UNIVERSITY OF CAPE COAST

ECONOMIC ANALYSIS OF INCLUSIVE AND SUSTAINABLE BUSINESS MODELS FOR SMALLHOLDER VEGETABLE FARMERS IN THE EASTERN REGION OF GHANA

STEPHEN DANSO AWUAKYE

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BY

STEPHEN DANSO AWUAKYE

A thesis submitted to the Department of Agricultural Economics and Extension of the School of Agriculture, College of Agricultural and Natural Sciences, University of Cape Coast, in partial fulfillment of the requirements for the award of a Master of Philosophy degree in Agricultural Economics

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: .... Date: ....

Candidate's Name: Stephen Danso Awuakye

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised under the guidelines on supervision of the thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature: .... Date: ....

Name: Prof. Henry De-Graft Acquah

Co-Supervisor's Signature: .... Date: ....

Name: Dr. Alexander T.K. Nuer

ABSTRACT

The essence of this study was to examine inclusive business models that could promote the adoption of new technologies among smallholder vegetable farmers in the Denkyembour District in the Eastern Region of Ghana. Data collection for the study was done through the administering of a structured questionnaire. Census was carried out on 150 smallholder vegetable farmers who were beneficiaries of the project titled: Building vegetable farmers' resilience to climate change. Descriptive statistics, gross margin analysis, stochastic profit frontier efficiency model, correlation, and binary logistic regression were used in analyzing the data. Findings from the study indicated that farmers who cultivated both okra and garden eggs had a gross margin of (83.23%) and were found to be more profitable than only okra farmers and only garden egg farmers. With the mean profit efficiency value of (93%), only okra farmers were found to be more profit efficient than the other vegetable-farmer categories. The results also showed that smallholder vegetable farmers had high competencies in Vegetable Production Management Practices (VPMPs) with moderate knowledge, high attitude, high skills, and high aspirations. Direct Farming was the existing Business Model type commonly practiced by the majority of farmers as a result of insufficient knowledge of farmers on inclusive business models (IBM). Farmers' choice of business model types was influenced by: age, level of education, main occupation, the use of irrigation facility, farmer group, number of times of accessing extension services, knowledge and attitude in VPMPs, and their awareness of IBM. The study proposed that smallholder vegetable farmers in the study area could extremely do well in an improved vegetable value chain model situated in an enabling regulatory framework with a financial mechanism. The study recommended that MOFA and other stakeholders in agriculture should educate smallholder farmers on the relevance of IBM in the vegetable industry, help to link them to other vegetable value chain actorsd regulate the contractual agreement between the farmers and their partners to minimize cheating or fraud in the value chain.

KEY WORDS

Climate change

Inclusive business models

Smallholder Vegetable farmers

Sustainability

Technological innovation

Vegetable production

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DEDICATION

To my father Robert Akwasi Owusu and my mother Cecilia Yaa Nkrumah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

B2B	Business-To-Business
B2C	Business-To-Customers
BM	Business Model
BoP	Base of the Pyramid
Cert	Certification
CFOS	Contract Farming and Out-Grower Scheme
CPA	Certified Public Accountant
DANIDA	Danish International Development Agency
DF	Direct Farming
ECA	Electronic Commerce Agriculture
ECR	Efficient Consumer Response
EFB	Empty Fruit Bunch
EU	European Union
FAO	Food and Agricultural Organization
FDA	Food and Drug Authority
FOB	Farmer-Owned Business
GAP	Good Agricultural Practice
GOPDC	Ghana Oil Palm Plantation Development Company Limited
GVC	Global Value Chain
HACCP	Hazard Analysis at Critical Control Points
IBM	Inclusive Business Model
IMO	International Maritime Organization
IRB	Institutional Review Board
ISBM	Inclusive and Sustainable Business Model

IT	Information Technology
JVs	Joint Ventures
LI	Legislative Instrument
MOFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organization
OGVF	Organic Greenhouse Vegetable Farming
SCM	Supply Chain Management
SCTF	Sharecropping and Tenant Farming
SDGs	Sustainable Development Goals
SPF	Stochastic Profit Function
TOP	Theory of Change
TR	Total Revenue
TVC	Total Variable Cost
UN	United Nations
UPA	Urban and Peri-Urban
VPMPs	Vegetable Production Management Practices
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background to the Study

Vegetable in the broadest sense usually refers to the fresh edible portions of certain herbaceous plants—roots, stems, leaves, flowers, fruit, or seeds. These plant parts are either eaten fresh or prepared in several ways, usually as a savory, rather than sweet, dish. Most fresh vegetables are low in calories and have a water content of over 70 percent, with only about 3.5 percent protein and less than 1 percent fat (Wadhwa & Bakshi, 2013). Vegetables are crucial in ensuring food and nutritional security, as they are rich in essential micronutrients such as Zinc, Calcium, Iron, and Vitamins, which are not present in most staple foods consumed. Vegetables are almost universally high in dietary fiber and antioxidants.

Typically, vegetables are categorized according to the plant portion that is used for food. Beets, carrots, radishes, sweet potatoes, and turnips are some of the root vegetables. Vegetables with stems include kohlrabi and asparagus. Potatoes are of edible subterranean stems or tubers. Brussels sprouts, cabbage, celery, lettuce, rhubarb, and spinach are examples of vegetables with leaves and stalks. Onions, leeks, and garlic are examples of bulbous vegetables. Artichokes, broccoli, and cauliflower are examples of vegetables with flowers on their heads. Cucumbers, eggplant, okra, sweet corn, squash, peppers, and tomatoes are fruits that are frequently used as vegetables. Legumes like peas and beans are frequently used as seed vegetables.

Vegetable production can be referred to as the cultivation of vegetables for human use, according to Welbaum (2015). Vegetable production practices started in different parts of the world over a thousand decades years ago, whereby families grew vegetables for their consumption or to trade locally. Initially, manual labor was used until when domesticated livestock was introduced to plow farmlands to improve productivity. Vegetable production has seen a radical transformation in more recent years as a result of mechanization, where vegetable farmers employ technological innovation in their farming practices. Dedicated farmers cultivate the specific crops that thrive in their region. These days, innovative techniques including aquaponics, raised beds, and glass-enclosed production is employed.

Vegetable production provides an attractive source of employment for rural and peri-urban dwellers. In rural areas, this typically takes place through truck farming (market-oriented, large-scale production of fresh produce) and in peri-urban areas through market and backyard gardening. Vegetable production thus plays an important role in rural and peri-urban livelihoods and at the same time provides much-needed nutrients for rural and urban dwellers (Laibuni et al., 2020). Thus, it has a high potential for reducing food and nutrition insecurity, and for improving rural employment and income in Ghana.

In Ghana, the consumption of vegetables per capita is below the minimum of 200 kg person-1 yr-1 (Afari-Sefa et al, 2012). Consequently, sustained awareness creation by the government and other industry players of the nutritional benefits of vegetables has led to excess local demand leading to the domestic vegetable market growing at over (10%) per year. Unfortunately, vegetable productivity is currently stagnating or declining in some areas despite the increases in the cultivated area (Eigennbrod & Gruda, 2015). Responsible factors include declining soil fertility, drought and heat stress arising from climate change, and the prevalence of pests and diseases. Climate change and variability is a growing global challenge and its impact on temperature and rainfall is predicted to significantly reduce crop yield.

In Ghana, the average annual temperature for all agroecological zones has increased by 1°C in the last three decades (Bunn et al, 2019). Simultaneously, rainfall totals are declining and becoming more erratic such that the rainfall regime is shifting towards a long dry season (Vercillo et al., 2020). For all agroecological zones in Ghana, projections show that average annual temperatures increased by 0.8°C in 2020 and it is expected to reach 5.4 °C in 2080, while average annual rainfall decreased by (1.1%) and (20.5%), respectively (Adzawla et al., 2020). Higher temperatures coupled with prolonged dry spells increase evapotranspiration, resulting in a decrease in soil moisture available for vegetable production.

Furthermore, most Ghanaian vegetable farmers are price-takers in traditional vegetable markets with little or no capacity to add value to their produce through quality improvements and/or improved marketing practices such as direct sales to supermarkets/wholesalers or off-season production. According to Djokoto et al. (2015), this is felt especially during the main cultivation seasons when vegetable prices plummet and undermine farm profits, while in the off-season consumers suffer from high prices and low quality.

Therefore, there is a need for agricultural transformation where vegetable farmers could adopt technological innovation that would help address climate change and develop adaptation strategies to mitigate emerging problems. Thus, an approach that simultaneously could address agronomic, farm-economic, and market constraints, thereby, likely to create value for both food producers, marketers, and consumers in the economy.

This thesis is an aspect of a work package of project titled “Building Vegetable Farmers Resilience to Climate Change” sponsored by the Ministry of Foreign Affairs of Denmark. The main objective of the project is; “To enhance vegetable farmers resilience towards increasing temperatures and erratic rainfall patterns in smallholder vegetable farming communities through the use of EFB as an organic amendment, identification of climate resilient vegetable varieties, simple irrigation infrastructure and rainwater harvesting technologies in a participatory approach”.

Therefore, this paper seeks to identify existing business models that can be used by the vegetable farmers in the Denkyemour District, Eastern Region of Ghana to mitigate the challenges posed by climate change, the extent of its use, the challenges that impede its adoption by the vegetable farmers, and then base on practical and literature review, propose an inclusive and sustainable business model that could enable smallholder vegetable farmers to adopt new technologies and innovation for vegetable farming. This would be done by reviewing the literature, administering questionnaires to the target stakeholders, and analyzing the results.

Statement of the Problem

The proportion of undernourished people in the world has declined from 15 percent in 2000-2004 to 8.9 percent in 2019, yet about 690 million people globally are undernourished (Mujwahuzi & Maselle, 2022). Researchers have proven that there is more than enough food produced in the world to feed everyone on the planet. However, as many as 811 million people worldwide go to bed hungry each night (Parnerkar, 2016). According to Brown (2012), small farmers, herders, and fishermen produce about 70 percent of the global food supply, yet they are especially vulnerable to food insecurity – poverty and hunger are most acute among rural populations. Tshekiso (2017) stated that, despite the effort of the government and the agricultural sector to reduce the issue of hunger in the economy, several rural and peri-urban areas in Ghana still face imminent food insecurity.

Vegetable production is one of the farm business ventures that farmers can use to argument any other activities they endeavor to sustain their livelihood because of the economic value of vegetable production. According to Fan and Rue (2020), Vegetable production provides an attractive source of employment for rural and peri-urban dwellers. This implies that vegetable farmers will potentially not only depend on their vegetable produce for food but will also serve as a source of income to them to enhance their standard of living.

However, despite the economic value of the vegetable production, Shahzadet al. (2021) asserted that there is stagnation of vegetable production in Ghana, especially among smallholder vegetable farmers. Some of the responsible factors contributing to the decline of the vegetable production are the decline of soil fertility, drought and heat stress arising from climate change, prevalence of pests and diseases, and the unstable nature of the price of vegetable produce. These factors have proven to be the major constraints that deters farmers from venturing into vegetable production. Kpeda (2022) in a report explained that, the income farmers derived from vegetable production in the Denkyebour District has drastically fallen by approximately 40 percent within a decade. Kpeda (2022) further explained that vegetable production in the Denkyebour district is no longer attractive and lucrative in the eyes of farmers. As a result, most vegetable farmers are diverting from vegetable farming to other business ventures. Thus, some potential and hardworking vegetable farmers have stopped producing for some time, said Kpeda (2022).

Notwithstanding, there is a growing consensus that one of the key priorities to address food and nutrition security is to aim at the transformation of agriculture and food systems (Danse et al., 2020). According to literature, agricultural technologies have boosted crop yield increases and household incomes, particularly, during the Green Revolution in Asia and some parts of Sub-Sahara Africa (Ochieng et al., 2016). Also, Santpoort (2020) asserted that, technological innovation enhances productivity and it has positive impact on farmers' livelihood. However, Ochieng et al. (2022) stated that, the adoption of yield-enhancing technologies in the vegetable subsector is still low, particularly among smallholder farmers. Ochieng et al. (2022) further explained that, most farmers inability to employ this technological innovation is due to the fact that most of these yield enhancing technologies are capital intensive but most of these smallholder farmers are on the other are not financially sound to afford such facilities. Moreover, the technical know-how of such facilities also deters some of the smallholder farmers from patronizing them (Ochieng et al., 2022).

Recent researchers (Kelly, Vergara & Bammann (2015), Kaminski et.al, (2020) etc.) and other stakeholders have designed different kinds of farming business practices (business models) such as contract farming that could help farmers, even smallholders to handle the current situations that they are facing. This is to enable farmers to access farm inputs, funds, reliable sources of market and more importantly to integrate farmers along the vegetable value network. Thus, the use of this farming business strategy will empower farmers to acquire all the necessary and available technological innovations that enhance productivity and thereby improve the livelihood of farmers. Meanwhile, most of these business models are underutilized or not being used at all among smallholder farmers in the Denkyembour district.

A report titled "Smallholder Farmers and Business Models for Sustainable Farming Systems" asserted that smallholder farmers' inability to adopt IBM is due to farmers' low access to knowledge and resources, inadequate collaborative partnerships, and inadequate supportive policies to promote inclusive business models (Wageningen University & Research, 2016). Also, a case study from Kenya indicated that limited access to inputs, lack of market information, and weak institutional support are the challenges faced by smallholder farmers in Kenya when implementing inclusive business models (Juliet et al., 2017). Furthermore, Boris et al. (2018) in a review titled "Inclusive Business Models in Agriculture" also asserted that access to finance, technology, markets, and infrastructure, among others are the potential constraints that smallholder farmers face in the implementation of IBM.

However, at the time of conducting the study, it was hard to come across any research work that has been conducted to investigate the reasons why smallholder vegetable farmers are not patronizing the existing business models in the Eastern Region of Ghana, especially within the context of the study area. Therefore, to help fill the existing knowledge gap, the study sought to do an economic analysis of inclusive business models for smallholder vegetable farmers in the Dekyembour District in the Eastern Region of Ghana.

Purpose of the Study

To examine an inclusive business model for technological and economic upgrading of smallholder vegetable farmers in the vegetable value network

Objectives the of Study

General Objective

To examine inclusive business models that promote the adoption of new technologies among smallholder vegetable farmers in the Denkyembour District in the Eastern Region of Ghana

Specifics Objectives

1. To examine the profitability performance of smallholder vegetable farmers in the Denkyembour District.
2. To examine the competence level in vegetable production management practices (VPMPs) of smallholder vegetable farmers in the Denkyembour District.
3. To examine existing business model types and the extent of use among smallholder vegetable farmers in the Denkyembour District.
4. To examine factors that influence the choice of inclusive business model type by smallholder vegetable farmers in the Denkyembour District.
5. To propose an inclusive and sustainable business model that could facilitate technological and economic upgrading for smallholder vegetable farmers in Denkyembour District.

Research Questions

1. What is the performance level of smallholder vegetable farmers in the study area in terms of profitability?

2. What are the levels of farmers’ competence in vegetable production management practices?
3. What are the exiting business model types and the extent of use by the smallholder vegetable farmers in the study area?
4. What factors influence smallholder vegetable farmers in choosing a particular business model over the other?
5. What inclusive and sustainable business model could be proposed as an appropriate model for smallholder farmers in the study area base on both literature and practical review?

Justification/Significance of the Study

Conducting an economic analysis of inclusive business models for smallholder vegetable farmers will help to identify and analyze existing business model types for smallholder vegetable farmers, the extent of their use, their impact on farmers’ livelihood, and the challenges associated with it. The success of this work would inform the project sponsors, NGOs, Agricultural Extension Agents, the government, and researchers on the existing business model types for smallholder vegetables and how far they are being utilized by farmers, why they are not being used, factors that influence the choice of farmers on one business models over another, and then recommend the most appropriate inclusive and sustainable model type that they could adopt to mitigate the impact of climate change and prevalence pest and diseases, and how they can link-up with other actors on the vegetable value network.

It is also envisaged that smallholder vegetable farmers in the study area would come to understand the essence of employing inclusive and sustainable business models in the farming business. Perhaps, it will enable smallholder vegetable farmers in the study area to make effective and efficient use of improved technological innovation in the field of agriculture, especially in the vegetable subsector.

Delimitation

This study is a work package of a project which seeks to enhance the resilience towards increasing temperatures and erratic rainfall patterns in smallholder vegetable farming in the Eastern Region of Ghana through the use of EFB as an organic amendment, identification of climate-resilient vegetable varieties, simple irrigation infrastructure and rainwater harvesting technologies in a participatory approach. This study addressed specific objectives such as: to examine the profitability performance of smallholder vegetable farmers in Denkyembour District; to examine the competence level in vegetable production management practices (VPMPs) of smallholder vegetable farmers in Denkyembour District; to examine existing business model types and the extent of use among smallholder vegetable farmers in Denkyembour District. ; to examine factors that influence the choice of inclusive business models type by smallholder vegetable farmers in the Denkyembour District; to propose an inclusive and sustainable business model that could facilitate technological and economic upgrading for smallholder vegetable farmers in Denkyembour District. A cross-sectional survey design was employed in this study. Descriptive statistics, gross margin analysis, stochastic profit frontier efficiency model, correlation, and binary logistic regression were used in analyzing the data.

Limitation

This study worked with a target farming group in the Eastern Regions of Ghana which will be given intensive training on vegetable production. Perhaps, generalizing the findings may be a little bit difficult, especially for a common farmer who just farms for survival. Moreover, almost all smallholder farmers do not keep proper records of their production activities which in turn affects the calculation for revenue maximization. Also, the unwillingness of the respondents to disclose some vital information was a hindrance to the progress of the study. Although all the respondents are going to benefit from the study since they are part of the project, some were expecting something from the research team.

Definition of Term

Business Model: A business model describes how any given enterprise – large or small, informal or formal – does business, markets its products, and sources inputs and finance. From the perspective of agriculture, it is the model that links small farmers to agricultural value chains. These include traders, farmer organizations, agri-food processors, retailers, and contract farming arrangements with large buyers

Inclusive and Sustainable Business Model (ISBM): this is a business model that promotes the integration of smallholders into markets with the underlying principle that there are mutual benefits for poor farmers and the business community whilst maintaining food security without jeopardizing the benefit of the future generation. The "inclusive" element of the ISBM concept relates to the constraints of linking commodity-dependent smallholders and small enterprises to markets. The "business" element relates to mainstreaming business tools and private sector approaches into agricultural development. The inclusive and business elements of an ISBM often involve competing forces

Profitability: Profitability is the degree to which a business or activity yields profit or financial gain. It is a measurement of the efficiency of a business's activities. Thus, profitability is the ability of a business to earn a profit. The profit here is what is left of the revenue a business generates after it pays all expenses directly related to the generation of the revenue, such as producing a product, and other expenses related to the conduct of the business activities.

Vegetables: Vegetables are parts of plants that are consumed by humans or other animals as food. Thus, they are edible plant matter, including flowers, fruits, stems, leaves, roots, and seeds. Vegetables can be eaten either raw or cooked and play an important role in human nutrition, being mostly low in fat and carbohydrates, but high in vitamins, minerals, and dietary fiber.

Smallholder farmer: The term "smallholder farmers" refers to farmers who own/control a small farm enterprise usually less than five acres in size. Thus, a farmer operates under a small-scale agriculture model. Some factors that distinguish them are the size of the land, food production technique or technology, involvement of family in labor, and economic impact.

Organization of the Study

This study is organized into five chapters. The first chapter consists of the background to the study, a statement of the problem, the purpose of the study, research objectives and questions, significance of the study, delimitations, limitations, definitions of terms, and organization of the study. Chapter two of this paper looks at the literature review, mainly on findings of the research made by different researchers related to the problem under investigation. Chapter three also emphasizes the research methods; research design, study area, population, sampling procedure, data collection instruments, data collection procedures, data processing and analysis, and chapter summary. Discussion of the results and methodology are also mentioned in chapter four. Chapter five focuses on the summary, conclusions, recommendations, and suggestions for further research.

Chapter Summary

The chapter emphasized the introduction to the study which focused on the background to the study, the statement of the problem of the study, the purpose and the objectives of the study as well as the research question and hypothesis that guided the research. The significance, limitations, and delimitation of the study were also presented in this chapter. Last but not the least, how the content of the study was organized systematically was also discussed in this chapter.

CHAPTER TWO

LITERATURE REVIEW

This chapter of the study presents the review of literature from several studies that are related to this study and elaborates on the theoretical basis for the study. This chapter discusses the theories underpinnings the study, an overview of vegetable production in Ghana, the socio-economic importance of vegetables, resources of vegetable production, marketing of vegetables, the concept of business models, types of business models common in vegetable production, the concept of inclusive business models, the empirical and conceptual framework of the study.

Theoretical Framework

Modernization theory

The notion of modernization is used to describe how societies modernize. The so-called "classical" modernization theories of the 1950s and 1960s drew on sociological critiques by Karl Marx, Emile Durkheim, and a scant reading of Max Weber. They also heavily drew on the works of Harvard sociologist Talcott Parsons. After 1991, it came back into fashion when Francis Fukuyama wrote about the conclusion of the Cold War as supporting evidence for modernization theory and, more broadly, for universal history. However, the theory is still a contentious one.

The term "modernization" describes a paradigm of a gradual change from a "pre-modern" or "traditional" society to a "modern" one. The modernization theory contends that traditional civilizations will advance as they take on more contemporary norms. The modernization theory's proponents contend that modern states are wealthier and more powerful than earlier ones and that this freedom allows their subjects to live in greater freedom and at higher standards. Modernization is required or at least preferred to the status quo due to developments like new data technology and the necessity to update conventional means of production, communication, and transportation. Since this viewpoint indicates that these advances dictate the boundaries of human connection rather than the other way around, it is challenging to criticize.

However, it also suggests that human action determines the rate and extent of modernity, which seems to be at odds with one another. According to the theory, civilizations going through the process of modernization often end up with systems of administration defined by abstract principles rather than being dominated by tradition. The argument holds that as modernity spreads, traditional religious beliefs and cultural norms typically lose significance. The theory considers a nation's internal dynamics and assumes that, with aid, "traditional" nations can be propelled toward growth in the same way that more advanced nations have. In addition to attempting to explain how civilizations evolve, modernization theory also tries to pinpoint the social factors that influence social development and advancement. Westernization and modernization have been expressly equated by writers like Daniel Lerner.

The concept of modernization, according to James and Steger (2014), is understood in three ways: 1) as the internal development of Western Europe and North America related to the European New Era; 2) as a process by which countries that do not belong to the first group of countries aim to catch up with them; and 3) as processes of evolutionary development of the most modernized societies (Western Europe and North America), i.e., modernization as a permanent pro. The emphasis in modernization theory is placed on both the process of change and the responses to that change. In addition to referencing social and cultural institutions, it also considers internal dynamics and the adoption of new technology.

The concept of modernization theory in agriculture refers to the development of institutions and technologies in agriculture that increase the welfare of poor and small-scale farmers relative to wealthy large-scale farmers. Accordingly, mechanization strategy is a component of technological change in agriculture as well as the modernization of agricultural behavior, structure, and institutions. Small-scale farmers' technological needs must be prioritized when choosing a technology, which is influenced by factors like price and societal policies. Mechanization and chemicalization are two aspects of agriculture modernization. Mechanization requires more capital investment, whereas chemicalization requires farmers to adopt practices that maximize the usage of fertilizer and other chemicals needed to generate a certain level of output.

In the context of this study, smallholder vegetable farmers are entreated to employ agricultural transformation by making use of technological innovations which have been introduced in the agricultural sector, even in the vegetable sub-sector. Also, with the help of agricultural transformation, smallholder vegetable farmers could as well make use of Inclusive Business Models such as Contract farming, Joint Ventures, and the like which would enable them to easily access funds and inputs for their production, and access a reliable source of market for their produce. This will help increase productivity and even all-year-round production.

The theory of change (TOC)

The Theory of Change (TOC) is a strategy that uses a causal analysis based on the information that is currently available to explain how a certain intervention, or collection of treatments, is likely to lead to a specific development change. This is essentially a thorough explanation of how and why a desired change is anticipated to occur in a specific setting. Any mission-driven project addressing the most critical social and environmental concerns on the planet is built on this principle. So, by describing the causal relationships in an endeavor, it clarifies the organization's intended path to impact (i.e., its short-term, intermediate, and long-term outcomes). Understanding the desired result is the main application of the theory of change. Inferentially, the Theory of Change outlines the influence any organization hopes to have as well as all the intermediate phases to make sure that the resources and activities are in line with the change. However, the theory of evolution needs to be stated before beginning every new endeavor or project, and it should be updated regularly.

Literature on the history and use of ToC shows how it developed from the 1960s' discipline of program theory and evaluation to its more recent appearance as a tool for examining the theories driving programs promoting social and political change (Vogel & Marcotte, 2012). The technique allows flexibility according to a user's demands across several disciplines because it lacks a single definition or predetermined methodology. For scenario planning, impact analysis, or a comprehensive planning, monitoring, and evaluation process, different organizations have used ToCs in different ways.

Mayne and Johnson (2015) highlight various applications for ToC in the design, management, and access of interventions, whether used ex-ante or ex-post. They also offer guidance on the necessity of avoiding complexity in a ToC, for instance, by layering specific sub-components inside a larger ToC. Rogers, cited in Vogel & Marcotte (2012), sums up the justification for using ToCs by stating that "every program is packed with beliefs, assumptions, and hypotheses about how to change happens-about the way humans work, or organizations, or political systems, or ecosystems; and ToC is about articulating these many underlying assumptions

Five primary parts make up the Theory of Change. These are: “Inputs, Activities, Outputs, Outcomes, and Impact”. The resource or investment required to make sure that the activities take place is referred to as “Input” in this context. The term "activities" in this context also refers to the different actions required for the achievement of each result. Output are the immediate results of the activities or products, and they are necessary for achieving the outcome. They are the indicators that determines whether the outcomes are on tract. The changes that the stakeholders are currently experiencing or may experience as a result of the intervention is the "outcome," both intended and unintended. In other words, the benefit the innovator aspires to is what the results are. The systemic change that the inventor anticipates to happen over time is sometimes referred to as the "Impact." Impact typically takes several years to materialize, which makes it challenging to assess, but it does provide a wonderful basis to identify the outcomes that the innovator may affect and quantify.

The Theory of Change comes to play in the context of this study with the reason being that smallholder vegetable farmers are entreated to change from their traditional way of farming (Direct farming model) to an inclusive and sustainable business model which would with the major aim of solving the problem of stagnation of vegetable production to ensure increase productivity in the vegetable value network.

This idea would be realized when farmers make use of agricultural transformation by adopting inclusive and sustainable business models which would enable them to access funds to acquire technological innovation, access the appropriate farm inputs materials on time, and also access a reliable market for their produce. This strategy will give farmers the capacity to produce all year round and in return improve the standard of living of stakeholders.

Theoretical Literature

Overview of Vegetable Production in Ghana

Africa, and Ghana in particular, have long engaged in the cultivation and use of vegetables, making them ancient customs. Most vegetables were introduced to the Gold Coast (Ghana) between the early 19th and early 20th centuries by traders from Portugal and other European countries as well as by Christian Missionaries (Kupperman, 2012). Since then, the development of the agricultural industry and the entire economy has been greatly impacted by the nation's output of vegetables. In light of this, various governments have promoted and helped the agricultural industry by providing farmers with the tools they need to raise food production, attain food security, and improve the welfare of farmers. Ngomuo et al. (2017) estimate that there are roughly 6,376 valuable indigenous African plants, of which 397 are vegetables. According to

Ngomuo et al. (2017), Ghana considers roughly 64 kinds of tropical African plants to be vegetables, although only a small number are produced, eaten, and traded.

Tomato, hot pepper, sweet pepper, cabbage, lettuce, green beans, cucumber, onion, okra, and garden eggs are the vegetables that are most frequently grown in Ghana (Boateng, 2018). Due to their high demand, garden eggs, tomatoes, peppers, onions, and okra are the most common among them, whereas the three northern areas' (Northern, Upper East, and Upper West) primary foods include leafy vegetables such amaranthus (alefu), roselle (bra), and white jute (ayoyo).

The majority of vegetables are grown in Ghana's urban and peri-urban regions (UPA) due to bad roads, storage issues, and high urban demand. According to Boateng (2018), the majority of vegetables are grown in the UPA since these countries have few transportation options, expensive transportation costs, and limited storage facilities. As a result, both customers and producers may quickly access veggies while also saving money on transportation. Urban veggies are primarily grown in Ghana's major cities, such as Tamale, Accra, Kumasi, Cape Coast, and Takoradi, under irrigation. Due to the lack of a natural water source in the city, Abdallah and Mourad (2021) determined that the majority of vegetable gardening in Tamale metropolitan is done alongside wastewater drains, close to dams with tiny lakes, or close to dugouts.

The prominence of fast-food catering services in the nation has led to an increase in the consumption of vegetables (Edward, 2013). They are renowned for boosting human immunity, preventing obesity, controlling chronic diseases, preventing cataract development, preventing stroke, and supplying ample amounts of protein, carbohydrates, vitamins, and minerals (Boateng, 2018). As a result, farmers and market women can earn more money through the production and marketing of vegetables (Ghimire & Wen-Chi, 2016).

Socio-Economic Importance of Vegetable

Vegetables are known to add nutrients like lipids, carbohydrates, and vitamins to some diets (Burlando et al., 2019). The importance of vegetable crops is felt by practically every household. Amoah et al. (2014) claim that in addition to adding flavor to food, veggies also contain a significant amount of protein, vitamins, and minerals. The majority of veggies contain little starch and are rich in phytonutrients. They act as roughage, assisting in digestion and avoiding constipation. In addition to enhancing diets' nutritional quality, vegetable crops also give many people jobs during the dry season by producing them under irrigation and selling them. An important part of the nation's food industry is the production of vegetables.

Despite not being a staple in the majority of Ghanaian communities, the commodity accounts for a sizable portion of the country's overall per capita intake of fruits and vegetables. The percentage of fresh veggies sold and consumed in Ghana is thought to be around (70%) (Acheampong et al., 2012). Vegetable markets, like those for other agricultural commodities, are characterized by low producer and high consumer pricing, a situation that points to an ineffective marketing strategy (Babiker & Frahna, 2017). Many tropical nations are experiencing population growth, which has increased awareness of the value of vegetable crops as a food source. This awareness has also been accompanied by the realization that many vegetables can provide essential nutritional materials that may not be easily available from other sources (Babiker & Frahna, 2017).

To survive and generate cash, vegetables are crucial. Recent studies conducted in Cameroon and Uganda by the Natural Resources Institute show that vegetables offer the poorest people a considerable potential to earn a living as producers and/or dealers without requiring large capital inputs. Due to their modest costs compared to other food items, they are essential commodities for low-income households (Gido et al., 2016).

According to Dittoh (2013), Nigerian dry-season vegetable growing has become a booming industry. There are other persons involved in getting the product from the producer to the customer in addition to the farmer and farm workers who grow the vegetables. Due to their abundance of vitamins, minerals, and other key micronutrients that are absent from the majority of Ghanaian staple foods, vegetables are essential for maintaining both food and nutritional security. Ghana's per capita vegetable consumption is below the recommended level of 200 kilograms per person per year (Afari-Sefa et al, 2012). As a result of continued government and industry efforts to raise knowledge of the nutritious benefits of vegetables, there is an excess of local demand, which is driving the domestic vegetable market's growth rate to over 10% annually (Rekhy & McConchie, 2014).

The production of vegetables offers rural and peri-urban residents a desirable source of employment. Truck farming, which is the large-scale, market-driven production of fresh produce, is the normal method for vegetable farming in rural areas. Whereas market and backyard gardening are the main methods in peri-urban areas for vegetable production. Thus, vegetable cultivation is crucial for rural and peri-urban livelihoods and also offers much-needed nutrients for people living in both rural and urban areas (Fan & Rue, 2020). As a result, it has a great chance of lowering food and nutrition insecurity as well as enhancing rural employment and income in Ghana.

Vegetable Production Resource

According to Vendryes (2014), agricultural land is legitimately the most significant natural resource and the key to boosting peasant output. The land was considered by Ogato (2013) as the most important productive resource in the rural economy. Investing in the land itself is necessary to increase agricultural productivity, claim Asiamah et al. (2021). Asiamah said that farmers could not invest much unless they were confident in the returns on the time and money, they invested in enhancing the land.

Since cultivable land is becoming increasingly rare, most nations have been unable to boost production (Kashyap & Agarwal, 2020). According to Kashyap and Agarwal (2020), this is made worse by the fact that the majority of lands have lost their ability for production at a time when the cost of cultivating additional lands is likewise expensive and rising. Production is hampered by land ownership and acquisition. According to Abubakari et al. (2016), the fragmentation of holdings in Ghana's land tenure system has acted as a barrier to improvements in agriculture.

As a result of the inheritance system, several people share a single plot of land, resulting in ongoing holdings fragmentation, which has the critical impact of discouraging economies of scale (Lechner & Boli, 2020). According to Kashyap and Agarwal (2020), if agriculture is the main line of work, the means of subsistence will depend not only on the fertility and ease of putting land to productive use but also on the distribution of property rights and the selling and sharing of its production.

According to Stanturf et al. (2014), the usage of land varies not just by biological or physical factors which may restrict what can be grown—but also by the tenure arrangements. In Ghana's traditional systems, where vegetables are farmed alongside other crops, farmers typically have no trouble acquiring land for vegetable production (Mulaudzi, 2017). He did, however, point out that an increase in commercial arrangements for renting land, particularly for the dry season, has coincided with the expansion in commercial vegetable cultivation.

Other vital resources that are crucial to the production of vegetables include labor and capital in addition to land. Without labor and capital, land cannot produce anything. Agriculture is the primary occupation of almost 75 percent of households in the nation. Approximately 90% of the population lives in savannah zones, 86% in the forest zone, and 51% in the coastal savannah zone (Dickson et al., 2017).

Commercial vegetable cultivation in Ghana is extremely labor-intensive, according to studies by Kleemann and Thiele (2015). Many farmers use family labor if their farms are small, and production typically competes with food and tree crops for family labor. Therefore, most farmers boost their own family's labor supply by hiring additional workers. Regarding urban and peri-urban agriculture, Manda (2022) notes that some peri-urban vegetable producers continue to lament the lack of labor, and it is frequently discovered that the available family and hired labor has been moved to higher-paying factory jobs.

To till the soil, water the crops, apply crop protection chemicals and process the obtained goods, equipment is required for vegetable production, according to Probst et al. (2014). Yaro, Teye, and Torvikey (2017) listed savings, gifts, inheritance, outside equity capital, leasing, contract production, and borrowing as some of the several ways to get money for farming. According to Pierce and Schott (2016), the availability of credit and financial possibilities restricts the use of alternative inputs (e.g., herbicides for labor-intensive tasks). Vegetable production is severely hampered by a lack of long-term, low-interest credit, more so for specialist vegetable producers than for rice farmers (Orsini et al., 2013).

Reliable rainfall is crucial for increasing agricultural yield. But Ghana's uneven distribution of rainfall has an immediate impact on crop productivity (Ndamani & Watanabe, 2014). To produce crops, irrigation is described as the application of additional water to that provided by precipitation (Karrou & Oweis, 2012). This broad description encompasses a variety of situations, such as complex formal irrigation systems with substantial permanent infrastructure facilities and conventional recession methods under strict water management measures (Nakawuka et al., 2018). Irrigation is used to grow a variety of crops, including vegetables, and has been used to boost production levels in many countries (Daccahe et al., 2014).

Water shortage, population expansion, and urbanization all contribute to increased wastewater creation in metropolitan areas, which is why wastewater is increasingly used in agriculture. Urban wastewater is used in agriculture more frequently as fresh water supplies become scarcer, especially in dry and semi-arid regions (Misra, A. K. (2014). The main problem is to maximize the benefits of wastewater as a resource for the water and nutrients it contains while minimizing the risks of its use on human health (Ofori et al., 2021).

Although there are international criteria for wastewater use and quality, these standards can only be met with effective wastewater treatment (Mara, 2013). Around the world, 40% of the food is produced through irrigated agriculture, according to Fader et al. (2013). Wastewater makes up a sizable amount of irrigation water. According to estimates by Adamu et al. (2012), at least 20 million hectares in 50 nations use untreated or only partially treated effluent for irrigation. Gondal et al. (2021) added that at least one-tenth of the world's population consumes food grown on land that has been irrigated with wastewater.

