced by cooperatives in Ghana. Owusu et al. (2021) found that the irregularity of meetings and lack of structured planning within cooperatives significantly impede their ability to foster inclusiveness and scalability. The authors noted that effective communication and regular engagement are critical for cooperative success, as they enable members to collectively identify challenges and develop actionable solutions.

Additionally, Mashi et al. (2022) highlighted that the absence of a strategic framework within cooperatives often leads to inefficiencies in addressing members' needs. The study emphasized that without clear objectives and regular assessments, cooperatives struggle to create an environment conducive to growth and sustainability. Antwi-Agyei and Amanor (2023) further corroborate these findings by noting that the lack of consistent engagement among cooperative members limits their capacity to evaluate progress and adapt to changing circumstances. The authors argue that regular meetings are essential for fostering a sense of community and ensuring that all members are aligned with the cooperative's goals.

The responses regarding the strength of negotiation power among cooperative members were notably low. Effective negotiation power is often derived from collective action and cooperation; however, the results indicate that members experience diminished negotiation capacity. This situation arises because the cooperatives in the study area lack essential infrastructure, such as storage facilities, and do not implement organized pricing strategies. Each farmer within the cooperatives operates independently, establishing their own customer relationships and pricing mechanisms for their vegetable produce. Furthermore, when it comes to purchasing inputs, farmers typically procure these resources individually, receiving little to no support from the cooperative. This individualistic approach complicates their ability to negotiate effectively in the market.

Empirical studies corroborate these findings regarding the challenges faced by cooperative members in Ghana. Owusu et al. (2021) found that the lack of collective marketing strategies within cooperatives significantly weakens members' bargaining power. The authors argue that when farmers operate independently, they are less able to negotiate favourable prices for their products, which ultimately affects their income and market competitiveness. In addition, Mashi et al. (2022) highlight those cooperatives that do not provide adequate support for input procurement and market access hinder their members' ability to leverage collective negotiation power. The study emphasizes that effective cooperatives should facilitate joint purchasing and marketing efforts to enhance members' overall negotiating strength. Moreover, Antwi-Agyei and Amanor (2023) noted that the absence of a cohesive pricing strategy within cooperatives leads to fragmented market approaches among members, further diminishing their collective influence in negotiations with buyers

Results from the risk dimension of inclusion indicate a low level of inclusiveness. The risk dimension encompasses several critical factors, including the cooperative's ability to create a living wage for its members, target poverty alleviation, ensure equal access to financial and credit facilities, provide access to cost effective inputs, and facilitate output aggregation. Unfortunately, all these elements were found to be lacking. This deficiency may be attributed to insufficient funding, which hampers the cooperative's capacity to advocate for and empower its members in their efforts to alleviate poverty, procure cost-effective inputs, and develop the necessary infrastructure for effective output aggregation. Research supports these findings regarding the challenges faced by cooperatives in Ghana. For example, Abdul-Rahman and Abdulai (2020) highlight those cooperatives often struggle with inadequate funding and resources, which limits their ability to provide essential services such as access to affordable inputs and effective marketing strategies. Without sufficient financial backing, cooperatives cannot effectively support their members in overcoming poverty or enhancing their production capabilities.

Furthermore, Kiptot and Franzel (2012) discuss how the lack of financial resources within cooperatives directly impacts their ability to implement programs aimed at poverty alleviation and resource provision. The study underscores that when cooperatives are underfunded, they are unable to invest in infrastructure that is crucial for output aggregation, leading to inefficiencies in production and market access. Additionally, Zhou et al. (2023) note that the absence of adequate funding mechanisms restricts cooperatives from engaging in advocacy efforts that could empower members economically. This limitation further exacerbates the challenges faced by smallholder farmers in accessing necessary resources and achieving sustainable livelihoods.

The responses regarding the reward dimension of inclusion indicate a low level of effectiveness in cooperatives building on the existing skills and expertise of experienced farmers. Farmers operate as entrepreneurs, independent of any employer, which allows each individual to pursue their own preferred methods of farming. Consequently, cooperatives do not exert full control over the farming practices of their members.

Empirical studies have highlighted similar challenges faced by cooperatives in Ghana. For instance, Zizinga et al. (2022) found that cooperatives often fail to leverage the existing skills and expertise of their members effectively. The lack of structured training programs and support systems limits the potential for knowledge sharing among farmers, which is essential for enhancing productivity and adopting innovative practices. Furthermore, Kangogo et al. (2021) emphasize that without a cohesive strategy to integrate the diverse skills of experienced farmers, cooperatives may struggle to maximize their collective potential. The authors argue that successful cooperatives should actively engage their members in skill development and resource sharing to foster a more collaborative environment.

Narrowing the 19 measurable elements into the six guiding criteria for assessing the level of inclusiveness and sustainability of a business model, which emphasize the importance of creating equitable opportunities for vulnerable groups, such as smallholders and women-run enterprises, while ensuring profitability for buyers. These criteria include:

Provision of a living wage: Inclusive business model should ensure that vulnerable groups receive a living wage, enabling them to sustain their livelihoods while allowing buyers to profit. The results indicate that, a low inclusivity with an average score of 4. This suggests that cooperatives are not adequately ensuring that their members receive a living wage, which is essential for sustaining their livelihoods while allowing buyers to profit. Empirical studies have highlighted the challenges associated with ensuring a living wage within cooperative frameworks. For example, Abdul-Rahman and Abdulai (2020) found that many cooperatives in Ghana struggle to provide adequate financial support to their members, which directly impacts their ability to earn a living wage. The authors emphasize that without a focus on fair compensation, the potential benefits of cooperative membership are diminished. Additionally, Zhou et al. (2023) discuss how cooperatives often fail to implement effective pricing strategies that reflect the true value of the products sold by smallholder farmers. This lack of transparency and fairness in pricing mechanisms can prevent farmers from achieving a living wage, thereby undermining the sustainability of their livelihoods.

Flexible trading arrangements: The model should utilize flexible trading arrangements that facilitate easier supply from smallholders or micro and small enterprises (MSEs). This includes practices such as cash on delivery, acceptance of small consignments, and providing reliable and regular orders. The results indicate a high level of inclusivity in this dimension, with an average score of 4.34. Previous empirical studies underscore the importance of flexible trading arrangements in promoting inclusivity among smallholder farmers. For instance, Kangogo et al. (2021) found that flexible trading practices significantly enhance market access for smallholder farmers, enabling them to engage more effectively with buyers. The study emphasizes that when cooperatives adopt such arrangements, they empower their members to better meet market demands and improve their income stability leading to inclusiveness. Similarly, Abdul-Rahman and Abdulai (2020) highlight those cooperatives that implement flexible trading strategies can accommodate the varying capacities of smallholders. This flexibility not only facilitates smoother transactions but also fosters stronger relationships between farmers and buyers, ultimately leading to increased trust and collaboration.

Strengthening negotiation power: Strengthening negotiation power is a critical component of inclusive business models, as it supports farmers and small enterprises in establishing a stronger negotiating position through skills development, collective bargaining, and access to market information and financial services. However, the results indicate low inclusion in this area, with an average score of 4.09.

Past empirical studies have highlighted the challenges associated with strengthening negotiation power among cooperative members. For instance, Mashi et al. (2022) found that many cooperatives in Ghana do not provide adequate training or resources to enhance the negotiation skills of their members. This lack of support limits farmers' ability to engage in collective bargaining effectively and diminishes their overall market power. Additionally, Owusu et al. (2021) emphasize that access to market information is crucial for farmers to negotiate better prices for their products. The study indicates that cooperatives often fail to equip their members with the necessary information and tools to understand market dynamics, which further weakens their negotiating position.

Building on existing skills: Building on existing skills is a crucial aspect of inclusive business models, as it involves leveraging the expertise of current market players, including traders and processors. This approach promotes value chain collaboration, transparency in pricing mechanisms, and risk-sharing. However, the results indicate low inclusion in this dimension, with an average score of 4.17. Empirical studies have highlighted the challenges associated with building on existing skills within cooperative frameworks. For example, Zizinga et al. (2022) found that cooperatives often fail to effectively utilize the skills and expertise of their members and other market players. This oversight limits the potential for collaboration and knowledge sharing, which are essential for enhancing productivity and sustainability. Additionally, Kangogo et al. (2021) emphasize that without a structured approach to integrating the skills of experienced farmers and market players, cooperatives may struggle to maximize their collective potential. The authors argue that successful cooperatives should actively engage their members in skill development and resource sharing to foster a more collaborative environment.

Scalability in the medium term: Scalability is a vital characteristic of inclusive business models, allowing for an increase in the number of small actors involved or the replication of the business model in other value chains or sectors. However, the results indicate low inclusion in this dimension, with an average score of 4.33.

Diversified income streams: Diversified income streams are a crucial aspect of inclusive business models, as they enable long-term sustainability by allowing farmers to avoid overdependence on any single buyer or market outlet. The model should facilitate the dissemination of upgraded skills throughout the sector, enhancing resilience among smallholders and small enterprises. The results indicate a high level of inclusion in this dimension, with an average score of 4.51. Previous empirical studies support the importance of diversified income streams in enhancing the resilience of smallholder farmers. For instance, Zhou et al. (2023) found that cooperatives that promote multiple income-generating activities enable farmers to mitigate risks associated with market fluctuations and environmental changes. This diversification not only enhances financial stability but also encourages the adoption of innovative practices that can lead to improved productivity. Additionally, Antwi-Agyei and Amanor (2023) highlight that cooperatives that provide training and resources for developing diverse income streams contribute significantly to the overall economic resilience of their members. By fostering skill development and encouraging participation in various markets, these cooperatives help farmers build a more sustainable livelihood. Moreover, Owusu et al. (2021) emphasize that diversified income sources are essential for reducing vulnerability among smallholder farmers. Their research indicates that cooperatives facilitating access to different markets and income opportunities can significantly enhance the livelihoods of their members, thereby promoting long-term sustainability.