In many cities, especially in less developed nations, a significant share of the fresh vegetables sold there are produced in urban and peri-urban areas. More than (60%) of the vegetables eaten in Dakar, Senegal, according to Mateo-Sagasta et al. (2015) are cultivated in urban areas utilizing a combination of groundwater and untreated wastewater. Only about (10%) of the wastewater in underdeveloped nations, according to Biswas et al. (2017), gets treated. The quantity and nature of industrial effluent discharged into sewage systems or drains, as well as the degree of dilution with potable water and any nearby natural sources of flow, all have an impact on the quality of wastewater. Research in urban, peri-urban, and rural locations close to Hyderabad, India, demonstrates how socioeconomic factors like caste, class, ethnicity, gender, and land tenure affect the types of wastewater-dependent livelihood activities that each individual engages in (Buechler et al., 2013).

The qualities of the natural environment and the quality of the wastewater both have an impact on the types of crops, livestock, and fish that farmers can cultivate. According to Maina et al. (2020), high rates of evaporation make wastewater saltier with higher total dissolved solids concentrations in hot areas with long dry seasons, which may limit the range of crops that may be grown.

Irrigated agriculture in Ghana is still practiced informally and receives no cross-sectorial government support. Farmers continue to utilize contaminated water because they have no other option in the majority of places. According to Mateo-Sagasta et al. (2015), farmers generally give more weight to the value of wastewater as a dependable water source than to its potential nutrient value. This is especially true during the dry season. When it comes to knowledge of pathogen contamination, a similar picture has been found.

Only one in four peri-urban farmers would not drink the irrigation water they used, according to Kurian et al. (2013). The water-health issue is not seen as a serious issue by farmers. Baltazar et al. (2015) assert that farmers are not overly concerned about the source or quality of their water. They place more value on its constant availability and the fact that they are not required to pay for it. According to Amponsah et al. (2016), the most pressing issues in peri-urban areas are access to loans, markets, and water supply, as well as land access, seed availability, and poor farm gate prices for urban agriculture. The general public has a low understanding of environmental and health issues or perceives them as being of lower priority than other issues affecting consumers' quality of life and health (Orsini et al., 2016).

Health issues are largely connected to agricultural and water contamination from feces-borne diseases. In Ghana, just (4.5%) of the population is served by sewage networks, and the majority of metropolitan areas lack facilities for treating wastewater (Diener et al., 2014). Utilizing wastewater in peri-urban and urban agriculture would not only reduce the strain on water supplies but will also boost water production by reusing water and nutrients that might otherwise be harmful to the environment. The environment and the general public's health, however, could be negatively impacted by this practice. Wastewater is a resource that is becoming more and more important on a worldwide scale, and its usage in agriculture needs to be properly managed to preserve the significant benefits while limiting the considerable hazards. Untreated wastewater irrigation poses a serious risk to the environment, food safety, and public health (for both people and livestock).

The Concept of Business Models

Since the beginning of business operations, business models have been a notion that outlines how values are created, captured, and supplied to customers for the organization to be profitable (Teece & Linden, 2017). However, it was not until the mid-1900s that the concept gained widespread acceptance, owing to new economic information, the expansion of the Internet and e-commerce, and other developments in various corporate activities (Williams, 2014). According to Van der Byl and Slawinski (2015), both research and practice have embraced the concept of the business model since then. Fleischman and Craig (2015) on the other hand presented that, although the business model concept is most well-known and studied in the e-commerce industry, it is also used in other industries such as media, manufacturing, biotechnology, and agriculture.

Despite the growing popularity of the business model concept, there is no consensus on what it means as reported by Trimi and Berbegal-Mirabent (2012). Bashir and Verma (2016), suggested that researchers could use different definitions depending on their research goals. With various variations, the majority of definitions concentrate on value generation and value offering (Lambert & Davidson, 2013). According to Pucihar et al. (2019), a solid theoretical framework in business models is still lacking despite the growing interest in business models and business model innovations in research. A business model, in general, outlines how a company does business, including its activities, operations, and value creation for its stakeholders (Spieth et al., 2014). Within the developing literature on new and sustainable business models, the concept of value has been enlarged beyond economic value to environmental and social value, thereby integrating the three pillars of sustainability (Aagaard & Ritzen, 2018).

Additionally, according to Henriksen (2012), the business model explains how value is created for the customers and how value is captured for the company and its stakeholders. Michelini and Fiorentino (2012), also defined a business model as a conceptual tool containing a set of objects, concepts, and their relationships to express the business logic of a specific firm. Kelly, Vergara, and Bammann (2015), also defines a business model as a business activity that describes how any given enterprise, large or small, informal or formal, does business, markets its products, and sources inputs and finance.

For this study, the business model could be referred to as a business activity that describes how a given enterprise whether small or large, formal or informal does business; how it accesses inputs for production, a source for funding, and how it markets its product to its buyers.

Types of business models

The diversity of the definition of the business model (based on a study of interest) makes it a little bit difficult to unify the types of business models (Evans et al., 2017). In the field of agriculture, different business models have evolved, even in vegetable production (Fleischman & Craig, 2015). Vegetable production, processing, and marketing employ a variety of business structures. The following are brief explanations of some of the models' types commonly known and/or practiced by vegetable producers in Ghana and other parts of Sub-Saharan Africa (Langemeier & Boehlje, 2018).

Traditional Agriculture (Direct Farming)

Traditional agriculture is a style of farming that use methods that have been refined over many years or centuries to assure a good, long-term output in a particular area or region (Altieri & Nicholls, 2017). Traditional agriculture is a rudimentary method of food production and farming that heavily relies on local knowledge, the use of the land, customary equipment, natural resources, organic fertilizer, and the farmers' cultural beliefs (Rahman & Alam, 2016). Half of the world's population still uses it as the primary agricultural food or production method (Alexandratos & Bruinsma, 2012).

According to Altieri et al. (2012), traditional agricultural methods are more frequently used in poor nations and on small family farms. Crop scheduling is determined by historical precedent while tilling and other farming practices are based on time-tested customs. Modern and conventional methods are frequently combined. This type of agriculture does not scale up well and does not provide the massive crop yields of industrial agriculture because it is based on artisanal knowledge (Altieri & Nicholls, 2017). It is, however, frequently more environmentally friendly and less polluting than comparable industrial methods.

Traditional agriculture, according to Hlatshwayo (2017), is characterized by a heavy reliance on local or indigenous knowledge, spirituality, and superstition when making agricultural decisions. Additionally, it calls for the heavy usage of low-tech or archaic tools like the axe, hoe, and stick. Traditional farming practices include slash-and-burn farming and shifting cultivation. Another one of its traits is a lack of accountability or environmental responsibility. There is not enough production to meet the needs of the farmer and his or her family. This is because most farmers who use this agricultural style fund their farms out of their money, which prevents them from producing on a huge scale.

For this study, a traditional farming model could be defined as a farm business model where farmers adopt the archaic style of food production and farming activities that involves the intensive use of indigenous knowledge, land use, traditional tools, natural resources, organic fertilizer, and cultural beliefs of the farmers with less or no improved farming technologies. Farmers are therefore dependent on natural resources and human resources, using outdated farming techniques and archaic economic practices (financing and marketing).

Contract Farming/Out Grower Scheme

Contract farming also referred to as an out-grower scheme, is a sort of business arrangement where a buyer purchases the goods produced by independent farmers under pre-established terms (Kaur et al., 2015). Thus, it is a vertical coordination business model with pre-determined supply and purchase agreements between farmers and purchasers, typically at an agreed-upon price and delivery date. According to Kaminski et al. (2020), small business owners and larger commercial organizations agree on particular costs, delivery dates, and the quality and quantity of goods to be produced. As cited by Ba et al. (2019), contract farming primarily comprises supplying smallholders with farm inputs (seed, feed, financing, extension, and training) in exchange for the delivery of a commodity. This makes it possible for smallholder farmers to improve their products, procedures, and capabilities without spending as much money.

According to Kaminski et al. (2020), these contractual arrangements are frequently vertical and, depending on how they are set up, may be advantageous to both farmers and other participants in the value chain. Contract farming agreements can control risk, handle supply chain coordination issues brought on by market flaws, and mitigate market failures (Abebe et al., 2013). Abebe et al. (2013) emphasize that contract farming, on the other hand, tends to reduce smallholder autonomy while increasing financial and production risks due to power imbalances, which are especially common during contract negotiation periods.

Regarding economic upgrading, the contract farming business model enables farmers to lower transaction costs, market risk, and market imperfections; it also increases access to inputs, which women and the poorest farmers lack; it also increases access to finance; and it increases access to new markets (Kaminski et al. (2020). From the standpoint of social upgrading, this paradigm has the potential to strengthen connections and mutual trust amongst nodes. For underprivileged populations in particular, it may result in better working conditions (Kaminski et al. (2020). Additionally, it may involve the emergence of non-production-related social situations (e.g., education, health).

Kaminski et al. (2020) also explained that the majority of smallholder farmers are not, however, ready to use the contract farming business model in their agricultural operations due to the model's danger to inclusivity, despite the advantages and benefits that can be received from it. Smallholders are the only ones who incur the production risk. Meeting contract obligations can occasionally be challenging too. Inequalities in power could result from this concept as well. It typically necessitates having access to certain resources, like lands, which frequently women and young people do not have. Additionally, because it is dependent on fixed prices, this model may be able to only produce a certain amount of profit. The business model for contract farming also runs the risk of excluding farmers or trapping them in binding contracts.

There are five types of contract farming models which are; centralized model, nucleus estate model, multipartite model, informal model, and intermediary model.

i. The Centralized Model

It is a type of contract farming model whereby an agribusiness operator buys his/her inputs from a large number of smallholder farmers under strict quality control conditions and in predetermined quantities. The involvement of agribusiness can vary from merely providing the seeds to providing different services and technologies at various stages. Nevertheless, the model usually involves the provision of extensive technical support, inputs, and close control of the production process.

ii. The Nucleus Estate Model

This model is a variation of the centralized model where an agribusiness owns the plantation adjacent to independent contracting farmers. The estate frequently serves as a trial and demonstration farm, but it can also be rather modest on occasion. The estate is frequently fairly vast to provide some assurance of throughput for the plant. Even though it no longer creates such estates, the British-based Commonwealth Development Corporation (CDC) was a pioneer of the nucleus estate idea. A typical strategy is for the sponsors to start with a pilot estate and then, following a trial period, introduce the technology and management methods of the specific crop to farmers (sometimes known as "satellite" growers). For oil palm and other crops, nucleus estates have frequently been utilized in conjunction with resettlement or transmigration initiatives, such as those in Indonesia and Papua New Guinea. There are instances of the nucleus estate concept with different products, although being primarily employed for tree crops. For instance, dairy nucleus estates have operated in Indonesia, with the central estate largely being utilized for the rearing of "parent stock."

iii. The Multipartite Model

This is a type of contract farming model that involves various actors in the contract such as governments, NGOs, and service providers. It usually also involves dealing with farmers' organizations such as cooperatives as well as joint ventures between the government and the private sector. Contracts under this model may involve a varying degree of coordination. According to Van Loon et.al. (2020), several case studies in Asia and Sub-Saharan Africa, this is the model that best fits the poor and smallholders as the integrated effort of many actors eases the burden on individual contracting parties. For instance, in Vietnam, there are several examples where agribusinesses provide the necessary inputs, with local governments providing extension services, disseminating information, facilitating the formation of farmers' cooperatives, and creating awareness about contract farming among farmers.

Besides minimizing the cost of providing extension and other services, agribusinesses can improve efficiency by using farmers' groups to deliver inputs and to ensure the application of appropriate technical standards. In addition, the third party (an NGO or the government) in the multipartite model can play an important role in dispute resolution and contract enforcement.

iv. The Informal Model

It is a type of contract farming model that is usually characterized by individual entrepreneurs and/or small companies that enter into informal contracts, usually on a seasonal basis. Unlike the above models, this model has limited resources for strong vertical coordination, so its success usually depends on the support provided by the government or other service providers. In this model, the provision of material and technical input is commonly limited to seeds and basic fertilizers, grading, and quality control.

v. **The Intermediary Model**

This model involves intermediaries between producers and buyers who subcontract buyers. In this model, because of the absence of strong linkages with farmers, buyers run the risk of losing control over quality, quantity, and price. For similar reasons, farmers operating within this intermediary model are not safe from market uncertainties. In practice, the aforementioned models are not mutually exclusive; combined features of different CF business models may be found in one contractual arrangement.

Joint Ventures

Joint ventures are business strategies where one person joins forces with another person, a group of people, or other business entities, to grow their firm and gain a stronger market position. Joint ventures date back to the 1920s when they first appeared. People in other exporting countries adopted this idea when it was originally employed by American businesses in particular (Lahiff et al., 2012). After World War II, this mode of conducting business became widespread. Due to the opening of the markets in China and Europe in the 1909s, the phrase "joint venture" became more common.

According to Kaminski et al. (2020), the Joint venture business model is a vertical coordination model where ownership of a business venture is entitled by two or more independent market actors or individuals who have agrees to do business with a full knowledge of share equity in the venture. Thus, sharing the financial risks and rewards of the business base on the agreed terms and conditions. In a nutshell, participants in a joint venture get together to accomplish their business goals that would be more difficult or expensive to do alone. Joint ventures differ from contract farming in that they are co-ownership agreements between businesses and small farmers (or farmer organizations, cooperatives, associations, and trusts). The two performers both own a portion of the company, dividing the financial risks and profits evenly. Investors and smallholders both contribute capital to joint ventures.

Smallholder farmers can usually unlock potential value from available land by utilizing it as leverage to seek greater ownership of the business through joint ventures. Joint ventures provide smallholder farmers with many economic upgrading prospects as well as equal decision-making authority between the two actors, which few other models do (Lahiff et al., 2012). Joint venture models and micro-franchising or contract farming models have a lot in common, with the main difference being joint equity funding.

Any business's ideal goal is to increase returns (net profits) and continually enter new markets to gain a larger customer base and superior resources. Joint ventures have recently emerged as one of the most effective corporate growth strategies (JVs). When a joint venture is formed with the right partner, it enables one party to take advantage of the other partner's resources to enter new markets, share resources to strengthen their position in the present market or expand into new businesses. The commercial sector, particularly the agro-industry, uses a variety of joint ventures. The goals that the parties involved would like to accomplish, however, will determine how they will decide to organize a joint venture partnership.

This study will address the project-based joint venture, vertical joint venture, horizontal joint venture, and functional-based joint venture as the most prevalent forms of joint venture practices by businesses.

i. **Project-Based Joint Venture**

This kind of joint venture involves partners joining together to carry out a certain task. As a result, it is a sort of joint venture in which the parties or persons engage in an agreement to carry out a specified task. This task might be anything, such as the execution of a certain project or a specific service that will be provided jointly. It might be built for things like building a toll road or an office development, among other things. The fact that the objective is clearly stated and restricted to completing a specific project by the venture agreement is a key characteristic. The Joint Venture ends after the project is finished. These partnerships are typically formed by businesses for a single, distinct purpose, and they end after the targeted project is completed.

ii. **Vertical Joint Venture**

This kind of joint venture occurs when parties who engage in separate stages of the same product decide to collaborate to strengthen their commercial relationship. This makes it a particular kind of joint venture where business is conducted between suppliers and customers. The two companies involved in this joint venture are part of the same supplier chain. When one of the entities creates a specific type of good for which it requires specialized raw materials, it will accomplish this. For this reason, such an organization can collaborate with the supplier to invest in building and maintaining the production's capacity and avoiding the uncertainty brought on by the lack of this input material. In this joint venture, many steps in the production of a single product are integrated to achieve economies of scale, which lowers the cost per unit of the product by streamlining the entire process. This kind of joint venture typically has a better success rate and positive connections between the buyer and supplier, both of which aid businesses by enabling them to provide customers with high-quality goods and services at competitive prices.

iii. **Horizontal Join Venture**

This kind of joint venture involves businesses that sell comparable goods and are in direct competition with one another. Together, they form a joint venture to produce a good that may simultaneously be marketed to the customers of the competition and their customers. One benefit of this is that one of the businesses can enter a new market, such as a specific geographic area. The international partner may benefit from economies of scale, while the local partner may have knowledge of the local market like an established distribution network. Additionally, because the partners in this sort of joint venture operate in similar industries, the parties experience opportunistic behavior. Gains made by this Alliance in the joint venture are split between the participants either equally or by the terms of the agreement.

iv. **Functional-Based Joint Ventures**

In this kind of joint venture, the parties join together to benefit from each other's complementary strengths. Thus, it is a sort of joint venture when commercial entities join together in an agreement to benefit from each other's knowledge in specific functional areas, or synergy, which can help them work more productively and effectively as a whole. In this arrangement, both parties join together because they each have specific competence in one or more company areas. As a result, they want to foster a symbiotic relationship between them and take advantage of the synergies that result from this. For instance, if one business has a fleet of vehicles while another has spare space for storage, the two can cooperate in inventory management, share costs for maintaining separate fleets or storage facilities, and utilize each other's resources when not in use.

E-Commerce Agriculture

The internet has brought about unprecedented change in society, spanning the entire globe and crossing all boundaries. The internet has redefined the methods of communication, education, health, commerce, etc. (Yrjola et al., 2020). According to Fonte (2013), the way people go about purchasing agricultural products is of great concern. Sometimes they have to travel far distances to obtain these products and unfortunately, sometimes the products may not be in stock.

E-commerce Agriculture is a set whereby buying and selling of agriculture products and services are carried out electronically with the use of computer systems linked together over inter-network protocols and standards (Sachitra & Ellawala, 2021). The various parties involved in electronic business dealings agree to conform to the norms, rules, and regulations guiding the industry (Cate & Mayer-Schonberger, 2013). E-commerce Agriculture enables good trading possibilities by supporting different business models such as multi-suppliers, e-sales, and several types of auctions (Nayak et al., 2019).

A typical scenario in commercial transactions in most countries today would include business dealings through physical contact (Shafi et al., 2020). This method has been in use for some time and its relevance is not in doubt. The use of computer systems has brought about improvement and efficiency over previous manual operations such as payroll processing, stock inventory analysis, and control and scientific processes (Zhao & Tu, 2021). In the same vein, E-commerce Agriculture has come to improve the way agricultural products are purchased (Ali & Siddiqui, 2021). E-commerce Agriculture is any method of using electronic communications and computer technology to conduct agricultural business so that trading partners can share a wide range of communiqué and data (Karine, 2021). E-commerce Agriculture has enhanced the way agricultural products are sold and the way farms interact with each other and customers through communication channels (Ji et al., 2020). In order words, this technology is a subject of the larger world of both Information Technology and Agriculture (Pivoto et al., 2018).

Furthermore, E-commerce Agriculture enables good trading possibilities by supporting different business models such as multi-supplier, e-sales, and several types of auctions (Eskia, 2019). E-commerce Agriculture converts the way people buy agricultural goods and services in the physical world to buying and selling in the virtual world (Akash & Mishra, 2015). E-commerce Agriculture blurs the distinction between the physical world and the virtual world, as the electronic presence of people, places, and products becomes commonplace (Malecki, 2017). Eventually, the movement of people, paper, and products within an agricultural farm is replaced with IT Internet representations (Verdouw et al., 2016). Both small and large farms are open to the same resources so the size of the farming plant does not matter.

According to Toyin and Damilola (2012), E-commerce Agriculture can be categorized into; Farm to Farm (F2F), Farm to Customer (F2C), and Customer to Customer (C2C). The farm to Farm (F2F) model is particularly designed for farms to collaborate or sell goods and services to each other through the use of the internet platform. That is a situation where a supplier is seen as a farm and the customers as another farm. Under this model, the two farms agree on a set of terms and continue to follow those terms in each transaction. There is sometimes an involvement of an agent who connects both parties but he/she does not interfere with the negotiation. The Farm to Customer (F2C) model allows farms to sell goods and services to their customer or an individual via the Internet. Usually, there is an agent who is responsible for price comparison. In regards to the Customer to Customer (C2C) model, the supplier and the buyer are different individuals who connect via the internet and transact business themselves without any agent or intermediary.

Despite the advantages of e-commerce agriculture has brought to the agricultural industry, some stakeholders are still not patronizing it (Nayak et al., 2019). For many people, establishing a relationship with the farms and farmers they are buying from is important, and it can be challenging to do so in an online setting because it requires them to physically visit you and interact with you and the farm environment.

E-commerce implementation takes a lot of time. There will be an additional time commitment for everything from e-commerce choices' research and evaluation for compatibility with business strategy and items to setup and ongoing maintenance. E-commerce necessitates technical expertise about both the platform and any related systems (such as inventory management, accounting, etc.) that have been set up. Consumers have a distinct experience when they see things in person. Whether at a farmers' market, on-farm market, or other events, individuals have the power to influence a consumer's purchase decision through direct interaction, free samples, or other strategies. These activities are not available on an internet format, hence the reliance on images, in-depth descriptions, client testimonials, and your reputation. Some products might not be suitable for e-commerce sales. Not all products are appropriate for e-commerce, especially if shipping is the only way to get the product into the customer's hands.

Farmer-Owned Businesses (Cooperatives, Associations or Groups)

It is a horizontal coordinating model where groups of farmers organize themselves together to generate collective action, share costs, and risks, and increase bargaining power. Farmer-owned businesses are normally incorporated business structures for farmers to pool their assets and limit the liability of individual members (Kaminski et al., 2020). Such businesses are often owned by cooperatives to facilitate business transactions. Kaminski et al. (2020) explain that smallholder farmers pool their resources in farmer-led models through formal organizational structures such as associations, trusts, cooperatives, or collectives.

Farmer-owned firms are similar to cluster arrangements in that the purpose is to gain access to financing, pool resources, and launch a related business, limiting individual members' risk (Kaminski et al., 2020). These collective groupings differ from farmer-owned firms in that the latter is formed and registered as businesses. While cooperatives are a well-known example of a collective action group, evidence suggests that larger corporations are wary of cooperating with cooperatives due to their delayed decision-making ability (Csaky, 2014). The main goal of agricultural co-operatives, which are owned by agricultural producers, is to boost member producers' output and earnings by improving their connections to the financial, agricultural input, information, and output markets (Badiru, Yusuf, & Anozie, 2016).

Ajates (2020) claims that the widespread adoption of agricultural cooperatives with mandatory membership in the 1970s and 1980s was linked to a decline in agricultural output per person. When farmers in Ethiopia were given the freedom to join or leave cooperatives at their discretion in 1991, cooperative membership decreased precipitously and yields increased (Mojo, Fischer& Degefa, 2017). There have undoubtedly been successful cooperatives in the area, such as those in the cotton and dairy industries in Mali, coffee in Ethiopia, and dairy in Kenya. Cooperatives can play a crucial role in sector development, as demonstrated by the examples of Taiwan, India, and Vietnam (Mojo, Fischer& Degefa, 2017). Unfortunately, no African nation has, to date, increased staple crop yields on a large scale and consistently as a result of cooperative action, and numerous cooperative development schemes have fallen short of their goals or have even backfired (Kumar, Wankhede & Gena, 2015). By combining their resources to support the provision of collective services and economic empowerment, agricultural cooperatives aim to assist farmers in increasing their yields and incomes (Kumar, Wankhede & Gena, 2015).

Agricultural cooperatives are viewed as crucial to meeting the government's development aims in the Growth and Transformation Plan due to its core mandate to support smallholder farmer production, and focusing on other forms of cooperatives requires a different framework for analysis. The supply of agricultural inputs, joint production, and agricultural marketing are just a few examples of the key categories of agricultural co-operatives as listed by Tefera, Bijman, and Slingerland (2017). Seeds and fertilizer are two examples of inputs that are supplied to farmers. Cooperatives engaged in cooperative agricultural production are presumed to be run by their members on communally held farmland. The third category is collaborative agricultural marketing of producer crops, in which farmers pool their resources to change a specific agricultural commodity before packaging, distributing, and marketing it.

The most common form of agricultural cooperation in Africa, however, has historically been the marketing of agricultural products once small farmers have finished their respective farm production activities. However, in some instances, crop marketing and input distribution have been merged by agricultural cooperatives. According to Kumar, Wankhede, and Gena (2015), agricultural cooperatives make it easier for small farmers to obtain resources like land and water. Additionally, it provides information, education, financial assistance, and extension services to smallholder farmers.

Farmers have access to markets, food, and productive resources like seeds and tools thanks to the cooperative model. Additionally, farmers can make decisions and policies through cooperatives that help them with their farming operations. Well-organized farmers can gain from aggregation ties to markets and services, access to centralized services that can help them achieve higher yields and higher revenues, and speaking with a unified voice to fight for their interests, according to cooperative development in many nations. Globally, nations like Taiwan, Korea, the Netherlands, France, and others with a large proportion of cooperatives in marketed products also have high average yields for food staples like rice and wheat as well as significant exports of cash commodities (Giller et al., 2021). In Ethiopia, farmers who belong to cooperatives frequently produce more, and staple products sold by cooperatives typically fetch a price premium of 7-8.5%. According to a study of the available data in the 2008 World Development Report, "Producer groups are crucial to ensure competitiveness for small-scale producers" (Berti & Mulligan, 2016).

A collective action problem, such as how to obtain inputs most effectively and market their outputs on more favorable terms than they could do on their own, is one that agricultural cooperatives assist farmers with solving. To increase the productivity and household income of smallholder farmers, agricultural cooperatives are expected to play a significant part in Ethiopia's Growth and Transformation Plan (Abebaw & Haile, 2013). According to (Giller et al., 2021), the government and NGOs employ cooperatives to expand training and other capacity-building efforts. Cooperative structures are used by many stakeholders to increase capacity in post-harvest processing procedures and commodity (maize and bean) quality. Post-harvest losses have greatly decreased to date, and this has enhanced market options for smallholder farmers (Abera et al., 2020). Some cooperatives provide services to their members to increase their capacity. Farmers can attend workshops on establishing their businesses and marketing strategies, literacy skills, and post-harvest and production procedures (Ovute & Eze, 2022). Since gaining entry to the market is one of the hardest obstacles to overcome, co-operatives' assistance in enabling economies of scale is becoming more and more crucial. Farmers can strengthen their negotiating power by attracting traders and institutional purchasers through cooperatives.

Aside from agriculture, co-operatives have also begun to develop in other industries, such as transportation or the transformation of commodities, with members purchasing trucks and milling equipment and launching their businesses (Giller et al.,2021). Through the supply of services and the development of jobs, these new endeavors benefit the local communities. As a result, the local economy grows and food security is improved. Poor management, a lack of capital resources, inadequate training, extension, and educational programs, a lack of communication and member participation, feudalistic social norms, ambiguous and insufficient government policies on the development of agricultural cooperatives, a high degree of holdings fragmentation, and weak connections between cooperative activities are challenges facing cooperatives, according to Kalogiannidis (2020). Some of the approaches governments and stakeholders have taken to address these issues include: reevaluating and improving farm policies; developing human resources through members' formal and informal training; developing commercial partnerships and joint ventures with private enterprises; developing marketing and agro-processing; implementing self-reliance projects; and diversifying agricultural products, including the development of export-oriented crops (Lamprinopoulou et al., 2014).

Despite the flexibility of this model, most smallholder farmers are not willing to employ it in their farm business due to the risks to the inclusiveness of the model. Thus, this model requires strong organizational and governance structures. There is also the risk of free-riding. It is not always accessible to all, as membership is often fee-based. With the use of this model, social norms may be pervasive, and inequalities can be replicated (i.e., for marginalized groups). This model often requires development support to set up.

Sharecropping and Tenant Farming

Two of the most common agricultural business types are sharecropping and tenant farming, both of which have been around for centuries (Mukhamedova & Pomfret, 2019). Under sharecropping, smallholders are in charge of managing a piece of land that is owned by an organization or a landowner, and inputs are commonly exchanged between the two parties (Kaminski et al., 2020). Smallholders give the landowner a portion of the agricultural yield, a portion of crop earnings, or some predetermined combination of the two. Through inclusive sharecropping arrangements, farmers (typically landless people) who work the land are provided access to the landlord's resources and expertise (Kaminski et al., 2020). Failures of the harvest or changes in pricing are frequently shared between the two actors. Similar practices apply to tenant farming, except that farmers take on all harvest risk when they lease land from a business or a landowner. Only rent is paid by the tenant (or business), who also fully owns the finished output (Belton & Thilsted, 2014).

In the Philippines, sharecropping and aquaculture have led to complex social structures where landowners and sharecroppers collaborate to produce goods for both local and international markets while poor landless individuals can still access some aquatic resources through gleaning and trade activities (Mialhe et al., 2015). Sharecropping and tenant farming have traditionally had negative repercussions for some smallholders due to the high probability of exploitative behaviors and disagreements (Kaminski et al., 2020), which can range from disagreements over how to use the land to how to split the rewards. Sharecropping and tenant farming, according to Hussain, Mohyuddin, and Ahmed (2013), can have advantageous outcomes when the terms and conditions are well outlined and regulated by a third party. In Sri Lanka, the government investigated sharecropping to allay worries about commercial shrimp farming encroaching on people's lands (Kaminski et al., 2020). As a result, opportunities for social upgrading between landowners and sharecroppers were increased by establishing a more equitable land tenure framework.

When landless farmers have access to farmable land, they obtain expertise that can improve information exchange and educational possibilities, as seen in India (Belton & Thilsted, 2014). According to Hausermann et al. (2018), there are various forms of tenant farming in Ghana, including situations where tenant farmers and landowners share land and situations were landowners lease land to groups of farmers. With the help of both kinds of tenant farming, farmers were able to diversify their incomes and effectively enter the tilapia aquaculture industry. Bangladesh has experienced several negative effects from sharecropping. Traditional sharecropping agreements changed from being sharecropping agreements to leasing agreements as shrimp farming replaced rice paddy farming, giving landless sharecroppers access to any land and suggesting that sharecropping is not adaptable to agricultural changes and commercialization (Belton & Thilsted, 2014).

Farmers in the Philippines obtained government-issued certificates of land ownership to enable them to temporarily lease property, giving them access to resources and guaranteeing the security of their land tenure (Kaminski et al., 2020). Small landowners that attempt sharecropping would not always have the resources to keep control. Powerful persons may employ smallholders, and in the worst situation, they may seize land from disadvantaged groups (Adnan 2013).

Sharecropping and tenant farming have obvious economic advantages, but if smallholders' land and other rights are not protected by governments or other parties, these arrangements carry the risk of escalating inequities. By providing mechanisms for loan and input provision, giving land access to landless farmers, and giving farmers opportunities for knowledge exchange and learning, this strategy improves the economic conditions of smallholder farmers (Kaminski et al., 2020). Sharecropping and tenant farming, according to Kaminski et al. (2020), can improve smallholder farmers' social standing by creating governance and land management systems that are tailored to local requirements. Additionally, it may have indirect development effects on "the poorest of the poor," such as food security.

Furthermore, by working on other farms, farmers can use newly discovered methods on their farms. Due to the significant likelihood of reproducing socioeconomic inequities, this paradigm appears risky to inclusion. Farmers are additionally subject to marketing risk. The use of this approach frequently exposes people to exploitative practices, including sharecropping. Uneven power relations could result as well (Kaminski et al., 2020).

Certification

A method by which a third party provides written confirmation that a good, process, or service complies with particular standards is called certification (Torres, 2017). One way to think of certification is as a supply-chain communication tool. According to Saccani, Visintin, and Rapaccini, 2014), the certificate shows the customer that the provider conforms to specific requirements, which may be more compelling than the supplier providing the guarantee.

A certification body or certifier is the company that does the certification. According to Carter (2017), the certifying body may perform the inspection itself or contract it out to an inspector or inspection body. The inspection report serves as the basis for the certification decision, which is the decision to give the written assurance or "certificate," and may be supplemented by additional information sources. A third party always performs certification. A party with no direct financial stake in the supplier-buyer relationship does the verification and offers assurance. Internal control is an independent examination. It is a second-party verification when a customer checks to see if a provider complies with a standard.

It's crucial to keep in mind that third-party confirmation does not always imply objectivity or the absence of conflicts of interest (Neltner et al., 2013). In the first place, anyone can set standards. The standard may be established by the producer (first party), in which case the interests of the producers are probably represented in the standard. Additionally, the standard may be established by the buyer (second party), in which case it will take economic interests into account. Second, there may be conflicts of interest if the organization responsible for setting standards and certifying compliance is the same entity. Certification decisions may be influenced by the standard-setting body's desire for high standards implementation rates or by its ideological prejudice towards particular producer types. Third, depending on who covers the certification fees, there can be a conflict of interest. Commercial certifying bodies are in rivalry with other bodies, and if they are overly strict, they risk losing clients.

In agriculture, Certification is widely regarded as a "hands-off" way of governance that encourages supplier upgrading by providing increased profitability when food production rules are adhered to (Bush & Doyon, 2019). Setting and enforcing norms, levels, and values are necessary to apply standards for the production and marketing of food items (Handford, Elliott, & Campbell, 2015). The effectiveness of initiatives for smallholder certification is hotly contested (Samerwong, Bush, & Oosterveer, 2018). Due to the high costs of compliance, smallholder farmers typically find it challenging to meet certification criteria (Belton & Thilsted, 2014). According to Kaminski et al. (2020), only a very small fraction of Vietnamese farmers was able to accept water use reduction measures as an environmental standard as part of a state-enforced governance certification procedure. According to Kaminski et al. (2020), smallholder Pangasius farmers chose not to participate in the value chain or purposefully decreased their output because it was difficult to match the requirements of foreign export markets.

Smallholder formal participation in a global certification program in Kenya that sought to offer horticulture farmers access to a higher-value export market declined by (60%), and only ten exporters controlled (50%) of the market, according to a review of the program (Kaminski et al., 2020). According to some research, certification can aid in smallholder integration when the risks involved in gaining certification are distributed among the smallholders (Kaminski et al., 2020).

Supply Chain in Agriculture

A supply chain is the flow and movement of products from producers to consumers (Heckmann, Comes, & Nickel, 2015). It is a series of flows that occur inside and between various phases of a continuum, from production to final consumption, to satisfy the needs of the client (Antràs, & Chor, 2013). According to Manzini and Accorsi (2013), when various actors are connected from "farm to fork" to provide a more efficient and consumer-focused flow of products, this is what is meant by a "supply chain." These supply chains could consist of producers, pickers, packers, processors, storage and transit coordinators, marketers, exporters, importers, distributors, wholesalers, and retailers. In addition to the producer and its suppliers, it may also comprise transporters, warehouses, merchants, and even the end-users themselves, depending on the logistical processes (Felea & Albăstroiu, 2013). A broader definition of supply chains encompasses research and development of new products, marketing, operations, distribution, finance, and customer support (Min, Zacharia, & Smith, 2019). Thus, supply chain growth can be advantageous to many sectors of society in emerging nations, both urban and rural.

Upstream, internal, and downstream are the three main divisions (components) of a supply chain, according to Quang et al. (2016).

The upstream supply chain: The operations of a business (a milk producer in our example) with its first-tier suppliers and their connections to their suppliers are included in the upstream portion of the supply chain (referred to as second-tier and third-tier suppliers). The supplier-customer relationship might go back to the source of the commodity (e.g., mining ores, growing crops). The primary activity in the upstream supply chain is procurement.

The internal supply chain: The internal operations that turn the suppliers' inputs into the company's outputs are all included in the supply chain's internal component. It covers the period from when inputs enter a company to when the finished goods are distributed outside of it. Production management, manufacturing, and inventory management are the primary concerns of the internal supply chain.

The downstream supply chain: All of the steps necessary to get the items to their intended clients are included in the supply chain's downstream segment. The downstream supply chain focuses on after-sale services, distribution, warehousing, and transportation.

An agriculture supply chain system consists of businesses or cooperatives that are in charge of producing and distributing goods made from plants, animals, or grains. Generally speaking, there are two main categories: "Agriculture food supply chains for fresh agricultural products" (such as fresh fruits, vegetables, and flowers) (Shukla & Jharkharia, 2013). Typically, these chains include retailers, specialized stores, wholesalers, importers, exporters, growers, auction houses, and their input and service providers (Badar et al., 2019). The intrinsic qualities of the product cultivated or produced are essentially unaffected by any of these steps. The primary operations involve handling, climate-controlled storing, packing, transportation, and particularly trading of these items. Secondly, "Agriculture food supply chains for processed food products," such as portioned meats, snacks, drinks, desserts, and canned goods (Galanakis, 2013). Agricultural products are employed as raw materials in these networks to create consumer goods with higher added value. The shelf-life of the products is typically extended by conservation and conditioning procedures (Bloemhof & Soysal, 2017).

Over the past ten years, a variety of new supply chain management solutions have been created. To improve supply chains' consumer orientation and cost-effectiveness, "efficient consumer response" (ECR) has been established. To enhance logistics, utilization of information and communications technology, and quality management, new management systems have been implemented (Nadeem et al., 2018). Farmers' organizations' positions are being strengthened by the emergence of new-generation cooperatives, and vertical alliances and strategic partnering are securing long-lasting coalitions across the whole supply chain.

'Integrated chain-care' technologies including social accountability, good agricultural practice (GAP), comprehensive quality management, and HACCP (hazard analysis at critical control points) have been developed in response to concerns about food safety (Nadeem et al., 2018). Assuring the quality and safety of their products and ensuring acceptable social chain performance are made possible by the use of such tools by chain participants along a cross-border supply chain. For perishables like fresh fish and meat, supermarkets in Brazil and Thailand, for instance, have implemented whole quality control programs and HACCP regulations.

Retailers including Walmart, Carrefour, Royal Ahold, Tesco, and Sainsbury have progressively set their quality requirements for suppliers, such as EUREP-GAP and BRC2. Throughout the supply chain, tracking and tracing technologies are employed to confirm product quality and maintain transparency in the movement of commodities (Azzi et al., 2019). Implementing such standards and processes affects not just how supply chains are organized but also how cooperative chains are funded (Dallasega et al., 2018). The agriculture industry is now using these standards and procedures, which have already shown their value in international initiatives. Sharper standards requirements have spurred both public and commercial players to launch several projects to expand or fortify agri-supply chains.

Participants in Agriculture supply chains, e.g., farmers, traders, processors, retailers, etc., understand that original good quality products can be subject to quality decay because of an inadequate action of another participant (Parwez, 2014). For example, when a farmer leaves a can of milk for pick-up on a roadside, under the sun, without any cover, there will be a loss of quality that may even render the raw material unfit for processing. Similarly, if processors, on the other hand, use packaging items and/or technologies that do not maintain the freshness and nutritional characteristics of their products as much as possible, retailers will be likely to face customer complaints.

Organic Greenhouse Farming

Crop production is a difficult industry since crops are frequently subjected to poor climatic conditions (Fróna et al., 2019). Crop production rates are greatly influenced by weather and climate conditions. But when crop output is so crucial to maintaining global food security, there is no room for restrictions (Gil et al., 2015). As a result, farming in a controlled environment is now practiced as a result of the quest for solutions. One of the fundamental types of farming in an enclosed space is greenhouse farming (Shamshiri et al., 2018). Worldwide, greenhouse farming has gained a lot of popularity. To meet the gastronomic needs of royalty, it first appeared in the 13th century (Holt-Giménez, 2017). Growing herbs and medicinal plants in greenhouses dates back hundreds of years. Today, scientific research on greenhouse growth is the focus of entire academic teams. Growing in productivity and profitability as a result of recent developments in agricultural technology, greenhouse farming is a growingly successful agricultural enterprise (Al-Kodmany, 2018).

The term "greenhouse" has diverse meanings to different people, according to Thomaier et al. (2015). Growing plants and vegetables in a greenhouse are referred to as greenhouse farming (Chang et al., 2013). Agricultural practice of growing crops in protected structures covered by a transparent material, such as glasshouses, shade homes, screen houses, and even crop top structures, according to Nainabasti et al. (2022). Growing crops in sheltered buildings covered by a transparent or partially transparent material is a unique farming approach known as greenhouse farming (Ahuchaogu et al., 2022).

The creation of greenhouse farming techniques often enables farmers to boost productivity and yields while enhancing the quality of their output. Additionally, it shields crops from outside dangers such as certain pests and severe weather. Light, ventilation, humidity, and temperature may all be managed in greenhouses. This enables the farmer to develop and give the best micro-ecosystems for their plants, assisting in their growth into strong, gorgeous, nutrient-rich, and delicious plants. In the agricultural sector, the adoption of greenhouse farming techniques has proven crucial. This is because, in nations with harsher climates, a well-designed greenhouse in a controlled environment can be a cheap way to increase a farmer's productivity and profitability. They are also a great way to expand one's knowledge of farming or gardening and raise the caliber of one's harvest. Nevertheless, not all crops can be produced in greenhouses (Emmott et al., 2015).

Typically, crops that grow well in greenhouses are those that need warm growing conditions or are highly delicate and only do well in a small range of climatic circumstances. To give a specific example, tomatoes are a type of crop that is sensitive by nature and needs a great deal of attention to detail to develop effectively. Perhaps the farmer needs to consider the soil type, soil quality, and typical ambient temperature for this crop to thrive. Greenhouses not only guarantee that delicate plants are well-cared for but also shield them from pests and abrupt changes in the weather (Rayhana et al., 2020). This is especially important in regions of the world where the weather frequently changes quickly and abruptly. Some crops do much better under the protection of a greenhouse since they are not able to adapt to such rapid and extreme environmental changes.

The most important factor determining what a farmer should have in their facility is the type of crops they will be produced in the greenhouse (Toensmeier, 2016). Every plant has unique requirements, so the facility should be set up for those. Having said that, certain elements are universal and must be included in every greenhouse, or at the very least considered. Where the facility or plant house will be located is, arguably, the most important decision. It must be placed in an area that receives enough sunlight, is adequately shielded from the wind, and is out of the way of any falling leaves from trees that could dirty or obstruct the frame. Remember to account for the fact that it typically takes at least 2 feet of access space to clean and repair a facility. Additionally, sufficient sunshine must still enter greenhouses to enable photosynthesis. Plants obtain their energy in this way; without the sun, there would be no crops. An experienced farmer's guideline appears to be 6 to 8 hours of light every day, with an air humidity of at least (45%) to (60%).

Furthermore, the greenhouse will of course need a sturdy, flat base—it can't just be placed on the ground! The best option is paving slabs, which may be wetted in the summer to maintain the humidity of the air. Furthermore, modern models are also offered in different materials like plastics and polycarbonates even though greenhouses are traditionally thought of as being built of glass. The choice of the material from which your greenhouse will be constructed is an important one. The most transparent and light-letting material is glass. In terms of single panels, it also has the longest lifespan and is the easiest to replace. But it also has the highest risk of breaking. Although they do not allow in as much light as glass and are frequently more expensive, plastics and polycarbonates are much less prone to break.

Another important factor to consider is that different types of glazing may be more suited for different climates due to their differing insulating qualities. Because polycarbonate sheeting typically insulates better, your greenhouse will lose less heat. If your garden is located in a very cool place, this will be advantageous. Average ambient temperatures should not rise beyond 20°C during the day and should not dip below 7°C at night, according to recommendations regarding temperature and heat. An electric fan heater with a propagator and a thermostat is the most effective heating option for a greenhouse. Additionally, warm air is produced using bubble insulation at a reduced cost. Finally, a decision must be made regarding whether this greenhouse will be powered by electricity. If so, installing the electricity will be less expensive the closer it is to the residence.

The main benefit of greenhouse farming is that it releases crops from being held captive by the natural seasonal cycles. Instead of being constrained by the seasons, greenhouse farmers can grow crops all year round since they can manage the atmosphere. Additionally, a variety of methods can be used to maintain a constant temperature and lengthen any given crop's growing season. To encourage robust development early in the season, it is a fairly popular practice to use natural materials that absorb, store, and release thermal heat.

The plants are kept safe in their greenhouse sanctuary regardless of how much it rains outside or how cold it is. The crops maintain their moisture no matter how hot the sun is or how dry the surroundings are. Seasonal fluctuations would not affect the crops because they can keep growing in their greenhouse unhindered. As a result of their varying relative abundances on the market, fruits and vegetables go through seasonal price changes. Crops will sell for less money during their peak season since there are more sellers than there are buyers. The supply is constant throughout the year when growing in a greenhouse, though. Furthermore, a greater variety of crops can be cultivated throughout the entire year, increasing yields. A greenhouse is a terrific way to ensure that you have more of a crop available when there is a shortage of it on the market, allowing you to sell it for more money.

Periods of drought and pests are perhaps the largest dangers to crops in traditional farming (Hathaway, 2016). Farmers who use greenhouse farming have complete control over what enters and leaves the greenhouse. The negative impact of pests on crops is reduced since pest management is made much simpler and more controlled. When established and properly operated, greenhouse agriculture is a very efficient method since it allows for year-round growth and allows for optimal resource management.

Like any enterprise, greenhouse farming has its downsides. For instance, growing crops in a greenhouse is substantially more expensive than growing them outdoors traditionally by about 260%. The majority of people do not have the upfront capital required to start a greenhouse farm, which is required to get started. To start their agricultural business, the majority of people look for outside capital. Despite the promise that agricultural advancements like greenhouse farming offer, the investment world still lags behind the times. The funding available to entrepreneurs pursuing agricultural paths and careers is still quite limited, unfortunately. There are a few potential reasons for this: A greenhouse farm's timing of returns does not correspond to the customary holding period of five years that private equity companies expect from a startup company. As previously noted, growing plants in a greenhouse gives you even more control over them. However, it is occasionally unavoidable for certain plants to harbor pests like whiteflies, which can quickly spread to the rest of the crops. It is also important to consider the fact that pollinators cannot access crops. Depending on the type of plants grown in the greenhouse, this may be a disadvantage to a greater or smaller level.

In conclusion, growing crops in a greenhouse is a terrific option if you want to cultivate some that may be more delicate than others, need a bit extra warmth, and protection from pests, or need to survive in bad weather (Jemison et al., 2014). A smaller surface is better suited for greenhouse farming. As a result, it is only permitted to produce small fruits and vegetables like strawberries as well as flowers, herbs, and flowers. The absence of pollination caused by the enclosed structure is another drawback of greenhouse farming. In addition to the negative aspects already mentioned, greenhouse farming is sometimes criticized for being an expensive farming method. However, the price of building and maintaining a greenhouse is entirely dependent on the form of the greenhouse and the farm management system being employed. In other words, smallholder and family farmers may far more easily finance basic greenhouse construction.

The Concept of Inclusive Business Models

Inclusive business models (IBM) have been defined in diverse contexts by many researchers. According to Kaminski et al. (2020), IBMs are pro-poor, equitable, and financially successful business operations that include poor producers, processors, retailers, distributors, and consumers in the value chain while producing broader favorable development results. Additionally, IBM was described by Ghosh and Rajan (2019) as a financially feasible business model that benefits low-income communities by engaging them as consumers, producers, entrepreneurs, or employees in the company's value chain. Business models are viewed as more inclusive, according to Sulle et al. (2014), if they entail close working collaborations with local landholders and operators and if they share value among the partners. However, for inclusive business models to be successful, all parties to the firm must operate under legal frameworks that clearly define resource ownership and risk and reward sharing. Governments must thus play a crucial part in creating an environment that is favorable to business.

This study uses the Kelly et al. (2015) definition of an inclusive business model (IBM), which describes it as a commercial activity that describes how a specific organization, large or small, informal or formal, conducts business, markets its goods, and acquires inputs and funding. By supporting local business model alliances that benefit smallholder groups and small value chain actors, the "inclusive" component tackles the development issues of linking smallholders and small players who are dependent on commodities to markets.

Through inclusive business models, small farmers are connected to agricultural value chains. Examples of these include traders, farmer associations, agri-food processors, merchants, and contract agriculture agreements with significant clients. Small farmers are also permitted to provide food to the public sector, including schools, hospitals, and food reserves, under institutional procurement business models. Because smallholder sourcing does not automatically ensure inclusive development, the term "inclusive" also refers to the quality of the inclusion. For a business plan to be considered inclusive, it must ultimately lead to the emancipation of smallholders from poverty and an increase in food security. Therefore, a business plan is inclusive if it incorporates smallholders into markets on the basis that poor farmers and the business community benefit from one another.

Criteria for Inclusive Business

According to Kelly et al. (2015), for a given business model to be considered as inclusive, it must satisfy the following criteria.

1. The strategy must enable purchasers to profit while ensuring that vulnerable groups, such as smallholder groups, small businesses, and women- and youth-run firms, receive a living income.

2. The model must make advantage of adaptable trade arrangements that make it simpler for smallholders or MSEs to supply a customer, like cash on delivery, taking small consignments, and offering dependable and frequent orders.
3. The model must assist small businesses and farmers in building a stronger negotiating position through the development of their skills, collective bargaining, and access to market data and financial services.
4. The model must support value chain collaboration, open pricing, risk sharing, and existing market participants' skills and knowledge, including traders and processors;
5. The concept needs to be replicable in other value chains or areas of the industry in the medium term so that the number of small actors involved can be raised;
6. To enable the industry to adopt new capabilities, the model must provide diversified income streams over the long run, preventing overdependence on any one customer or market outlet.

Empirical Review

Empirical review of some types of existing business models

Some business models used in agriculture are examined by Kaminski et al. (2020) in a review article titled "A review of inclusive business models and their use in aquaculture development." To evaluate the utilization of seven business models that are frequently utilized in agriculture development in lower-income countries, the study concentrated on 36 articles related to these models. The various IBMs' goals for social and economic upgrading were examined using a global value chain (GVC) analysis, along with the diverse forms of relational coordination employed by chain participants to attain development goals. Contract farming, sharecropping, tenant farming, farm-owned businesses, joint ventures, micro-franchises, public-private partnerships, and certification were the several types of business models mentioned in this article.

With an emphasis on how they may ensure or pose a risk to inclusivity through the relationships and upgrading opportunities evident in their make-up, it was assessed to what degree these IBMs assisted poor actors in overcoming certain barriers. The investigation revealed that most models prioritized economic improvement over social improvement. To accomplish the inclusive goals of IBMs, chances for the latter are crucial. Further prospects for economic upgrading can be created under greater horizontal coordination between actors, as this paper's analysis of nodes upstream and downstream in a value chain demonstrates. Additionally, it is examined that one model might not always offer smallholder farmers the economic and social upgrading they may require to constantly produce at a high level. It might require the company of one or more of the other IBMs. Therefore, the ability of farmers to increase their output and status is largely dependent on the vertical and horizontal connections they can forge within other IBMs.

The authors of the study "The business case for SDGs: an analysis of inclusive business models in emerging economies" (Ghosh & Rajan, 2019) also address the variety of business models used in the fields of housing, energy, education, and health in ten emerging economies. The Sustainable Development Goals (SDGs) are highlighted in the report. These goals emphasize the importance of collaboration among all parties involved to build a sustainable future. The SDGs are most appealing to the business sector because of the crucial and varied role they can play in achieving the SDGs. Inclusionary business (IB) models are examined by Ghosh and Rajan (2019) as market-based approaches to help accomplish the SDGs and assist individuals at the Base of the Pyramid (BoP). Both B2B (business-to-business) and B2C (business-to-customers) enterprises are included in the models, which offer a wide range of goods and services. The article looked at 20 firms from emerging economies in five different industries to examine the IB models and their social impact. Each organization had explicitly stated its impact as part of the planning and design step of the measuring process, according to the findings. The business sector, development communities, and governments should adopt and scale up excellent IB models and practices as a result of these results to support inclusive economic growth and social impact.

The essay "Inclusive business models in agriculture" by Sulle et al. (2014), on the other hand, is a policy-formulated piece that focuses on smallholder cane growers in Mozambique. Sulle et al. (2014) claim that they wrote this policy brief to "interrogate policy and suggest mechanisms for enabling and strengthening smallholder farmers' participation in and securing returns from large-scale investments" based on their examination of the current large-scale sugar estates and milling companies, as well as smallholder involvement as out-growers in the Mozambican sugar industry. The production, processing, and selling of sugar involve a variety of business models, according to Sulle et al. (2014). The article provides examples of the models used by sugarcane farmers in Mozambique and other countries in sub-Saharan Africa.

These models include block farming, out-growers scheme/contract farming, plantation/estate farming, and hybrid business models.

Empirical review on inclusivity of a business model relevant to the study

The Kelly et al. (2015) published a book titled "Inclusive Business Models: Guidelines for improving linkages between producer groups and buyers of agricultural produce" that outlines some recommendations for the expansion of inclusive business models (IBMs) that incorporate smallholder farmers into agricultural value chains. These recommendations are meant to assist professionals working in the public and private sectors who develop and carry out these projects. With assistance from the European Union (EU) and the Government of Ireland, the methodology in the study was pilot tested across Africa, the Caribbean, and the Pacific. It was supplemented by guidance tips, principles, and criteria based on experiences during its implementation. The study's findings were grouped by into three categories: cash, high-value, and food staple crops. These categories offer another source of advice that will be helpful during the design, planning, and implementation phases. These recommendations are furthered by an FAO policy brief that outlines how the public sector might support inclusive business models' competitive and inclusive goals.

Analytical Framework

Profitability Analysis

Pervan and Višić (2012) define profitability analysis as an analysis of the profitability of an organization's output. The ability of a business to provide a sufficient return on sales, total assets, and capital invested can be evaluated using its profitability (Boakye, 2020). According to Boakye (2020), partial budgeting net profits, gross margin costs, and marginal return or payback period rates can all be used to assess a venture's profitability. For this work, the analysis of the gross margin and the profit function was used.

Gross Margin Analysis

A company's gross profit less the variable cost of obtaining it is its gross margin. According to Bösch et al. (2018), variable expenses are those that are directly traceable to a company but vary depending on its size. Because overhead and fixed costs like depreciation, interest rates, and expenditures for power, water, insurance, or mortgages are not taken into consideration, the gross margin is not the same as the gross profit (Boakye, 2020). Assessment of the gross margin, according to Boakye (2020), may be utilized in two ways: to identify the shortcomings of the current farm business and to recommend reorganizing it.

Analysis of gross margins is crucial for comparing farm enterprise performance. According to Boakye (2020), a farm enterprise's relatively low gross margin may be caused by:

a) Unfavorable input costs concerning product pricing.
b) Low output as a result of low variable costs (pointing to inadequate expenditure on a variable cost; for example, feed, fertilizer, labor, and machine expenses).
c) Excessive inputs in comparison to production value.
d) A production technology that is outdated, insufficient, or otherwise inappropriate.

Assuming a producer creates a nonnegative vector of M outputs from a nonnegative vector of N inputs, written as x = (x1... xN) R + N. The definition of this output vector is y = (y1... yM) R+ M. The technology set is thus defined as the collection of all technically possible input and output vectors as follows:

$T = \{(y, x): x\ can\ produce\ y\} \in R+\ M+N$ ………………… (2.1)

The following assumptions are made regarding the technology set:

1. $(0, x) \in T\ and\ (y, 0) \in T \Rightarrow y = 0.$

2. It is a closed set.

3. T is bounded for each $\in R+\ N$

4. $(y, x) \in T \Rightarrow (\lambda y, x) \in T for\ 0 \leq \lambda \leq 1$

5. $(y, x) \in T \Rightarrow (y, \lambda x) \in T\ for\ x \geq 1$

6. $(y, x) \in T \Rightarrow (y', x') \in T \forall\ (y', -x') \leq (y, -x)$

7. T is a convex set.

According to the first presumption, no output can be produced from a specific set of inputs, and no output can be produced in the absence of any input. Technically effective input and output vectors are guaranteed by the second supposition. The third characteristic assures that finite input cannot result in endless output. Both radial contractions and expansions are guaranteed to be achievable by the weak monotonicity (weak disposability) features of assumptions 4 and 5. Strong disposability properties are frequently used to replace these two presumptions. Any increase in inputs or decrease in outputs is not restricted to radial movement. Although the convexity assumption is not commonly necessary, if it is, commodities must be continuously divisible.

Using output or input sets, the production technology can also be depicted. The output settings can be used to define set T's definition of technology comparably. P(x) is the set of viable outputs, where x is a vector of inputs.

P(x) is expressed formally as;

$P(x) = \{y: x\ can\ produce\ y\} = \{y: (y, x) \in T\} \in R+$

N ………….. (2.2)

The output sets P(x) are defined in terms of T, and since T is assumed to satisfy certain properties, it follows that P(x) can satisfy corresponding properties. Similar properties as T are assumed for P(x).

A third characterization of the technology can be defined by the input set, L(y). L(y) is represented as,

$L(y) = \{x: x\ can\ produce\ y\} = \{y: (y, x) \in T\} \in R+$

M ………… (2.3)

This input set consists of all input vectors x that can produce a given output vector, y. As with P(x), L(y) is assumed to satisfy similar properties corresponding to T. This method is pertinent to the study since it gave the researcher the ability to gauge the smallholder farmers' levels of technical and scale efficiency. The researcher was able to identify those farmers who were technically efficient and those who were not.

Stochastic profit frontier model

Stochastic frontier analysis (SFA) is a method of economic modeling. It has its starting point in the stochastic production frontier models simultaneously introduced by Parmeter and Kumbhakar (2014). The production frontier model without random components can be written as: $\boldsymbol{y_i = f(x_i;\beta). TE_i}$; where y_i is the observed scalar output of the producer i, $i=1...I$, x_i is a vector of N inputs used by the producer i, $f(x_i, \beta)$ is the production frontier, and β is a vector of technology parameters to be estimated. TE_i denotes the technical efficiency defined as the ratio of observed output to maximum feasible output. $TE_i = 1$ shows that the *i-th* firm obtains the maximum feasible output, while $TE_i < 1$ provides a measure of the shortfall of the observed output from the maximum feasible output.

A stochastic component that describes random shocks affecting the production process is added. These shocks are not directly attributable to the producer or the underlying technology. These shocks may come from weather changes, economic adversities, or plain luck. We denote these effects with ***exp*** $\{v_i\}$. Each producer is facing a different shock, but we assume the shocks are random and are described by a common distribution. The stochastic production frontier will become: $y_i = f(x_i;\beta).\ TE_i.\ exp\ \{v_i\}$. It is assumed that TE_i is also a stochastic variable, with a specific distribution function, common to all producers. This can also be written as an exponential $TE_i = exp\{-ui\}$, where $u_i \geq 0$, since it requires $TE_i \leq 1$. Thus, this led to the following equation: $yi = f(xi;\beta).\ exp\{-ui\}.\ exp\{vi\}$

Perhaps, if it could be assumed that $f(x_i, \beta)$ takes the log-linear Cobb–Douglas form, the model can be written as: $\ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i$: where v_i is the "noise" component, which we will almost always consider as a two-sided normally distributed variable, and u_i is the non-negative technical inefficiency component. These together constitute a compound error term, with a specific distribution to be determined, hence the name of "composed error model" as is often referred to.

According to Parmeter and Kumbhakar (2014), the stochastic frontier analysis also examines "cost" and "profit" efficiency. The "cost frontier" approach attempts to measure how far from full-cost minimization (i.e., cost-efficiency) is the firm. Modeling-wise, the non-negative cost-inefficiency component is added rather than subtracted in the stochastic specification. "Profit frontier analysis" examines the case where producers are treated as profit-maximizers (both output and inputs should be decided by the firm) and not as cost-minimizers, (where the level of output is considered as exogenously given). The specification here is similar to the "production frontier" one. Stochastic frontier analysis has also been applied to microdata of consumer demand in an attempt to benchmark consumption and segment consumers. In a two-stage approach, a stochastic frontier model is estimated and subsequently, deviations from the frontier are regressed on consumer characteristics (Baltas 2020).

Dziwornu and Sarpong (2014) defined the stochastic profit frontier model as a statistical model used in measuring a ratio of inputs to outputs and it is essentially related to production and cost. They claim that this model is one of the ideal models used in estimating profit efficiency. Špička and Machek (2015) defined production efficiency as the ability of a producer to produce goods and services through an optimal combination of inputs to produce maximum output at minimum cost. Shrestha, Bhandari, and Pandey (2022), also defined profit efficiency as a combination of three components: technical, allocative, and scale efficiencies. Technical efficiency refers to the capacity of a farm to produce the optimum level of outputs in the given level of inputs, while inefficiency is the level of output below the frontier line (Rahman, 2003). A farm is allocative efficient when the combination of inputs is in the optimal proportion with the minimum cost that produces a given quantity of outputs (Shrestha, Bhandari & Pandey, 2022).

In a profit-maximizing framework, scale efficiency exists if a farm produces output level by equating the product price with marginal cost (Syverson, 2019). Recent empirical development combined all these measures into a single system that enables more efficient estimates, which can be obtained by a simultaneous equation system using a profit function framework (Shrestha, Bhandari, and Pandey, 2022) Thus, profit efficiency is the ability of a farm to achieve the optimum possible level of profit given the prices and levels of fixed factors of production (Syverson, 2019). Profit efficiency is the ratio of the actual to the maximum possible profit, while inefficiency is the loss of profit because of not operating the farms at the highest possible frontier level (Bruch & Müller, 2014).

For this study, the stochastic profit frontier is the most suitable approach to estimate the profit efficiency because it assumes that any errors in the production decision are translated into lower profit for the farmers (Syverson, 2019). Also, this approach is found to be theoretically consistent with the production technology to estimate production, revenue, and cost efficiency with cross-section data and that led me to adopt this approach in my study.

Conceptual Framework

According to Kerlin (2012) and Ngulube et al. (2015), a conceptual framework can be referred to as a tool (connected notions) that aids in comprehending the connections between ideas or variables in the context of the real world. To frame the project in question, each concept is connected. Thus, a conceptual framework is designed to illustrate the correlation between the key variables employed in a particular research study.

The conceptual framework as presented in this study elaborates on some factors contributing to the stagnation of vegetable production among smallholder farmers and how it could be mitigated. Figure 1 indicated that vegetable production has declined despite the increases in the cultivated area, and the effort of the government and the agricultural sector as a result of a decline in soil fertility, heat, and drought stress arising from climate change, the prevalence of pest and diseases, and unstable prices for vegetable produce due to smallholder vegetable farmers' little or no capacity to add value to their produce through quality improvements and/or improved marketing practices such as direct sale to supermarkets/wholesalers or off-season production.

Moreover, the use of ancient farming practices like the direct/traditional farming model is also a factor in the current stagnation in vegetable production. Perhaps, smallholder vegetable farmers of the study area often employ archaic farming business practices which does not enhance their productivity due to the effect of climate change on agriculture and other unforeseen factors.

This scenario calls for the need for agricultural transformation where improved farm inputs and machinery (technological innovation) are employed to enhance production activities. However, according to Meijer et al. (2015), most smallholder farmers are financially incapable and technologically incompetent to adopt this technological innovation which could enable them to maximize productivity and profit. This call for the needs for the introduction of inclusive business models (e.g., contract farming and out-grower scheme, joint ventures, etc.) that would offer smallholder farmers access to fund, access to farm inputs, and access to a reliable market. Perhaps, these models will empower the farmers financially and also equip them with the adequate knowledge to employ some essential improved technologies that could help mitigate the adverse effect of climate change and other factors contributing to the stagnation of vegetable production and thereby increasing productivity and profit.

Therefore, the theory of change and theory of modernization becomes necessary in this study because smallholder vegetable farmers have to change from their indigenous farming practices and adopt the modern way of farming by patronizing technological innovation in their vegetable farming businesses to boost their yield. Thus, to improve the productivity of vegetable production in the value network, smallholder vegetable farmers must change from their traditional farming practices makes it a bit challenging to mitigate the adverse effect of climate change, a decline in soil fertility, the prevalence of pests and diseases, and unstable pricing strategies. Furthermore, as the smallholder vegetable farmers adhere to the theory of change, they can then switch to agricultural transformation by employing technological innovations and inclusive business models in their farming businesses. The technological innovation would help mitigate the responsible factors causing the stagnation of vegetable production whereas the inclusive business models would also give the farmers access to farm inputs and implements, funds to acquire the needed resources for the production and marketing of produce, and access to a reliable market that could offer them a reasonable price of their produce at every particular point in time. These systems would help both the poor and the rich, the young and aged to improve their productivity at every production season, “all other things being equal”.

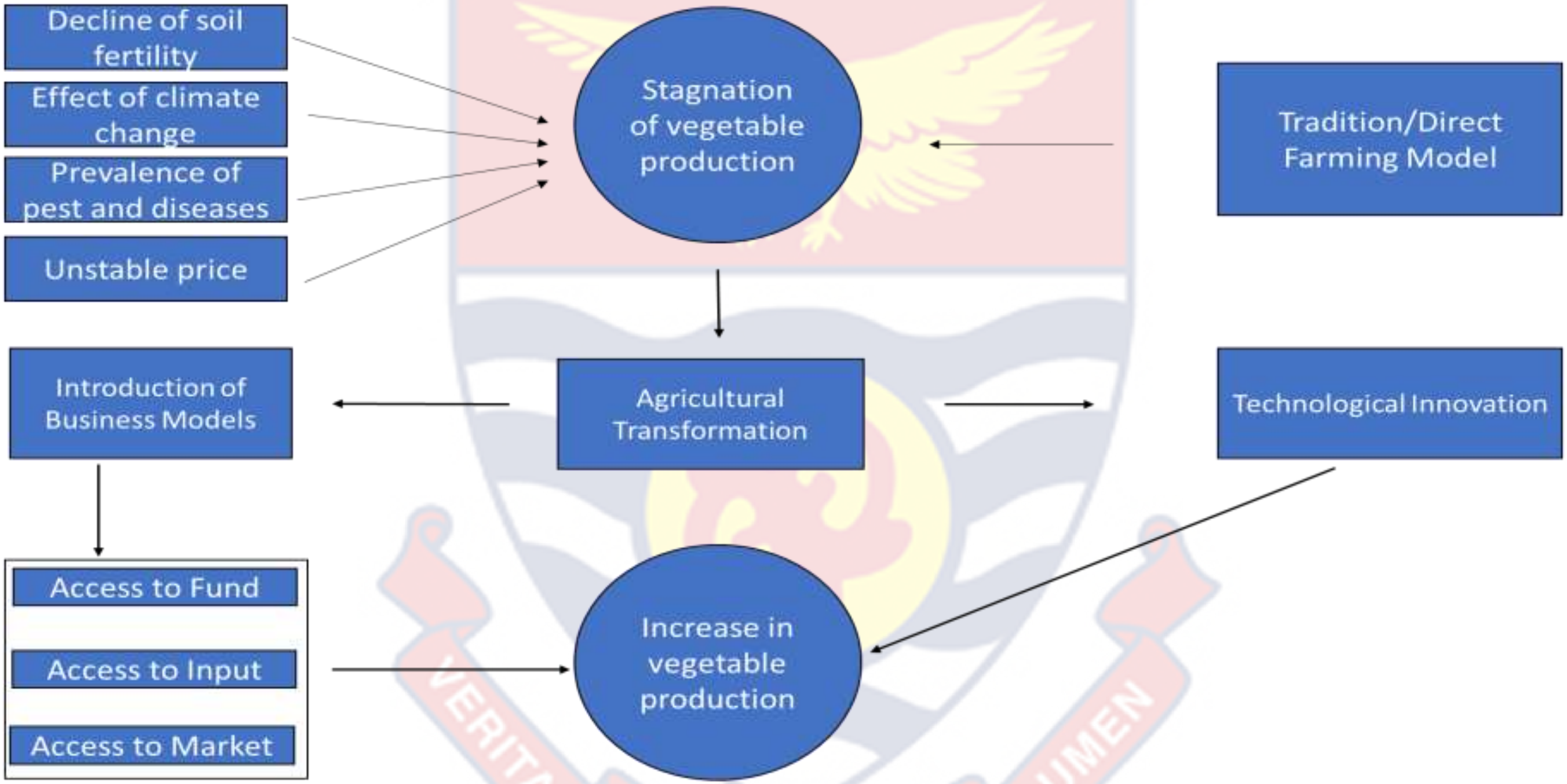

Figure 1: Conceptual Framework

Source: Field Survey, Awuakye (2022)

Chapter Summary

This chapter of the study reviewed relevant literature which is related to the study. The chapter discussed the overview of vegetable production in Ghana, the socio-economic importance of vegetables, resources for vegetable production, and the marketing of vegetables. The concept of business models, the types of business models common in vegetable production, and the concept of inclusive business models were also elaborated on in this chapter. The chapter also reviewed the literature on some estimation methods employed in the study including profitability analysis, gross margin analysis, descriptive statistics, and multiple regression. Modernization theory and the theory of change were reviewed as theories underpinnings the study. This chapter finally reviewed some empirical results related to the study and the conceptual framework for the study.

CHAPTER THREE

RESEARCH METHODS

This chapter presented the research methods that were used in conducting the study and were organized as follows; research design, study area, population, sampling procedure, data collection instruments, pilot – testing, data collection procedures, data processing, and analysis that was employed as well the rationale behind the choice of these techniques for the study.

Research Study Design

A research design is a plan and procedure involving how data of a research study is collected and analyzed (Ponce & Pagán-Maldonado, 2015). The plans and the procedures include the decisions about how the study will be conducted, how respondents will be approached, and when, where, and how the research will be completed (Ponce & Pagán-Maldonado, 2015). A research design determines the hypothesis to be tested and ensures that the findings answer the research questions without unambiguity (Marczyk et al., 2015).

A descriptive survey research design was employed in this study since it provides a quantitative description of trends, attitudes, or opinions of a population by studying a sample of that population or the whole population. It includes cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection, with the intent of generalizing from a sample to a population (Ponce & Pagán-Maldonado, 2015). A cross-sectional survey was used in this study. This is because, data collection in this study was done at one point in time on a single group measuring the current attitudes, beliefs, opinions, and practices of the respondents in the district.

Cross-sectional studies are observational and are known as descriptive research. The cross-sectional survey design enabled the researcher to accurately and systematically describe the current situation of existing business models, the extent of use, and the challenges that impede their adoption by the farmers. This survey design is appropriate to capture varieties of information such as farmers' knowledge and skills on business model usage, the source of and information about business models, and their competence level in the area of vegetable production at a wider perspective in a cost-effective manner (Klerkx et al., 2017). The rationale for using the cross-sectional survey design is an attempt to create an accurate picture of the current state of the business model used in the study area. The data was collected at one point in time and therefore changes cannot be measured (Babbie, 2014). However, the cross-sectional design is good to produce primary data to establish a causal relationship between and among the variables for further research (Wang & Cheng, 2020).

Study Area

The Denkyembuor District is one of the 26 Administrative Districts in the Eastern Region. The district was carved out of the Kwaebibirem District on 9th February 2012 (Osei-Amponsah et.al. 2012). It was established by Legislative Instrument (LI) No. 2042 and has Akwatia as its capital. The Denkyembuor District is located in the South-Western part of the Eastern Region. It shares boundaries with Kwaebibirem and Akyemansa Districts to the North, West Akim Municipality to the South, and Birim Central Municipality to the South-West. The major mountain range, the Atiwa Range, is found in the North-East of the District around Dwenase and Apinamang which are notable towns. Apart from this area, the general height in the district is less than 500 meters above sea level. The Birim River traverses the District from the North to the South. Besides the Birim River, there are other notable rivers such as Mmo, Abanza, Subinsa, Aweasua, and Supong.

Temperature ranges between a minimum of 26.50C and a maximum of 270C. The district lies within the semi-equatorial climate zone with a double maxima rainfall regime. The highest monthly rainfall is 414.0mm. The district lies within the semi-deciduous forest zone and the vegetation consists of low-lying species of hardwood. Large plantations of oil palm have been cultivated in Okumaning and Kusi and other parts of the district. The district is greatly endowed with a diamond that the Great Consolidated Diamond Company Ltd is currently mining on one of its concessions, the rest are reserves in Akwatia, Wenchi, and Topremang. These precious minerals also occur in pockets elsewhere in the district that could be exploited. Gold deposits also exist around Topremang, Apampetia, and Apinamang areas.

The economy of the Denkyembuor District is predominantly agrarian with the production of both food and cash crops on subsistent and commercial bases representing about three-quarters of the working population. Trade, Commerce, and agro-base business are the main features of the district economy. Small-scale oil palm processing is the main activity people engage in. People cart agricultural produce like palm oil, maize, plantain, etc. out of the district and bring in products that are not locally produced.

The Denkyembuor District has a congenial climate for agricultural activities. The district produces a wide variety of both cash and food crops. These include crops such as cocoa, orange, and oil palm. Food crops grown include plantain, cocoyam, cassava, and cereals, as well as vegetables. Animal husbandry is also practiced on small-scale bases. The Oil Palm Research Institute and the University of Ghana Agricultural Research Stations are all located in the district. The district has large oil palm plantations cultivated by individuals and corporate organizations such as the Ghana Oil Palm Plantation Development Company Limited (GOPDC).