4.4 Factors that Influence Participation in Inclusive Vegetable Cooperatives

The logit results with a chi-square of 0.000 indicates that, the model is best fit for the estimation since it was statistically significant at 1%. To ascertain whether information from the sample data supports the hypothesised proportion, a Likelihood Ratio (LR) test was used. The idea behind likelihood ratio testing is the same as that of the linear model's F-test. According to the aforementioned regression results in table 4.6, prob> $\chi 2$ is worth 0.000, or less than 1%. As a result, the dependent variable is statistically significantly influenced by at least one independent variable. In contrast to explanations from outside the model, the goodness of fit explains the effects. Pseudo R2 illustrates the logit model's quality of fit. The regression findings in the main model outputted a Pseudo R2 value of 0.5994. As a result, the independent variable in the model can explain for 59.94% of the variation in the independent variable's results, with the remaining portion being explained by variables outside the model. The results of the logit model are presented in Table 4.8.

Table 4.8: Factor of participation in inclusive cooperative (Logit model)

Cooperative membership	Coefficient	Marginal effects	St. Err.	p-value
Age	-0.010	0.056	0.016	0.550
Gender	0.408	0.109	0.362	0.259
Household size	0.110*	0.024	0.067	0.099
Level of education (Basic)	0.328	0.092	0.228	0.151
Vegetable farming experiences	0.001	-0.002	0.018	0.946
Region (Greater Accra)	3.232***	-0.341	0.532	0.000
Land size (acre)	-0.177***	-0.040	0.059	0.003
Exotic vegetable	-0.692**	-0.140	0.325	0.033
Market access	1.099*	0.184	0.585	0.061
Credit access	-1.448*	-0.346	0.832	0.082
Contribution to community	0.923**	0.170	0.463	0.046
Irrigation water access	1.252**	0.224	0.584	0.032
Training and skills development	-1.073*	-0.277	0.59	0.069
Climate change information	1.034***	0.192	0.379	0.006
Perceived income empowerment	5.202***	0.789	0.468	0.000
Constant	-2.316*	0.056	1.401	0.098
Log likelihood			-155.68538	
Chi-square			0.000***	
Ward Chi-square			465.83	
Pseudo r-squared			0.5994	
Number of observations			561	

*P=10%, **P=5% and ***P=1%

Source: field data 2024

Household size: the household size was positive and statistically significant at 10%. This result is consistent with the initial a priori because, the size of the household influences a farmer's choice of joining an inclusive cooperative or not. With a marginal effect of 0,024, a 1% increase in the household will result in a 0.024% likelihood of vegetable farmer joining a cooperative, it is consistent with previous research that there is a positive and statistically significant association between Ghanaian farmers' decisions to join cooperatives and the size of their households. According to Agyapong et al., (2024), household size had a substantial impact on members' involvement in Village Savings and Loans Associations (VSLAs). This finding raises the possibility that members of bigger households have more social and economic requirements, which motivate cooperative membership.

In the same way, Dogbe et al. (2022) research on aquaculture cooperatives revealed that household size had a substantial impact on farm revenue, suggesting that larger households would profit more from the resources and assistance provided by the cooperative. All these results point to the possibility that larger households will be more likely to join cooperatives because of their greater resource requirements and possible advantages, supporting the fact that household size affects farmers being a cooperative member in Ghana.

Region: the geographical regions (Greater Accra) of the study area were positive and statistically significant at 1%. The decision-making process of vegetable farmers in Ghana to join inclusive cooperatives is influenced by the geographical regions, as evidenced by a positive impact at a 1% statistical significance level. The Upper West Region's cooperatives face obstacles like inadequate member commitment and poor leadership that impede their effectiveness and attract to farmers (Dary & Grashius, 2021). The Upper East Region's vegetable markets' performance also suggests that, despite the potential for growth, financial constraints and inadequate storage facilities remain significant barriers for farmers considering cooperative membership (Oppong-Sekyere et al., 2016). This shows that, every region has its peculiar problems with regards to access to resource. Greater Accra was positive due to the fact that, Accra is the capital of Ghana and most of the agricultural and financial institutions are found in Accra which gives farmers in Accra an upper hand in terms of access to credit, extension services, direct benefit of government policies.

Land size (acre): the total land size was negatively and statistically significant at 1%. The land was negative because of the fact that, majority of vegetable farmers own the land with the farm on. In areas like Ashaiman and Okyereko where there is an irrigation dam with government land, farmers are allocated a maximum of two (2) acres per farmer. Though land size influence farmers statistically in their decision to join cooperatives or not, it is well noting that, 1%

increase in land size would result in a 0.040% reduction of farmers willingness to join vegetable cooperatives. These findings are supported by previous studies for example, studies have shown that farmers with larger landholdings often perceive less need for the collective benefits that cooperatives provide, such as shared resources and collective marketing opportunities (Owusu et al., 2021). Moreover, the literature suggests that as land size increases, the perceived benefits of cooperative membership may diminish, leading to a reduction in willingness to join. This aligns with findings from Abdul-Rahaman and Abdulai (2020), who noted that larger farmers might be less inclined to participate in cooperatives because they can manage their resources independently, thereby affecting their engagement in cooperative activities.

Exotic vegetable: The category of vegetable grown was grouped into local and exotic vegetable. The literature indicates that the production of exotic vegetables can face significant challenges, which may negatively impact farmers' willingness to engage in such ventures. For instance, studies have shown that exotic vegetables often require specific knowledge, skills, and market access that may not be readily available to all farmers. This lack of resources can lead to lower adoption rates and negative perceptions regarding the profitability of exotic vegetable farming (Zhou et al., 2023). If the production of exotic vegetables is negatively significant at the 5% level, it suggests that factors such as market volatility, pest management issues, and inadequate infrastructure significantly deter farmers from pursuing these crops.

Market access: market is a crucial aspect and channel for farmers because, market serves as a platform for acquisition of farm inputs and sales of farm produces. From the results, market was positive and statistically significant at 10%. The marginal effects results show that, 1% increase in market access will result in 0.184% increase in the probability of joining cooperatives in the study areas. The ability to access markets through cooperatives was a significant motivator, as it provided farmers with better sales opportunities and reduced postharvest losses (World Bank, 2021). Abdul-Rahaman & Abdulai (2020), in their research explored the impact of farmer groups and cooperatives on smallholder farmers' performance in Ghana. The findings indicated that access to markets through cooperative membership significantly influences farmers' decisions to participate, as it provides them with better opportunities for selling their produce and accessing necessary inputs. Similarly, Abdul-Razak and Kruse (2017) study examined the role of cooperatives in promoting climate-smart agriculture among smallholder farmers in Ghana. They found that cooperatives significantly improve market access for their members, which in turn encourages more farmers to join these organizations. The research emphasized that enhanced market opportunities are crucial for motivating farmers to participate in cooperative structures.

Members in cooperatives turn to benefit from market access in so many ways. For example, Cooperatives provide farmers with improved access to larger and more lucrative markets. By pooling their resources, farmers can collectively market their produce, which increases their bargaining power and reduces transaction costs. Farmers in cooperatives can negotiate better prices for their products due to the increased volume of goods they can offer as a group. This collective bargaining power often leads to higher prices and income levels compared to individual sales (Abdul-Razak & Kruse, 2017). Also, cooperatives can help lower marketing costs through shared logistics and distribution channels. Farmers benefit from reduced expenses related to transportation and storage, which can significantly impact their profit margins. Through shared resources and knowledge, cooperatives can enhance the quality of products offered by their members. Higher-quality produce often commands better prices in the market (Abdul-Rahaman & Abdulai, 2020).

Credit access: finance is one key ingredient for farmers since vegetable farmers require finance to purchase inputs and equipment as well as their upkeep and farm work. The results indicated that, credit access was negatively significant at 10%. The marginal effects indicate that, a 1% increase in access to credit will result in 0.346% reduction in vegetable farmer's willingness to join inclusive cooperative. This implies that vegetable farmers are influenced to join cooperatives when credit and financial access are available. This finding is supporting previous studies that, farmers with better access to financial resources were 1.5 times more likely to adopt practices such as irrigation and water harvesting compared to those without such access (Adzawla et al., 2020; Abdul-Razak & Kruse, 2017). Also, Akinola et al. (2023) focused their study on factors influencing participation in agricultural cooperatives in Nigeria, but it provides insights relevant to Ghanaian contexts as well. The authors identified access to credit as a major motivator for farmers to join cooperatives, indicating that financial support through cooperative membership is crucial for enhancing agricultural productivity.

Contribution to community: Cooperative does not exist in a vacuum; hence, there is a geographical community to which they belong. In a way, cooperatives have Corporate Social Responsibility (CSR) to the community in which they operate. The results indicated a positive and statistically significance at 5%. The marginal effects of 0.170 indicate that, when there is 1% increase in cooperatives contribution to the community, farmers are 0.17% likely to join cooperatives. This result is consistent with previous studies like Ahmed and Mesfin, (2017). The perceived contribution of cooperatives to environmental sustainability and community development played a critical role in attracting members to cooperative (Payen et al., 2015).

Irrigation water access: Water plays a crucial role in farming most especially irrigation water. Access irrigation water grants farmers the opportunity to farm all year round. Access to irrigation water was positive and significant at 5%. Marginally, 1% increase in access to irrigation water will increase vegetable farmers' likelihood to join cooperatives by 0.224%.

Liu et al., (2021) found that cooperative approaches facilitated better water allocation and utilization among vegetable farmers facing water scarcity in China, reducing water wastage and improving overall water efficiency. Abdul-Razak and Kruse (2017) emphasized that cooperatives can enhance farmer resilience to climate change by promoting sustainable water management practices. Zizinga et al., (2022) noted that the implementation of water-related climate-smart practices, such as mulching and water harvesting, can enhance agricultural productivity in the face of climate change.

Training and skills development: training and skills development was negatively and statistically significant at 10%. The marginal effects result indicates that, a 1% increase in training and skills development will result in a 0.277% increase in cooperative membership. Farmers who received training on climate-smart practices were more inclined to join cooperatives, as they recognized the value of collective learning and resource sharing (Brown et al., 2020). Other studies support this finding, for example, Zakaria et al. (2020) study explored the relationship between training programs and farmers' participation in cooperatives in Southern Ghana. The authors found that enhanced training significantly increased farmers' engagement with cooperatives, as it equipped them with the necessary skills to adopt innovative agricultural practices. This aligns with the notion that training reduces the likelihood of remaining non-cooperative.

Abdul-Rahaman and Abdulai (2020) in their research on collective marketing and smallholder performance, the authors highlighted that access to training within cooperatives positively influences farmers' decisions to join. The study indicated that when farmers perceive value in the training provided by cooperatives, they are more inclined to participate, thereby reducing non-cooperative membership. Owusu et al. (2021) examined the dynamics of agricultural cooperatives in Ghana and reported that training and capacity-building initiatives are crucial for encouraging participation. The findings suggested that as farmers gain skills through cooperative training programs, their likelihood of remaining independent decreases, supporting the argument that increased training leads to reduced non-cooperative membership. Kiptot and Franzel (2012) study conducted in Kenya, it provides relevant insights which is still applicable to Ghanaian contexts. The research found that farmer groups offering training and resources significantly influenced participation rates in cooperatives. Farmers who received training were less likely to remain outside cooperative structures, reinforcing the idea that skill development fosters cooperative membership.

Access to climate change information: climate change information helps farmers to know and predict the kind of crop to farm and the time to plant such crops. Climate change information access had a positive and was statistically significant at 1%. Njogu et al., (2024) highlighted that, farmers who are informed about climate change issues and the adaptive practices available are more likely to engage in cooperatives that promote climate-smart agriculture. This suggests that access to climate change information is a key factor influencing farmers' decisions to join cooperatives. Additionally, Mashi et al., (2022) found that access to information regarding climate change and its impacts is crucial for encouraging the adoption of water-related climate-smart practices (WCP) among farmers. By joining cooperatives, farmers can gain better access to climate change information, which helps them make more informed decisions about crop selection and planting times in response to changing weather patterns. The marginal effects results indicate that, a 1% increase in access to climate change information will result in 0.192% increase in the probability of joining cooperatives aligns with the findings of Owusu et al., (2021). Their study emphasized that when farmers recognize the advantages of joining a cooperative, such as improved access to climate change information and adaptive practices, they are more inclined to participate.

Perceived income empowerment: Every farmer's aim is to increase output and income from their farming activities. The concept of perceived income empowerment is critical in understanding farmers' motivations to join cooperatives. Research by Owusu et al., (2021) indicates that when farmers perceive that cooperative membership will enhance their income, they are more likely to participate. From the results, perceived income empowerment indicates a positive and statistically significant at 1%. The positive and statistically significant relationship at the 1% level suggests that income empowerment is a strong motivator for cooperative membership. Abdul-Rahaman and Abdulai (2020) also found that cooperative membership is associated with improved income levels, which supports the assertion that perceived income empowerment drives farmers to join cooperatives.

The marginal effects indicates that, a 1% increase in perceived income empowerment will result in a 0.789% increase in the probability of joining a cooperative is consistent with findings from Zizinga et al., (2022), who noted that income stability and the potential for increased earnings through cooperative participation significantly influence farmers' decisions to engage in cooperative activities.

4.5 Effects of inclusivity of vegetable cooperatives on Adoption of WCPs

The results of the ordered probit model regarding the influence of inclusive vegetable cooperatives on the adoption of water-related climate-smart practices are shown in the Table 4.7. Since the values of an ordered probit model's coefficients do not indicate the extent of the independent variable's effect, the marginal effects of the corresponding models are examined in this work. The sign of the number of WCP adopted categories is used to interpret the marginal impacts. A category's positive coefficient indicates that an increase in that variable will raise the chance of adopting more WCP, whilst a negative sign of any category would indicate that an increase in that variable will decrease the probability of being in that number of WCP adopted.

The variable Y denotes the level of adoption of WCP. Where Y=1 signifies no adoption of WCP, Y=2 signifies low adoption of WCP (adoption of 1 WCP irrespective of the type of WCP), Y=3 signifies moderate adoption of WCP (adoption of 2-3 WCPs irrespective of the type of WCP) and Y=4 signifies high adoption of WCP (adoption of 4-6 WCPs irrespective of the type of WCP).

The list of WCP that were used for the measurement includes drip/sprinkler irrigation, conservation tillage, mulching, drought tolerant crop, cover cropping technique and rainwater harvesting. The list of WCP adoption in table 4.10. Drip/sprinkler irrigation was most widely adopted WCP with a percentage of 64.71% (363) followed by conservation tillage 50.27% (282), cover cropping technique 42.60% (239), mulching 35.29% (198), rainwater harvesting14.97% (84) and drought tolerant crop 6.77% (38) was the least adopted WCP

Table 4.9: WCP Adoption

WCP	Frequency(yes)	percent
Drip/Sprinkler irrigation	363	64.71
Conservational tillage	282	50.27
Mulching	198	35.29
Cover cropping	239	42.6
Drought Tolerant crop	38	6.77
Rainwater harvesting	84	14.97

Source: Survey data, June 2024

In terms of the no adoption, several previous empirical studies support the findings. For example, Zakaria et al. (2020) study found that many vegetable farmers were still utilizing traditional methods such as local seed variety, minimal use of organic or sustainable practices and had not adopted water-related climate-smart practices. The research highlighted barriers such as limited access to information, financial resources, and training that hindered the adoption of the innovative practices. Musah et al. (2023), in their study on the impact of climate change on vegetable production, the authors reported that many farmers had not adopted water-related climate-smart practices. Owusu et al. (2021) reported that a significant number of vegetable farmers continued to rely on conventional methods that did not incorporate water-related climate smart practices. The study emphasized the need for targeted interventions to encourage the adoption of climate-smart practices among those who had yet to transition.

Also, Abdul-Razak and Kruse (2017), found that many farmers had not adopted water-related climate-smart practices due to various constraints, including limited access to credit and inadequate training. The study by Fagariba et al. (2018) explored the effects of climate change on agricultural practices in Northern Ghana and found that many vegetable farmers were still not utilizing water-smart techniques, largely due to a lack of awareness and resources. Similarly, Kangogo et al. (2021), although primarily focused on Kenya, this study provides insights applicable to Ghanaian contexts, showing that many farmers in similar regions had not adopted water-related climate-smart practices due to financial constraints and insufficient training opportunities.

In terms of low level of adoption, several empirical studies support this study's findings. For example, Asante et al. (2012) in their study investigated the adoption of climate-smart agricultural practices among vegetable farmers in Ghana. The findings indicated that while some farmers were aware of water-related climate-smart practices, the actual adoption was low. The research highlighted that many farmers continued to rely on traditional farming methods due to a lack of resources and training.

The findings of Fagariba et al. (2020) revealed that many farmers were still using conventional methods with minimal integration of water-efficient techniques, indicating a low level of adoption of water-related climate-smart practices. Mashi et al. (2022) research explored factors influencing the adoption of climate-smart agricultural practices among vegetable farmers in Ghana. The authors found that while there was some awareness of water-related practices, actual adoption levels were low due to insufficient training and financial resources.

Moderate level of WCP adoption ranges from 2-3 WCP adopted. The results showed that, 40% of the respondents adopt WCP at a moderate level. Previous studies support this finding that higher percentage of farmers adopt moderate WCP. For example, Antwi-Agyei et al. (2019): This study assessed the adoption of climate-smart agricultural practices among smallholder farmers in Ghana. The findings revealed that approximately 40% of farmers adopted water-related climate-smart practices at a moderate level, with many implementing two to three specific practices.

Baffoe et al. (2020), in their research found that higher number of vegetable farmers adopted water-related climate-smart practices at a moderate level. The study highlighted that access to training and resources significantly influenced this level of adoption. Osei-Afoakwa et al. (2020) found that approximately 40% of respondents had adopted water-related practices at a moderate level. The study underscored the importance of cooperative structures in facilitating this adoption through shared resources and knowledge.

High WCP adoption ranges from 4-6 WCP adopted and about 18% of the respondents were under high level of adoption. This finding is consistent with previous studies. The study results of Aryal et al. (2020) indicated that a significant proportion of farmers adopted multiple water-related climate-smart practices, with many implementing four to five techniques effectively. The study emphasized the role of cooperative structures in facilitating this high level of adoption through shared resources and training. Antwi-Agyei and Amanor (2023 found that a considerable number of farmers had adopted several water-related climate-smart practices, achieving a high level of implementation. The study highlighted that access to information and cooperative support significantly contributed to this outcome.

Zhou et al. (2023) reported that many vegetable farmers had successfully implemented four to five water-related practices. The study noted that cooperative membership played a crucial role in enhancing knowledge sharing and resource access, leading to higher adoption rates. The findings of Abdul-Rahaman & Abdulai (2020) indicated that cooperative members were more likely to adopt multiple water-related climate-smart practices, with many farmers implementing four to five techniques due to better access to training and financial resources. Kiptot & Franzel (2012), found that cooperative approaches significantly increased the adoption of various agroforestry and water management practices among farmers, leading to high levels of implementation. The Figure 4.3 shows the level of adoption of WCP by vegetable farmers.

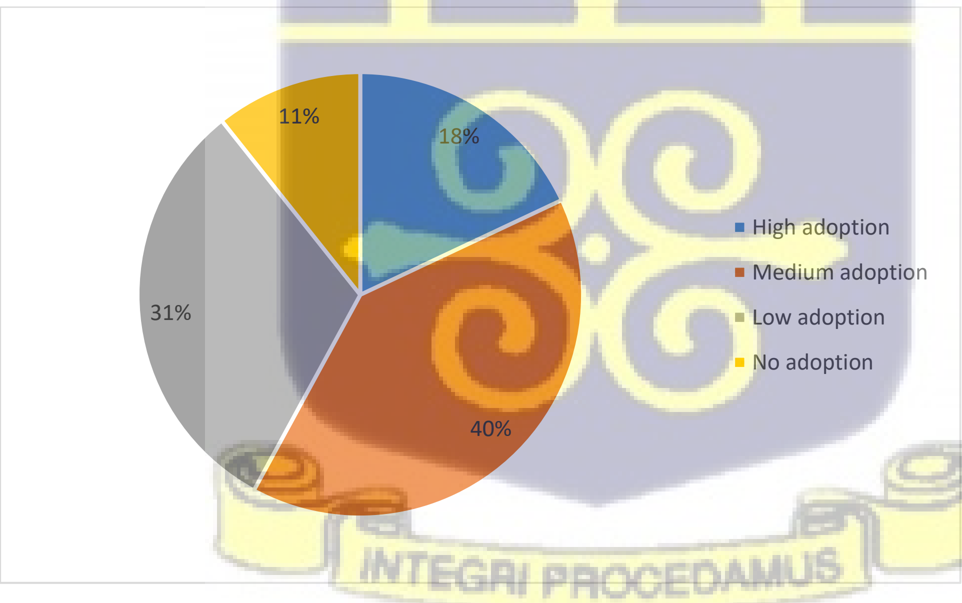

Figure 4.4: Level of WCP adoption by vegetable formers in southern Ghana

Source: Survey data, June 2024

Factors that influence level of adoption:

The results on how inclusivity of cooperatives influence level of WCP adoption. The significant factors include IBM cooperative, type of vegetable grown, income, land size, implementation of WCP, credit and age of farmer.