The main industrial activities in the local economy are agro-based. Small-scale oil palm processing mills abound in the district. These are common in Kusi, Wenchi, Takorowase, and Anweaso. In addition, there is the Great Consolidated Diamonds Limited at Akwatia and a small-scale mining concession at Apinamang and other towns for further exploration. There are small-scale timber-milling plants at Boadua.

MAP OF THE EASTERN REGION OF GHANA SHOWING THE DISTRICT OF THE STUDY AREA

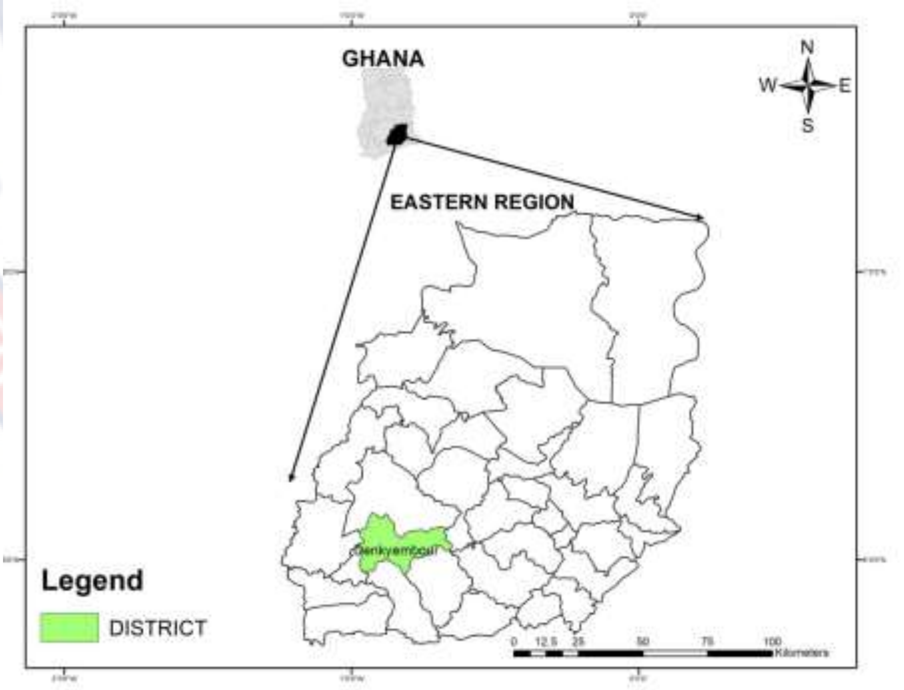

Figure 2: Map of the Eastern Region of Ghana Showing the District of the Study Area

Source: Field Survey, Awuakye (2022)

Population

Population for a study refers to all the respondents from whom we wish to conclude (Babbie, 2014). The population for the study comprises some registered smallholder vegetable (okra and garden eggs to be precise) farmers in the district who are beneficiaries of the project titled “Building vegetable farmers resilience to climate change”. The total number of registered smallholder vegetable farmers on the project was one hundred and fifty (150).

According to Singh & Masuku (2014) and Parker, Scott, & Geddes (2019), a bigger sample size would be required to generate more representative results that are trustworthy and have sufficient power, indicating the results are relevant and appropriate to draw conclusions. Parker, Scott, and Geddes (2019) added that a sample size of 20 people or items can be considered reasonable for quantitative research if the researcher is primarily interested in understanding the trends in their data and prefers to work with a smaller sample size or if the sample is limited in scope.

Base on the assertion from Parker, Scott, and Geddes (2019), the 150 smallholder vegetable farmers was deem fit to be used as the population for the study since the major aim of the researcher was to gain understanding in the trend of the data set with regards to the profit performance of the participants, the competences level of the respondents, and as well as the use of existing business model types among the participants of the study.

Sample and Sampling Procedure

A census is a carefully planned process for acquiring, documenting, and analyzing data about the population's members. Every single unit of the universe is counted in this official and comprehensive count of the cosmos. Here, the term "universe" refers to any geographic area (such as a city or country) or population that can be used to collect data. With the help of this method, the population is counted while considering every single person. To obtain information from every single unit of the population, this strategy needs a lot of time, money, and labor.

In this study, all 150 smallholder vegetable farmers were involved in the survey to collect the data. Census was appropriate to use as far as this study was concerned since the population was not that large, and it was possible to access every unit of the population to collect information.

Source of Data

Researchers use either primary data, secondary data, or both types of data sources when doing their research. All sources are collectively referred to as primary sources. In contrast, the term "primary data source" particularly refers to the first-hand gathering of data for a specified purpose (Glatthorn & Joyner, 2005). Secondary data is information that has previously been gathered from primary sources and made available for use by other researchers. This particular type of data has already been gathered in the past. A researcher may have gathered the information for a specific project and subsequently made it accessible for use by other researchers. Like with the national census, the data may also have been gathered for broad use without a particular study goal. Examples of secondary sources of data include journals, websites, newspapers, books, government records, and the like.

This study employed primary data sources by gathering data from the target population of the study through a cross-section survey mainly based on the objectives of the study.

Data Collection Instruments

This process involves the development of a research instrument for data collection, analysis, and interpretation of the study (Babbie, 2014). This study employed a structured questionnaire for farmers who could read the items in the instrument and write their responses by themselves, and a structured interview schedule for those who could not read the items in the instrument and write their responses by themselves.

The structured questionnaire/interview schedule was designed in English and translated into 'Twi'; the native language which is very common and well understood by a majority of the farmers in the Denkyembour District. Nevertheless, both English and Twi were used to gather data for the study. The structured interview schedule contains closed and open-ended questions concerning the objectives of the study. The answers to the open-ended questions complement the close-ended questions. The use of a structured interview schedule for data collection was appropriate to achieve a higher rate of responses since the researcher can clarify issues that may arise during the process of data collection to help improve the response rate (Babbie, 2014). The weakness of the structured interview schedule was biasing that may come from the side of the interviewers which may affect the quality of the analysis. However, the data collection team was well-trained to limit all forms of biases to achieve a well-defined analysis for the best possible results. The instrument was divided into seven (7) sections as follows:

Part 1: This section gathers information on the socio-demographic characteristics of the smallholder vegetable farmers covering sex, age, marital status, and household size, position in the family, educational level, household annual income.

Part 2: The section contains questions on farm characteristics such as the current land holding status, the size of the vegetable farm, annual farm income, source of labor, the type of vegetables the farmer cultivates, what farmers do to sustain their farming business, the type of irrigation facility farmers employs for their farming business and what motivates them in using such technologies.

Part 3: This section covers a set of questions relating to institutional characteristics such as the extension services available to the farmers and the number of times they access them within a production season, the forms of credit available to farmers, and where and to who they sell their produce.

Part 4: This asks questions on the farmer's awareness, knowledge, and practices of existing business models' types in the system, their perception of business models, and their knowledge level on the benefit of the use of business models in vegetable farming, the existing business models that they practice, and as well as the challenges of business models that impede its implementation in vegetable production in the study area.

Part 5: This part outlines the criteria set by FAO to determine what an inclusive and sustainable business model is.

Part 6: This section assesses the competencies areas of the farmer in vegetable production management practices. Using a Likert scale of 1 -5, this section analyses the knowledge, attitude, skills, and aspiration information of farmers in vegetable production where; 1=very low, 2=low, 3=moderate, 4=high, and 5=very high.

Part 7: This section examines the performance level of smallholder vegetable farmers in terms of profitability. This part seeks information on productivity; how much they produce, the quantity sold and the unit of price sold, and the quantity consumed. This section also asks questions on the various cost to be incurred throughout a production season.

Pre-Testing

In an attempt to investigate the suitability of the research instruments in measuring the variables the researcher intended to measure, pre-testing was conducted. The pre-testing was done to reduce inconsistencies, ambiguities, and all difficulties that could have arisen from administering the research instruments. The weaknesses and ambiguities identified in the research instrument were corrected to ensure that the research instrument was fit and adequate to be used to elicit the required data. The pre-testing of the instruments was done at Akim Kokobeng in Achiase District in the Eastern Region of Ghana from the 24th to 25th of May, 2022. The number of respondents engaged for the pre-test was twenty (20) Okra and Garden Eggs farmers in the community. The data collected was then sorted, cleaned, and entered into statistical software. Importantly, the reliability coefficients were calculated for the Likert-typed items in the research instrument. The reliability was estimated through the Cronbach alpha statistic. The Statistical Package for the Social Sciences (SPSS) version 21 was used to analyze the scale items to generate Cronbach's Alpha coefficient to find the reliability of all items.

Accordingly, a reliable instrument is expected to give consistent results when used by different researchers in similar studies. According to Babbie (2014), an alpha coefficient of 0.60 or more depicts that the subscales on the research instrument are reliable. Meanwhile, Rachman (2019) pointed out that, a reliability coefficient of 0.7 or better is acceptable for social research. This assertion is supported by Karstad et al. (2018) who also noted that a reliability coefficient of 0.70 is good and thus such an instrument be judged as okay for data collection. Notwithstanding, Numminen (2019), posited that an alpha level of 0.65 or more on a sub-scale is reliable and acceptable to be used in social research.

Table 1: Reliability Analysis of Subscale of the Research Instrument of smallholder vegetable farmers.

Construct	Cronbach's alpha	Number of Items
Farmer's Perception of IBM	0.674	11
Challenges of implementing IBM	0.886	12
Competencies Area In VPMP		
Knowledge	0.939	20
Attitude	0.922	20
Skill	0.863	20
Aspiration	0.910	20

Source: Field Survey, (Awuakye, 2022)

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Data Collection Procedures

The data collection process started with the training of agricultural extension agents which was to equip them with the requisite skills to enrich the quality of their behavior in reducing biases and errors during the data collection exercise. The training also helped the interviewers to familiarize themselves with the essence of research to ensure accuracy, clarity, and consistency in the data collection exercise. In the course of the training, the researcher demonstrated the interview procedure by interviewing the interviewers to serve as a guide. The interviewers also made practiced by interviewing themselves to enable the researcher to make the corrections that may arise.

The data collection exercise commenced in the 2nd week of August 2022 and ended in the last week of August 2022. The time for the data collection was subject to the farmer's schedules since the data collection time fells within the farming season. All protocols including that of COVID -19 were observed accordingly. Upon entering the residence of each selected farmer, the research team introduced themselves and explained their mission to clear doubts or mistrust which the farmer might have perceived. The farmers were assured of their right to anonymity and confidentiality to facilitate honest responses. The criteria used for selecting each of them for the exercise were explained as well.

The respondents were made to understand that their participation was voluntary, and for that matter, they were free to withdraw in the course of the interview without any punishment. However, they were encouraged to complete the questionnaire to achieve a high response rate. An estimated time of 30min - 45min was assigned to engage each farmer for the interview and it was disclosed to each farmer to assess whether there was enough time to participate or will arrange for another time. During the interviews, the researcher was most often than not available to clarify and resolve issues that aroused. The researcher crosschecked all filled questionnaires to ensure that all the questions were answered appropriately. This exercise continued till all the respondents were contacted and the required information solicited.

Data Processing and Analysis

The data was collected using a KoboCollect application tool. The data was then retrieved from the KoboCollect application tool and converted into a Microsoft Excel sheet for thorough cleaning to avoid any unwanted material and edited to detect discrepancies and other doubtful figures for correction to improve the quality of the data for analysis. The use of the KoboCollect tool helped in the sense that, there was no need for coding the variables in the questionnaire into IBM SPSS. Thus, all the necessary captions for each variable in the questionnaire were generated into the KoboCollect tool during the designing of the template. The data was later imported from the Excel sheet into the IBM SPSS for analysis.

IBM SPSS package was used because it offers a variety of statistical analyses such as frequency, mean, standard deviation, and inferential statistics that were useful for this study. IBM SPSS is a software package that offers a broad set of techniques suitable for data transformation and file manipulation. Moreover, R 3.4.0 statistical software was also used to run some of the objectives, especially concerning profit efficiency (objective 1).

Both the raw data and cleaned data have been stored in the personal account of the researcher's google drive cloud platform. This platform provides adequate security since third parties can only have access through authentication and the provision of a password. The researcher has archived the data on the same platform until the next six years. This is because the researcher intends to undertake further studies that may build on the finding of this proposed study.

Demographic characteristics, farm characteristics, and institutional characteristics of smallholder farmers were analyzed using frequencies, and percentages and also were regressed on other objectives to determine how they influence farmers' choice of an inclusive business model.

In analyzing objective one, the study employed Stochastic Frontier Analysis (SFA) to determine the profit efficiency of the various farmer groups whereas gross margins were used to ascertain the profitability level of each farmer group. Also, descriptive statistics were conducted on the fixed and variable cost items employed by the various farmer groups.

Concerning objective two, descriptive statistics and ordinary least squares (OLS) regression were conducted to determine the level of competence of the smallholder vegetable farmers in vegetable production management practices and how their socioeconomic characteristics influenced their competencies in vegetable production management practices (VPMPs).

Objective three was also analyzed with the use of frequencies and percentages to determine the level of farmers' awareness of the existing business model, their usage, and their preference among the farmers. A correlation was also conducted to examine the relationship among smallholder farmers' awareness of existing business model types, their usage of those business model types, and their preferences for the business model types.

In examining the factors that influence the choice of the existing business model by smallholder farmers, binary logistic regression was employed. The binary logistic regression had the usage of the existing business model as the dependent variable regressed against the independent variables (socioeconomic characteristics, competencies in VPMP, and awareness of the existing business models).

For objective five, descriptive statistics were conducted on the farmers' perception and their knowledge of the benefit of Inclusive Business Models (IBM) in their farming businesses. Kendall's coefficient of concordance test was also conducted on the smallholder vegetable farmers' challenges in utilizing inclusive business models (IBM) in their farming businesses. Based on the findings, the study proposed an inclusive and sustainable business model that could help them increase their productivity. This model was illustrated in the study in a designed framework.

Model Specification

Profit

Profit is seen as the primary goal of any business over the long term. This ensures that the business will continue to operate or not in the long run. An indication of an organization's lifeblood is its capacity to maximize profit. Profit is therefore the lifeblood of any farm business. Profit is seen by the farm owner as the return for taking a chance on implementing a program or piece of technology. Farm business owners must turn a profit at some point to stay in business or to remain relevant in an industry that is rife with risk and uncertainty. The revenue that exceeds the cost of production is referred to as profit.

However, while break-even profit (revenue equal to costs) is ideal, it is not sustainable. The amount and price of the output determine the total revenue, just as the output determines the total cost. Total cost refers to the expenses related to the manufacturing process, whereas total revenue refers to the earnings or income that the business realized as a result of carrying out the enterprise. Profit is what remains after costs are subtracted from revenues. As a result, profit can be mathematically defined as;

Profit = TR – TC 3.1

Where; TR = P.Q 3.2

TC = TFC + TVC 3.3

Hence: TR = Total Revenue, TC = Total Cost, TFC = Total Fixed Cost, TVC = Total Variable Cost, P = Price per unit of output produced, and Q = Quantity of output produced

The profit margin, on the other hand, is the difference between the revenue from the farm business and the profit. The most ideal situation for an enterprise is one with a high-profit margin. Based on the enterprise's profit contribution, this might serve as the basis for choosing one business over another.

Mathematically, the profit margin is calculated as:

$$\text{Profit margin} = \frac{Profit}{Total\ Revenue} \quad 3.4$$

Gross Margin

Gross margin is the difference between the total revenue (TR) and variable costs from the farm operation. All costs that fluctuate in the cost of producing an agricultural enterprise's output are referred to as total variable costs or TVCs. The term "variable cost" is also used to describe the costs associated with running the business, such as the sales and administrative costs. It displays how much money the farm business would make from the product if it were sold for a specific price. As a result, revenue is measured as a function of output or quantity and price. This shows that costs rise in direct proportion to the number of units produced. When the value of the fixed cost is minimal or stays the same across a group of businesses, gross margin is helpful. A favorable gross margin indicates that the total revenue exceeds the variable costs, whereas a negative gross margin indicates that the total revenue is less than the variable costs, resulting in an unfavorable gross margin. There are circumstances where the cost and the revenue are equal, and in those circumstances, the gross margin does not change. However, a favorable gross margin is something that every agricultural business hopes for.

Mathematically, Gross Margin is calculated as:

GM = TR – TVC 3.5

TR = P.Q 3.6

TVC = f (Q) 3.7

Where; GM = Gross Margin, TR = Total Revenue, TVC = Total Variable Cost, P = Price per unit of output produced Q = Quantity of output produced

Stochastic Profit Frontier Model

Concepts of allocative and technical efficiency are combined in the SPF model. The model assumes that inefficient production systems can result in lower sales or earnings. According to the theory of production, a smallholder vegetable farmer will select an input-output combination that ensures the highest possible profit given the available resources, both monetary and technological. The profit of a farm is determined by the quantity of these outputs and the costs of these inputs. The SPF model can be implicitly described as per Battese and Coelli (1995) by way of Eq. (3.8):

$$\pi_i = (Pi, Z_i)\exp(e_i)\,;\; e_i = v_i - u_i \qquad 3.8$$

Where πi is the ith smallholder vegetable farmer's normalized profit, Pi is the normalized price of the traditional input variables, Zi is the number of fixed inputs used in vegetable farming, and ei is the error term. The independent and identically distributed vi term is linked to random errors that can be attributed to inefficiencies brought on by variables outside of the control of producers. The non-negative random variables that the farmer can influence are represented by ui. It reflects a half-normal distribution with constant variance and a mean of 0. Equation 3.9 presents the model for inefficiency effects ().

$$u_i = \delta 0 + \sum \delta k \; n \; k{=}1 \; Wdi + \varepsilon i \qquad 3.9$$

Where Wdi stands for the inefficiency-related explanatory variables, εi stands for the two-sided random errors, and $\delta 0$ and δk are estimated coefficients. Profit efficiency is defined by Chiona, Kalinda, and Tembo (2014) as the ratio of the observed stochastic profit function to the frontier profit function and is denoted by the following formula:

$$\pi_e = \pi_i \; \pi_{max} \qquad 3.10$$

$$\pi_e = f\ (P_{ij}, Xij, \beta i).\ exp\ (v_i{-}u_i)\ f\ (P_{ij}, Xij, \beta i).\ exp\ (v_i) \qquad 3.11$$

$$\pi_e = \exp(-u_i) \qquad 3.12$$

$$\text{Profit inefficiency} = 1 - \pi_e \qquad 3.14$$

Where πe represents the profit efficiency of an individual farmer, πi is the observed profit, while πmax represents the maximum (frontier) profit. The error term ( ) has two components that are unrelated to each other and have normal distributions; where ui is the component associated with inefficiency, and vi is the component associated with random disturbances. Where ui = 0, it indicates that a producer's profit is on the frontier i.e., fully efficient whereas when ui < 0, it means that profit is below the frontier. The further the deviation from the frontier, the lower the profit efficiency.

Empirical Estimation

The more adaptable translog stochastic frontier model was used in the study. Compared to the Cobb-Douglas model, the translog functional form imposes fewer limitations. The translog model is written as follows:

$$ln\pi_i = \beta_0 + \beta_1 \; ln\pi_1 \; + \beta_2 \; ln\pi_2 + \beta_3 \; ln\pi_3 + \beta_4 \; ln\pi_4 + \beta_5 \; ln\pi_5 + 1.5\beta_{11} (ln\pi_1)^2 + 1.5\beta_{22} \; (ln\pi_2)^2 + 1.5\beta_{33} \; (ln\pi_3)^2 + 1.5\beta_{44} \; (ln\pi_4)^2 + 1.5\beta_{55} (ln\pi_5)^2 + \beta_{12} \; ln\pi_1 \, ln\pi_2 + \beta_{13} \; ln\pi_1 \, ln\pi_3 + \beta_{14} \, ln\pi_1 \, ln\pi_4 + \beta_{15} \, ln\pi_1 \, ln\pi_5 + \beta_{23} \, ln\pi_2 \, ln\pi_3 + \beta_{24} ln\pi_2 \, ln\pi_4 + \beta_{25} \, ln\pi_2 \, ln\pi_5 + \beta_{34} \, ln\pi_3 \, ln\pi_4 + \beta_{35} \, ln\pi_3 \, ln\pi_5 + \beta_{45} \, ln\pi_4 \, ln\pi_5 \ldots + v_i - u_i \qquad 3.15$$

Where ln represents natural logarithm, π is the normalized profit; β_1 is the normalized cost of capital (depreciated value); β_2 is the normalized cost of labor; β_3 is the normalized fertilizer; β_4 is the normalized cost of other agrochemical product; and β_5 is the normalized cost of other operational expenses. ($vi– ui$) represents the composite error term (ei,) where ui represents farm-specific and socioeconomic characteristics related to production inefficiency while vi represents random disturbances in the production.

The Cobb-Douglas model on the other hand is written as:

$$ln\pi_i = \beta_0 + \beta_1 \; ln\pi_1 + \beta_2 \; ln\pi_2 + \beta_3 \; ln\pi_3 + \beta_4 \; ln\pi_4 + \beta_5 \; ln\pi_5 + v_i - u_i \qquad 3.16$$

NB: The interpretation of the variables in the Cobb-Douglas model is the same as the one in the translog model.

The inefficiency model is also given as:

$$u_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 \ldots\ldots\ldots + \delta_n z_n \qquad 3.17$$

Where $z_1, z_2, z_3 \ldots\ldots z_n$ represents the socioeconomic characteristics that contributed to the farmers' profit inefficiencies. These include age, years of formal education, household size, farm size per hectare, times of accessing extension service, access to credit (dummy: =1 if yes), and farmer groups (association) (dummy: =1 if yes).

Logistic Regression

The use of binary logistic regression for the estimation of the choice of inclusive business models was to help explain how socioeconomic variables, farmers' competencies in VPMP, and farmers' awareness of existing business models influence smallholder vegetable farmers' choice of inclusive business model, thereby allowing implementation agents to develop a lucrative strategy that will enable smallholder vegetable farmers to employ the most appropriate inclusive business model which could promote the utilization of technological innovation in the agriculture sector and preferably in the vegetable sub-sector. These variables serve as a driving force for farmers to be willing or not of a technology or service, hence the necessity to measure these variables to find out how they impact farmers' decisions.

A binary choice is always suitable for measuring how some characteristics affect farmers' decision-making due to the binary response nature of the data available. The most used form of binary choice is the probit and logit. The binary logistic regression was used to estimate the influence of the independent variables on the dependent (usage of existing business model). The choice of model was measured on a binary scale with 0- Use of other existing business model and 1- Use of direct farming business model. Logit and Probit have been used extensively in cases with limited dependent variables in obtaining information when the distribution is non-normal in technology studies. The logistic regression model has been used for categorical and a mix of categorical and continuous variables (Ranganathan, 2017).

In this study, the logistic regression model is estimated below:

Logit (p_i) = log $(\frac{p_i}{1-p_i})$ = ß$_0$ + ß$_1$ (Age) + ß$_2$(Level of education) + ß$_3$ (Household size) + ß$_4$ (Main occupation) + ß$_5$ (Use of irrigation facility) + ß$_6$ (Farmer group) + ß$_7$ (Times of accessing extension service) + ß$_8$ (Target market) + ß$_9$ (Aspiration) + ß$_{10}$ (Attitude) + ß$_{11}$ (Knowledge) +ß$_{12}$ (Awareness of IBM) + ß$_{13}$(Edu)+e 3.18

Where: Logit (p_i) = the odd of the event occurring p_i= the probability of the event will occur, 1- p_i= the probability of the event not occurring, ß$_0$ = Constant of the equation and e = Error term

Variables in the Equations

Dependent Variable

The dependent variable was the usage of the existing business model. The study presented nine (9) existing business models to the farmers and the choices from the various respondent was used as an indicator, to sum up, to form the dependent variable "the usage of existing business model". It was noted that direct farming was the common business model that existed among the only Okra farmers, only Garden Egg farmers, and both Okra and Garden Egg farmers in the study area. Accordingly, the dummy coding of the use of the existing business model was reduced to 1 – vegetable farmer using direct farming and 0 – otherwise.

Independent variables

Based on a review of the theoretical and empirical literature and the flexibility of the analytical tool, the following factors were deemed to influence the dependent variables and these were considered in the model.

Age

Age was considered a continuous variable defined as the age of the respondent at the last birthday. Age was measured in years. It was expected that as farmers advance in age their output will eventually increase as well as a result of the level of experience gathered over time of their farming life. However, it makes them used to the old method of farming and may not be willing to employ new technologies. Therefore, age was expected to have a positive relationship with the choice of direct farming model instead of inclusive business models.

Level of education

Education was captured as a dummy variable with 0 – as No formal education, and 1 – as formal education. It was expected that as farmers' level of education increases their ability to use information will also increase with ease. Thus, the level of education was anticipated to have negative relationship with the farmers' choice of direct farming business models. This implies that as farmers level of education increases the probability of them choosing inclusive business over direct farming also increases.

Household size

The household size was treated as a continuous variable measured per the number of people living under one roof at the time of the study. According to Ahlheim and Schneider (2013), a larger household size implies large household expenditure and a decrease in disposable family income. Perhaps, as household size increases the demand for a new way of farming to get more income will increase as well. Therefore, it was envisaged that there will be negative relationship between household size and the choice of direct farming business mode. Thus, as farmers' household size increases the probability of them choosing inclusive business models over direct farming model is higher.

Main occupation

The main occupation in this study refers to the major work that the respondents do for their main source of income for livelihood. In this study, it was stated clearly to farmers to answer whether vegetable farming was their major work for livelihood. It was captured as a dummy variable assuming 0 – Not main occupation and 1 – Main occupation. The assumption was that farmers who had vegetable farming as their main occupation would dedicate much of their resources to their main source of livelihood. Therefore, it was expected that the main occupation would have a positive relationship with farmers' choice of an inclusive business model over the direct farming model.

Use of Improved Irrigation Facility

The use of irrigation facility in this study stands for the use of water apart from rainfall to irrigate vegetable farms. It was captured as a categorical variable with 0 – No, use of irrigation facility, and 1 – yes, use of irrigation facility. The use of irrigation facilities is capital-intensive, especially concerning drip, sprinkler, and flood irrigation. Since irrigation facility is capital intensive, the assumption is that they will encourage farmers to choose inclusive business models which could empower them to increase production levels. Therefore, it was anticipated that the use of irrigation facilities would have negative relationship with farmers' choice of a direct farming business model over the inclusive business model.

Farmer group

Farmer group as an independent variable here refers to farmers of the study who happens to be part of cooperative societies with aim of supporting each through team works in acquiring inputs, price determination, and accessing the appropriate market for their goods. It was also captured as a dummy variable with 0 – Not a member of the farmer group, and 1 – A member of the farmer group. It was expected to have a negative relationship with the choice of direct farming model over inclusive business since farmer groups enable farmers to access current information relating to their farming business.

Times of accessing extension service

This implies the number of times farmers receives services from extension agents. It was treated as a continuous variable. The study anticipated to have a positive relationship between the number of times farmers access extension services and the choice of inclusive business models by farmers over direct farming model.

Target market

The target market refers to the buyers who buy from the farmers after harvesting their produce. It was captured as a dummy variable with 1 – middlemen, and 0-others. It was assumed that depending on the terms of the agreement between the buyer and the farmer that is what could determine whether the farmer would be willing to choose inclusive business models over direct farming model or otherwise. The study anticipated both negative and positive relationship between the target market and the choice of inclusive business models base on price determination.

Competence

The competence level of the farmers in vegetable production management practices was measured in terms of their knowledge, attitude, aspiration, and skills. It was captured as a continuous variable with 1 – Very Low, 2 – Low, 3 – Moderate, 4 – High, and 5 – Very High. Presumably, competence was expected to have a positive relationship with the choice of inclusive business models by the farmers over direct farming model. This is because the competencies of the farmers ascribe to how well a farmer is doing in vegetable production management practices.

Awareness of IBM

Awareness of IBM implies how knowledgeable the farmers are in terms of IBM before the study. It was treated as a dummy variable with 0 – Not aware of IBM and 1 – Aware of IBM. It was anticipated that awareness of IBM should have a negative relationship with the choice of direct farming model over IBM by farmers. This is assumed that the awareness of technology influences the choice of farmers.

Table 2: Variables and their measurement included in the model

	Variables	Unit of measurement	Expected direction
Dependent Variable	Usage of existing business model	1 – use of direct farming 0 – otherwise	
Independent Variable	Age	Years	+
	Level of education	0 – no formal education, 1 – formal education	-
	Household size	Number of people under one roof	-
	Main occupation	0–not main occupation, 1 – main occupation	-
	Use of irrigation facility	0-no use of irrigation, 1-use of irrigation	-
	Farm group	0-Not a member of farmer group, 1- A member of farmer group	-
	Times of accessing extension service	Number of times	-
	Target market	1-Middlemen, 0- others	-/+
	Aspiration	Continues variables	-
	Attitude	Continues variables	-
	Knowledge	Continues variables	-
	Awareness of IBM	0-Not aware, 1- Aware of IBM	-

Source: Field Survey, Awuakye (2022)

Kendall's Coefficient of Concordance

Kendall's Coefficient of concordance was used to rank the various constraints to know which of the constraint the most limiting constraint to the farmer is. Although, there are ranking methods like the Garret ranking method, Freedman ranking, and Spearman ranking method. However, Kendall's coefficient of concordance was used because of the small asymptotic variance that makes it efficient and the small gross error sensitivity that makes it more robust. Kendall's Coefficient of Concordance is a non-parametric statistical procedure used to identify a given set of constraints, from the most limiting to the least limiting constraints, and to measure the degree of agreement among the respondents.

The challenges that hinder smallholder vegetable farmers from using Inclusive Business Models (IBMs) were ranked from the most limiting constraint to the least limiting constraint using numerals (1, 2, 3 …, and 10). The variable with the highest mean score was ranked as the most restricting variable whereas the variable with the lowest score was calculated as the least challenging variable.

Kendall's Coefficient of Concordance was calculated using the total score (W). Koufie (2020), illustrated Kendall's Coefficient of Concordance mathematically as:

$$W = \frac{12[\sum T^2 - (\sum TP)^2/n]}{nm^2(n^2-1)}$$

Where, W= Kendall's Coefficient of Concordance, T = Sum of ranks for the challenging variables being ranked, m = Total number of respondents (smallholder vegetable farmers), and n = Total number of challenges being ranked.

Kendall's Coefficient of Concordance (W) was then tested for significance in terms of the F-distribution. The –ratio is presented as:

$$F = [(m-1)\,W/\,(1-W)]$$

According to Koufie (2020), the degree of freedom is given as:

$$df = \frac{(n-1) - (\frac{2}{m})}{m - 1[(n-1) - \frac{2}{m}]}$$

Test of Hypothesis

The following null hypothesis was tested:

Ho: Farmers do not agree on the ranking of the constraints to show the most limiting challenges pertain to the study

H_1: There is an agreement between the rankings of the challenging variables

Ethical Consideration

An introductory letter was sent to the head of the department of agriculture, Denkyembour District to enable the research team to visit the selected farmers for the administering of the questionnaires. A one-day training was organized for four technical staff from the department of agriculture in the study area on the instrument and how to administer them to the respective respondent after approval has been made from the Institutional Review Board (IRB) of the University of cape Coast (UCC) to enable the student researcher in the data collection exercise

Chapter Summary

The chapter dealt with the methodological issues that were studied and used in the research. The study described the area of study, thus, Denkyembour District in the Eastern Region of Ghana, and also examined the research design approaches used for carrying out the study. There were also descriptions of processes used for developing quantitative research tools. The section also describes how the variables have been operationalized. The target population for the research was smallholder vegetable farmers who happened to be beneficiaries of a particular project that this study was worked directly under.

Using a questionnaire, quantitative information was gathered. The data collected were cleaned and analyzed using Microsoft Excel, 25.0 of SPSS, and R 3.4.0 statistical software.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter presents the results and discussion of the analyses that were performed to meet the objectives of the study. It emphasizes descriptive statistics of the socio-demographic characteristics of the respondents, farm characteristics, and institutional characteristics of the respondents. Also, this chapter discusses the results of the analyses of the various objectives of the study.

Socio-Economic Characteristics of Respondents

The variables used to ascertain the socio-economic characteristics of the respondents are gender, age, level of education, marital status, household size, main occupation, and household annual income. Figures 3,4 and 5, and Table 3 present the results of the socioeconomic characteristics of the respondents.

Gender

Figure 3 shows that 55 percent of the respondents were male farmers whilst 45 percent of them were female farmers. This implies that the project beneficiaries were dominated by male farmers.

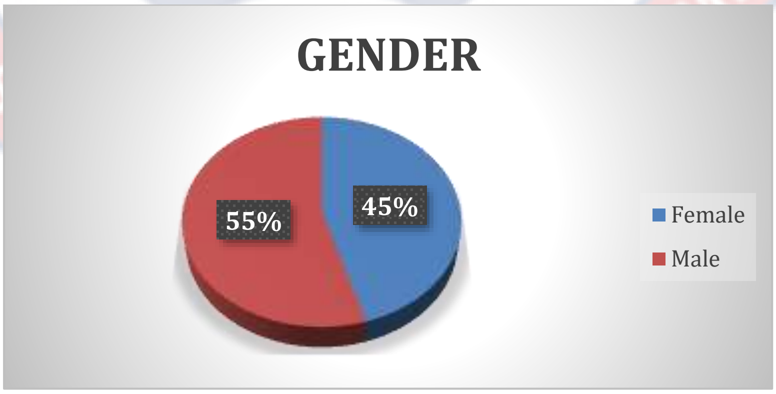

Figure 3: Gender of the respondents

Source: Field Survey, Awuakye (2022)

From the findings, it was revealed that vegetable production was labor and capital-intensive which deter most female farmers from getting involved. Also, the cultural setting of the study area grants male farmers easy access to land, capital, and other farm inputs which gives males an upper hand concerning vegetable production as compared to female farmers. This agrees with the findings from Koufie (2020) who reported that the cultural setting of farmers plays a role in access to both acquisitions of lands and production inputs that gives them an upper hand in farming over females. Additionally, Joshi and Kalauni (2018), in an article titled "Gender role in vegetable production in the rural farming system of Kanchanpur, Nepal" stated that, "male farmers have easy access to arable lands for vegetable production than that of female farmers". Igwe and Onyenweaku (2013) also reported, there are more male farmers in agriculture than female farmers. Finally, Okeyo (2020), supports the assertion by adding that men typically dominate small-scale farming while women typically work in processing and harvesting.

According to Koufie (2020), age affects a farmer's capacity for managing risk as well as his or her level of innovation. As a result, as a farmer becomes older, his or her capacity to conduct manual labor declines. From the findings as presented in Table 3, the minimum and maximum age of the respondents were 27 years and 86 years respectively, and the mean age was 48 years. This implies that the average age of the respondents is above the youthful age range. During the survey, it was observed that the study area is a mining community and most of the youth in the communities engage in mining activities. Perhaps, they prefer mining activities to farming businesses since they could earn more income from mining activities than that farm businesses though it is very tedious. This concurs with an article titled "Rural youth and employment in Ethiopia" which explicitly that the majority of the youth force engages in non-agricultural work (Schmidt & Bekele, 2016).

Level of Education

With regards to education as presented in figure 4; 67.3 percent of the respondents had attained MSL/JSS/JHS education, 17.3 percent had attained primary education, and 2.7 percent had attained SSS/JHS and 12.7 percent of the respondent had no formal education.