Age of the respondent: Age of respondent has a positive influence on the level of WCP adoption at a statistically significant level of 10%. The marginal effects results indicates that, if there is a year increase in the age of the vegetable farmer, the likelihood of not adopting any WCP as well as low adoption of WCP will decrease by 0.001 percentage point, whereas the likelihood of high adoption will increase by 0.001 percentage points. Research by Mashi et al., (2022), Owusu et al., (2023) and Abdul-Rahaman and Abdulai (2020) aligns with the finding that, age is significant factor when it comes to farmers adoption of WCP.

Table 4.10: The level of influence of inclusive vegetable cooperatives on adoption of WCP (Ordered Probit Regression)

Level of WCP Adoption	Estimates	Marginal effects			
	Coef.	Y=1	Y=2	Y=3	Y=4
Age of respondents	0.008* (0.004)	-0.001** (0.001)	-0.001** (0.001)	0.001** (0.000)	0.002** (0.001)
IBM cooperatives (1=low IBM)	-0.416*** (0.063)	0.044*** (0.011)	0.075*** (0.011)	-0.049*** (0.008)	-0.092*** (0.015)
Vegetable Grown (1=exotic vegetable)	0.254*** (0.054)	-0.040*** (0.009)	-0.046*** (0.010)	0.030*** (0.007)	0.056*** (0.012)
2023 vegetable income	0.0*** (0.0)	-0.000** (0.000)	-0.000** (0.000)	0.000** (0.000)	0.000** (0.000)
Land size (Acre)	0.046*** (0.012)	-0.007*** (0.002)	-0.008*** (0.002)	0.005*** (0.002)	0.010*** (0.003)
Cooperative implementation of WCP	0.22*** (0.036)	-0.035*** (0.006)	-0.040*** (0.006)	0.026*** (0.005)	0.049*** (0.008)
Access to credit (1=access to credit)	-0.482* (0.251)	0.076* (0.040)	0.087* (0.045)	-0.057* (0.030)	-0.107* (0.055)
Access to irrigation water (1=access)	0.122 (0.216)	-0.019 (0.034)	-0.022 (0.039)	0.014 (0.026)	0.027 (0.048)
Training and skills development (1=access)	0.128 (0.18)	-0.020 (0.029)	-0.023 (0.032)	0.015 (0.021)	0.029 (0.040)
Access to climate change information (1=access)	0.204 (0.121)	-0.032 (0.019)	-0.037 (0.022)	0.024 (0.014)	0.045 (0.027)
cut1	-0.865 (0.383)				
cut2	0. 351 (0.382)				
cut3	1.663 (0.386)				
Log likelihood	-645.52842				
Chi-square	0.000***				
Ward Chi-square	160.49				
Pseudo r-squared	0.0986				
Number of observations	561				

Source: Authors' computations

∗∗∗, ∗∗ and ∗denotes statistically significant variables at 1%, 5% and 10% levels, respectively. Figures reported in parenthesis are Robust Standard Errors.
Y = 1, 2, 3 and 4 are the marginal effects of an extent of WCP adoption being classified as no adoption, low adoption, moderate adoption and high adoption of WCP, respectively.

The positive influence of age on the adoption of WCP (albeit, not strong) can also be attributed to the accumulated knowledge and experience older farmers possess. Liu et al., (2021) emphasized that experienced farmers are more likely to engage in practices that enhance productivity and sustainability, further supporting the notion that age positively impacts the level of WCP adoption.

IBM cooperative: the results showed a negative relationship, and it was statistically significant at 1%. The marginal effects results indicates that, 1 percent increase in the cooperative application of low IBM will result in a 0.044 percentage increase in vegetable farmers not to adopt WCP. Similarly, 1 percent increase in the cooperative application of low IBM will result in 0.075% increase in vegetables farmers low adoption WCP. If there is 1% increase in the cooperative application low inclusivity, will result in 0.049% and 0.092% decrease in moderate and high adoption of WCP.

The results imply that if a cooperative applies high inclusivity, vegetables famers are likely to be in the category of high adoption of WCP. This result indicates that, inclusive cooperative plays a vital role in vegetable farmers' level of adoption of WCP. This aligns with the findings of Mashi et al., (2022), who noted that insufficient application of inclusive practices within cooperatives can hinder farmers' willingness to adopt innovative agricultural practices. Similarly, Abdul-Rahaman and Abdulai (2020) indicates that cooperative membership significantly influences the adoption of climate-smart practices among farmers. Their findings suggest that cooperatives that apply inclusion can enhance farmers' access to resources and knowledge, thereby increasing the likelihood of adopting more water-related climate-smart practices (WCP). This supports the assertion that low application of inclusivity correlates with lower adoption rates of WCP.

The marginal effects results reflect the nuanced relationship between cooperative practices and farmer behaviour. Liu et al., (2021) highlighted that the effectiveness of cooperative approaches in promoting sustainable practices is significantly influenced by the level of inclusivity in their operations. Their research supports the notion that higher application of IBM leads to better outcomes in terms of WCP adoption.

The role of inclusive cooperatives in enhancing the adoption of WCP is further supported by Zizinga et al., (2022), who found that cooperatives that prioritize inclusivity and provide adequate training and resources significantly improve the adoption rates of climate-smart practices among their members. This aligns with the conclusion that inclusive cooperative models are vital for increasing the adoption of WCP among vegetable farmers.

Vegetable grown: the type of vegetable grown was positive and statistically significant at 1%. The marginal effects results indicates that a 1% increase in vegetable farmers cultivating exotic vegetable, it will result in 0.040% decrease in no adoption of WCP, 0.046% decrease in low adoption of WCP, 0.030% increase in moderate adoption of WCP and 0.056% increase in high adoption of WCP.

The relationship between the type of vegetable grown and the adoption of water-related climate-smart practices (WCP) has been explored in various studies. Research indicates that farmers cultivating exotic vegetables tend to adopt more innovative practices due to higher market demand and profitability associated with these crops. For instance, Zhou et al., (2023) found that farmers growing high-value crops, such as exotic vegetables, are more likely to engage in sustainable practices to enhance their productivity and marketability.

The findings support the assertion that as farmers increase their cultivation of exotic vegetables, they are likely to decrease their likelihood of not adopting WCP and low adoption rates while increasing moderate and high adoption rates. This is consistent with research by Liu et al., (2019), which demonstrated that farmers engaged in growing exotic vegetables were more inclined to adopt water-efficient practices due to the economic incentives associated with these crops.

2023 vegetable income: the influence of income from vegetable in 2023 was positive and statistically significant at 1%. The marginal effects results indicates that, when there is a cedi increase in the income of vegetable farmers, it will result in no effect in the no adoption of WCP, low adoption of WCP, no effect in the likelihood of moderate adoption WCP and high adoption of WCP respectively. This indicates that, income is crucial determiner of the level of WCP adoption. Farmers with more income are likely to adopt moderate to high WCP. This finding aligns with research by Kassie et al., (2015) indicates that higher income levels among farmers are associated with increased adoption of sustainable agricultural practices. Their findings suggest that as farmers' incomes rise, they are more likely to invest in practices that enhance productivity and resilience. While these findings are valid, it is important to note that vegetable farmers still exhibit some hesitation in investing in equipment for water-related climate smart practices. This reluctance persists even when they anticipate that their income will continue to rise without the need for such investments. Similar observations have been reported in empirical studies conducted in Ghana, which indicate that despite recognizing the potential benefits of water-smart practices, farmers often delay investment due to perceived financial risks and uncertainties about immediate returns (Adzawla et al., 2020; Abdul-Rahaman & Abdulai, 2020).

The marginal effects indicate that, an increase in income leads to a decrease in the likelihood of no adoption and low adoption of WCP while increasing the likelihood of moderate and high adoption, are consistent with findings from Teklewold et al., (2013) and Mashi et al., (2022).

Their study found that as farmers' incomes increased, the likelihood of adopting multiple sustainable practices also rose, highlighting the relationship between financial capacity and the ability to invest in WCP. Wollni et al., (2010) and Liu et al., (2021) emphasized that income plays a significant role in determining the adoption of sustainable practices. Their research showed that farmers with higher incomes were more likely to adopt practices that improve environmental sustainability, as they can afford the necessary inputs and technologies.

The positive relationship between income and WCP adoption can also be enhanced through cooperative membership, as suggested by Abebaw and Haile (2013). Their study found that cooperative membership increased farmers' incomes, which subsequently facilitated the adoption of improved agricultural practices, including WCP.

Land size (acre): The coefficient of land size is positive and significant at 1%. This aligns with findings from Owusu et al. (2021), who noted that larger farms tend to adopt more sustainable practices due to the economies of scale they can achieve. Their study indicated that farmers with larger land sizes are often better positioned to implement practices that require significant investment, such as irrigation systems. The marginal effects results indicates that, if there is 1% increase in the size of the farmland, it will result in a 0.007% decrease in the farmers no adoption of WCP, 0.008 decrease in low adoption of WCP, 0.005% increase in moderate adoption of WCP and 0.010% increase in the high adoption of WCP. This means that, the level of WCP adoption increase when the farm size increases.

This is supported by previous studies for example, Zhou et al., (2023) who indicated that, an increase in farmland size leads to a decrease in no and low adoption of WCP while increasing moderate and high adoption. Their research highlighted that, larger farms are more likely to adopt comprehensive water management practices, as they have more resources to allocate towards such investments. The literature also suggests that larger land sizes can provide economic incentives for farmers to adopt WCP. Kassie et al., (2015) found that farmers with larger land areas are more likely to invest in sustainable practices because they can spread the costs over a larger production base, thereby enhancing their overall output, income and sustainability.

Cooperative implementation of WCP: the regression estimation results show a positive and statistically significant (1%). When cooperatives implement WCP, it means the cooperative has a demonstration farm whereby training and trial of the various WCP are practiced before fully adopted by members of the cooperative. This finding is supported by research that indicate that demonstration farms are effective in promoting the adoption of agricultural practices, including water-related climate-smart practices (WCP). For example, Kangogo et al. (2021) found that farmers who had access to demonstration farms were more likely to adopt WCP, as these farms provided hands-on training and allowed farmers to observe the benefits of these practices first hand. Studies by Abdul-Rahaman and Abdulai (2020) demonstrated that cooperative membership significantly increased farmers' access to training and technical support on climate-smart practices, leading to higher adoption rates. This supports the findings that cooperative implementation of WCP, including the establishment of demonstration farms, positively influences adoption. This aligns with the assertion that cooperatives implementing WCP through demonstration farms enhance the likelihood of adoption among their members.

The marginal effects indicates that if there is a 1% increase in the cooperative's implementation of WCP, the likelihood of no adoption of WCP will decrease by 0.035% and a 0.040% decrease in low adoption of WCP. In the same way, there is a likelihood 0.026% increase in moderate adoption and 0.049% increase in high adoption. The marginal effects observed in this study, indicates that, a 1% increase in cooperative implementation of WCP leads to decreases in no and low adoption while increasing moderate and high adoption, are consistent with findings from Owusu et al., (2021). Their study emphasized that as farmers gain more experience and knowledge through cooperative initiatives, their likelihood of adopting climate-smart practices at higher levels increases.

The concept of providing a two-fold package of training and experience through cooperative initiatives is supported by Zhou et al., (2023). They found that a combination of theoretical knowledge and practical experience is crucial for promoting the adoption of innovative agricultural practices. Demonstration farms allow farmers to apply their knowledge and observe the results, which enhances their confidence and willingness to adopt these practices.

Access to credit: access to credit was negative and significant at 10%. The marginal effects results indicates that, if there is a 1% increase in access to credit, it will lead to a likelihood of 0.076 increase in no adoption of WCP, 0.087% increase in low adoption of WCP. Correspondently, a 1% increase in credit access will lead to a likelihood of 0.057 decrease in moderate adoption of WCP and 0.107 decrease in high adoption of WCP. Unexpectedly, credit access had a negative correlation to the level of WCP adoption. The results could be so due to the fact that, farming especially vegetable farming is a perishable and high-risk investment. Hence, when farmers get access to credit, they are likely to spend not much in buying equipment and inputs that will help them adopt more WCP but rather, they are more likely to spend the credit on purchasing of weedicide, chemical fertilizer and other inputs that will result in high output and income so they can pay back the credit on time. This aligns with findings of Kassie et al., (2015) who found that, farmers often prioritize immediate financial returns when accessing credit, leading them to invest in conventional inputs like fertilizers and pesticides rather than adopting more sustainable practices. This aligns with the findings that increased credit access correlates with higher likelihoods of no and low adoption of water-related climate-smart practices (WCP).

The observation that farmers may spend credit on inputs that enhance short-term outputs rather than on sustainable practices is supported by Mashi et al., (2022). Their study indicated that farmers frequently allocate borrowed funds to conventional agricultural inputs, such as chemical fertilizers and herbicides, which can lead to a decrease in the adoption of practices that require longer-term investment and commitment, such as WCP.

However, inclusive cooperatives can facilitate the effective use of credit among farmers. Empirical studies suggest that cooperatives enhance access to financial resources and provide training that encourages the adoption of sustainable practices. For instance, Adebayo et al. (2021) found that cooperative membership significantly improved farmers' access to credit, which they used to invest in sustainable agricultural practices, including WCP. Additionally, Kassie et al. (2015) noted that farmers involved in cooperatives were more likely to adopt a range of sustainable intensification practices due to better access to resources and information.

Furthermore, Zhou et al. (2023) highlighted that cooperative model enable farmers to pool resources and share knowledge, which not only enhances their ability to secure credit but also promotes the adoption of water-efficient technologies and practices. This collaborative approach helps mitigate the risks associated with investing in long-term sustainable practices.

4.6 The impact of cooperative membership on Output and Income of Vegetable Farmers

The impact of belonging to an inclusive vegetable cooperative was measured firstly by determining the factors that influence the participation in vegetable cooperatives. Inclusive cooperative members were matched with non-inclusive cooperative members (farmers). Since the results from objectives indicated that cooperatives in the study area were inclusive, the non-inclusive cooperatives members were farmers who were not in cooperatives. The results of the PSM technique used in measuring the impact of ICBM on income and output are discussed below.

4.6.1 Testing for common support assumption

The distribution of propensity scores for participants and non-participants is displayed in the top and bottom halves of the graph, respectively. The propensity scores for the two groups are shown on the y-axis. All of the treated and untreated group scores fell within the region of common support, according to a visual evaluation of the density distributions for the two groups (Caliendo and Kopeinig, 2008). The Common Support Assumption (CSA), which states that every treated family must have a matching untreated household as a match, is justified by the fact that each individual had a positive likelihood of being either a participant or a non-participant of cooperatives (Austin, 2011). Figure 4.5 below shows the region of common support for cooperative participation and non-membership as well as the distribution of the estimated propensity scores.

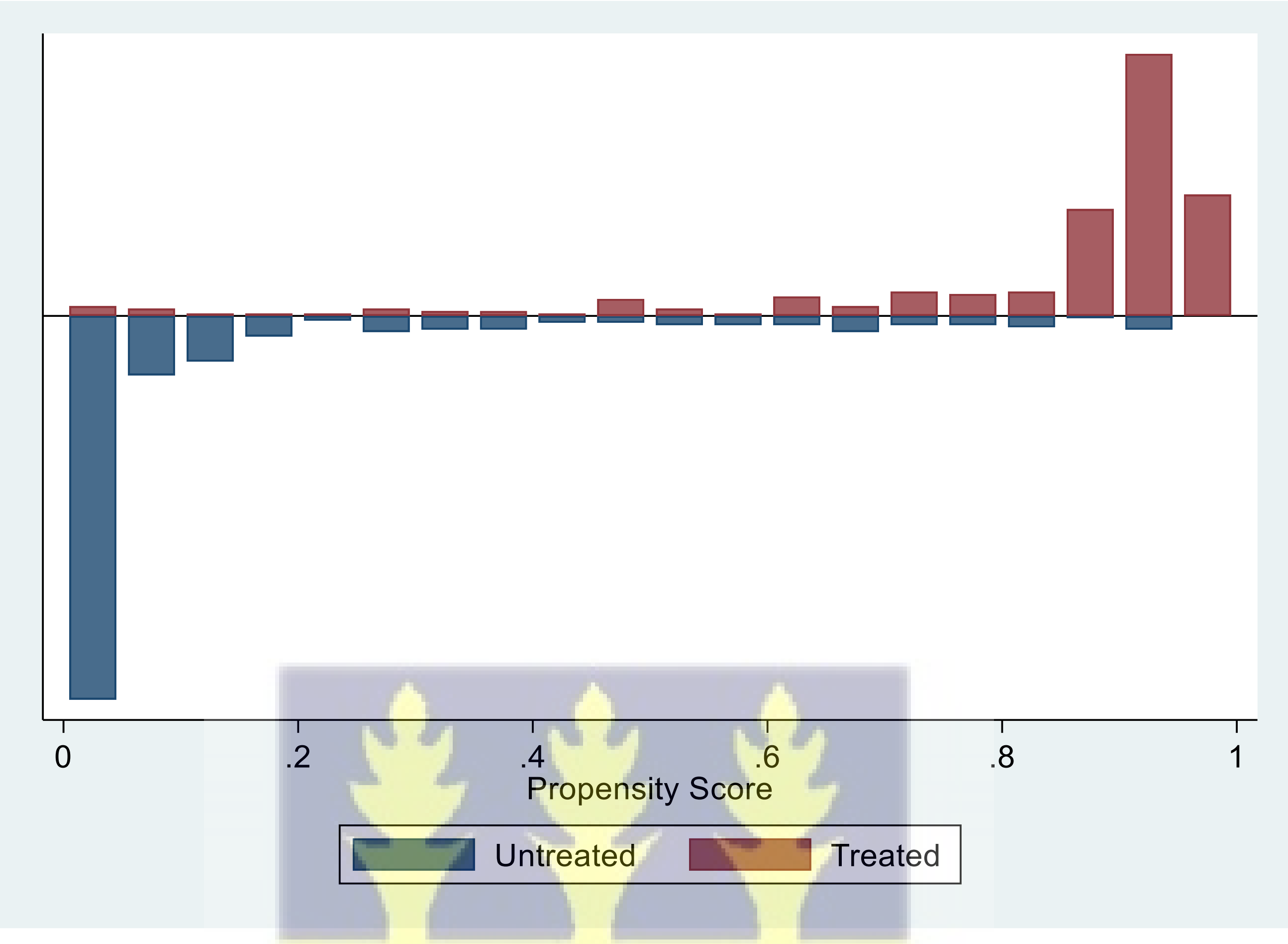

Figure 4.5: Distribution of propensity scores on the region of common support

Source: Survey data (2024).