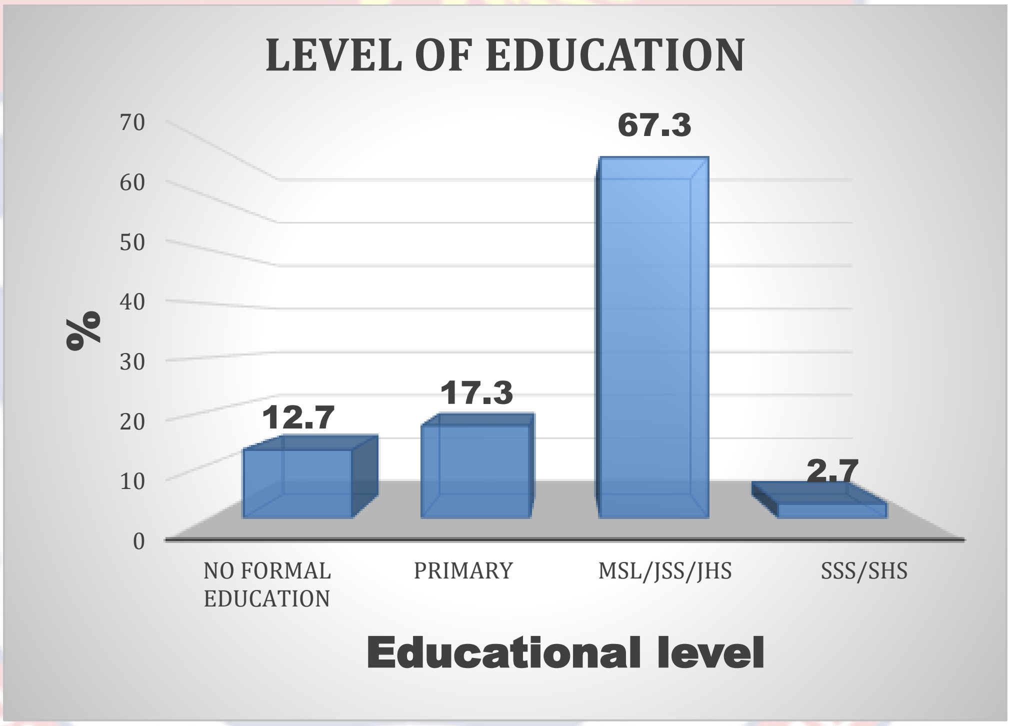

Figure 4: Level of Education.

Source: Field Survey, Awuakye (2022)

Also, none of the respondents had an opportunity to go through tertiary education. It was realized that the minimum, maximum, and average years of formal education were 4, 15, and 10 years respectively. This implies that the majority of the respondents have had some form of formal education. Perhaps, this has contributed to their access to information and also adopting and applying new technological innovations such as Inclusive and Sustainable Business Models in their farming businesses. This concurs with Koufie (2020), and Igwe and Onyenweaku (2013) who both reported that the majority of the respondents in their studies were literate. However, findings from Amankwah et al. (2018 refute the results from these studies, as they presented that the majority of farmers are illiterate.

The main source of occupation

From Table 3, 88.7 percent of the respondents had farming as their main source of occupation whilst 11.3 percent had off-farm jobs such as mason, mining, etc. as their main occupation. This implies that the majority of the respondents solely depend on the farming business for their livelihood. According to Galt (2013), farmers who solely depend on farming activities for their livelihood turn out to be more dedicated to their farming business to enable them to maximize their productivity and profit. However, farmers' engagement in off-farm activity gives them an avenue to improve their capital to support the farming business and also supplement household income (Morris, Henley, & Dowell, 2017). This in return helps avoid unnecessary borrowing from either formal or informal financial institutions.

Table 3. Demographic Characteristics

Variables		Frequency		Percentage
Farming as Main Occupation				
No		17		11.3
Yes		133		88.7
Household Status				
Child		1		0.7
Spouse		54		36.0
Head		95		63.3
Total		150		100
Continues Variable	Mean	SD	Min.	Max.
Age	48.01	9.59	27	86
Household size	7.33	2.58	1	18
Years of formal education	9.90	2.385	4	15
Annual household income	19730.00	16254.75	8,000	200,000

Source: Field Survey, Awuakye (2022)

Household status

The study further revealed that 63.3 percent of the farmers are heads of families, 36.0 percent are spouses and 0.7 percent were children. Thus, the study is dominated by heads of families who usually have an influence on the families for decision-making.

Household Size and Annual Household Income

Table 3 also shows that the minimum number of people living in the house of each respondent is one (1) and the maximum number is eighteen (18). On average, seven (7) people live in the house of each respondent according to the findings in Table 3. Finally, Table 1 shows that the minimum and maximum annual household income of the respondents is GH₵8,000.00 and

GH₵200,000.00 respectively. And on average, each respondent attains GH₵19,730.00 according to findings from Table 3.

Marital Status

Concerning marital status, Figure 5 shows that 86.7 percent of the respondents were married and 13.3 percent were unmarried. Thus, the respondents are dominated by married farmers. This concurs with Abdulai et.al. (2017) reported that vegetable production businesses are mostly dominated by married people.

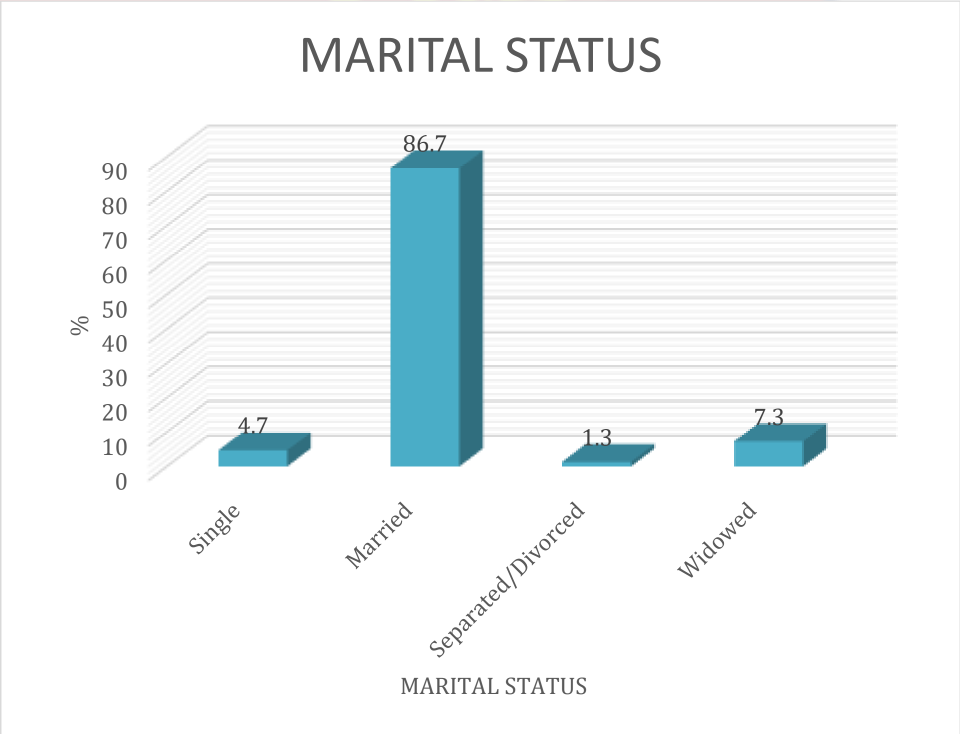

Figure 5: Marital Status.
Source: Field Survey, Awuakye (2022)

Farm Characteristics of the Respondents

The farm characteristics of this study were analyzed in terms of land holding status, source of labor, use of irrigation facility, size of land, years of farming experience, and annual farm income of the respondents.

Landholding status

Table 4 shows that 34.7 percent of the respondents usually use rented lands for vegetable cultivation. 22.7 percent of the respondents used family land whilst 20.7 percent used owned land for their vegetable production. Also, 4 percent of the respondents used the sharecropping land tenure system whilst 18 percent of the respondents used both family land and owned land. This implies that the majority of the farmers incur additional costs to secure land for production since it was only a few of the farmers were using owned farmland. During the survey, it was observed that farmers who use rented land do not use it for a longer period which in turn may affect their willingness to accept some technological innovation. They could only agree to that if only when they are hiring the land for at least more than two years.

Source of labor for Production

With regards to the source of labor for production, Table 4 depicts that, 60 percent of the respondents use both families and hired sources of labor for their farming business activities. 36 percent of the respondents also employ the use of hired labor whilst 4 percent of the respondents used family labor. This implies that the source of labor for this study is dominated by both families and hired sources of labor. On average, farmers may not spend much on the labor cost of production since farmers usually do not incur any costs on family labor. The findings agree with Abdulai et al. (2017) indicated smallholder vegetable farmers often employ both families and hired labor for their farming activities.

Table 4: Farm Characteristics

Variables	Frequency	Percentage
Landholding status		
Family land	34	22.7
More than one option	27	18.0
Own land	31	20.7
Renting	52	34.7
Sharecropping	6	4.0
Source of Labor		
Family	6	4.0
Hired	54	36.0
Both family and hired	90	60.0
Users Of Irrigation Facility		
No	4	2.7
Yes	146	97.3
Farmer Category		
Okra Farmers	35	23.33
Garden Eggs Farmers	24	16
Okra & Garden Eggs Farmers	91	60.67
Total	150	100.0
Continues Variable	Means	SD
Farm Size	1.51	0.86
Years of experience	16.95	10.27
Annual farm income	15,500.00	5,440.65

Source: Field Survey, Awuakye (2022)

Irrigation Facility

Table 4 also shows that 97.3 percent of the respondents used some form of irrigation facility. This is because the vegetable is a type of crop that is very fragile and needs a lot of moisture to enhance growth and fruit yield (Ranjan et.al. 2017). Therefore, it is expedient not to solely depend on rainwater, especially during the minor season. 2.7 percent of the respondents who happens not to be using any form of irrigation facilities were farmers who usually plant their crops during the major seasons when there is some assurance of enough rainfall. However, the study indicated the majority of the farmers who were using irrigation facilities were using the manual form of irrigation system. Thus, most of them were not able to afford improved irrigation systems because they are capital intensive.

Farmer Category

The total population was grouped into three categories; that is farmers who cultivated only okra, only garden eggs, and those who cultivated both okra and garden eggs. Table 4 indicated that 23.33 percent of the respondents were only okra farmers, 16 percent of the respondents were garden eggs farmers whereas the remaining 60.67 percent of the respondents happened to be vegetable farmers who cultivated both okra and garden eggs. This implies that the study was dominated by smallholder vegetable farmers who plant both okra and garden eggs.

Farm Size

With regards to farm size, Table 4 shows that the minimum and the maximum vegetable farm size of the respondents were 1 acre and 6acres respectively whereas the average vegetable farm size is 1.5 acres. This implies the smallholder vegetable of the study were potential farmers who could plant more vegetables to supply society and get more returns (all other things being equal).

Years of experience

Experience in vegetable production is often determined by the number of years a vegetable farmer has effectively been engaged in producing vegetables over a while (Xaba & Masuku, 2013). The average years of vegetable farming experience of the respondents happen to be 17 years with a minimum and maximum number of farming experiences of 1 year and 60 years respectively according to Table 4. This implies that average, each farmer had enough farming experience in vegetable produce which should cause them to be effective and efficient in the farming businesses (Xaba & Masuku, 2013).

Institutional Characteristics

For this study, the institution characteristic was analyzed using variables such as; farmers' access to extension services, the number of times they access extension services, access to credit, farmers association (cooperatives), and their target market.

Access to extension services

To Table 5, 84.7 percent of the respondents had access to extension services. This implies that the majority of the farmers are being guided by agricultural extension agents. This will help the farmers with the right use of farm inputs coupled with the right agronomic practices which will in turn cause farmers to be cost-effective and efficient and also maximize their profit, "all other things being equal".

Table 5: Institutional Characteristics of Respondents

Variables	Frequency	Percentages		
Access to Extension Service				
No	0	0.00		
Yes	150	100		
Access to Credit				
No	120	80.0		
Yes	30	20.0		
Farmers Association				
No	114	76.00		
Yes	36	24.00		
Target Market				
Retailers	8	5.30		
Middlemen	142	94.70		
Cooperatives	0	0.00		
Total	150	100.0		
Continues Variable	Means	SD	Min	Max
Times of Accessing Extension Agent	3.92	2.230	2	15

Source: Field Survey, Awuakye (2022)

Among the 84.7 of farmers, the minimum number of times farmers access extension services is two (2), the maximum number of times they access extension services were fifteen (15), and the average number of times respondents access extension services is four (4). This implies that during each production period, a farmer at least got in touch with an extension officer four times. Also, the results show that all the respondents had access to extension services in one way or the other. Meaning, the smallholder vegetable farmers of the study had access to vital information and knowledge that could enable them to be effective and efficient in their vegetable production management practices. This contradicts with Antwi-Agyei and Stringer (2021), who disclosed that the lack of extension services and research in Ghana's savannah region is to blame for the communication gap between the ministry of food and agriculture and farmers.

Access to Credit

Regarding credit, 80 percent of the farmers had no access to any form of credit, and even the 20 percent of respondents who had access to some forms of credit were from some middlemen who happens to be buying their produce after harvesting. The farmers made it known to the researcher during the survey that, loan from the middlemen were not encouraging because they usually determine the price for them despite the prevailing price of the commodity at the various market. These findings concur with Ciaian et al. (2021), who observed that while farmers do not have much access to credit when it comes to land, they do have a lot of credit restrictions when it comes to cash.

Target Market

Finally, from Table 5, 94.70 percent of the farmers sell their produce to middlemen, 5.30 percent sell theirs to retailers, and none of the respondents used to sell their produce to a cooperative society. This implies that the middlemen were the major source of market for vegetable farmers in the study area. These findings agree with Mukaila et.al. (2021), who reported that middlemen are the most common intermediary between smallholder farmers and their final consumers. Thus, any decision that middlemen make in their businesses influences the smallholder vegetable farmers and their farming businesses (Mukaila et.al. 2021).

Sources of Extension Services Information

Figure 7 presents results on the sources of extension services available to the farmers. The study presented five sources of extension services to the respondents. These include; farmer – to – farmer extension agents, private extension agents, government extension agents, NGOs extension agents, and both farmer – to – farmer-extension agent and government extension agents

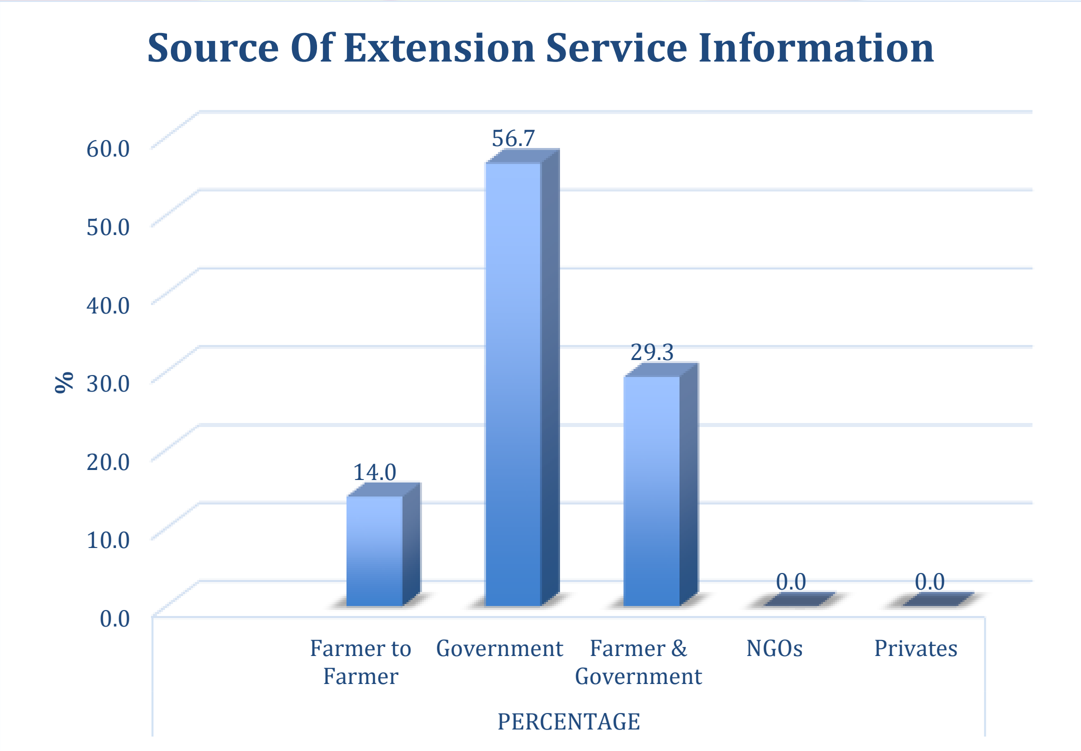

Figure 6: Sources of Extension Services Information
Source: Field Survey, Awuakye (2022)

The results from Figure 7 indicate that 14 percent of the respondents receive their extension services assistance from their colleagues. 56.7 percent of the respondents also access government extension agents from the Department of Agriculture (MOFA) in the district. 29.3 percent of the farmers also receive their aid in extension services from both farms–to–farmer agents and government agents. However, none of the respondents had extension services from NGOs and Private extension agents. This implies that the majority of the farmers had access to government officials who could give them the appropriate agronomic activities to enhance their productivity. Also, the smallholder vegetable farmers did not spend much amount of money on extension services since extension services derived from government officials are free.

Objective One: To Examine the Profitability Performance of Smallholder Vegetable Farmers in the Denkyembour District.

The objective of this study is to analyze the performance of the farmers in terms of profitability. To ascertain the profit of any business, the cost items (fixed cost and variable cost) of the business and the sales (the product) have to be measured to estimate the profit margin gain by the various actors involved. Under this objective, the study discussed the fixed cost and the variable costs incurred by the smallholder vegetable farmers in the study. The farmers were segregated into three categories; okra farmers, garden eggs farmers, and farmers who cultivated both okra and garden eggs. Out of one hundred and fifty farmers in the study, thirty-five of them cultivated only okra, twenty-four of them cultivated only garden eggs whereas ninety-one of the farmers were found to be cultivating both okra and garden eggs. This objective also examined the production and marketing cost analysis to ascertain the profitability of each farmer group of the study. Profit efficiency was also conducted under this objective to determine whether each of the farmer group in the study were economically efficient despite the profit they make in their farm businesses.

Descriptive Statistics of Fixed Cost Items Identified by Each Farmer Group of the Study

Table 6 presents the fixed-cost items used by the various farmer categories in the study. It shows the mean, standard deviation, and minimum and maximum prices at which each of the items was paid for within one production season.

Land

The economic value of land was calculated based on rent. That is, it was calculated based on how much an acre of land was worth in the study area. Also, for accountability, land owned by the farmers was accounted for in the study. The study revealed that okra farmers paid an average price of GH₵394.29 (SD= 174.47) for land use at minimum and maximum prices of GH₵200.00 and GH₵600.00 respectively. Farmers who cultivated only garden eggs also paid an average price of GH₵337.50 (SD= 123.58) for land use at a minimum price of GH₵200.00 and GH₵600.00 as the maximum price. Farmers who cultivated both okra and garden eggs on the other hand paid an average price of GH₵387.14 (SD= 197.31) for land use at a minimum and maximum price of GH₵150.00 and GH₵1000.00 accordingly. This implies that on average, farmers who cultivated only okra paid a higher amount of money for land use than those who cultivated only garden eggs and those who cultivated both okra and garden eggs, although both okra and garden eggs farmers recorded the maximum amount of money paid for land use.

Knapsack Sprayer

Knapsack sprayer was identified to be one of the fixed-cost items that all the farmers were using apart from the land. Farmers who produced okra were revealed to be paying an average price of GH₵135.57 (SD=103.61) for knapsack sprayers with minimum and maximum prices at GH₵70.00 and GH₵450.00 respectively whereas farmers who produced only garden eggs paid an average price of GH₵286.88 (SD=148.78) for knapsack sprayer with a minimum price of GH₵75.00 and a maximum price of GH₵550.00.

Farmers who cultivated both okra and garden eggs paid an average price of GH₵252.36 (SD=151.05) for knapsack sprayers with GH₵70.00 and GH₵650.00 as minimum and maximum prices respectively. This implies that on average, only garden eggs paid more money than the other categories of farmers of the study for the use of knapsack sprayer.

Table 6: Fixed Cost Items for smallholder Vegetable Farmers of the Study.

Variables	Only Okra				Only Garden Eggs				Both Okra & Garden Eggs			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Land	394.29	176.47	200.00	600.00	337.50	123.58	200.00	600.00	387.14	197.31	150.00	1000.00
Knapsack Sprayer	135.57	103.61	70.00	450.00	286.88	148.78	75.00	550.00	252.36	151.05	70.00	650.00
Modernized Irrigation Facilities	650.00	25.50	650.00	650.00	650.00	25.50	650.00	650.00	644.62	91.53	500.00	900.00
Hoes	20.00	4.47	20.00	20.00	30.00	5.48	30.00	30.00	28.75	3.54	20.00	30.00
Watering Can	20.00	4.47	20.00	20.00	00.00	00.00	00.00	00.00	75.00	7.07	70.00	80.00
Waterholes	00.00	00.00	00.00	00.00	150.00	12.25	150.00	150.00	154.00	25.03	100.00	200.00
Cutlass	30.14	1.91	25.00	40.00	30.63	3.99	25.00	40.00	29.50	2.56	25.00	40.00

Source: Field Survey, Awuakye (2022)

Modernized Irrigation Facilities

The modernized irrigation facilities comprise mechanized and other high-rated equipment used for irrigating crops on the field. Examples of these facilities are pumping machines, sprinkler irrigation gadgets, and the like. The average price of GH₵650 (SD=25.50) was paid by only okra farmers and only garden egg farmers as well with minimum and maximum prices of GH₵650.00 and GH₵650.00 respectively. Both okra and garden egg farmers on the other hand paid an average price of GH₵644.62 (SD=91.53) for modern irrigation facility usage with a minimum price of GH₵500.00 and a maximum price of GH₵900.00. This implies that, although, there was only one farmer each among only okra farmers and only garden egg farmers who used improved irrigation facilities yet on average they paid more money for the use of improved irrigation facilities than farmers who cultivated both okra and garden eggs.

Cutlass

Table 6 also indicated that farmers who cultivated only okra paid an average of GH₵30.14 (SD=1.91) for the use of cutlass with minimum and maximum prices of GH₵25.00 and GH₵40.00 accordingly. Only garden egg farmers were also found in the study to be paying an average price of GH₵30.63 (SD=3.99) for the use of cutlass with a price of GH₵25.00 and GH₵40.00 as minimum and maximum prices respectively. Farmers who cultivated both okra and garden eggs paid an average price of GH₵29.50 (SD=2.56) with minimum and maximum prices of GH₵25.00 and GH₵40.00. This also implies that on average farmers who cultivated both okra and garden eggs paid less for the use of cutlass than those farmers who cultivated only okra and only garden eggs.

Descriptive Statistics of Variable Cost Items Identified by Each Farmer Group of the Study

Table 7 shows the variable cost items used by the various farmer categories in the study. It shows the mean, standard deviation, and minimum and maximum prices at which each of the items was bought. The variable cost items identified in the study include land preparation cost, nursery expenses, cost of transplanting, cost of pesticides, cost of insecticides, cost of weedicides, cost of fertilizer, the labor cost of preproduction, labor cost of production, labor cost of harvesting, the labor cost of loading and unloading, and transport cost.

Table 7 reveals that on average, only okra farmers spent a high amount of money on the labor cost of harvesting at GH₵465.71 (SD=318.72) with a minimum price of GH₵300.00 and a maximum price of GH₵1800.00. The second item that only okra farmers happened to be spending much on was transport cost at an average price of GH₵422.857 (SD=218.73) with minimum and maximum prices of GH₵150.00 and GH₵1300.00 respectively. Only garden egg farmers were also identified to spend a lot of money on the cost of fertilizer at an average price of GH₵1360.47 (SD=745.77) with minimum and maximum prices of GH₵150.00 and GH₵4000.00 respectively. The labor cost of harvesting was the next variable cost item that only garden eggs farmers spent a lot on at an average price of GH₵1216.87 (SD=824.92) with a minimum price of GH₵200.00 and a maximum price of GH₵4200.00. Both okra and garden egg farmers were also identified to spend a higher cost on the labor cost of harvesting at an average price of GH₵1388.90 (SD=625.37) with minimum and maximum prices of GH₵400.00 and GH₵3200.00 and followed by labor cost of production at an average price of GH₵1331.25 (SD=772.32) with a minimum price of GH₵200.00 and maximum price of GH₵2400.00.

Table 7: Variable Cost Items for smallholder Vegetable Farmers of the Study.

Variables	Only Okra				Only Garden Eggs				Both Okra & Garden Eggs			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Land Preparation	284.29	162.60	100.00	800.00	633.63	446.91	150.00	2000.00	707.08	500.33	100.00	1600.00
Pesticides	142.86	22.42	100.00	200.00	282.71	140.10	100.00	500.00	337.62	144.15	120.00	500.00
Labor Cost of Loading & Unloading	297.14	214.53	200.00	1000.00	822.97	649.00	200.00	3500.00	816.67	651.03	200.00	2500.00
Transplanting	00.00	00.00	00.00	000.00	220.60	105.97	30.00	600.00	232.75	95.72	90.00	600.00
Labor Cost of Preproduction	365.43	266.97	140.00	1600.00	742.25	550.81	180.00	2500.00	850.00	761.64	150.00	2400.00
Labor Cost of Production	396.57	250.94	150.00	1200.00	1054.84	717.19	200.00	3000.00	1331.25	772.32	200.00	2400.00
Nursery Expenses	0.00	0.00	0.00	0.00	48.74	30.10	20.00	150.00	49.31	30.42	20.00	150.00
Transport	422.86	218.73	150.00	1300.00	1032.89	817.83	120.00	4800.00	954.17	483.63	250.00	1900.00
Fertilizer	414.43	186.41	120.00	900.00	1360.47	745.77	150.00	4000.00	1388.90	625.37	400.00	3200.00
Labor Cost of Harvesting	465.71	318.72	300.00	1800.00	1216.87	824.92	200.00	4200.00	1070.83	571.06	200.00	2400.00
Insecticides	315.43	156.74	200.00	1000.00	847.91	652.96	200.00	4500.00	877.50	504.24	200.00	2000.00
Weedicides	303.33	119.81	180.00	800.00	564.68	306.64	200.00	1200.00	586.97	290.75	200.00	1600.00

Source: Field Survey, Awuakye (2022)

Table 7 also indicates that farmers who cultivated only garden eggs and farmers who cultivated both okra and garden eggs spent less on nursery expenses and followed by the cost of transplanting. The average cost for nursery expenses were GH₵48.74 (SD=30.10) and GH₵49.31 (SD=30.42) for only garden eggs farmers and both okra and garden eggs farmers respectively with minimum and maximum prices of GH₵20.00 and GH₵150.00 for only garden eggs farmers and GH₵20.00 and GH₵150.00 for both okra and garden eggs farmers. Only garden eggs farmers paid for the cost of transplanting at an average price of GH₵220.60 (SD=105.97) with minimum and maximum prices of GH₵30.00 and GH₵600.00 whereas both okra and garden eggs farmers paid an average price of GH₵232.75 (SD=95.72) with a minimum and maximum price of GH₵90.00 and GH₵600.00 for the cost of transplanting. However, farmers who cultivated only okra did not spend on nursery and transplanting. This was because the okra seeds were planted at stake. Moreover, the costs of seeds were not captured among all three farmer groups because all the farmers in the study reported using seeds from their farms.

Production and Marketing Cost Analysis of Smallholder Vegetable Farmers

Concerning the production and marketing cost analysis of the respondents, the farmers were segregated into three categories. That is, farmers who cultivate only okra, farmers who cultivate only garden eggs, and farmers who cultivate both okra and garden eggs. Among the 150 respondents, the study shows that 35 of them cultivate only okra, 24 of them cultivates only garden eggs whereas 91 respondents out of the 150 cultivate both okra and garden eggs.

According to Table 8, the average total cost for farmers who cultivates only okra was estimated at GH₵3528.71 whereas their total revenue was estimated at GH₵6590.71. These estimates gave a gross profit of GH₵3062.00 and a profit margin of 46.46 percent. Farmers who cultivated only garden eggs indicate an average total cost of GH₵9955.84 with total revenue, gross profit, and gross margin at GH₵26093.29, GH₵16137.45, and 61.85 percent respectively.

Table 8. Production And Marketing Costs Analysis Of Smallholder Vegetable Farmers Per Growing Season

Variables	n	Mean	SD	Min	Max
Okra					
Depreciated Fixed Cost	35	584.00	281.77	305.00	1680.00
Variable Cost	35	2944.71	1157.60	1850.00	6425.00
Average Total Cost	35	3528.71			
Output	35	24.54	11.53	12	60
Quantity Sold	35	24.54	11.53	12	60
Unit Price	35	268.57	43.87	150	350
Total Average Revenue	35	6590.71			
Gross Profit	35	3062.00			
Gross Margin	35	46.46%			
Garden Eggs					
Depreciated Fixed Cost	24	722.92	366.42	370.00	1930.00
Variable Cost	24	9232.92	3962.20	3080.00	16970.00
Average Total Cost		9955.84			
Output	24	111.83	86.35	35.00	450.00
Quantity Sold	24	111.83	86.35	35.00	450.00
Unit Price	24	233.33	80.31	100.00	450.00
Total Average Revenue	24	26093.29			
Gross Profit	24	16137.45			
Gross Margin		61.85%			

Table 8: Cont.

Both					
Depreciated Fixed Cost	91	753.69	415.81	276.00	2051.00
Variable Cost	91	8578.69	4294.57	2180.00	19770.00
Average Total Cost	91	9332.38			
Output	91	117.02	89.51	31.00	508.00
Quantity Sold	91	117.02	89.51	31.00	508.00
Unit Price	91	477.03	90.19	250.00	750.00
Total Average Revenue	91	55822.05			
Gross Profit	91	46489.67			
Gross Margin		83.28%			

Note: M= mean, SD = standard deviation, Min = minimum, and Max = maximum. All prices and monetary values are estimated in Ghana Cedis (GH₵), whereas all output and quantity of produce were also estimated per bag (sack).

Source: Field survey, Awuakye (2022)

Farmers who cultivate both crops (okra and garden eggs) estimated total cost, total revenue, gross profit, and gross margin were GH₵9332.38, GH₵55822.05, GH₵46489.67, and 83.28 percent respectively. Apparently, from Table 8, farmers who cultivate both crops performed very well for cost and benefit analysis. This could be because most of the fixed-cost items are used for the production of both commodities. Thus, a farmer would pay for such an asset once and use it for the production of both crops as and when the need arises. This helps farmers who produce both crops to minimize the cost of production other than those who produce only one crop. According to Oladimeji and Abdulsalam (2014) and Osalusi et.al. (2019), okra production is a very lucrative and profitable vegetable farming venture in their respective study area. However, this study revealed that though only okra farming and only garden eggs farming are profitable business ventures but growing both okra and garden eggs looks more profitable than a single commodity. This implies that smallholder vegetable farmers are to be encouraged to cultivate more than one crop enterprise to enhance their profitability performances in their farming businesses.

Profit Efficiency of Smallholder Vegetable Farmers in the Denkyebour District in the Eastern Region of Ghana

This section presents findings from the stochastic profit frontier which was used to estimate the profit efficiency levels of smallholder vegetable farmers in the study area. The study discussed; the empirical estimates of the profit efficiency using the stochastic translog profit frontier model. The distribution of the profit efficiency scores among the smallholder vegetable farmers in the study area, determinants, or some factors that contributed to the profit inefficiency level of the smallholder vegetable farmers of the study was also analyzed using the model.

The log-likelihood ratio test was used to evaluate the Cobb-Douglas and Translog functions' model fitness. This test empirically aided in determining which of the two models' greatest fitness given its robustness and effective outcomes for the data set. The log-likelihood ratio test results from the Translog model were 222.933, 98.550, and -1.778 for okra farmers, garden egg farmers, and farmers who cultivated both okra and garden eggs respectively. The Cobb-Douglas model (presented in the Appendix) on the other hand, indicated log-likelihood test results as 53.766, 69.067, and -25.528 for okra farmers, garden eggs farmers, and farmers who cultivated both okra and garden eggs respectively. In other to decide on which model to use, the Cobb-Douglas and Translog models were subjected to a generalized likelihood ratio test with a specified hypothesis where the Cobb-Douglas model served as the null hypothesis and the Translog model served as the alternative.

The findings revealed that with regards to the Translog model; the okra farmers were statistically significant at 1 percent (p-value = 2.2e-16) with a chi-square value of 338.330. Garden egg farmers were also statistically significant at 1 percent (p-value = 3.793e-07) with a chi-square value of 58.967. The farmers who cultivated both okra and garden eggs were also statistically significant at 1 percent (p-value = 3.062e-05) with a chi-square value of 47.499. However, concerning the Cobb-Douglas model, all three sets of farmers were not statistically significant and there were no chi-square values for any of the farmer categories.

Therefore, it can be certainly concluded that the Translog model is the best-fit model for the data set of the study; subsequently, the discussions of the profit efficiency estimates have been done based on the Translog results in Table 9. Accordingly, the results of the Cobb-Douglass model estimation have been sent to Appendix C7, C8, and C9.

Table 9: Maximum Likelihood Estimates of Stochastic Translog Profit Frontier Model of Smallholder Vegetable Farmers.

Variable	Okra		Garden Eggs		Okra & Garden Eggs	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
(Intercept)	-4.492***	0.490	47.779***	0.937	12.733***	2.723
LogCapital	-15.844***	0.215	-0.178	0.851	-4.484***	0.580
LogLabor	3.250***	0.628	5.153***	0.756	-2.609**	0.869
LogFertilizer	-9.669***	0.211	-20.919***	0.921	1.757	2.333
LogAgrochemicals	-3.310***	0.639	28.674***	0.777	-1.469**	0.682
LogOthers	18.350***	0.721	-45.476***	0.791	-2.280	3.710
0.5LogLabourLabour	-30.381***	0.208	12.031***	0.669	-2.068**	1.051
0.5LogOthersOther	-1.384***	0.041	18.072***	0.676	1.908*	0.997
0.5LogCapitalCapital	-25.457***	0.487	11.127***	0.676	-2.921***	0.649
0.5LogAgrochemAgrochem	-1.653***	0.070	9.520 ***	0.532	2.093	2.790
0.5LogFertFert	2.152***	0.071	10.672***	1.035	-5.916***	1.852
LogLabourFert	-4.261***	0.147	-16.120***	0.611	1.319	1.103
LogLabourAgrochem	5.472***	0.239	-10.030***	0.480	0.877	1.459
LogLabourCapital	13.136***	0.266	-0.921**	0.404	-1.403	0.935
LogLabourOthers	1.637***	0.132	11.684***	0.611	1.532*	0.891
LogCapitalFert	2.853***	0.063	10.445***	0.655	1.276	0.864
LogCapitalOthers	-6.391***	0.105	-19.302***	0.618	0.435	0.466
LogCapitalAgrochem	14.164***	0.172	4.288***	0.394	2.754***	0.585
LogOthersFert	-1.113***	0.049	6.961***	0.749	-4.857	0.704
LogOthersAgrochem	1.702***	0.039	-14.672***	0.424	1.666***	1.203
LogFertAgrochem	-10.444***	0.076	4.362***	0.573	1.662***	0.092

Table 9:Cont.

Diagnostic Statistics			
Sigma square	0.002***	0.011	0.275***
Gamma	1.000***	1.000***	1.000***
Log-likelihood	222.933	98.550	-1.778
Likelihood ratio test	311.8***	141.97***	47.147***
Mean efficiency	0.930 (93%)	0.827 (83%)	0.696 (70%)

NB: *, **, and *** denotes statistically significant levels at 10%, 5%, and 1% respectively; Source: Awuakye (2022)

The model suited the data well, as evidenced by the sigma-squared coefficient's statistical significance of all three farmer categories. The gamma parameter's value also shows that all the volatility (100%) in smallholder vegetable farmers' profit levels of all three farmer groups was due to the effects of profit inefficiency (Amesimeku & Anang, 2021). In other words, all of the fluctuations in profitability among all three farmer categories were caused by variables that farmers could control.

Apart from the interaction effects of all the variables in the model of the profit frontier, Table 9 also indicated that the cost of capital had a negative relationship with all the three farmer groups with a coefficient value of -15.844, -0.178, and -4.484 for okra farmers, garden eggs farmers, and both okra and garden eggs farmers respectively at (1%) statistically significant except only garden eggs farmer who was not statistically significant. This implies that a percentage increase in the cost of capital will decrease the profit of okra farmers by (15.8%), garden egg farmers by (0.2%), and both okra and garden egg farmers by (4.5%). Thus, among the three farmer categories in the study, only okra farmers happened to be the farmer group who were not the most efficient in the utilization of their capital. These results concur with the findings from Shrestha, Bhandari, and Pandey (2022) which indicated a negative relationship between capital and vegetable farmers at (1%) statistically significant with a coefficient value of -3.94. This means that a percentage increase in the cost of capital decreases the profit efficiency of vegetable farmers.

The study also revealed that only okra farmers and only garden egg farmers had a positive relationship between the cost of labor and their profit efficiency with a coefficient value of 3.250, and 5.153. Both okra and garden eggs farmers on the other hand had a negative relationship between the cost of their labor and their profit efficiency with a coefficient value of -2.609 though all three farmer categories were statistically significant. This implies that a percentage increase in the cost of labor will contribute to an increase in the profit efficiency of only okra farmers and only garden egg farmers by 3.3 percent and 5.2 percent respectively but the profit efficiency of both okra and garden egg farmers will be decreased by 2.6 percent. This could be the fact that both okra and garden egg farmers spent more than necessary on labor.