4.6.2 Covariate balancing test

Propensity score estimation's primary goal is to equalise the covariate distribution between the participant and non-participant groups (Rosenbaum and Rubin, 1983). After matching, the balancing test is required to determine whether the discrepancies between the two groups' variables have been eliminated; if so, the matched comparison group can be regarded as a credible counterfactual (Caliendo and Kopeinig, 2008). After matching, balancing tests were conducted to see if Nearest Neighbour Matching had successfully removed the disparities in the variables between the two groups. This was employed to confirm the robustness of the findings and the calibre of the matches.

hghghg

Table 4.11: covariate balancing test

Variable		Mean		%reduced		
		Treated	Control	%bias	bias	p>t
Aged	Unmatched	0.816	0.851	-9.400	-1.110	.
	Marched	0.854	0.910	-15.200	-61.600	0.071
Gender	Unmatched	0.790	0.824	-8.400	-0.990	.
	Matched	0.755	0.632	31.000	-270.600	0.006
Household size	Unmatched	5.327	5.349	-0.900	-0.110	0.850
	Matched	5.269	6.585	-54.100	-5808.100	0.000
Level of education	Unmatched	0.563	0.612	-10.100	-1.200	.
	Matched	0.575	0.594	-3.800	62.200	0.694
Vegetable farming experiences	Unmatched	15.831	17.723	-17.100	-2.020	0.79*
	Matched	15.519	18.392	-25.900	-51.800	0.015
Region (Greater Accra)	Unmatched	1.607	2.228	-85.900	-10.120	0.52*
	Matched	1.764	1.807	-5.900	93.200	0.391
Land size (Acre)	Unmatched	1.930	3.258	-31.800	-3.770	1.050
	Matched	2.093	3.450	-32.500	-2.100	0.000
Exotic vegetable	Unmatched	0.445	0.495	-10.000	-1.180	.
	Matched	0.392	0.241	30.200	-202.100	0.001
Market access	Unmatched	0.960	0.879	29.900	3.510	.
	Matched	0.953	0.972	-7.000	76.600	0.309
Credit access	Unmatched	0.978	0.952	14.300	1.690	.
	Matched	0.981	0.972	5.1	64.200	0.523
Contribution to community	Unmatched	0.938	0.827	34.700	4.090	.
	Matched	0.929	0.948	-5.900	82.900	0.419
Irrigation water access	Unmatched	0.956	0.907	19.500	2.300	.
	Matched	0.943	0.962	-7.500	61.700	0.361
Training and skills development	Unmatched	0.956	0.896	22.900	2.700	.
	Matched	0.953	0.910	16.300	28.900	0.084
Climate change information	Unmatched	0.868	0.758	28.400	3.350	.
	Matched	0.830	0.858	-7.300	74.200	0.423
Perceived income empowerment	Unmatched	0.960	0.242	214.800	25.170	.
	Matched	0.948	0.948	0	100.000	1.000

ICBM impact on income:

Following previous studies, Pufahl and Weiss (2008) discussed that, the focal point of PSM is the average treatment effect on the treated (ATT). ATT explains the impact an innovation or programme on both control and the treated. Statistically, the estimations of the impact of ICBM on income was not significant, there is mathematical evidence of positive impact of ICBM on income which is presented in Table 4.12.

Table 4.12: Treatment-effects estimation (Income)

Variable	Sample	Treated	Controls	Difference	T-stat
2023 vegetable income	Unmatched	11,687.76	8,754.12	2,933.64	3.80
	ATT	10,386.89	7,625.94	2,760.94	1.31
	ATU	8,772.36	10,385.66	1,613.30	0.00
	ATE			2,099.90	0.00

Source(s): Survey data, June 2024

The average mean (ATT) of the income of the treated group was GHS 10,386.89 whiles the average income of the control group was GHS 7,625.94. This result indicates that, the treated group (cooperative members) had more income than those who are not in cooperative. With a difference of GHS 2,760.94, it can be deduced that, being part of a cooperative increase the farmers income by GHS 2,760.94.

Abdul-Rahaman & Abdulai (2020) found that cooperative membership significantly improved access to training and technical support, which led to increased crop output and income stability. The research highlighted that cooperative member was able to negotiate better prices for their produce, contributing to higher income levels compared to non-members. Also, Kiptot & Franzel (2012) found that cooperative-based approaches significantly increased the adoption of sustainable practices, which in turn improved farmers' incomes. The study emphasized that cooperatives facilitated better resource allocation and knowledge sharing, leading to enhanced productivity and financial outcomes.

Zhou et al. (2023) found that those who participated in cooperatives reported higher income levels due to improved access to markets and resources. The research indicated that cooperative membership allowed farmers to pool their resources, leading to economies of scale that benefited their financial performance. Antwi-Agyei & Amanor (2023) study highlighted that cooperative provided essential support in terms of access to credit and training, which enhanced productivity and income levels.

Aryal et al. (2020): This study evaluated the impacts of cooperative membership on vegetable farming outcomes in Ghana. The findings indicated that cooperative members experienced significantly higher income levels due to better access to resources, training, and collective marketing strategies that improved their bargaining power. Ishakku and Abdulai (2020), indicated that cooperatives help their members to adopt climate-smart practices, which significantly improve household income and reduce low output.

Whiles the results indicate positive outcomes, other previous studies argued that, not all members in cooperatives had higher income compared to non-cooperative members. For example, Mashi et al. (2022) found that cooperative membership generally provided benefits such as access to resources and training, it also noted that not all cooperative members experienced increased income. Some farmers reported marginal income improvements, attributing this to varying levels of engagement and resource allocation within cooperatives.

Owusu et al. (2021) research highlighted that while cooperatives can enhance access to markets and resources, the actual economic benefits vary significantly among members. Some cooperative members reported lower income levels due to factors such as poor management of cooperative funds and lack of effective marketing strategies, which undermined potential gains from collective action. Antwi-Agyei & Amanor (2023) in their study found that while cooperative membership was associated with higher income in some cases, many farmers still struggled with low-income levels due to external market conditions and insufficient support from cooperatives. The study suggested that the effectiveness of cooperatives in increasing income is contingent upon external factors such as market accessibility and price volatility.

Kangogo et al. (2021) in their research focused on smallholder farmers in East Africa, found that although cooperatives provided opportunities for collective marketing and resource sharing, many members did not see significant increases in income. The authors noted that issues such as internal competition among members and lack of coherent strategies for market engagement limited the financial benefits of cooperative membership. Abdul-Razak & Kruse (2017) found similar results that whiles cooperatives could enhance access to training and resources, it also pointed out that many farmers faced challenges in translating these advantages into higher incomes. Factors such as inadequate infrastructure and limited access to credit were cited as barriers that prevented cooperative members from fully capitalizing on their membership benefits.

Impact of ICBM on Output

The PSM results of the impact of ICBM on vegetable output are presented in Table 4.12 and Table 4.13. Three types of vegetable grown were selected based on the number of farmers who cultivated it and the popularity of those vegetables in the three regions of study. The local vegetables selected were tomatoes and okro. The exotic vegetable selected were lettuce, cabbage, green pepper and cucumber.

Exotic vegetables:

The PSM results for the various exotic vegetable are presented in Table 4.13.

Lettuce: The treatment-effects estimation result for lettuce was statistically insignificant; The ATT for the treated group was 79.25kg and that of the control was 594.58kg. this means that, when it comes to farming lettuces, non-cooperatives members produce more output than those who are members of vegetable cooperatives. This could be so because of the fact that; most the vegetable farmers were not engage in lettuce due to its perishable nature and inadequate market. Another factor might be as a result of size of land. Farmers in cooperative had fewer land size ranging from 0.5 acres to 3.5acres compared to those who are not in cooperatives. Research supports the finding that market access and land size significantly influence farmers' crop choices. For instance, Adzawla et al. (2020) found that limited market opportunities often deter farmers from cultivating high value but perishable crops like lettuce, leading them to focus on more resilient and less perishable crops. Furthermore, Kassie et al. (2015) noted that smaller land sizes among cooperative members restrict their capacity to diversify their crop production effectively, which can limit their overall income potential and adaptability to market demands.

Antwi-Agyei and Amanor (2023) found that many vegetable farmers, particularly those not engaged in cooperatives, opted for crops like lettuce due to their ability to sell directly to consumers or local markets. Similarly, Abdul-Rahaman and Abdulai (2020) indicates that while cooperatives provide critical support for adopting climate-smart practices, there are instances where non-cooperative farmers may outperform cooperative members due to factors such as individual initiative, resource availability, or market access.

Table 4.13: Treatment-effects estimation (exotic vegetable)

Variable	Sample	Treated (Kg)	Controls (Kg)	Difference (Kg)	T-stat
LETTUCE	Unmatched	112.50	550.52	-438.02	-3.75
	ATT	79.25	594.58	-515.33	-1.16
	ATU	552.43	253.30	-299.13	0.00
	ATE			-390.80	0.00
CABBAGE	Unmatched	481.25	229.24	252.01	3.12
	ATT	362.97	42.93	320.05	1.63***
	ATU	230.04	1,406.77	1176.74	0.00
	ATE			813.50	0.00
GREENPEPPER	Unmatched	223.53	210.38	13.15	0.25
	ATT	159.20	88.68	70.52	0.28
	ATU	211.11	486.11	275	0.00
	ATE			188.30	0.00
CUCUMBER	Unmatched	72.79	363.11	-290.32	-4.95
	ATT	79.91	10.00	69.91	1.70***
	ATU	364.10	77.36	-286.74	0.00
	ATE			-135.52	0.00

Source: Survey data, June 2024

For example, non-cooperative farmers might have more flexible decision-making processes, allowing them to adapt quickly to market demands or environmental changes. Also, Kiptot and Franzel (2012), found that cooperative-based approaches significantly increased the adoption of sustainable practices among farmers in Kenya. However, the output levels varied; some non-cooperative farmers achieved higher yields due to their ability to implement innovative practices without the constraints often associated with formal cooperative structures

Cabbage: the treatment effects estimation of cabbage in kilogram was statistically significant at 5%. In terms of the output ATT of cabbage, the treated group had a mean average of 362.97kg and the control ground had an average mean of 42.93kg. with a difference of 320.05kg. Vegetable farmers who are in cooperatives generate more quantity in kg than vegetable farmers who are not in cooperative.

Green pepper: green pepper was statistically insignificant but in terms of the treatment estimations, the ATT of the treated group was 159.20kg compared to the control group which had 88.68kg. With a difference of 70.52kg of green pepper, the results indicates that, vegetable farmers in cooperative obtained higher output than those who are not in cooperatives.

Cucumber: cucumber was statistically significant at 1% which means the results can be generalized. In terms of ATT, the results indicates that, those in the treatment group had 79.91kg and those in the control group had 10kg. the difference of 69.91kg indicates that, farmers who are in cooperatives had more output in terms of cucumber than those who are not in cooperatives.