Also, only okra farmers and only garden egg farmers were statistically significant at (1%) with a negative coefficient value of 9.669 and 20.919 for the cost of fertilizer. Both okra and garden eggs farmers on the other hand were not statistically significant with the cost of fertilizer through their coefficient value having a positive relationship with their profit efficiency level. Thus, a percentage increase in the cost of fertilizer will negatively influence the profit efficiency of okra farmers and garden eggs farmers by (9.7%) and (20.9%) accordingly. This could also be the fact that the amount of fertilizer farmers applied on their land was either not producing the expected output or was more than the needed number of fertilizers by the land.

Concerning the use of agrochemical products, the study shows that there was a negative relationship between the use of agrochemical products and the profit efficiency among only okra farmers and both okra and garden eggs farmers. Only garden egg farmers on the other hand had a positive relationship between the use of agrochemical products and their profit efficiency levels. This implies that a unit increase in the use of agrochemical products caused a decline in the profit of only okra farmers and both okra and garden eggs farmers whereas the profit of garden eggs farmers was improved by a unit increase in the use of agrochemical products.

"Other operational cost" was found to be statistically significant among only okra farmers and only garden egg farmers at (1%) but only okra farmers had a positive relationship whereas only garden egg farmers had a negative relationship between other operating costs and profit efficiency levels of the farmers. Both okra and garden egg farmers were shown not to be statistically significant to other operational costs. This implies that a percentage increase in the expenditure on other operational costs would lead to an increase in the profit of only okra farmers but the profit of only garden egg farmers will decrease. Therefore, only garden egg farmers have to take caution about the expenditure that they make on other operational costs.

Distribution of the Profit Efficiency Level of Smallholder Vegetable Farmers

The profit efficiency levels of the smallholder vegetable farmers are shown in Figure 7. The results from Table 10 indicate that the okra farmers, the garden eggs farmers, and farmers who cultivated both okra and garden eggs had average profit efficiency values of 0.930, 0.827, and 0.696 which signifies (93%), (83%), and (70%) respectively. This implies that farmers who cultivated only okra commodities performed better than those who cultivated both commodities and so as those who cultivated only garden eggs. Okra farmers, garden eggs farmers, and both okra and garden eggs farmers can potentially increase their profits by (7%), (17%), and (30%) respectively when the sources of inefficiency are adequately addressed. Shrestha, Bhandari, and Pandey (2022) evaluated mean profit efficiency of 0.72 which implies that on average, the sampled vegetable farms could increase their profit by (28%) within the existing technology by overcoming the constraints. According to Jonah et al. (2020), the average profit efficiency among the farmers in the research area was 0.8823, which suggests that there is room for improvement. This implies that the study's farmers can increase their profit efficiency using the same inputs by (11.77%). In other words, without changing the current input mix and production methods, there was the potential for farmers to boost current profits by (11.77%). It is very obvious from the results of the study that only okra farmers were very efficient in terms of profitability than the garden eggs farmers and the farmers who cultivated both okra and garden eggs. This implies that even as smallholder vegetable farmers are encouraged to cultivate more than one crop, they should as well learn how to utilize their resources effectively and efficiently. Moreover, smallholder vegetable farmers in general have rooms to improve their profit efficiency level despite their competencies in vegetable production.

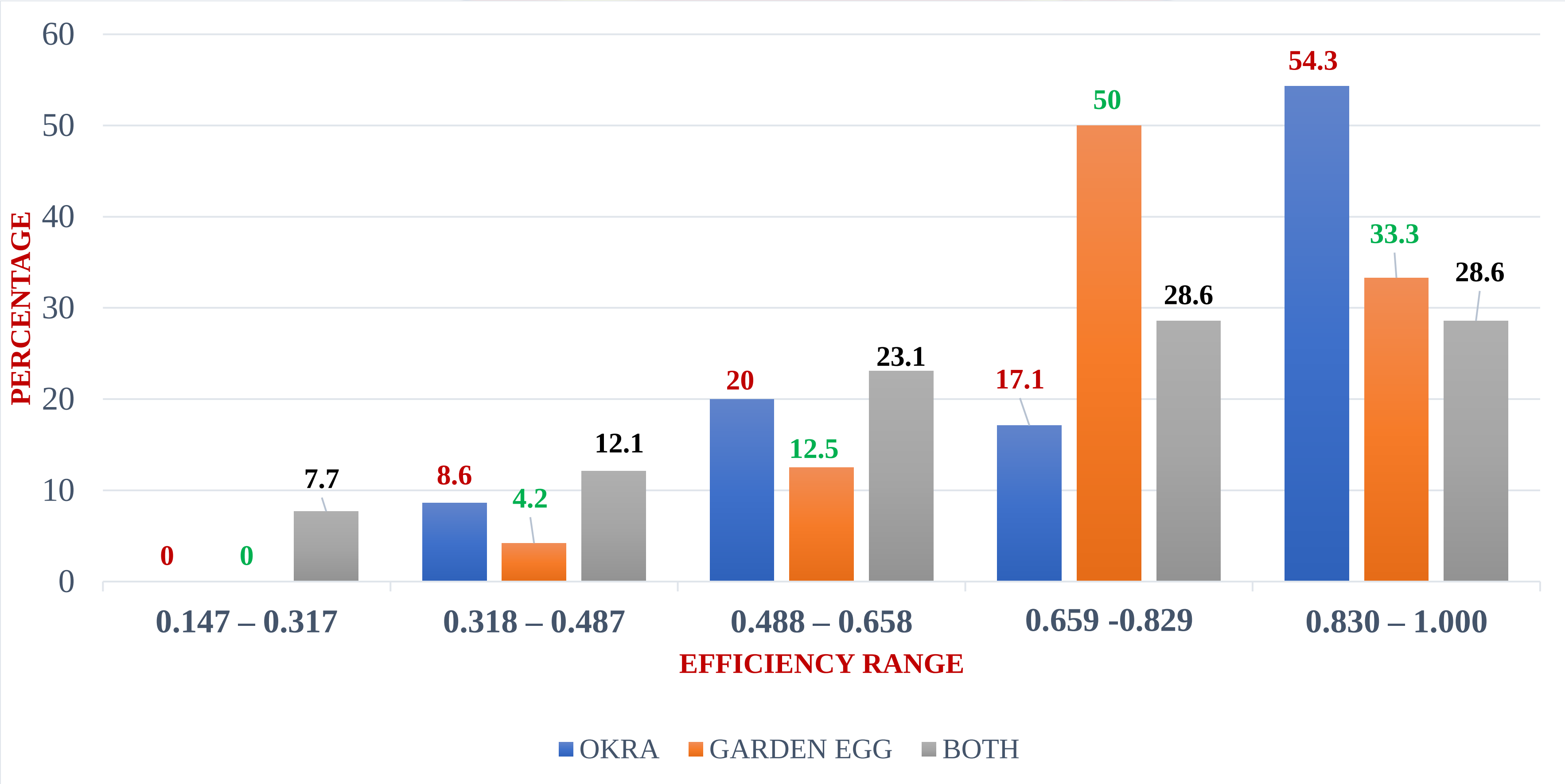

Figure 7: Distribution of Profit Efficiency Scores

Source: Field Survey, Awuakye (2022)

Also, smallholder vegetable farmers' profit efficiency ranged from 0.147 through to 1.000 with a minimum and maximum score of (Min=0.147, Max=0.998) for only okra farmers, (Min=0.433, Max=1.000) for only garden eggs farmers, and (Min=0.147, Max=0.998) for both okra and garden eggs farmers respectively. According to the findings, approximately 8.6 percent of the only okra farmers produce far below the profit frontier with the majority (54.3) of them falling within the 0.830-1.000 range. Only 4.2 percent of the farmers who produced only garden eggs produced far below the profit frontier and the majority (50.0) of them produced within the profit efficiency range of 0.659-0.829. Smallholder vegetable farmers who produced both okra and garden eggs also had 19.8 of them producing far below the profit frontier with 28.6 of them producing with 0.830-1.000 range of the profit efficiency. This implies that the farmers who produced only Okra still turned out to be profit efficient concerning profit efficiency distribution among them farmers.

Determinants of Profit Inefficiency of the Study

In the study, it was hypothesized that some significant socio-economic and institutional variables would have an impact on the productivity and profitability of smallholder vegetable producers. Using the predicted profit efficiency levels as the dependent variable, the coefficients of these model-included variables were simultaneously evaluated by the maximum likelihood method. Table 10 shows the efficiency model that was fitted as a part of the one-step method for estimating the profit function with the greatest likelihood. To make the analysis more understandable, the causes of profit inefficiency are separated from estimates of the stochastic profit frontier parameters. It is significant to remember that the profit frontier-adjusted error term's inefficiency component serves as the dependent variable. The coefficients are therefore understood to represent the impact of each variable on the degree of profit inefficiency rather than efficiency. However, by taking the opposite sign of each coefficient, the coefficients may be immediately understood as the impact of each variable on profit efficiency (Gaganis & Pasiouras, 2013). Factors that contributed to the profit inefficiency in the study are presented in Table 10.

The profit efficiency of only okra farmers was statistically influenced by age, years of formal education, household size, farm size per hectare, times of accessing extension services, access to credit, and farmer group. The profit efficiency of only garden egg farmers was also statistically influenced by years of formal education, household size, farm size per hectare, times of accessing extension services, access to credit, and farmer group. The profit efficiency of the farmers who cultivated both okra and garden eggs were also revealed to be influenced by age, years of formal education, farm size per hectare, and access to credit.

Age had a positive relationship with the profit inefficiency of only okra farmers and it had a negative relationship with the profit inefficiency of both okra and garden eggs farmers. This implies that as only okra farmers get older, they become inefficient in their vegetable production in terms of profit. This could be because despite the knowledge and experience acquired over time in the vegetable production, they will still be inefficient because of their unwillingness to adopt improved technologies and new agricultural practices, and loss of strength due to old age. These results concur with Mujuru, Mishi, and Mdoda (2022) who reported that, in a farming system with little or no machinery, becoming older would be connected with a physical decline in capacity to perform manual labor efficiently, which would be extremely obvious. Yegon, Kibet, and Lagat, (2015) also asserted that the probability of smallholder-aged farmers employing technological innovation in their farm businesses is very low even as they decline in capacity to do more manual work due to old age.

Both okra and garden egg farmers had a negative relationship between age and profit inefficiency. This implies that as the farmers get older, more efficient they become in vegetable production. This agrees with some studies like Amesimeku & Anang (2021) and Shrestha, Bhandari, and Pandey (2022) who confirm that as smallholder farmers grows older, the more efficient they become due to knowledge, skills, and experience they obtain in production activities.

Years of formal education in all the three farmer categories had a negative correlation with profit inefficiency according to Table 10. This implies that the number of years a farmer has spent in formal education enhances their efficiency level in farming activities. This result agrees with a prior expectation and literature. Thus, the number of years of formal education which can probably be explained by the level of education can determine how knowledgeable the farmer is in terms of accessing information, employing technological innovation, and utilization of the available resources to achieve specific goals and objectives. According to Shrestha, Bhandari, and Pandey (2022), education has an influence on the productivity of vegetable farmers "all other things being equal".

Access to credit also had a negative correlation with the profit inefficiency of all three farmer categories. This implies that a percentage increase in farmers' access to credit improves their productivity. Thus, improved agricultural technologies are capital intensive whilst most smallholder vegetable farmers are not financially sound. Therefore, farmers' accessibility to credit will enable them to acquire the needed agricultural machinery and inputs to facilitate their farm production. Mujuru, Mishi, and Mdoda (2022) also asserted that farmers' access to credit influences their productivity in their farm businesses.

Table 10 : Determinants of Profit Inefficiency of Smallholder Vegetable Farmers

Variable	Okra		Garden Eggs		Okra & Garden Eggs	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
(Intercept)	-4.188***	0.230	1.437**	0.463	1.236**	0.638
Age	0.045***	0.002	0.004	0.009	-0.016**	0.006
Years of formal education	-0.136***	0.005	-0.050**	0.016	-0.085**	0.030
Household size	0.072***	0.014	-0.081**	0.042	-0.045	0.032
Farm size per hectare	2.686***	0.085	-1.614***	0.261	-0.928***	0.187
Times of accessing extension service	-0.267***	0.017	-0.077***	0.018	0.012	0.007
Access to credit	-2.301***	0.310	-1.587***	0.230	-0.144***	0.036
Farmer group	-1.354***	0.090	0.529***	0.140	0.220	0.159

NB: *, **, and *** denotes significant levels of 10%, 5%, and 1%: Source: Field Survey, Awuakye **(2022)**

Objective Two: To Examine the Competence Level in Vegetable Production Management Practices (VPMPs) of Smallholder Vegetable Farmers in Denkyembour District.

This objective discussed the competencies of smallholder vegetable farmers in vegetable production management practices (VPMPs). This objective also looked into how the socio-economic characteristics of the farmers in the study area influence their competencies in VPMPs.

Competencies of Smallholder Vegetable Farmers in the Vegetable Production Management Practices.

Table 11 presents results on the overall competencies of smallholder vegetable farmers in vegetable production management practices. The results revealed that farmers demonstrate high competencies (composite mean = 3.45, SD= 0.13) in vegetable production management practices in general. However, the results reveal that the farmers have moderate knowledge (composite mean = 3.37, SD= 0.14) whereas they demonstrate high Attitude (composite mean = 3.45, SD= 0.10), high Skills (composite mean = 3.46, SD= 0.13), and high Aspiration (composite mean = 3.51, SD= 0.16) in vegetable production management practices. This implies that the smallholder vegetable in the study area is very competent in vegetable production management practices in general but they have to improve upon their knowledge level in the area of VPMPs.

The results specifically demonstrate that the smallholder vegetable farmers only have very high competency in the selection of a type of vegetable for production (composite mean = 4.57, SD= 0.58). Notwithstanding that, they have high competency in determining appropriate healthy seeds/seedlings (composite mean = 4.01, SD= 0.55), selection of an appropriate type of soil/medium for production (composite mean = 4.05, SD= 0.52), competency in the production of vegetables (composite mean = 4.16, SD= 0.43), management of vegetable production (composite mean = 4.21, SD= 0.44), a combination of different types of vegetable that enhance yields (composite mean = 3.63, SD= 0.84), identification of the various vegetable diseases (composite mean = 3.84, SD= 0.60), period of fertilizer application(composite mean = 4.14, SD= 0.61) Effective application of weedicides(composite mean = 4.02, SD= 0.76), insecticides and pesticides (composite mean = 3.71, SD= 0.62), and Erosion and leaching management (composite mean = 3.67, SD= 0.66).

The findings also showed that the farmers have moderate competency in determining the appropriate source of funding to finance the vegetable production(composite mean = 3.01, SD= 0.52), selection of market(composite mean = 2.67, SD= 0.59), identifying unique market preposition(composite mean = 2.91, SD= 0.48), provision of source water(composite mean = 3.00, SD= 0.70), "growing variety of seeds that are resistant to pest and diseases" (composite mean = 2.43, SD= 0.53), planting a variety of seeds that are climate change resilience(composite mean = 3.16, SD= 0.80), and transportation of produce (composite mean = 3.31, SD= 0.56)

The results also reveal that the farmers have low competency in the prevention of postharvest losses management (composite mean = 2.38, SD= 0.49), and segregation of the target market (composite mean = 2.29, SD= 0.44). However, none of the farmers had a very low competency in all the parameters of vegetable production management practices. The findings from the study reveal that the smallholder vegetable farmers in the study area are very competent in vegetable production management practices in general but they have to improve upon their knowledge level in VPMPs, especially with regards to post-harvest management and target market preposition.

Table 11: Competence of Smallholder Vegetable Farmers in Vegetable Production Management Practices (VPMP)

Vegetable Production Management Practices (VPMPs)	Knowledge		Attitude		Skills		Aspiration		Competencies	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Selection of type of vegetable for production	4.55	0.72	4.53	0.63	4.59	0.49	4.62	0.49	4.57	0.58
Determining appropriate healthy seeds/seedlings	3.87	0.64	4.00	0.57	4.19	0.40	3.99	0.59	4.01	0.55
Selection of appropriate type of soil/medium for the production	3.81	0.71	4.41	0.49	3.85	0.36	4.11	0.51	4.05	0.52
Determining the appropriate source of funding to finance the vegetable production	3.32	0.62	2.75	0.43	2.93	0.58	3.03	0.44	3.01	0.52
Competency in the production of vegetables	4.12	0.48	4.17	0.37	4.27	0.44	4.09	0.43	4.16	0.43
Management of vegetable production	4.12	0.48	4.27	0.44	4.30	0.46	4.15	0.36	4.21	0.44
Selection of market	2.61	0.49	2.67	0.63	2.65	0.56	2.76	0.69	2.67	0.59
Identifying unique market preposition	2.88	0.52	2.78	0.42	2.97	0.46	3.01	0.52	2.91	0.48
Provision of source water	2.75	0.59	3.08	0.64	3.05	0.99	3.13	0.59	3.00	0.70
Combination of different types of vegetables that enhance yields	3.46	0.83	3.65	0.71	3.70	0.99	3.71	0.84	3.63	0.84
The growing variety of seeds that are resistant to pests and diseases	2.48	0.50	2.43	0.50	2.35	0.63	2.47	0.50	2.43	0.53

Table 11: Cont.

Planting a variety of seeds that are climate change resilience	3.19	0.76	3.05	0.79	3.20	0.83	3.19	0.81	3.16	0.80
Identification of the various vegetable diseases	3.62	0.50	3.61	0.60	4.16	0.57	3.97	0.74	3.84	0.60
Period of fertilizer application	4.00	0.53	4.10	0.69	4.08	0.51	4.36	0.71	4.14	0.61
Agronomic practices management in general	3.87	0.65	4.35	0.86	3.51	0.75	4.33	0.77	4.02	0.76
Effective application of weedicides, insecticides, and pesticides	3.00	0.00	3.87	0.82	4.19	0.78	3.77	0.86	3.71	0.62
Erosion and leaching management	3.52	0.50	3.03	0.66	3.43	0.50	3.48	0.99	3.67	0.66
Transportation of produce	3.23	0.62	3.41	0.49	3.29	0.67	3.30	0.46	3.31	0.56
Prevention of postharvest losses management	2.34	0.47	2.43	0.50	2.35	0.48	2.40	0.49	2.38	0.49
Segregation of target market	2.19	0.40	2.39	0.49	2.19	0.39	2.37	0.48	2.29	0.44
Composite Mean	3.37	0.14	3.45	0.10	3.46	0.13	3.51	0.16	3.45	0.13

Source: Field Survey, Awuakye (2023). N=150 **Means were calculated from a scale of 1-1.44=Very Low, 1.45-2.44 = Low, 2.45 – 3.44 = Moderate, 3.45 – 4.44 = High, and 4.45 – 5.00 = Very High

Effects of socio-economic characteristics of farmers on their competencies in VPMPs

Table 12 presents ordinary least square (OLS) regression which indicates how the socioeconomic characteristics of the farmers influenced their competencies in vegetable production management practices (VPMP). The focus was on the level of their knowledge, attitude, skills, and aspiration concerning VPMP, and the general competence level (i.e., putting all four parameters together). From Table 12, knowledge was explained by the independent variables by (15.9%) and it was statistically significant at $p<0.05$ (F – Change: 2.400). Attitude on the other hand was explained by the explanatory variables by (20.6%) and it was statistically significant at $p<0.01$ (F – Change: 2.922). Skills were also found to be explained by the independent variables by (25.5%) and it was also found to be statistically significant at $p<0.01$ (F – Change: 3.534). Table 12 also revealed that aspiration was explained by the independent variables by (18.4%) and it was statistically significant at $p<0.01$ (F – Change: 2.667). The composite competencies of smallholder vegetable farmers were also explained by the independent variables (26.7%) and it was found to be statistically significant at $p<0.01$ (F – Change: 3.695). The results from the study indicate that the model was a good fit for analyzing the data set.

Knowledge

Table 12 shows that age was statistically significant at (10%) with a negative coefficient value of 0.003 and that implies that a percentage increase in the age of smallholder vegetable farmers would cause a decline in the knowledge level of the farmers by (0.3%). Thus, as smallholder vegetable farmers grow older their knowledge of the VPMPs gradually declines. This could be the fact that farmers find it difficult to adopt new agricultural technologies as they get older because aged farmers are risk averse and are not willing to take any adventure (Tambo, & Abdoulaye, 2012). However, according to Collier and Dercon (2014), agricultural business activities in the contemporary world is dynamic; that is, agricultural business practices keep changing as days go by. Therefore, keeping to the old method of farming would result in a decline in the farmers' knowledge of VPMPs. The land holding status also indicated (5%) statistically significant with a positive coefficient value of 0.086. This also implies that a unit increase in the ownership of land use by the farmers will result in an increase in the knowledge level of farmers in the VPMPs by (8.6%). Thus, farmers who own their farmlands turn to be more conscious about the management of their land in all dimensions which gives them room to know more about their farm businesses, according to Tambo and Abdoulaye (2012).

According to Table 12, farm size was statistically significant at (10%) with a positive coefficient value of 0.27. This also implies that a unit increase in the size of land use by farmers will improve the knowledge of smallholder vegetable farmers in VPMPs by (27%). This result affirms Rahman et.al. (2016) reported that vegetable farmers desire to know more about their vegetable venture as they increase their farm size to maximize their profit as well. Moreover, annual farm income according to Table 13 indicated (5%) statistically significant with a positive coefficient value of 6.254E-6. This implies that a percentage increase in farmers' farm annual income will increase the knowledge of farmers in VPMPs by (0.0006254%). Thus, the probability of smallholder vegetable farmers increasing their annual farm income can be determined by the level of the farmers' knowledge of VPMPs. Irrigation users also showed (10%) statistically significant with a positive coefficient value of 0.240. Meaning, a percentage increase in the use of irrigation facilities will increase the farmer's knowledge of VPMPs by (24%). This is because effective and efficient use of improved irrigation facilities requires some adequate level of insight into VPMPs. Thus, smallholder vegetable farmers' level of knowledge in VPMPs will inform them to demand improved irrigation facilities in their farm businesses. Access to credit was statistically significant at (5%) with a positive coefficient value of 0.077. This implies that a percentage increase in farmers' access to credit will lead to a 7.7 percent rise in the farmers' knowledge of VPMPs. Thus, smallholder vegetable farmers' ability to access credit will enable them to employ agricultural technological innovation which most smallholder vegetable farmers could not afford because of their capital demands (Cafer & Rikoon, 2018).

The target market on the other hand had (10%) statistically significant with a positive coefficient of 0.87, which implies that a percent increase in farmers' access to middlemen as their target market improves farmers' knowledge in VPMPs by (8.7%). This could also be to the fact that some middlemen give specifications to farmers for the quality and quantity of the farm produce (Abebe et al., 2016). In addition, Abebe et al. (2016) reported that some middlemen also give credits in terms of cash and inputs to farmers at zero interest rate to facilitate their farming businesses. All these factors help to improve the knowledge of smallholder vegetable farmers in VPMPs. Therefore, the chances of smallholder vegetable farmers improving upon their knowledge level in VPMPs are high as they access reliable middlemen as their target market to purchase their produce at a reasonable price.

Attitude

For the attitude of farmers in VPMPs, main occupation, and annual farm income indicated a statistically significant at (5%) each respectively. The main occupation showed a positive coefficient value of 1.679. This implies that a percentage increase in the number of farmers who had vegetable farming as their main occupation will lead to a rise in the attitude of farmers in VPMPs by (167.9%). This is because smallholder vegetable farmers who do vegetable farming as their main work for livelihood would gear all their commitment towards it thereby ensuring a good standard of living. These findings concur with Bisht, Rana, and Pal Ahlawat (2020) who asserted that smallholder farmers whose major source of livelihood depends on their farming activities commit everything within their means to ensure sustainability. Therefore, the probability that the attitude of farmers will increase as the number of them having vegetable farming as their main occupation increases is high.

Annual farm income also had a positive coefficient value of 9.319E-5 which implies that a percentage rise in the annual farm income of farmers will lead to a little significant rise in the attitude of farmers in the VPMPs. Thus, smallholder vegetable farmers will respond positive attitude to the VPMPs when they realize an increase in their annual farm income (Ochieng, Kirimi, & Mathenge, 2016). The results reveal that the rest of the variables were not statistically significant concerning smallholder vegetable farmers’ attitudes toward VPMPs.

Skills

Table 13 indicated that household size was statistically significant at (10%) with a positive coefficient value of 0.174. This implies that a percentage increase in household size will positively affect the skills of smallholder vegetable farmers by (17.4%). Thus, as the number of people increases, different qualities and abilities will emerge from the people and result in the enhancement of the skills of the smallholder vegetable farmers. These findings agree with Adepoju, Abimbola, and Oluwakemi (2013) who reported that smallholder farmers turn to perform better and reduce labor costs as their household size increases. The number of times farmers access extension service also indicated a (1%) statistically significant with a positive coefficient value of 0.422. This means that a percentage rise in the number of times smallholder vegetable farmers access extension services will improve their skills in VPMPs by (42.2%).

By implication, smallholder farmers' encounter with extension officers helps the farmers to know the right agronomic practices to undertake as well as any other agricultural practices to employ to improve productivity (Aliber & Hall, 2012). Source of extension service, access to credit, and target market were also statistically significant with a positive correlation concerning the skills of smallholder vegetable farmers in the VPMPs. This implies that a percentage rise in those variables influences the skills of the smallholder vegetable farmers positively in the VPMPs.

Aspiration

The results from Table 12 indicated that the level of education, main occupation, landholding status, farm size, the source of extension service, access to credit, and target market were statistically significant with a positive correlation with the aspiration of smallholder vegetable farmers in VPMPs. Similar to what has been discussed in the parameters above, the positive correlation between the variables and the aspiration of the smallholder vegetable farmers implies that a percentage increase in any of the variables mentioned above will arouse the aspiration of the farmers in their VPMPs. Years of formal education and years of farming experience were also statistically significant but had a negative correlation with the aspiration of smallholder vegetable farmers. Thus, a percentage rise in either year of formal education or years of farming experience declines the farmers' desire and passion to engage in vegetable production. This could the fact that as farmers spend a lot of years in formal education their occupational interest drives toward off-farm activities instead of vegetable farming. This implies that the vegetable farming business does not look lucrative to the farmers as they attempt to spend more years in formal education.

These findings confirm Leavy and Hossain (2014) who asserted that the farming business does not look attractive to many people who spent a lot of years going through formal education. Years of farming experience will affect the aspiration of smallholder vegetable farmers negatively only when the farmers realize that they proportionately earn less than what they invest in the vegetable business and preferably desire to switch to other business ventures (Beingessner & Fletcher, 2020).

Competencies

With regards to the composite competencies of smallholder vegetable farmers in VPMPs, Table 12 shows that level of education, landholding status, times of accessing extension services, and target market were statistically significant and positively correlated. This implies that a percentage rise in any of the aforementioned variables will significantly improve the competencies of smallholder vegetable farmers in VPMPs. Years of formal education and access to credit were statistically significant but negatively correlated with the composite competencies of smallholder vegetable farmers in VPMPs. Thus, the results from the study indicated farmers who happen to spend numerous years acquiring knowledge through formal education are probably not well competent in VPMPs whereas the probability of the smallholder vegetable farmers accessing credit is low, and as such it affects the competencies of the smallholder vegetable farmers.

Table 12: Effects of socio-economic characteristics of farmers on their competencies in VPMPs.

Variable	Knowledge		Attitude		Skills		Aspiration		Competencies	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
(Constant)	3.194***	.210	69.093***	2.932	62.263***	3.695	59.854***	4.670	12.754***	.448
Gender	-.030	.048	.492	.666	-.949	.840	.691	1.062	-.018	.102
Age	-.003*	.002	.037	.024	.002	.030	-.049	.038	-.003	.004
Level Education	.079	.061	1.088	.845	-.505	1.066	3.445**	1.347	.280**	.129
Years of formal education	-.008	.005	-.085	.075	.027	.095	-.274**	.120	-.024**	.011
Marital Status	-.031	.024	-.379	.335	.246	.423	-.205	.534	-.048	.051
Main Occupation	-.037	.039	1.679**	.540	.930	.681	.268*	.861	-.061	.083
Household Status	-.051	.048	.969	.668	-1.136	.842	.840	1.064	-.018	.102
Household Size	.000	.005	-.098	.074	.175*	.093	-.096	.118	-.018	.011
Landholding status	.086**	.029	.010	.410	-.061	.517	1.719**	.653	.170**	.063
Farm Size	.027*	.015	.276	.207	.056	.261	.695**	.330	.024	.032
Annual farm income	6.254E-6**	.000	9.319E-5**	.000	-2.243E-5	.000	2.516E-5	.000	1.731E-6	.000
Farming experience	.000	.002	-.016	.021	-.029	.027	-.059*	.034	-.005	.003
The major source of labor	.031	.046	-.881	.647	1.225	.816	.164	1.031	.056	.099
Type of Crop	.044	.038	.554	.523	-.053	.659	.600	.833	.099	.080
Irrigation Users	.240*	.142	-.822	1.978	.048	2.493	4.120	3.150	.408	.302
Times Of Accessing Extension Service	-.002	.006	.085	.078	.422***	.099	.142	.125	.030**	.012

Table 12: Cont.

Source of Extension Service	-.006	.008	-.056	.107	.351**	.134	.315*	.170	.024	.016
Access to Credit	.077**	.031	-.201	.434	2.177***	.547	2.407***	.691	-.316***	.066
Farmer Group	-.022	.029	.558	.410	-.194	.516	-.276	.653	-.018	.063
Target Market	.087*	.050	1.131	.700	3.378***	.882	2.820**	1.115	.454***	.107
Model Summary										
R Square	.273		.313		.356		.294		.366	
Adjusted R Square	.159		.206		.255		.184		.267	
Std. Error of the Estimate	2.59436		1.80725		2.27781		2.87871		.27622	
R Square Change	.273		.313		.356		.294		.366	
F Change	2.400		2.922		3.534		2.667		3.695	
Sig. F Change	.002		.000		.000		.000		.000	

NB: *, **, and *** denotes significant levels of 10%, 5%, and 1%: Source: Field Survey, Awuakye (2022)

Objective Three: To examine existing business model types and the extent of use among smallholder vegetable farmers in the Denkyembour District.

This study presented nine (9) sets of agricultural business models which are common and often used among farmers in Sub-Saharan Africa. These models include Direct/Traditional farming (DF), Contract Farming and Out-grower Scheme (CFOS), Organic Greenhouse Vegetable Farming (OGVF), E-Commerce Agriculture (ECA), Supply Chain Management (SCM), Sharecropping and Tenant Farming (SCTF), Farm-Owned Businesses/Cooperative Farms (FOB), Joint Ventures (JV), and Certification (Cert). Under this objective, the study discussed smallholder vegetable farmers' awareness, usage, and preference of BM. The study also discussed the relationship between smallholder vegetable farmers' awareness of BM, its' usage, and their preference.

Smallholder vegetable farmers' awareness, usage, and preference of existing Business Models

The results from Table 14 shows that Direct Farming (DF) model is the only agricultural business model which was known to all the smallholder vegetable farmer in the study and most of the farmers confirmed that it was introduced to them by their parents. The existing business model type that was next to the most common model to the farmers was Contract Farming and Out-grower Scheme (CFOS). Thus, 34 percent of the smallholder vegetable farmers of the study were aware of the CFOS and they stated that the model was made known to them by their buyers (middlemen).

Table 13: Business model awareness, usage, and preferred

BM	Awareness	% Awareness	Usage	% Usage	Preferred BM	% Preferred
Direct Farming	150	100.0	148	98.7	1	0.7
Contract Farming& Out-grower Scheme	51	34.0	0	0.0	146	97.3
Organic Greenhouse Vegetable Farming	5	3.3	0	0.0	0	0.0
E-Commerce Agriculture	3	2.0	0	0.0	0	0.0
Supply Chain Management	0	0.0	0	0.0	1	0.7
Sharecropping & Tenant Farming	34	22.7	2	1.3	1	0.7
Farm Owned Business	11	7.3	0	0.0	0	0.0
Joint Ventures	17	11.3	0	0.0	1	0.7
Certification	3	2.0	0	0.0	0	0.0

Source: Field Survey, Field Survey, Awuakye (2022)

Table 13 also reveals that none of the smallholder vegetable farmers were aware of Supply Chain Management (SCM) model in vegetable farming businesses. This implies that smallholder vegetable farmers' awareness of inclusive business models is very minimal and this could be because the other stakeholders such as agricultural extension officers, NGOs, and vegetable buyers (middlemen) hardly educate the farmers on an inclusive business model in their vegetable farming businesses. Vorley et.al. (2019) asserted that smallholder farmers are used to traditional farming strategies which, however, do not fetch them enough returns on their investment. Therefore, agriculture extension officers and other vital stakeholders have to educate the farmers on other farm business models which are inclusive enough to ensure sustainability, thereby encouraging the farmers to employ them in their farm businesses.

Table 13 also reveals that among the nine (9) existing business models, 98.7 percent of the farmers were using the Direct Farming model whereas the remaining 1.3 percent were also using Sharecropping and Tenant Farming (SCTF). This implies that the rest of the existing business models were not being patronized by the farmers. This is not surprising since the majority of the farmers were not having adequate knowledge about most of the existing business models presented in the study (Fielt, 2013). Bocken, Boons, and Baldassarre (2019) asserted that the level of farmers' patronage of any invention that is new to them is determined by their level of awareness and understanding of the model in question.

After a detailed explanation of all the existing business models presented in the study by the researcher, 97.3 percent of the smallholder vegetable farmers responded that they would prefer to use Contract Farming and Out-grower Scheme model to the rest of the models including the model they were currently using. The reason was that the contract farming and out-grower scheme model sounded lucrative and attractive in the eyes of the farmers. Thus, the assurance of capital, inputs and ready market that contract farming and out-grower schemes offer to farmers was very convincing to the farmers though they heard that their produce would be bought at predetermined prices. This implies that smallholder vegetable farmers would like to contract with stakeholders who will be willing and ready to make capital and farm inputs available to them when necessary and also buy all their produce whenever they are ready, even at a predetermined price. The results also show that none of the farmers preferred to use Organic Greenhouse Vegetable Farming (OGVF) model, Electronic Commerce Agriculture m (ECA) model, Farm Owned Business (FOB) model, and Certification (Cert) model. Farmers' rejection of the aforementioned models could be the nature and the principles governing those models. It could also be that the farmers thought those models may not be favorable in their farming setting and context.

Relationships among Farmers' Awareness of Business Model Types, Their Usage of These Business Model Types, and Their Preferences for the Business Model Types

The study further examined the relationships among farmers' awareness of business model types, their usage of these business model types, and their preferences for the business model types by running a correlation coefficient.

That was done to verify and draw a conclusion on the extent of use of the existing business model. In the correlation matrixes presented in Table 14, Pearson moment correlation was run to assess the relationships that existed among the variables (awareness of business models, business model's usage, and business model's preference). Awareness of the business model was used as the dependent variable whereas the business model's usage and the business models preferred were used as the explanatory variables.

Table 14: Correlation matrix showing the relationship among farmers' Awareness of BM, Usage of BM, and BM Preferred.

	Awareness OF Business Models	Business Models Usage	Business Models Preferred
Awareness of Business Models	1		
	(.)		
Business Models Usage	0.819***	1	
	0.000	(.)	
Business Models Preferred	0.016	-0.035	1
	0.842	0.666	(.)

NB: *, **, and *** denote significant levels of the Correlation at 10%, 5%, and 1% (2-tailed). Source: Field Survey, Awuakye (2022)

Table 14 indicated that awareness of business and business models' usage were statistically significant at (1%) but awareness of business models and business models preferred as well as business model usage and business models preferred were not statistically significant. The results also showed that there was a very strong positive relationship between awareness of business models and business model usage with a coefficient value of 0.819. This implies that the farmers' use of business models is highly influenced by their level of knowledge of the relevance of these existing business model types in their farm business space. Awareness of business models also had a positive relationship with business model preferred though it was very weak and their coefficient value was 0.016. This also indicates that smallholder vegetable farmers' preferences to use one business model over other depends on some level of their awareness of the various models though its impact is not that much. Business models' usage and business models preferred on the other had a negative weak relationship with each other with a coefficient value of -0.035. This also implies that smallholder vegetable farmers' preferences on the business model type to use do not have a statically significant relationship with the business model type that they were currently using in their farm enterprises.