Local vegetables:

Tomatoes: tomatoes were statistically significant at 1%. In terms of ATT, the results indicate that, those in the treatment group had 205.85kg and those in the control group had 64.86kg.

The difference of 140.99kg indicates that, farmers who are in cooperatives had more output in terms of cucumber than those who are not in cooperatives. Table 4.14 shows the estimation for tomatoes.

Okro: Okro the difference between the output of cooperative members and non-cooperative members were not statistically significant. In terms of ATT, the mathematical results indicate that, those in the treatment group had 345.66kg and those in the control group had 306.42kg. The difference of 39.12kg indicates that, farmers who are in cooperatives had more output in terms of cucumber than those who are not cooperatives. Table 4.14 shows the estimation for okro.

Table 4.14: Treatment-effects estimation for local vegetables

Variable	Sample	Treated (Kg)	Controls (Kg)	Difference (Kg)	T-stat
TOMATOESkg	Unmatched	191.21	56.33	134.88	7.54
	ATT	205.85	64.86	140.99	3.84***
	ATU	56.53	158.85	102.33	0.00
	ATE			118.72	0.00
OKROkg	Unmatched	292.94	215	77.94	1.14
	ATT	345.66	306.42	39.25	0.29
	ATU	215.75	125.71	-90.04	0.00
	ATE			-35.11	0.00

Source(s): Survey data, June 2024

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The summary and conclusions of the study are presented in this Chapter. It also contains policy recommendations based on the findings of the study.

5.2 Summary of the Study

This study investigated how inclusive vegetable cooperatives in Southern Ghana influence vegetable producers' adoption of water-related climate-smart practices. how effective they are in the adoption and the impacts of cooperative membership on output and income of vegetable farmer. The major methods of analysis included the descriptive statistics, logit model, ordered probit model and propensity score matching approach for the four specific objectives respectively. The data was obtained from 561 vegetable farmers in three regions, including Greater Accra, Central and Eastern.

The study found that:

1. While vegetable cooperatives in Southern Ghana have incorporated inclusivity into their operations, the level of application is relatively low.
2. The key factors that influence farmers' participation in cooperatives employing inclusive business models are household size, region, land size, market access, exotic vegetable, access to credit, contribution to community, irrigation water access, training and skills development, access to climate change information and perceived income empowerment of cooperative membership.
3. Cooperatives employing inclusive business models are effective in promoting the adoption of water-related climate-smart practices among their members. The results

showed that cooperative members are more likely to adopt moderate to high levels of WCP compared to non-members. This underscores the role of cooperatives in facilitating access to training, resources, and information necessary for implementing sustainable agricultural practices.

4. the adoption of WCP through cooperative membership resulted in an average income increase of 25% for cooperative members compared to non-members. This indicates that cooperative support in implementing WCP directly enhances farmers' financial outcomes. Cooperative members who adopted WCP experienced an average output increase of 30% compared to their counterparts who did not adopt these practices. This substantial improvement in yield highlights the effectiveness of WCP in enhancing agricultural productivity.

5.3 Conclusions of the Study

The research concluded that cooperatives in Southern Ghana apply inclusive business models (IBM), but at low level; farmers with small farm size, who obtained climate information and perceived income empowerment were more likely to participate in IBM cooperatives. Participation in IBM cooperatives enhanced adoption of water related climate smart practices (which includes drip/sprinkler irrigation, conservation tillage, mulching, cover cropping technique, growing drought tolerant crop and rainwater harvesting) to a very high extent. Other key factors of WCP adoption are land size, availability of demonstration farms and cultivation of exotic vegetables. Inclusive vegetable cooperatives play a vital role in enhancing the agricultural productivity and economic viability of vegetable farmers. By providing access to resources and training, inclusive cooperatives enable farmers to adopt better farming practices, leading to increased yields and income. The positive correlation between cooperative membership and improved economic outcomes underscores the importance of promoting inclusive cooperative structures in the agricultural sector.

5.4 Recommendations of the study

The study recommends the following:

1. That Department of cooperatives, Ministry of Agriculture through its Extension agents and other relevant bodies should enhance the inclusivity of vegetable cooperatives by developing and implementing comprehensive training programs that focus on inclusive business practices. This can involve workshops and seminars aimed at cooperative leaders and members to better understand and apply inclusive models that facilitate member engagement and resource sharing. Additionally, regular assessments should be conducted to evaluate the level of inclusivity and identify areas for improvement.

2. Department of cooperatives and Extension agents should increase awareness and education about the benefits of cooperative membership through targeted outreach programs. This can include community meetings, informational campaigns, and success stories from existing cooperative members. Addressing barriers to participation, such as access to information and resources, will encourage more farmers to join cooperatives.

3. Government and other stakeholders should ensure cooperative members have access to climate change information, market, credit, training and skills development to ensure a more inclusive cooperative that will empower its members to increase their output and income.

4. Strengthen the support systems within cooperatives to promote the adoption of water-related climate-smart practices. This can be achieved by providing technical assistance and resources for implementing water-related climate smart practices, such as access to improved irrigation technologies and training on irrigation (drip/sprinkler), rainwater harvesting, drought tolerant

crops, conservational tillage, cover cropping and mulching practices. Cooperatives should also facilitate knowledge-sharing platforms where members can exchange experiences and best practices related to WCP.

5. Researchers and policy makers should conduct regular evaluation of the socio-economic impacts of innovations such as WCP adoption among cooperative members. This can involve collecting data on income levels, yield improvements, and resilience against climate-related shocks. The findings should be used to advocate for more support and resources for cooperatives, demonstrating the tangible benefits of adopting climate-smart practices. Additionally, policymakers should consider integrating these findings into broader agricultural and climate policies to enhance support for cooperative models.

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APPENDICES

Appendix 3.1: Farmer questionnaire on "inclusivity of vegetable cooperative and effect on adoption of water-related climate smart practices among vegetable farmers

QUESTIONNAIRE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS (DAEA)

SCHOOL OF AGRICULTURE (SoA)

COLLEGE OF BASIC AND APPLIED SCIENCE (CBAS)

UNIVERSITY OF GHANA (UG)

TOPIC: INCLUSIVITY OF VEGETABLE COOPERATIVE AND EFFECT ON ADOPTION OF WATER-RELATED CLIMATE SMART PRACTICES AMONG VEGETABLE FARMERS IN SOUTHERN GHANA

I am carrying out a study on the topic "Inclusivity of Vegetable Cooperative and Effect on Adoption of Water-Related Climate Smart Practices among Vegetable Farmers in Southern Ghana".

This study is part of my master's Thesis project with major objective of assessing how inclusive cooperative business model (ICBM) drive adoption of water-related climate smart practices (WCP) among vegetable farmers.

The specific objectives are to:

1. Determine the extent to which vegetable cooperatives in Ghana are inclusive,
2. Identify the factors that influence participation in vegetable cooperatives are inclusive,
3. Determine the level to which inclusive vegetable cooperatives are effective in the adoption of WCP and
4. Measure the impact of cooperative membership on output and income of vegetable farmers.

The study is based on a selected sample in Ghana, so your active participation is important. The outcome of this study will enhance knowledge on the role of Inclusive Cooperative Business Model in driving the adoption of Water Smart Agriculture.

I do understand that your time is valuable, I believe the exercise will only take not more than thirty minutes (30m) of your time. Information gathered however, will be treated confidentially, and the results will be presented in such a way that no individual may be recognized the identity of the respondent.

Thank you for your time and contribution

Jerry A. Akanwake (0545442178)

SECTION A

Background of respondents

1. What is your age? …………………………………..
2. What is your gender? Male (1) [ ] Female (0) [ ]
3. What is your religion? Christianity (1) [ ] Islam (2) [ ] Traditional (3) [ ] Others(4) [ ]
4. What is your main occupation? Farmer (1) [ ] Trader (2)[ ] Teacher(3) [ ] Security (4) others (5)[ ]
5. How many years have you been farming vegetable? ……………
6. What type of vegetable you farm?

   Lettuce (1) [ ] cabbage(2) [ ] green pepper (3) [ ] tomatoes(4) [ ] cucumber (5) [ ] others (6) [ ]

7. What is your level of education?

PhD	Master's Degree	Undergraduate Degree	Secondary	Basic	No Formal education
1	2	3	5	6	7

8. What is your marital status unmarried (1) [ ] married (2)[ ] divorced(3) [ ] widow (er) (4) [ ]
9. What is your household size? ……………………………………………
10. What is the number of your household dependant? ……………………………..
11. How many of your household dependent work on the farm?
12. What is your residential status? House owner (1) [ ] Tenant (2) [ ] Housekeeper(3) [ ]
13. In the last farming season (2023 season), how much did you earn annually (GHS)? ……………………………
14. Do you own the land for your vegetable farming? Yes (1) [ ] No (0) [ ]
15. How did you get the land you are farming on? Friend's land (1) [ ] Government land (2) [ ] Rented land (3) [ ] cooperative land (4) [ ]
16. What is your total land size? (acres) ………………………
17. How many acres of your total land size is under vegetable irrigation?........................

Section B: Cooperative

18. Do you belong to a cooperative? Yes (1) [ ] No(0) [ ]
19. Has this cooperative been officially registered? Yes (1) [ ] No(0) [ ]
20. What is the name of this cooperative? …………………………………
21. What is your position in the cooperative? Cooperative Executive (1) [ ] Cooperative Member(2) [ ]
22. How many years has it been in operations? ………
23. How many years have you been in the cooperative? ....

24. What is the total number of members in your cooperative? …………………

SECTION C

Cooperative's application of Inclusive Business Model

Select the most appropriate that best describe your rating of your agreement on the extent of your cooperative's application of the Inclusive Business Model in the following areas. Please rate on a scale of 1 to 5, with 1 being "strongly disagree" 2 being "disagree", 3 "neutral", 4 being "agree" and 5 being "strongly agree."