Objective Four: To examine factors that influence the choice of inclusive business models type by smallholder vegetable farmers in the Denkyembour District

Table 15 shows the results of a binary logistic regression analysis that revealed certain factors that affect the smallholder vegetable farmers' choice of business model type in their vegetable farming businesses. Based on research on farmers' decisions on the use of new agricultural technology, the socioeconomic traits and other parameters for the analysis were chosen (Mittal & Mehar, 2016). The model was significant at a (5%) alpha value, according to the model diagnostic test and this demonstrates how well the logistic regression's variables match the model (Ives, 2015).

This study compared the structural parameters' estimates using the two-stage least squares (TSLS) and ordinary least squares (OLS) estimators in the regression under the null hypothesis of no endogeneity. The Durbin and Wu-

Hausman test was used to determine whether the structural model contained endogeneity. According to Drukker, Egger, and Prucha (2013) and Heckman (1977), endogenous variables have values that are determined by other variables in the system. Thus, having endogenous regressors in a model will cause ordinary least squares estimators to fail, as one of the assumptions of OLS is that there is no correlation between a predictor variable and the error term.

Therefore, The Durbin and Wu-Hausman test was carried out in an attempt to figure out if the predictor variables such as farmers' awareness of business models, farmers' knowledge, attitude, and aspiration in vegetable production management practices were endogenous with the dependent variable. This was to help to decide on the best regression method to use. The results from the table presented in Appendix E indicated that the Durbin and Wu-Hausman test had a p-value of 0.935 and 0.943 respectively. This implies that the scores from the test were statistically not significant hence the null hypothesis which states that the variables are exogenous is accepted. Therefore, the OLS regression was deemed fit to be used in examining the factors that influence the choice of inclusive business model types by smallholder vegetable farmers in the study area.

In this study, only variables whose coefficients were statistically significant at less than or equal to (10%) probability levels were discussed.

Age

The age of the smallholder vegetable farmers had a positive relationship with the dependent variable and this implies that the higher the age of the smallholder vegetable farmers increases their probability of choosing the direct farming model over the other business models. This could be the fact that the older smallholder vegetable farmers might have become conversant with the old method of farming due to the long experience gathered over time and this makes it difficult for them to employ new farming strategies. However, Tazeze and Ketema (2012) stated that the age of farmers influences the adaptation to climate change positively because as smallholder farmers advance in age, they are expected to gain more experience in weather forecasting and that helps increases the chances of farmers adopting new strategies against climate change. Thus, whiles older farmers' chances of adaptation strategies to climate change are higher, according to Tazeze and Ketema (2012), this study indicated that the probability of older farmers using of inclusive business model is very low because they are familiar with and used to the direct/traditional business model in their farming businesses.

Level of education

Smallholder vegetable farmers' educational level also had a positive relationship with the dependent variable. This implies that the smallholder vegetable farmers' usage of the inclusive business model was not determined by the level of their education they attained. Means, unlike Tazeze and Ketema (2012) who explained that the probability of farmers adopting to climate change was influenced by farmers' educational level, this study indicated that smallholder vegetable farmers' use of the direct farming model instead of the inclusive business model was not influenced by the level of their education status.

Household size

The household size of smallholder vegetable farmers (total number of household members legally living with the farmer) had a negative relationship with the use of an existing business model. This implies that a unit increase in the size of smallholder vegetable farmers would increase the probability of smallholder vegetable farmers choosing inclusive business models other than the direct farming model by 29 percent. This may be because households with large families may be compelled to divert a portion of their labor force to non-agricultural pursuits to generate income to relieve the pressure of a large family's consumption demands rather than having everyone engage in direct farming, which may not generate much income (Tazeze & Ketema, 2012).

Main occupation

Smallholder vegetable farmers who practice vegetable production as their main source of livelihood also had a negative relationship with the dependent variable. The results show that a unit change in the number of people who are doing vegetables as their main occupation would influence the probability of smallholder vegetable farmers choosing an inclusive business model over a direct farming model by a value of -2.20. Farmers who practice vegetable farming as their main occupation would do everything humanly possible to increase their productivity to enhance their livelihood. Therefore, the chances that such farmers would choose an inclusive business model over the direct farming model are higher.

Improved irrigation facility

The use of improved irrigation facilities had a positive relationship with the dependent variable. That is, the results show that smallholder vegetable farmers who happened to be using some form of improved irrigation facility chose the direct farming model over the other models. This could be the fact that those farmers seem to be financially sound and could afford most of the technological equipment needed to enhance their productivity. Thus, they could finance their farming business and did not need others investors to partner with them.

Farmer groups (Cooperatives)

The findings indicated that the farmer group has a positive relationship with the dependent variable with a coefficient value of 1.384. This implies that the probability that a percentage change in the number of farmers who belongs to farmer associations or cooperatives would influence their choice of the direct farming model over the other business models is explained by 138 percent. Cooperative farmers are usually protected against unusual price fluctuation and some have access to input and other farm materials and this might not encourage them to enter into any contractual agreement with some investors (Mgbenka, Mbah, & Ezeano, 2016). This could be the reason why such smallholder vegetable farmers choose the direct farming model rather than inclusive business models.

Times of accessing extension service

Table 15 also revealed that the number of times smallholder vegetable farmers accessed extension services had a positive relationship with the dependent variable. According to the results, the tendency of smallholder vegetable farmers to choose the direct farming model over the other types of business model was influenced by a coefficient value of positive 0.297. This implies that a percentage change in the number of times smallholder vegetable farmers access extension services would increase the probability of them not choosing the other business models (inclusive business model) by 30 percent. This could be the fact that there is no or little education on inclusive business models from agricultural extension agents to farmers. It could also be to the fact that smallholder vegetable farmers of the study have been encouraged by their extension officers to have full control over their farm businesses and their produce.

Attitude

Table 15 also indicated the attitude of the smallholder vegetable farmers in VPMPs had a negative relationship with the choice of the existing business model at a coefficient value of -0.521. This implies that smallholder vegetable farmers who have a high attitude toward VPMPs would be willing to choose inclusive business models over direct farming. According to the results, there is a probability that a percentage change in the attitude of smallholder vegetable farmers in VPMPs would influence their choice of inclusive business models over the direct farming model by 52 percent. Meaning the attitude of smallholder vegetable farmers in VPMPs influences their choice of business model type to use.

Table 15: Logistic Regression for Factors That Influences Choice of Inclusive Business Models Type by Smallholder Vegetable Farmers.

Variables	Coefficient	Standard Error
Demographics		
Age	.061*	.036
Level of education	.78*	.426
Household size	-.294**	.138
Main occupation	-2.202**	1.08
Farm Characteristics		
Use of Irrigation facility	1.93**	.838
Institutional characteristics		
Farmer group	1.384**	.561
Times of accessing extension service	.297**	.144
Target market	1.616	1.031
Competence		

Table 16: Cont.

Aspiration	.153	.102
Attitude	-.521***	.178
Knowledge	-.271**	.121
Awareness Of BM	-.561**	.254
Constant	44.357***	15.24

Mean Dependent Var	0.776	Sd Dependent Var	0.419
Pseudo R-Squared	0.307	Number Of Obs	150
Chi-Square	48.093	Prob > Chi2	0.000
Akaike Crit. (Aic)	136.471	Bayesian Crit. (Bic)	178.338

**** P<.01, ** P<.05, * P<.1*

Source: Field Survey, Awuakye (2022)

Knowledge

Knowledge of the smallholder vegetable farmers in VPMPs also had a negative relationship with the dependent variable with a coefficient value of -0.271. This implies that smallholder vegetable farmers who have high knowledge of VPMPs would probably choose inclusive business models over the direct farming model. The results show that a percentage increase in the knowledge level of the smallholder vegetable farmers would perchance influence the smallholder vegetable farmers to choose inclusive business models over the direct farming model by 27 percent. Therefore, the choice of a model type by smallholder vegetable farmers is influenced by their knowledge of VPMPs.

Awareness of business models

Smallholder vegetable farmers' awareness of business models had a negative relationship with the dependent variable with a coefficient value of -0.561. Thus, there is a probability that smallholder vegetable farmers who are aware of the inclusive business model would choose the inclusive business model over the direct farming model. According to the results, a percentage increase in the awareness of business models by smallholder vegetable farmers would probably influence smallholder vegetable farmers' choice of inclusive business by 56 percent.

Objective Five: Inclusive and sustainable business model that facilitates technological and economic upgrading for smallholder vegetable farmers

This objective aimed to propose an inclusive and sustainable business model that smallholder vegetable farmers in the study area could employ to enhance their productivity. Before proposing the inclusive and sustainable business model for the smallholder vegetable farmers, this objective discussed smallholder vegetable farmers' perception of IBM, their knowledge of the benefit of IBM in their farming businesses, and challenges that might have impeded the use of IBM in the study area.

Perception of Smallholder Vegetable Farmers on the Inclusive Business Models

Table 16 presents results on smallholder vegetable farmers' perception of the inclusive business model and the findings indicated that smallholder farmers strongly agreed that the inclusive business model is an effective means of achieving optimum productivity (Mean= 4.47, SD=0.56). Thus, the farmers strongly believe that the use of inclusive business models is the best business for smallholder vegetable farmers to get a higher yield from their production activities at the end of each production period (Lüdeke-Freund et al., 2018). Table 17 also revealed that smallholder vegetable farmers agreed that the inclusive business model (IBM) is the best means of achieving a higher income (Mean=4.02, SD=0.64). This implies that smallholder vegetable farmers affirm that there is a probability to increase their farm income with the use of inclusive business models during every farming season.

Verhofstadt and Maertens (2015) reported that one major way that smallholder farmers can overcome poverty is to employ an inclusive business model since that could empower the farmer with the necessary and adequate materials and tools to increase productivity and thereby increase their farm income. Smallholder vegetable farmers of the study were also found to strongly agree that there would be a ready market for their produce as they use IBM (Means=4.67, SD=0.56). Thus, smallholder vegetable farmers strongly agree that the probability of accessing a reliable market for their produce at a reasonable price is very high through the use of IBM (all other things being equal). Kaminski et.al. (2020) emphasize that utilizing an inclusive business model is the best approach for smallholder vegetable farmers to access a reliable market source for their produce. This implies that smallholder vegetable farmers will be able to sell all that produce if they make use of an inclusive business model in their farming businesses.

The variable IBM is a threat to farm business" (Means=1.51, SD=0.61) on the other hand was found to be disagreed by the smallholder vegetable farmers. Thus, smallholder vegetable farmers do not agree that the use of IBM could be a threat to their farming business. According to Likoko and Kini (2017), every business venture involves risk-taking but smallholder looks safer with the use of IBM than other stakeholders since there are some forms of insurance for smallholder farmer against natural disaster. Kaminski et.al. (2020) also asserted that smallholder farmers who practice inclusive business models are usually protected against risk because of insurance schemes that are available to smallholder farmers. Thus, inclusive business models give smallholder farmers the to share some of the risks associated with their farm business with other stakeholders such as partners, insurance companies, and so on.

Table 16 also indicated that the farmers strongly agree that IBM will be compatible with most socio-cultural beliefs and values (Mean=4.79, SD=0.41). This implies that the concept of inclusive business models does not contradict the principles and cultural beliefs and values of society.

Table 16: Perception of smallholder vegetable farmers on IBM

Variable	Mean	SD	Min	Max
IBM is an effective means for achieving optimum productivity	4.473	.564	3.000	5.000
IBM is the best mean of achieving a higher income	4.020	.650	3.000	5.000
There is a ready market for my produce	4.667	.564	3.000	5.000
IBM is a threat to farm business	1.513	.610	1.000	3.000
IBM is the most significant for farm business	4.620	.487	4.000	5.000
IBM will be compatible with most socio-cultural beliefs and values	4.793	.406	4.000	5.000
IBM will be compatible with the current needs of the vegetable farming	4.660	.577	3.000	5.000
IBM will be compatible practices of the farm	4.000	.000	4.000	4.000
Vegetable farmers will accept IBM when mandated by law from the government	4.627	.485	4.000	5.000
Reduce production cost	4.000	.000	4.000	4.000

Source: Field Survey, Awuakye (2022). n=150 **Means were calculated from a scale of 1-1.44=Strongly Disagree, 1.45-2.44 = Disagree, 2.45 – 3.44 = Neutral, 3.45 – 4.44 = Agree, and 4.45 – 5.00 = Strongly Agree

Also, Table 16 indicated that farmers strongly agree that IBM will be compatible with the current needs of the vegetable farmers ((Mean=4.66, SD=0.58). Thus, the use of IBM will not conflict with the current needs of the farmers but rather helps the farmers to meet their current needs (Kaminski et.al, 2020). The results also revealed that farmers agree that IBM will be compatible with the current practices of the farm (Mean=4.00, SD=0.00). This also implies that the farmers believe that employing IBM will not conflict with the agronomic practices of the farmers. Thus, despite the new arrangement that IBM could bring into the farm business, it will not sabotage farming practices.

Moreover, the farmers strongly agree that vegetable farmers will accept IBM when mandated by law from the government (Mean=4.62, SD=0.49). This implies that the farmers are of the view that, smallholder vegetable farmers will be willing and ready to employ IBM when it is backed by law from a government institution. Thus, this will give the farmers some assurance of protection against fraud and exploitation. Finally, the farmers agree that IBM will help reduce production costs (Mean=4.00, SD=0.00). The farmers believe that the introduction of IBM in their farming businesses will allow them to access an adequate amount of farm inputs and equipment needed at the right time which will enable the farmers to produce efficiently and effectively (Likoko & Kini, 2017).

Smallholder Vegetable Farmers' Knowledge of the Benefit of Inclusive Business Models in Their Farming Business

Table 17 shows results on smallholder vegetable farmers' knowledge of the benefit of IBM in their farm business. The findings indicated that all the farmers (100%) were aware that; implementing IBM would be profitable to their farm business, would help to reduce post-harvest losses, and would also help to make available their produce all year round. Also, all the farmers (100%) were aware that IBM could help them to overcome market failure, poverty alleviation, improve access to credit and insurance, access agrochemical inputs, access inputs fertilizers, access financial capital, and also enable to produce all year round. However, only (27.3%) of the respondents agreed that the use of IBM could help to reduce production costs. The results also showed that (99.3%) of the respondents believed the use of IBM in their farm businesses would help them to market their produce whereas (95.3%) of the farmers affirmed that the use of IBM is an effective means to achieve optimum productivity. Meanwhile, (25.3%) of the respondents had the opinion that the use of IBM would not allow them to make their own decisions. Moreover, (96%) of the farmers affirmed that the use of IBM would help them to get a ready market for their produce and also get a higher level of livelihood.

Table 17: Smallholder Vegetable Farmers' Knowledge of the Benefit of Inclusive Business Models in Their Farming Business.

Variables	Yes	
	Frequency	Percentage
IBM helps the farmer market his or her produce	149	99.3
IBM is an effective means of achieving optimum productivity	143	95.3
Under IBM farmers are not allowed to make their own decisions	38	25.3
IBM helps to get a ready market for the produce	144	96.0
Higher level of livelihood when one implements IBM	144	96.0
Implementing IBM is profitable for to farm business	150	100
Reduction in post-harvest loses	150	100

Table 17: Cont.

Increase farmers sales	150	100
Year-round availability of produce	150	100
Overcoming market failures	150	100
Reduce production costs	41	27.3
Poverty alleviation	150	100
Improving access to credit and insurance	150	100
Access to agrochemical inputs	150	100
Access to inputs fertilizers	150	100
All year-round production	150	100
Access to financial capital	150	100

Source: Field Survey, Awuakye (2022).

Challenges to smallholder vegetable farmers' usage of an inclusive business model (IBM)

The results from the study indicated that smallholder vegetables are not utilizing inclusive business models in their farm businesses due to some challenges which are not within their control.

The study employed Kendall's coefficient of concordance to evaluate the most limiting challenges among the challenging variables that have been discouraging the farmers from using IBM. The results indicated that there was a 58.8% level of agreement among the farmers in the ranking of the challenges (Wa =58.8, or 58.8%) with a Chi-square value of 793.354, a degree of freedom of 9 (df=9) and statistically significant at 1%.

The study identified ten variables as limiting challenges to smallholder vegetable farmers concerning the use of IBM. The constraints variables were ranked on a scale of 1 to 10, with 1 being the most limiting challenge and 10 being the least limiting challenge. The study took the average responses of the farmers to ascertain the mean rank of each challenge. According to Table 18, the most important challenging variable was fraud with a mean rank of 7.91 whereas the least important challenging variable was lack of fund accessibility with a mean rank of 2.14. This implies that the majority of the smallholder vegetable farmers in the study area were not using inclusive business models because of the fear of fraudsters.

The second constraint variable against the farmers' usage of IBM in the study area was the lack of consideration of IBM topics in farmers' training sessions. Hence, AEAs and other stakeholders have to consider some vital IBM topics during farmers' training thereby promoting the use of IBM among smallholder vegetable farmers.

Table 18: Challenges to Smallholder Vegetable Farmers' Usage of IBM

Challenges	Mean Rank	Ranking Position
Lack of funds accessibility	2.14	10
Uncertainty of IBM's return on investment	2.36	9
Lack of local expectations on IBM	4.03	8
Unequal bargaining power	5.14	7
High rate of consultancy fees	5.28	6
Lack of knowledge of IBM innovations	6.38	5
Exploitation	6.98	4
Lack of local expectations on IBM	7.24	3
Lack of consideration of IBM topics in farmer's training sessions	7.53	2
Fraud	7.91	1
N	150	
Kendall's W[a]	.588	
Chi-Square	793.354	
Df	9	
Asymp. Sig.	.000	

Rank 1= most important, Rank 10= least important;

Source: Field Survey, Awuakye (2022)

Recommended IBM for vegetable production in the study

Based on the findings from the study, it can be recommended that smallholder vegetable farmers could perfectly do well in vegetable production in an improved value chain situated in an enabling regulatory framework supported with financial mechanisms that are compatible with the socio-cultural beliefs and values of the farmers and sustainable farm practices.

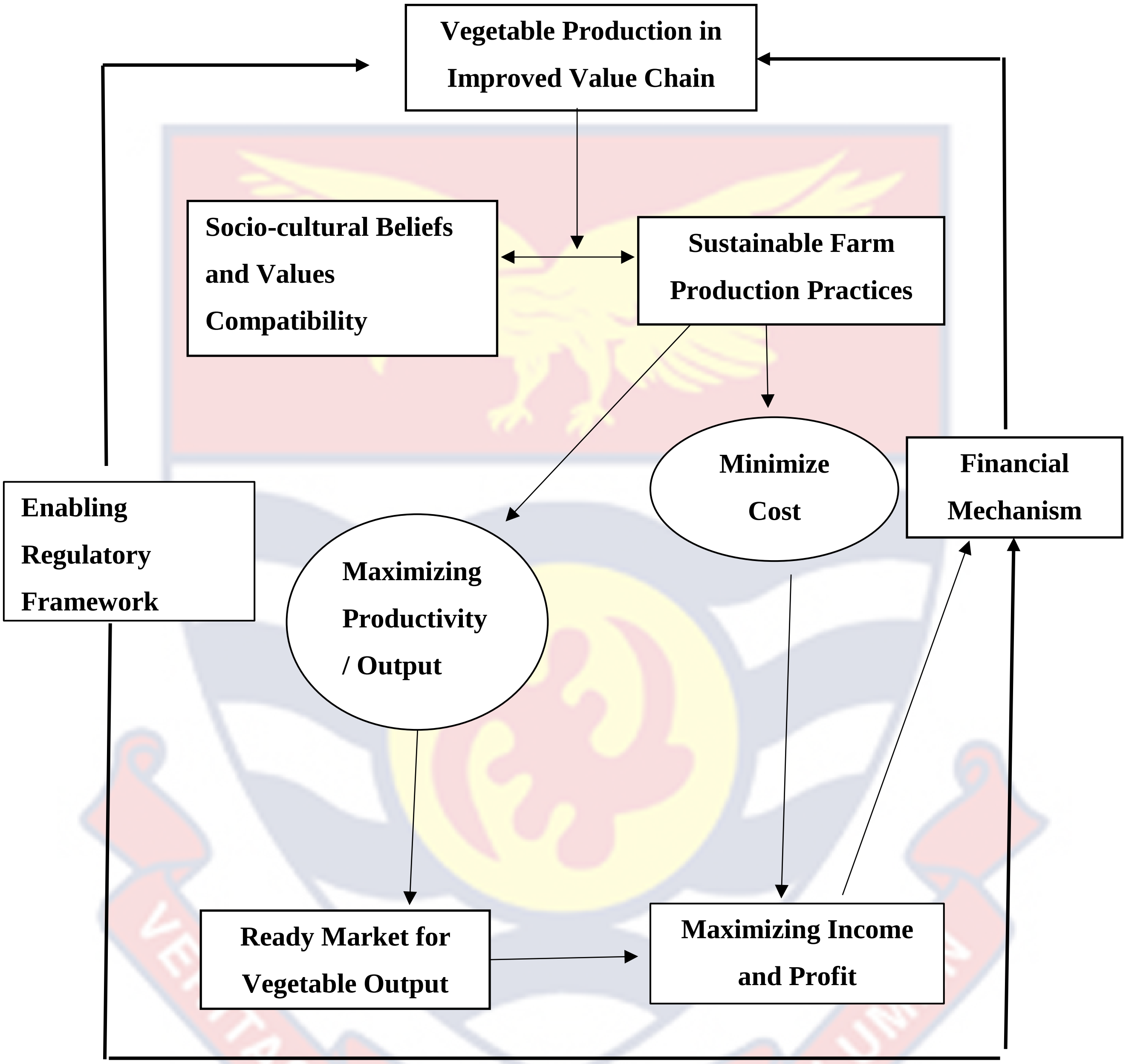

Figure 8: Recommended IBM for Smallholder Vegetable Farmers in Denkyembour District

Source: Field Survey, Awuakye (2022)

The Enabling Regulatory Framework (ERF) could be referred to Government Institutions and/or Non-Governmental Agencies (NGOs) such as the Ministry of Food and Agriculture (MOFA), Environmental Protection Agency (EPA), Plant Protection and Research Institution (PPRI), etc. that could serve as a regulatory body among the various actors along the chain to prevent cheating and even fraud. The Financial Mechanism implies financial institutions or other stakeholders who could offer financial assistance to the actors on the value chain under a favorable terms and conditions promptly.

The study believed that smallholders vegetable farmers ability to operate in a farm business environment that are compatible with their socio-cultural beliefs and values, and promotes sustainable farm practices would enable smallholder vegetable farmers to minimize cost production and thereby maximize productivity/output. Perhaps, smallholder farmers ability to minimize cost would directly or indirectly translate into the profit maximization of the farmers' earnings from their productivity.

Moreover, the study asserted that an improved value chain is a potential value network that could offer a ready and reliable market for vegetable outputs for the smallholder farmers. Thus, in a farming business context where farmers can sell all their produce at the end of the production period, they will surely be able to maximize income and profit. This is because smallholder vegetable farmers would be able to minimize or even do away with postharvest losses.

Finally, the study asserted that with the help of financial mechanisms, farmers would be able to save from their proceeds and later reimburse it into their business to ensure sustainability. Thus, assistance from the financial institutions with respect to how save for future with interest the smallholder vegetable farmers not to spend all their earnings from their farm business but rather learn how to save some with the financial institutions and later withdraw it whenever the need arises.

Chapter Summary

This chapter presented and discussed the results of the study. It was introduced to reflect the content of the chapter. The socioeconomic characteristics of the smallholder vegetable farmers were presented using tables and figures to give a pictorial view of the background of the farmers of the study. This chapter presented results on the production and marketing cost and benefit analysis of the study, and the profit efficiency component of the study for objective one. Objective two also presented results on the competencies of smallholder vegetable farmers in the area of VPMPs and factors that influence their competencies. This chapter also presented and discussed results on the farmers' awareness, usage, and preference of existing business models. Factors that inhibit smallholder vegetable farmers' choice of existing BMs. Finally, this chapter presented and discussed findings on the farmers' perception, knowledge on the benefit of IBM, challenges to implementation of IBM in the study, and then designed a recommended inclusive and sustainable business model for vegetable production actors.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATION

Introduction

This chapter presents the summary, conclusions, and recommendations of the study. The summary and conclusions of the study were based on the specific objectives of the study. This chapter also presented recommendations based on the conclusions in conformity with the specific objectives and also suggested further areas for the research.

Summary

Overview of the Study

Ghana's vegetable yield has recently stagnated despite the expansion in cultivated areas and the effort of the government as well as the agricultural sector. The primary contributing causes are an increase in pests and diseases, decreased soil fertility, heat stress, and drought brought on by climate change. Additionally, vegetable farmers' inability to add value to their produce and inappropriate pricing technique has led to them earning low prices. Therefore, there is a need for agricultural transformation where vegetable farmers could adopt technological innovation that would help address climate change and develop adaptation strategies to mitigate the emerging issues and problems which simultaneously could address agronomic, farm-economic, and market constraints, and likely to create value for both food producers, marketers, and consumers in the economy. However, according to Meijer et al. (2015), most smallholder farmers are financially incapable and technologically incompetent to adopt these technological innovations which could enable smallholder vegetable farmers to maximize productivity and profit. This call for the needs for the introduction of inclusive business models (e.g., contract farming and out-grower scheme, joint ventures, etc.) in the vegetable sector that would offer smallholder farmers access to the fund, access to farm inputs and access a reliable market

The primary objective of this paper was to examine existing business models (BM) that smallholder vegetable farmers could employ to upgrade themselves, technologically and economically, to mitigate the contributing factors to the stagnation of vegetable production. The specific objectives of the study were: a) Examine the performance level of smallholder vegetable farmers in Denkyembour District in terms of profitability, b) Examine the competence level in vegetable production management practices (VPMP) of smallholder vegetable farmers in Denkyembour District, c) Examining existing business model types and the extent of use among smallholder vegetable farmers in Denkyembour District, d) Examining factors that influence smallholder vegetable farmers in Denkyembour District's choice of business models type, e) Propose inclusive and sustainable business model that could facilitate technological and economic upgrading for smallholder vegetable farmers in Denkyembour District.

The study was conducted in the Denkyembour District in the Eastern Region of Ghana, West Africa. This district was preferably selected because this study is a work package of a particular which was undertaken in that district with one hundred and fifty smallholder vegetable farmers recommended by the department of agriculture in the district.

The study employed a cross-sectional survey design and quantitative research approach. The population for the study was one hundred and fifty registered smallholder vegetable farmers who were actively engaged in the project upon which this study is a work package. The study made use of a census to obtain the data since the target population was not so much and they were easy to be identified with the help of an extension agent from the department of agriculture in the district. A structured questionnaire designed in a "KoboCollect" was used as a data collection instrument to solicit farmers' responses based on the specific objectives of the study. The data was processed and analyzed using Microsoft Excel, STATA, IBM SPSS, and R software. Analytical tools such as descriptive statistics, Gross margin analysis, Stochastic Profit Frontier Analysis, Correlation, Binary Logistic Regression, and Kendall's Coefficient of Concordance.

Socio-Economic Characteristics

The findings indicated that the study was dominated by male farmers with a difference of (10%) as shown in Figure 1. The findings also revealed that the farmers were relatively above their youthful age and this was because the study area happens to be a mining community. Perhaps, the youth preferred mining activities to vegetables despite the tedious nature of the mining activities. The results presented that (87.3%) of the farmers have had formal education and it was dominated by farmers who have attained MSL/JSS/JHS education (67.3%). Also, (88.7%) of the farmers were found to have vegetable production as their main occupation which implies that the farmers were very committed and focused on vegetables since that is their major source of livelihood. The results also showed that the study was dominated by farmers who rent (34.7%) their farmlands for their vegetable production and (60%) of the respondents were also found using both family and hired labor for the production activities.

The average size of farmland in the study was found to be 1.5 acres and the average farming experience of the farmers was presented as 17 years respectively. The findings also revealed that (84.7%) of the farmers had access to extension services with an average number of four times of accessing within a production period. This implies that there was a high tendency of farmers to acquire adequate information about the right use of farm inputs coupled with the right agronomic practices thereby ensuring cost-effectiveness and efficiency that leads to profit maximization. However, the findings indicated that (80%) of the respondent had no access to credit facilities.

Finally, the results indicated that (94.7%) of the farmers sold their produce to middlemen but the farmer complained that these middlemen usually cheat them. Thus, the middlemen often did not pay what they were supposed to pay to them but due to the perishability nature of the product and no other reliable source of the market, these farmers were under obligation to sell to them in an attempt to avoid waste.

Production and marketing cost analysis of smallholder vegetable farmers

The farmers of the study were segregated into three categories; okra farmers, garden eggs farmers, and okra and garden eggs farmers. The findings indicated that the study was dominated by farmers who produced both okra and garden eggs (60.66%). It was revealed from the results that okra farmers made a gross profit of GH₵3062.00 whereas garden eggs farmers and both okra and garden eggs farmers made a gross profit of GH₵16137.45 and GH₵46489.67 respectively. It was obvious that farmers who produce both crops do well in terms of earning more profit. This could also be to the fact of most of the fixed assets and even some variable materials could be used for managing both commodities especially when they are cultivated on the same piece of land. This in return will help to minimize the cost of production.

Profit Efficiency of Smallholder Vegetable Farmers in the Denkyebour District in the Eastern Region of Ghana

The study made empirical estimates of the smallholder farmers' profit efficiency, distribution of farmers' efficiency scores, and determinants of their profit inefficiency using both the stochastic Translog profit frontier and the Cobb-Douglas model. The Translog model was chosen over the Cobb-Douglas model for the discussion in the study due to its greatest likelihood ratio test from the finding. The stochastic profit frontier and the inefficiency component were computed simultaneously. The sigma-squared coefficient for all the farmer groups indicated that the model was a good fit for the data set of the study. Also, the gamma coefficient for all three farmer groups revealed that (100%) variance of the farmers' profit inefficiency was caused by factors that were within the control of the farmers. However, the results indicated that okra farmers, garden eggs farmers, and okra and garden eggs farmers were average profit efficient at (93%), (83%), and (70%) respectively. This implies that the various farmer groups had room to improve their profit efficiency level by (7%), (17%), and (30%) accordingly.

The profit efficiency level of smallholder vegetable farmers

The individual profit efficiency level of the smallholder vegetable farmers ranged from 0.147 to 1.000. On average, the okra farmers, garden eggs farmers, and the okra and garden eggs farmers were efficient at (60%), (83%)

and (67%) respectively. Thus, okra farmers had the potential to increase their profit by (40%). The garden egg farmers also had the potential to increase their profit by (17%) whereas okra and garden egg farmers had the potential to increase their profit by (33%).

Determinants of profit inefficiency

The study revealed that the profit inefficiency of okra farmers was statistically influenced by age, years of education, household size, farm size per hectare, number of times of accessing extension services, access to credit, and farmer group. The profit inefficiency of the garden was also found to be influenced by years of education, household size, farm size per hectare, number of times of accessing extension services, access to credit, and farmer group. Farmers who cultivated both okra and garden eggs were indicated to be influenced by age, years of education, size, farm size per hectare, and access to credit.

Competencies of Smallholder Vegetable Farmers in the Vegetable Production Management Practices (VPMPs)

The results revealed that farmers demonstrate high competencies (composite mean = 3.45, SD= 0.13) in vegetable production management practices in general. However, the results reveal that the farmers have moderate knowledge (composite mean = 3.37, SD= 0.14) whereas they demonstrate high attitude (composite mean = 3.45, SD= 0.10), high Skills (composite mean = 3.46, SD= 0.13), and high Aspiration (composite mean = 3.51, SD= 0.16) in the vegetable production management practices. The results specifically demonstrate that farmers only have very high competency in the selection of the type of vegetable for production (composite mean = 4.57, SD= 0.58).

Notwithstanding that, they have high competency in determining appropriate healthy seeds/seedlings (composite mean = 4.01, SD= 0.55), selection of the appropriate type of soil/medium for production (composite mean = 4.05, SD= 0.52), etc. The findings also showed that the farmers have moderate competency in determining the appropriate source of funding to finance the vegetable production (composite mean = 3.01, SD= 0.52), selection of market (composite mean = 2.67, SD= 0.59), identifying unique market preposition (composite mean = 2.91, SD= 0.48), etc. The results also reveal that the farmers have low competency in the prevention of postharvest losses management (composite mean = 2.38, SD= 0.49), and segregation of the target market (composite mean = 2.29, SD= 0.44). However, none of the farmers had a very low competency in all the parameters of vegetable production management practices.

Effects of socio-economic characteristics of farmers on their competencies in VPMPs

The findings from the study indicated that knowledge of the farmers in vegetable production management practices was explained by the independent variables by (15.9%) and statistically significant at $p<0.05$ (F – Change: 2.400). Farmers' attitude in VPMPs was also explained by the independent variables by (20.6%) and it was statistically significant at $p<0.01$ (F-Change: 2.922). Skills of the farmers also were indicated to be explained by the independent variables by (25.5%) and statistically significant at $p<0.01$ (F-Change: 3.534). Also, the aspiration of the farmers in VPMPs was explained by the independent variables (18.4%) and statistically significant at $p<0.01$ (F-Change: 2.667).

The general competence of the farmers was also found to be explained by the independent variables (26.7%) and statistically significant at $p<0.01$ (F-Change: 3.695)

Knowledge was revealed to be statistically significantly influenced by age of the farmers, landholding status, farm size, annual farm income, the use of irrigation facilities, access to credit, and the target mark of the respondents. The attitude was also found to be influenced by the main occupation of the farmers and the annual farm income of the respondents. Skills on the other hand were found to be influenced by household size, the number of times farmers access extension services, the source of extension service, access to credit, and the target market of the farmers. Aspiration of the farmers was also statistically found to be influenced by the level of education, years of formal education, the main occupation of the farmers, landholding status, and farm size, farming experience, the source of extension service, access to credit and the target market of the respondents. The competencies of the farmers, in general, were also indicated to be influenced by the level of education, years of formal education, landholding status, number of times of accessing extension service, access to credit, and the target market of the farmers.

Examining existing business model types and the extent of use among smallholder vegetable farmers in the Denkyembour District

The findings revealed that among the nine sets of agricultural business models presented in the study, all the farmers were aware of the Direct/Traditional Farming model and farmers confirmed during the survey that it was introduced to them by their parents. The next model that is highly known among smallholder farmers was contract farming and the out-grower scheme.

Thus, (34%) of the farmers were found to be aware of the contract farming and out-grower scheme. However, none of the farmers knew supply chain management. Moreover, (98.7%) of the farmers were found to be using the direct farming model, and (1.3%) of the farmers happened to be using sharecropping and tenant farming. This implies that the other seven models were not patronizing by the smallholder vegetable farmers. At the end of the study, it was discovered that (97.3%) of the respondents preferred the CFOS model to the model that they are currently using. (0.7%) preferred Direct Farming, Supply Chain Management, Sharecropping Tenant Farming, and Joint Ventures models respectively.

Relationships among smallholder vegetable farmers' awareness of business model types, their usage of these business model types, and their preferences for the business model types

The study employed matrix correlation (Pearson Correlation) in assessing the extent of use of the existing business models by examining the relationships that existed among the farmers' awareness of the models, their usage, and their preferences for the model types. The results showed that there was a very strong positive relationship between awareness of business models and business model usage with a coefficient value of 0.819. This implies that the farmers' use of business models is highly influenced by their level of knowledge of the relevance of these existing business model types in their farm business space. Awareness of business models also had a positive relationship with business model usage though it was very weak and their coefficient value was 0.016. This also indicates that smallholder vegetable farmers' preferences to use one business model over other depends on some level of their awareness of the various models though its impact is not that much. Business models' usage and business models preferred on the other had a negative weak relationship with each other with a coefficient value of -0.035. This also implies that smallholder vegetable farmers' preferences on the business model type to use do not have a statically significant relationship with the business model type that they were currently using in their farm enterprises.