	Ownership Dimensions	1	2	3	4	5
25.	The cooperative is open to every farmer engaged in vegetable farming and does not exclude vulnerable groups like; women, disable, poor and the less educated.					
26.	The cooperative does not discriminate against any member based on the state of ability and disability.					
27.	Within the cooperative, there are flexible trading arrangements that make it easier for smallholders or micro or small enterprises (MSEs) to supply a vegetable buyer, such as cash on delivery, accepting small consignments, and providing reliable and regular orders.					
28.	The cooperative helps land-poor farmers to have access to land for their farming activities.					
29.	The cooperative provides opportunities for young farmers to join and gain access to training					
30.	The cooperative makes members have a sense of belonging and ownership of their farms and farm produce					
	Voice Dimension					
31.	The cooperative is scalable in the medium term so that the number of small actors who practice WCP can be increased.					
32.	When it comes to the adoption of WCP, there is inclusive participation of small-scale farmers in decision-making processes.					
33.	The cooperative advocates and ensures there are sustainable farming practices					
34.	The cooperative supports farmers and small enterprises to establish a stronger negotiation position through skills development, collective bargaining and access to market information and financial services for them to adopt WCP.					
35.	The cooperative ensures there is gender equity and equality					
	Risk Dimension					
36.	The cooperative creates an avenue to provide WCP assistance and a living wage for vulnerable groups, such as smallholders, small enterprises, women-and youth-run enterprises, while also enabling buyers to profit					
37.	The cooperative targets poverty eviction for all members					
38.	There is equal access to finance and credit facilities for all members within the cooperative so they can afford to participate in WCP.					
39.	The cooperative provides access to cost effective inputs					

40.	The cooperative provides avenues for output aggregation and market for members produces.					
	Reward Dimension					
41.	The cooperative allows for diversified income streams in the long term, enabling the dissemination of upgraded skills to other crops and livestock farming that empowers WCP					
42.	The cooperative builds on the skills and expertise of existing farmers such as traditional water management practices, and promotes value chain collaboration, transparency in pricing mechanisms and risk sharing most especially WCP equipment.					
43.	The cooperative organizes and give technical advice and training to members					

44. What is your perception of inclusion in your cooperative? No inclusion (0) [ ] Inclusive (1) [ ]

SECTION D

Factors that influence participation in inclusive business model of vegetable cooperatives.

Please select the most appropriate that best describe your agreement on the factors that influence participation in inclusive business of vegetable cooperatives. Select **"yes"** if it influences your participation and **"no"** if the statement does not influence your participation.

		Yes	No
45.	When there is finance and credit facility assistance		
46.	When there are market access opportunities for members		
47.	When there is trust and confidence in cooperative executive and management		
48.	When there is inclusiveness of members in decision making		
49.	When there is access to water resources for irrigation		
50.	the cost of purchasing inputs and equipment influence my participation		
51.	When there is training and skills development for members		
52.	When there is access to climate change information		
53.	The level of my income influences my participation in cooperatives		
54.	The perceive contribution of cooperatives to the social and environment impact to the community		
55.	When I know the cooperative will empower and increase my income		
56.	The number of my household dependents influence my participation		
57.	The size of my farm influences my participation		

SECTION E

Effectiveness of Inclusive Cooperative Business Model in adopting Water-Related Climate-Smart Practices.

58. How familiar are you with climate smart practices in vegetable farming? Not familiar at all (1)[ ] Somewhat familiar(2) [ ] Quite familiar(3) [ ] Very familiar(4) [ ]
59. Does your cooperative prioritize water smart agriculture practices? Yes (1) [ ] No(0) [ ]
60. Does your cooperative have a demonstration farm for WCP? Yes (1) [ ] No(0) [ ]

Has your cooperative implemented any of the following water-related climate-smart practices? (Select "Yes" if your cooperative implemented and "No" if not implemented by your cooperative).

61. Drip and/or sprinkler irrigation (MEPIDs) Yes (1) [ ] No(0) [ ]
62. Conservation tillage Yes (1) [ ] No(0) [ ]
63. Mulching Yes (1) [ ] No(0) [ ]
64. Cover cropping techniques (cover cropping and agroforestry) Yes (1) [ ] No(0) [ ]
65. Growing drought-tolerant crops Yes (1) [ ] No(0) [ ]
66. Rainwater harvesting Yes [ ] No [ ]

Have you a farmer implemented any of the following water-related climate-smart practices? (Select **"Yes"** if your cooperative implemented and **"No"** if not implemented by your cooperative)

67. Drip and/or sprinkler irrigation (MEPIDs) Yes (1) [ ] No(0) [ ]
68. Conservation tillage Yes (1) [ ] No(0) [ ]
69. Mulching Yes (1) [ ] No(0) [ ]
70. Cover cropping techniques (cover cropping and agroforestry) Yes (1) [ ] No(0) [ ]
71. Growing drought-tolerant crops Yes (1) [ ] No(0) [ ]
72. Rainwater harvesting Yes [ ] No [ ]

Please rate the following factors on a scale of 1 to 5, where 1 represents the strongly disagree 2 represents disagree, 3 represents neutral, 4 represents agree and 5 represents the strongly agree.

Drip and/or sprinkler irrigation (MEPIDS)

		1	2	3	4	5
73.	The cooperative has created an avenue for easy access to water for irrigation					
74.	The cooperative has aided in my access to water pumping machine for irrigation					
75.	The cooperative has created avenue to purchase pipes at a less cost					
76.	The cooperative has created avenue to purchase drips and sprinklers equipment at a less cost					
77.	The cooperative has been organising capacity building training about irrigation.					
78.	The cooperative has empowered me not to depend on rainfall					
79.	My vegetables have enough moisture and water for their growth					
80.	The cooperative has dugout and dams to be used for irrigation					

81.	The cooperative has an underground water access for irrigation					
82.	The cooperative has been effective in helping to adopt irrigation					
83.	The cooperative has made available solar powered irrigation for our farms					
84.	We can use remote control to irrigate our farms					

Mulching

85.	The cooperative advocates for the use of mulching to aid water retention					
86.	The cooperative has empowered me with training on mulching					
87.	Through the cooperative, mulching has improved my soil moisture and water retention					
88.	Mulching have helped farmland to be fertile					
89.	The cooperative has been effective in helping me adopt to mulching					

Conservational Tillage

90.	The cooperative advocates for the practice of conservation tillage					
91.	The cooperative has been organising training on conservation tillage					
92.	The cooperative has helped me to manage my farmland					
93.	Conservation tillage has improved the soil fertility of my farm					
94.	The cooperative has been effective in helping me to adopt conservation tillage					

Cover cropping

95.	The cooperative advocates for the practice of cover cropping					
96.	Cover cropping has helped in weed control in my farm					
97.	Cover cropping has helped in pest and disease control					
98.	Through cover cropping, there had been an increase my yield					
99.	The cooperative has been effective in helping me to adopt cover cropping					

Growing Drought-Tolerant Crops

100.	The cooperative advocates for the use of drought tolerant crops during the dry season					
101.	The cooperative has been organising training on drought tolerant crops					
102.	The cooperative has helped me to purchase seeds of drought tolerant crops at a lower cost					
103.	Drought tolerant crops have reduced the risk of crops failure					
104.	The cooperative has been effective in helping me to adopt the growing of drought tolerant crops					

Water Harvesting

105.	The cooperative has empowered me with training on water harvesting					
106.	The cooperative has help me to afford containers to harvest rainwater at a lower cost					
107.	The cooperative has helped in the conservation of water					
108.	The cooperative has helped improve water availability to be used for farming purposes					
109.	The cooperative has been effective in helping me to adopt the practice of rainwater harvesting					

110. Will you recommend vegetable farmers to join inclusive cooperative? Yes (1) [ ] No(0) [ ]

111. If no, why …………………………………………………………………………………… ……………………………………………………………………………………………

SECTION F

Measure the effects of WCP adoption on yield and income of vegetable farmers

Yield

112 WCP adoption has improved my farmland soil fertility. Yes (1) [ ] No(0) [ ]

113 How many times do you used to farm vegetable in a year? ………….

114 After adopting WCP, how many times do you farm in a year now?.........................

115 What was the quantity of vegetable harvested per acre (in cup/75 g)? ……….

116 What quantity of vegetable did you harvest during the 2023 farming season (cup/75g)? ………..

117 Was there market access to sell your produce? Yes (1) [ ] No(0) [ ]

118 Has WCP adoption increased your vegetable yield? Yes (1) [ ] No(0) [ ]

Income

119 Adoption of WCP have created employment. Yes (1) [ ] No(0) [ ]

120 How much do you sell your vegetables per cup (75g)?....................

121 How much was your total income for the 2023 farming period (GHS)?.................

122 WCP adoption have enabled me the opportunity to cultivate diversified crops which has created diversified income. Yes (1) [ ] No(0) [ ]

123 WCP adoption have doubled my income. Yes (1) [ ] No(0) [ ]

124 How much do you spend per month on your household (GHS)?..............

125 Adopting WCP, has it created opportunity for you to take care of your household expenses? Yes (1) [ ] No(0) [ ]

126 Did the adoption of WCP helped you reduce money spend to buy chemical fertilizer for your vegetable farm? Yes (1) [ ] No(0) [ ]

127 Can you estimate the amount of money saved from buying chemical fertilizer because of WCP adoption?.................

128. Do you think the inclusive cooperative business model has helped in the adoption and implementation of water-related climate smart practices in your vegetable farming? Yes (1)[ ] No(0) [ ]

129. If no, explain ………………………………………………………………………………………… …………………………………………………………………………………………………

Please select from "Yes" if you faced any challenges in adopting Water Related climate Smart Practices and "No" if you have not faced any of the following challenges.

Have you faced any of the following challenges in adopting WCP?

130. Land tenure arrangement Yes (1) [ ] No(0) [ ]
131. Inadequate capacity building training Yes (1) [ ] No(0) [ ]
132. Limited funding Yes (1)[ ] No(0) [ ]
133. Limited access to credit Yes (1) [ ] No(0) [ ]
134. Production cost Yes (1) [ ] No(0) [ ]
135. Lack of government support Yes (1) [ ] No(0) [ ]
136. Do you have any other comment that you want to add? Yes (1) [ ] No(0) [ ]

137. If yes, ………………………………………………………………………………………………… …………………………………………………………………………………………………

Thank you for your time and participation.