Factors that influence smallholder vegetable farmers in Denkyembour District's choice of business model's type

Factors that influence smallholder vegetable farmers' choice of business model type were analyzed using a binary logistics regression model. The model was statistically significant at 5%. The results revealed that the age, level of education, and main occupation of the farmers were statistically significant in terms of their influence on the farmers' choice of the business model type. It was indicated age and level of education had positive relation whereas household size and the main occupation of the respondent had a negative relation with farmers' choice of model types and they were predicted with a coefficient value of 0.061, 0.78, -0.294, and -2.202 respectively. The use of irrigation facilities was also found to be significant and positively related to farmers' choice of business model type with a coefficient value of 1.93. Also, the farmer group (cooperative association) and the number of times farmers accessed extension service were also significant and positively influenced farmers' choice of a business model type with a coefficient value of 1.384 and 0.297 respectively. For farmers' competence in VPMPs, farmers' choice of business model type was statistically significantly influenced by knowledge and attitude with coefficient values of -0.521 and -0.271. Finally, farmers' awareness of IBM also influenced their choice of business model type positively with a coefficient value of 0.561.

Perception of smallholder vegetable farmers on the inclusive business models

The perception of the farmers on IBM was examined using descriptive statistics to know how farmers perceive IBM to be. The findings indicated that smallholder vegetable farmers strongly agreed that the use of IBM is an effective means to achieve optimum productivity, there would be a ready market for their produce with the use of IBM. Farmers also agreed to the fact that using IBM would be the best means to achieve a higher income. The results also revealed that smallholder vegetable farmers disagreed that the use of IBM is a threat to farm businesses. Moreover, the findings indicated farmers agreed that IBM would be compatible with their current farm practices and strongly agreed that it will be compatible with their sociocultural beliefs and values. Also, the smallholder vegetable farmers strongly agreed that IBM will be accepted by vegetable farmers when mandated by law from the government.

Smallholder vegetable farmers' knowledge of the benefit of inclusive business models in their farming business

Descriptive statistics were conducted to verify farmers' knowledge of the benefit they will be derived from the use of IBM. The results revealed that farmers responded yes to the fact that; IBM will help them to market their products and it is an effective means of achieving optimum productivity. The farmers also affirmed that there is an assurance of a higher level of livelihood when one implements IBM. They also said that implementing IBM is profitable for the farm business and it helps in the reduction of post-harvest losses, increases farm sales, year-round availability of produce, overcoming market failures, poverty alleviation, improves access to credit and insurance, access to agrochemical inputs, access to fertilizers, all year-round production, and access to financial capital. However, the farmers responded no to disagree with the statement of two variables which are; under IBM farmer farmers are not allowed to make their own decisions and IBM reduces production costs.

Challenges of inclusive business model implementation by smallholder vegetable farmers

Kendall's coefficient of concordance was used to evaluate the most limiting challenges among the challenging variables that have been discouraging the farmers from using IBM. The results indicated that there was a (58.8%) level of agreement among the farmers in the ranking of the challenges (Wa =58.8, or 58.8%) with a Chi-square value of 793.354, a degree of freedom of 9 (df=9) and statistically significant at (1%). The study reveals that the most important challenging variable was fraud with a mean rank of 7.91 whereas the least important challenging variable was lack of fund accessibility with a mean rank of 2.14. This implies that the majority of the smallholder vegetable farmers in the study area were not using inclusive business models because of the fear of fraudsters. The second constraint variable against the farmers' usage of IBM in the study area was the lack of consideration of IBM topics in farmers' training sessions. Hence, AEAs and other stakeholders have to consider some vital IBM topics during farmers' training thereby promoting the use of IBM among smallholder vegetable farmers.

Recommended IBM for vegetable production in the study area

They recommended that smallholder vegetable farmers could do well in business when they are connected to an improved value chain situated in an enabling regulatory framework governing by government institutions and Non–Governmental Agency and financial mechanisms where farmers would have access to the required farm inputs, funds and reliable source of market for their produce at every production period. This system will help farmers to minimize the cost of production thereby maximizing profit and income which would as well help farmers to save proceeds and later reimburse into the business as and when the need arises.

Conclusion

Based on the summary of the key findings of the study, it can be concluded that;

The study was full of farmers who were above their youthful age and this was because vegetable production was not looking appealing to the youth of the study. Also, almost all the farmers have had some level of formal education which makes it easy for them to learn to become abrasive with a new way of vegetable production in their farm businesses. Moreover, almost all the farmers had vegetable production as their main source of occupation which makes them pay much attention and some level of commitment to earn a livelihood.

According to the finding from the study, access to extension services was not a problem for the farmers in the study area. Therefore, the extension agents in the study area can be used as a medium to bring transformation to the vegetable production business in the study area.

The study also indicated that access to credit (both inputs and cash) was accessible to smallholder vegetable farmers in the study. Perhaps, making use of improved technological facilities in vegetable production was a challenge since they are capital-intensive.

The findings from the study also revealed that the study was dominated by farmers who cultivated both okra and garden eggs and they happened to be more profitable with a gross margin of (83.23%) as compared to those who cultivated either only okra or only garden eggs. This could be because they enjoy economies of scale since most of their fixed assets and variable materials were used in managing both crops at the same time. The study evaluated profit efficiency and the sources of inefficiency among okra farmers, garden eggs farmers, and okra and garden eggs farmers of the study. The okra farmers, garden eggs farmers, and okra and garden eggs farmers had a mean profit efficiency of 0.93, 0.83, and 0.70 respectively. This implies okra farmers had sufficient room to increase efficiency by (7%), garden eggs farmers had sufficient scope to increase efficiency by (17%) whereas okra and garden eggs farmers had sufficient scope to increase efficiency by (30%) using the existing business model type, technology and level of inputs. Okra and garden egg farmers happened to be more profitable as compared to okra farmers and garden egg farmers but the okra farmers were also found to be more profit efficient as compared to the other two farmer categories. The determinant that contributed to profit inefficiency were age, years of formal education, household size per hectare, number of times of accessing extension services, access to credit, and farmer groups (cooperatives).

It can also be concluded based on the findings that, smallholder vegetable farmers in the study have high competencies in VPMPs in general with moderate knowledge, high altitude, high skills, and high aspiration in VPMPs respectively. The results of the study presented that knowledge of smallholder vegetable farmers was influenced by age of the farmers, landholding status, farm size, annual farm income, the use of irrigation facilities, access to credit, and the target mark of the farmers.

The attitude of the farmers in VPMPs was influenced by the main occupation and annual income of the farmers. Household size, the number of times farmers access extension services, source of extension service, access to credit, and target market of the farmers were found to influence the skills of the farmers in VPMPs. The aspiration of the farmers in VPMPs was also found to be influenced by the level of education, years of formal education, the main occupation of the farmers, landholding status, farming experience, the source of extension service, access to credit, and the target market of the farmers. The results indicated that the competencies of smallholder vegetable farmers were influenced by the level of education, years of formal education, landholding status, number of times of accessing extension service, access to credit, and target market of the farmers.

The study revealed that the awareness and usage of IBM by smallholder vegetable farmers do not necessarily depend on the competencies of VPMPs. The findings indicated that the Direct/Traditional Farming Model is the business model type that was common to the farmers and that is what they practice. This was due to a lack of knowledge of IBM. Based on the findings, it can be concluded that the use of IBM is highly influenced by their level of knowledge of the relevance of these existing business model types in their farm business space. The findings also indicated that smallholder vegetable farmers' preferences to use one business model over other depends on some level of their awareness of the various models though its impact is not that much and their preference was not certainly dependent on the current model that they were using. Smallholder vegetable farmers' choice of business model types was influenced by age, level of education, main occupation, the use of irrigation facility, farmer group, number of times of accessing extension services, knowledge and attitude in VPMPs, and their awareness of IBM.

It can also be concluded that despite the challenges that may come along with IBM, the implementation of IBM is the best decision for smallholder vegetable farmers to increase productivity, access a reliable source of market for their produce, and also to income and profit.

Smallholder vegetable farmers in the study area should be connected to an improved vegetable value chain situated in an enabling regulatory framework and with a financial mechanism to facilitate increased productivity and profit maximization.

Recommendation

Based on the findings and the conclusions of the study, the study recommends that, the Department of Agriculture (MOFA) in the district should intensify their farmers' training and encourage smallholder vegetable farmers to make use of technological innovation made available in the vegetable sub-sector to boost vegetable production.

Smallholder vegetable farmers who cultivated either only okra or garden eggs should be encouraged by Agricultural Extension Agents (AEAs) and the project sponsors to grow both crops since it looks more profitable than the individual enterprises. Notwithstanding, farmers who cultivated both crops should be admonished by the AEAs and the project sponsors to learn how to utilize their resources effectively and efficiently to increase their profit efficiency level.

Also, the AEAs, the project team leaders, and NGOs in agriculture should educate the smallholder vegetable farmers on the relevance of IBM in the vegetable industry to promote their interest in employing IBM in their vegetable farm businesses. Moreover, financial institutions and other money lenders should make credit facilities available to smallholder vegetable farmers to empower them to patronize technological innovation that could enhance productivity at every production period.

Finally, the study recommends that, the AEAs, NGOs, the Project Team Leaders, and other Agribusiness related body like FDA, EPPA, etc. should help link the smallholder vegetable farmers to other vegetable value chain actors and regulate the contractual agreement between them thereby minimizing cheating or fraud on the side of the farmers.

Suggestions for Future Research

This study dealt with a targeted population who were participants in a project in the study area. Future research should therefore aim to expand the study's scope to other ecological areas in the region, and even possibly other regions of the nation.

Also, the study considered vegetable farmers who cultivated only okra, only garden eggs, and both okra and garden eggs. Further studies should be done on smallholder vegetable farmers who cultivate other varieties of vegetables apart from okra and garden eggs to ascertain the economic analysis of inclusive business models among such farmers.

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APPENDICES

APPENDIX A

UNIVERSITY OF CAPE COAST

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

Economic Analysis of Inclusive and Sustainable Business Models for Smallholder Vegetable Farmers in the Eastern Region of Ghana

This study is designed to examine inclusive and sustainable business model for technological and economic upgrading of smallholder farmers in the vegetable value network: A Study in the Eastern Region of Ghana. You have been identified as an individual to provide information to achieve the objectives of the study. The interaction session is expected to last for about 30 minutes. Please respond honestly to the questions on this questionnaire/interview schedule. Be assured that all the information that will be provided will be used for the intended objectives and will be kept confidentially. Your phone number would be requested to assist us to reach you again for follow-up questions. Participation in this survey is voluntary and you can choose not to answer any individual question or all of the questions. However, I hope that you will participate in this study since your views are important.

At this time, do you want to ask me anything about the survey? 1. Yes [ ] 2.No [ ]

1. Zone: ………………………………………………………………………
2. Community……………………………………………………………...
3. Phone number ……………………………………………….

Part 1: Socioeconomic characteristics of farmers in the study areas.

1. Gender: 1. Male [ ] 2. Female [ ]
2. Age at last birthday: _______ years
3. Are you a native of this community? 1= Yes [ ] 0=No [ ]
4. What is your highest level of education? 1=Primary [ ]
   2=MSLC/JSS/JHS [ ] 3=SSS/SHS [ ] 4=Tertiary [ ]
5. Yeas of formal education ……………………………………….
6. Marital Status: 1=Married [ ] 2=Single [ ]
   3=Separated/Divorced [ ] 4=Widowed [ ]
7. Religion: 1=Christian [ ] 2=Muslim [ ] 3=Traditionalist [ ]
   4=others [ ] (please,
   specify…………………………………………..)
8. Is farming your main occupation? Yes [ ] 2. No [ ]
9. If not, what is your main occupation?....................................
10. Status in the household. 1=Head [ ] 2=Spouse [ ] 3=Child [ ]
    4=others, specify ………………
11. Please indicate your household size………………………………
12. What is your household annual
    income?..(GHC)

Part 2: Farm Characteristics

1. What is your current land holding status? 1=Own land [ ]
   2=Family land [ ] 3=Renting [ ] 4= Sharecropping [ ] 5= More than one option [ ] 6= others, specify ……………………………
2. What is the size of your vegetable
   farm?……………………….(Acres)

3. What is your annual farm income?..(GHC)
4. How long have you been a vegetable farmer?.....................................
5. What is the major source of labor for your vegetable production activities? 1=Family [ ] 2=Hired [ ] 3= Cooperatives 4= Both Family and Hired [ ] 5= Others (Specify)…………………………………
6. Do you grow only okro/garden eggs on your farm?

   1=Yes [ ] 0=No [ ]
7. If no, please respond to the following questions concerning farm output, quantity sold, and price annually.

Crop	Output	Qty sold	Unit Price (GH¢)	Qty consumed
Vegetable crops				
Cucumber				
Pepper				
Tomatoes				
Carrot				
Others:Specify…………				
Food crops				
Maize				
Cowpea				
Rice				
Cassava				
Cocoa				
Plantain				
Others: specify………………				
Livestock				
Sheep				
Goat				
Cattle				
Poultry				
Others;specify………………..				

8. How do you sustain your farming business?

…………………………………………………………………………………

………………………………………………………………………………

9. Do you use any form of irrigation facility? 1=Yes [ ] 0= No [ ]

10. If yes to question (9), which type of irrigation facility do you use?

Methods of irrigation system	Image of methods of irrigation system	Method of irrigation system used by the farmer
Manual irrigation system		
Flood irrigation system		
Bed/Border strip irrigation system		
Drip/trickle irrigation system		
Sprinkler irrigation system		
Others, specify;		

11. Apart from the irrigation facility you are using, what other alternative irrigation facility would you prefer to use or recommend?

………………………………………………………………………………………

………………………………………………………………………………………

12. Why the said response in question (11)?

………………………………………………………………………………………

………………………………………………………………………………………

3. What motivates you to keep using your current irrigation facility?

………………………………………………………………………………………

………………………………………………………………………………………

Part 3: Institutional characteristics

14 Do you have access to any extension services? 1=Yes [ ] 0=No [ ]

15 If **yes** to **(14)**, how many times do you have access to extension services during a planting season……………………?

16 If **no** to (14) why…………………………………?

17 What is the source of extension service? 1= Farmer to farmer [ ] 2= NGOs [ ] 3= Private Extension Agents [ ] 4= Government Extension Agents [ ]

18 Do you have access to any form of credit? 1=Yes [ ] 0=No [ ]

19 If **yes,** in what form was the credit accessed? 1= Cash [ ] 2=Inputs [ ] 3= Both Cash & Input 4= Others (specify)…………………

20 Please provide the source (s) of credit in the table below

Source of finance	**Amount taken (GH¢)**	**Interest Charged %**
Banks		
NGOs		
Microfinance		
Family/relatives		

Friends		
Money lenders		
Middlemen		
Others (Specify)		

21 Do you belong to any farmer-based group/organization/association? 1=Yes [ ] 0=No [ ]

22 Who do you sell your product to? a. Individuals [ ] b. Middlemen [ ] c. Cooperative society [ ] d. Others [ ] (Specify)………………

23 Where do you sell your products? a. Farm gate [ ] b. In the Market [ ] c. In the House [ ] d. Others [ ] (Specify)…………………….

Part 4: Farmers' Awareness, Knowledge and Practice about existing Business Models (BM) types

24 What type of business model are you aware of? Respond **Yes** or **No** to the table below.

Awareness of BM	**Yes**	**No**	**Source of awareness**
Direct/Traditional farming			
Contract farming and out-grower scheme			
Organic Greenhouse Vegetable Farming			
E-commerce agriculture (Business-to-customer) B2C			
Supply Chain Management Farming			
Sharecropping and tenant farming			
Farm-owned business (Cooperatives, associations)			
Joint ventures			
Certification			

25. Please indicate the business model type you mainly employ in your vegetable production from the table below by responding Yes or No.

The Exiting Business Model Type Practice by the Farmer	**Yes**	**No**
Direct farming		
Contract farming and out-grower scheme		
Organic Greenhouse Vegetable Farming		
E-commerce agriculture (Business-to-customer) B2C		
Supply Chain Management Farming		
Sharecropping and tenant farming		
Farm-owned business (Cooperatives, associations)		
Joint ventures		
Certification		
Others: Specify;		

26. Apart from the business model type selected in question (25), what other alternative business model would you prefer to use or recommend?

……………………………………………………………………………………

27. Why the said response in question (26)?

……………………………………………………………………………………

……………………………………………………………………………………

28. What motivates you to keep using your current business model type?

……………………………………………………………………………………

……………………………………………………………………………………

…………

Part 5: To propose an inclusive and sustainable business model for smallholder vegetable farmers

Part 5a: characteristics of an inclusive business model

29. Please indicate yes/no to the following criteria of inclusive and sustainable business model that are applicable to your vegetable production activities

Characteristics of Inclusive and Sustainable Business Model	Business Model Type									
	DF	CF	SCTF	FOB	ECA	JV	OGVF	CERT	SCM	OTHERS
Does the model provide a living wage for vulnerable groups, such as smallholder groups, small enterprises, women- and youth-run enterprises, while also enabling buyers to profit?										
Does the model use flexible trading arrangements that make it easier for smallholders or MSEs to supply a buyer, such as cash on delivery, accepting small consignments, providing reliable and regular orders?										
Does the model support farmers and small enterprises to establish a stronger negotiation position through skills development, collective bargaining and access to market information and financial services?										
Does the model build on the skills and expertise of existing market players, including traders and processors, and promotes value chain collaboration, transparency in pricing mechanisms, and risk sharing?										
Is the model scalable in the medium-term so that the numbers of small actors involved can be increased and/or										

the type of business model can be replicated in other value chains or parts of the sector?										
Does the model allow for diversified income streams in the long term to enable the dissemination of upgraded skills to the rest of the sector, avoiding overdependence on any single buyer or market outlet?										

Part 5b: Farmers' perception of IBM

30. Please tick the perception statements(s) that apply to you. Respond on a Likert scale 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree.

Perceived characteristics of BM in vegetable production	**1**	**2**	**3**	**4**	**5**
IBM is an effective means of achieving optimum productivity					
IBM is the best means of achieving a higher income					
There is a ready market for my produce					
Post-harvest losses will be minimized					
IBM is a threat to farm business					
Implementing an IBM is most significant for farm business					
IBM will be compatible with most socio-cultural beliefs and values					
IBM will be compatible with the current needs of the vegetable farming					
IBM will be compatible with the current practices of the farm					
Vegetable farmers will Accept IBM when mandated by law from the government					
Reduce production cost					
Others: Specify;					

Part 5c: Farmers' Knowledge on IBM

31. Please indicate your **knowledge of the benefit** of IBM. Responding either **Yes**/**No**.

Knowledge on the Characteristics of IBM in Vegetable Production	**Yes**	**No**
IBM helps the farmer in the marketing of his or her produce		
IBM is an effective means of achieving optimum productivity		
Under IBM farmers are not allowed to make their own decisions		
IBM helps to get a ready market for the produce		
Higher level of livelihood when one implement IBM		
Implementing IBM is profitable to farm business		
Reduction in post-harvest loses		
Increase farmers' sales		
Year-round availability of produce		
Overcoming market failures		
Reduce production costs		
Poverty alleviation		
Improving access to credit and insurance		

Access to inputs agrochemicals		
Access to inputs fertilizers		
All year-round production		
Access to financial capital		
Others: Specify;		

Part 5d: Challenges of IBM's implementation in vegetable production in Ghana

32. Please tick the challenges statements(s) that apply to you. Respond on a Likert scale 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree.

Challenge	**1**	**2**	**3**	**4**	**5**
Uncertainty of IBM return on investment					
Lack of funds accessibility					
Investment fund availability					
High rate of consultancy fees					
Exploitations					
Lack of local expectations on IBM					
Lack of farmers' awareness of IBM					
Lack of farmers' basic knowledge in IBM					
Luck of consideration of IBM topics in farmers' training sessions					
Lack of knowledge in IBM innovations					
Unequal bargaining power					
Fraud					
Others: Specify					

Part 6: Competencies Areas in Vegetable Production Management Practices

33. Choosing from the appropriate skill indicate your level of your knowledge, skill, attitude and aspirations in the following competencies in vegetable production management using the scale below. Knowledge: Having information about vegetable production practices using: 1=Very low, 2=Low, 3= Moderate, 4=High and 5=Very High. Attitude: Perceived importance of vegetable production practices using; 1= Not very important, 2=Not Important, 3= moderately important, = highly important and 5=Very highly Important. Skills: Extent to which you can practice these competencies Using: 1=Very low skill, 2= Low skill, 3=Moderate Skills, 4=High Skills and 5= Very High Skills and **Aspirations (behavior towards applying to your production using** 1=Very low skill, 2= Low skill, 3=Moderate Skills, 4=High and 5= Very High

	Knowledge (Having information)					**Attitude (perceive importance)**					**Skills (Ability)**					**Aspirations (behavior towards applying to your production)**				
Vegetable Production Management Competencies	**VL**	**L**	**M**	**H**	**VH**	**NVI**	**NI**	**MI**	**HI**	**VHI**	**VL**	**L**	**M**	**H**	**VHS**	**VL**	**L**	**M**	**H**	**VHS**
Scale	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
a. Selection of type of vegetable for production																				
b. Determining appropriate sources of healthy seeds/seedlings.																				

c. Selection of appropriate type soil/medium for production																				
d. Determining appropriate sources of fundings to finance the vegetable production																				
e. Competency in the production of vegetables																				
f. Management of vegetable production																				
g. Selection of market																				
h. Identifying unique market preposition																				
i. Provision of source of water																				
j. Combination of different types of vegetable that enhance yields.																				
k. Growing variety of seeds that are resistant to pest and disease																				
l. Planting variety of seeds that are climate change resilience																				
m. Identification of the various vegetable diseases																				
n. Periods of fertilizer application.																				
o. Agronomic practices management in general																				

p. Effective application of weedicides, insecticides and pesticides management																				
q. Erosion and leaching management																				
r. Transportation of produce																				
s. Prevention of postharvest losses management																				
t. Segregation of target market																				

Part 7: Examine the performance level of smallholder vegetable farmers in terms of profitability with the use of inclusive business model

34. Please indicate your level of production of the following vegetables

Crop	Output	Qty sold	Unit Price (GH¢)	Qty consumed (GH¢)
Okra				
Eggplant				

35. Indicate Yes/No to the following vegetable inputs items based on what you use on your field and write the amount charged on each of them

Pre-production	**Use (Yes/No)**	**Amount paid (GH¢)**
Land		
Land preparation		
Seeds		
Nursery expenses		
Transplanting		
Others:		
Cost of labor		
Pre-production		
Production		
Harvesting		
Storage		
Parking		
Others:		
Agrochemical product		
Fertilizer		
Insecticides		
Pesticides		
Weedicides		
Others:		
Storage cost		
Sacks		
Rubber mat		
Drier		
Refrigerator		
Others		
Transportation		
Carriage inwards		
Carriage outwards		
Others: Specify		

Farm hardware	Use (Yes/No)	Amount Paid	Date of Purchased
Irrigation equipment			
Cutlass			
Hoes			
Fork			
Rake			
Knapsack Sprayer			
Watering can			
Water hoes			
Others:			

APPENDIX B

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309
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OUR REF: UCC/IRB/A/2016/1460
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

2ND AUGUST, 2022

Mr. Stephen Danso Awuakye
Department of Agricultural Economics and Extension
University of Cape Coast

Dear Mr. Awuakye,

ETHICAL CLEARANCE – ID (UCCIRB/CANS/2022/27)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Economic Analysis of Inclusive and Sustainable Business Models for Smallholder Vegetable Farmers in the Fanteakwa South District, Eastern Region of Ghana.** This approval is valid from 2nd August, 2022 to 3rd August, 2023. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

APPENDIX C

Appendix C1: Fixed Cost Items for Okra Farmers of the study

VARIABLE	N (%)	MEAN	STD DEV	MIN	MAX
Land					
Usage	35 (100)				
Amount Paid		394.2857	176.47339	200.00	600.000
Knapsack Sprayer					
Usage	35 (100)				
Amount Paid		135.5714	103.60964	70.000	450.000
Modernized Irrigation Facilities					
Usage	1(2.9)				
Amount Paid		650.000	25.495	650.000	650.000
Hoes					
Usage	1(2.9)				
Amount Paid		20.000	4.472	20.000	20.000
Watering Can					
Usage	1 (2.9)				
Amount Paid		20.000	4.472	20.000	20.000
Waterholes					
Usage	0(0.0)				
Amount Paid		00	00	00.000	00.000
Cutlass					
Usage	35 (100)				
Amount Paid		30.14	1.91	25.00	40.00

Appendix C2: Fixed Cost Items for Garden Eggs Farmers of the study

VARIABLE	N (%)	MEAN	STD DEV	MIN	MAX
Land					
Usage	24 (100)				
Amount Paid		337.500	123.579	200.00	600.000
Knapsack Sprayer					
Usage	24 (100)				
Amount Paid		286.875	148.784	75.000	550.000
Modernized Irrigation Facilities					
Usage	2 (8.3)				
Amount Paid		650.000	25.495	650.00	650.000
Hoes					
Usage	1(4.2)				
Amount Paid		30.000	5.477	30.000	30.000
Watering Can					
Usage	00 (00)				
Amount Paid		00.000	00.000	00.000	00.000
Waterholes					

Usage	2 (8.3)				
Amount Paid		150.000	12.247	150.000	150.000
Cutlass					
Usage	24 (100)				
Amount Paid		30.625	3.987	25.000	40.000

Appendix C3: Fixed Cost Items for both Okra and Garden Eggs Farmers of the Study

VARIABLE	N (%)	MEAN	STD DEV	MIN	MAX
Land					
Usage	91 (100)				
Amount Paid		387.143	197.311	150.00	1000.000
Knapsack Sprayer					
Usage	91 (100)				
Amount Paid		252.363	151.049	70.000	650.000
Improved Irrigation Facilities					
Usage	13 (14.3)				
Amount Paid		644.615	91.526	500.00	900.000
Hoes					
Usage	8 (8.8)				
Amount Paid		28.750	3.536	20.000	30.000
Watering Can					
Usage	2 (2.2)				
Amount Paid		75.000	7.071	70.000	80.000
Waterholes					
Usage	10 (11.0)				
Amount Paid		154.000	25.033	100.000	200.000
Cutlass					
Usage	91 (100)				
Amount Paid		29.495	2.558	25.000	40.000

Appendix C4 : Variable Cost Items for Okra Farmers of the Study

VARIABLE	N (%)	MEAN	STD DEV	MIN	MAX
Land Preparation					
Usage	35(100)				
Amount Paid		284.286	162.595	100.000	800.000
Pesticides					
Usage	28 (80)				
Amount Paid		142.857	22.420	100.000	200.000
Labor Cost Of Loading & Unloading					
Usage	35(100)				
Amount Paid		297.143	214.525	200.000	1000.000
Transplanting					
Usage	00(00)				
Amount Paid		00.00	00.00	00.000	000.000
Labor Cost Of Preproduction					
Usage	35(100)				
Amount Paid		365.429	266.969	140.000	1600.000
Labor Cost Of Production					
Usage	35(100)				
Amount Paid		396.571	250.939	150.000	1200.000
Seed					
Usage	35 (100)				
Amount Paid		0.000	0.000	0.000	0.000
Nursery Expenses					
Usage	00 (00)				
Amount Paid		0.000	0.000	0.000	0.000
Transport					
Usage	35 (100)				
Amount Paid		422.857	218.734	150.000	1300.000
Fertilizer					
Usage	35 (100)				
Amount Paid		414.429	186.409	120.0000	900.000
Labor Cost of Harvesting					
Usage	35 (100)				
Amount Paid		465.714	318.723	300.000	1800.000
Insecticides					
Usage	35 (100)				
Amount Paid		315.429	156.738	200.000	1000.000
Weedicides					
Usage	27 (77.1)				
Amount Paid		303.333	119.808	180.000	800.000

Appendix C5: Variable Cost Items for Garden Eggs Farmers of the Study

VARIABLE	N (%)	MEAN	STD DEV	MIN	MAX
Land Preparation					
Usage	24(100)				
Amount Paid		633.626	446.914	150.000	2000.000
Pesticides					
Usage	24 (100)				
Amount Paid		282.714	140.103	100.000	500.000
Labor Cost Of Loading & Unloading					
Usage	24 (100)				
Amount Paid		822.967	648.998	200.000	3500.000
Transplanting					
Usage	24 (100)				
Amount Paid		220.602	105.972	30.000	600.000
Labor Cost Of Preproduction					
Usage	24 (100)				
Amount Paid		742.253	550.814	180.000	2500.000
Labor Cost Of Production					
Usage	24 (100)				
Amount Paid		1054.835	717.188	200.000	3000.000
Seed					
Usage	24 (100)				
Amount Paid		0.000	0.000	0.000	0.000
Nursery Expenses					
Usage	24 (00)				
Amount Paid		48.742	30.104	20.000	150.000
Transport					
Usage	24 (100)				
Amount Paid		1032.890	817.829	120.000	4800.000
Fertilizer					
Usage	24 (100)				
Amount Paid		1360.471	745.774	150.0000	4000.000
Labor Cost Of Harvesting					
Usage	24 (100)				
Amount Paid		1216.868	824.919	200.000	4200.000
Insecticides					
Usage	24 (100)				
Amount Paid		847.912	652.963	200.000	4500.000
Weedicides					
Usage	18 (75)				
Amount Paid		564.684	306.644	200.000	1200.000

Appendix C6 : Variable Cost Items for Okra and Garden Eggs Farmers of the Study

VARIABLE	N (%)	MEAN	STD DEV	MIN	MAX
Land Preparation					
Usage	91 (100)				
Amount Paid		707.083	500.334	100.000	1600.000
Pesticides					
Usage	72 (79.1)				
Amount Paid		337.619	144.149	120.000	500.000
Labor Cost Of Loading & Unloading					
Usage	91 (100)				
Amount Paid		816.667	651.030	200.000	2500.000
Transplanting					
Usage	91 (100)				
Amount Paid		232.747	95.720	90.000	600.000
Labor Cost Of Preproduction					
Usage	91 (100)				
Amount Paid		850.000	761.640	150.000	2400.000
Labor Cost Of Production					
Usage	91 (100)				
Amount Paid		1331.250	772.322	200.000	2400.000
Seed					
Usage	91 (100)				
Amount Paid		0.000	0.000	0.000	0.000
Nursery Expenses					
Usage	91 (100)				
Amount Paid		49.311	30.418	20.000	150.000
Transport					
Usage	91 (100)				
Amount Paid		954.167	483.627	250.000	1900.000
Fertilizer					
Usage	91 (100)				
Amount Paid		1388.901	625.372	400.0000	3200.000
Labor Cost Of Harvesting					
Usage	91 (100)				

Amount Paid		1070.833	571.055	200.000	2400.000
Insecticides					
Usage	91 (100)				
Amount Paid		877.500	504.236	200.000	2000.000
Weedicides					
Usage	76 (83.5)				
Amount Paid		586.974	290.746	200.000	1600.000

Appendix C7

OKRA

COBB-DOUGLAS FUNCTION

final maximum likelihood estimates

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	2.5647e+00	2.3713e-01	10.8154	< 2.2e-16	***
LogCapitalHect	5.9289e-02	7.9022e-02	0.7503	0.4530777	
LogLabourHect	-9.6600e-03	1.2581e-01	-0.0768	0.9387952	
LogFertHect	-3.1337e-02	8.5723e-02	-0.3656	0.7146932	
LogAgrochemHect	4.2076e-01	1.3735e-01	3.0634	0.0021881	**
LogOthersHect	-3.7668e-02	1.3080e-01	-0.2880	0.7733654	
Z_(Intercept)	-6.7814e+00	1.7672e+00	-3.8373	0.0001244	***
Z_Age	3.5391e-02	1.0264e-02	3.4482	0.0005644	***
Z_Yearsofformaleducation	-1.0473e-01	2.7325e-02	-3.8327	0.0001268	***
Z_householdsize	4.1332e-01	1.0102e-01	4.0915	4.286e-05	***
Z_FarmSizeHectare	1.9028e+00	4.8009e-01	3.9635	7.387e-05	***
Z TimesofAccessingExtensionSer	4.9822e-01	1.2197e-01	4.0846	4.416e-05	***
Z_AccessToCredit	-4.9275e-02	1.2421e-01	-0.3967	0.6915804	
Z_FarmerGroup	-2.3513e+00	6.2754e-01	-3.7469	0.0001791	***
sigmaSq	7.4525e-03	1.6106e-03	4.6271	3.708e-06	***
gamma	1.0000e-08	4.0489e-07	0.0247	0.9802959	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

log likelihood value: 53.76623

total number of observations = 53

mean efficiency: 0.9288654

LIKELIOOD RATIO TEST FOR OLS AND COBB-DOUGLAS

Likelihood ratio test

Model 1: OLS (no inefficiency)

Model 2: Efficiency Effects Frontier (EEF)

 #Df LogLik Df Chisq Pr(>Chisq)

1 7 27.318

2 16 53.766 9 52.896 1.427e-08 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

LIKELIHOOD RATIO TEST FOR COBB-DOUGLAS AND TRANSLOG

Model 1: cobb_doug2

Model 2: translog2

 #Df LogLik Df Chisq Pr(>Chisq)

1 16 53.766

2 31 222.933 15 338.33 < 2.2e-16 ***

Appendix C8

GARDEN EGGS

COBB-DOUGLAS

final maximum likelihood estimates

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	3.8781440	0.4822840	8.0412	8.896e-16	***
LogCapitalHect	-0.0124312	0.0577406	-0.2153	0.8295387	
LogLabourHect	-0.1893184	0.1241332	-1.5251	0.1272285	
LogFert	0.3491569	0.0946594	3.6886	0.0002255	***
LogAgrochem	-0.2422116	0.0774263	-3.1283	0.0017583	**
LogOthersHect	0.1862332	0.0969396	1.9211	0.0547158	.
Z_(Intercept)	1.2700228	0.4642682	2.7355	0.0062279	**
Z_Age	0.0080671	0.0057372	1.4061	0.1596939	
Z_Yearsofformaleducation	0.0385417	0.0246244	1.5652	0.1175409	
Z_householdsize	0.0504298	0.0441855	1.1413	0.2537360	
Z_FarmsizeHectare	-6.0027791	2.6921097	-2.2298	0.0257629	*
Z_AH	0.0957794	0.0853736	1.1219	0.2619112	
Z_AccessToCredit	-0.1407304	0.1016306	-1.3847	0.1661366	
Z_FarmerGroup	0.9477339	0.0974810	9.7222	< 2.2e-16	***
sigmaSq	0.0130197	0.0044963	2.8956	0.0037838	**
gamma	0.8386474	0.0686560	12.2152	< 2.2e-16	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

log likelihood value: 69.06679

total number of observations = 59

mean efficiency: 0.8431581

LIKELIHOOD RATIO TEST FOR OLS AND COBB-DOUGLAS

Likelihood ratio test

Model 1: OLS (no inefficiency)

Model 2: Efficiency Effects Frontier (EEF)

```
  #Df  LogLik Df  Chisq Pr(>Chisq)
1   7 -12.600
2  16  69.067  9 163.33  < 2.2e-16 ***
```

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

LIKELIHOOD RATIO TEST FOR COBB-DOUGLAS AND TRANSLOG

Model 1: cobb_doug1

Model 2: translog1

```
  #Df LogLik Df  Chisq Pr(>Chisq)
1  16 69.067
2  31 98.550 15 58.967  3.793e-07 ***
```

Appendix C9

OKRA AND GARDEN EGGS

final maximum likelihood estimates

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	4.2279976	0.5146291	8.2156	< 2.2e-16	***
LogCapitalHect	-0.0736237	0.1073685	-0.6857	0.492895	
LogLaborhect	-0.3498197	0.1875673	-1.8650	0.062176	.
LogFertHect	0.0633138	0.1592147	0.3977	0.690879	
LogAgrochemHect	0.3928370	0.1472250	2.6683	0.007624	**
LogOthersHect	0.2786612	0.2097436	1.3286	0.183987	
Z_(Intercept)	2.1089835	0.2780379	7.5852	3.319e-14	***
Z_Age	-0.0012320	0.0029271	-0.4209	0.673838	
Z_Yearsofformaleducation	-0.0229079	0.0058811	-3.8952	9.813e-05	***
Z_householdsize	-0.0160824	0.0120125	-1.3388	0.180635	
Z_FarmSizeperHectare	-0.7886232	0.1356430	-5.8140	6.101e-09	***
Z_AccessToCredit	-0.0251731	0.0552801	-0.4554	0.648840	
Z_FarmerGroup	0.0542954	0.0652349	0.8323	0.405236	
sigmaSq	0.0808224	0.0084423	9.5735	< 2.2e-16	***
gamma	1.0000000	0.0900691	11.1026	< 2.2e-16	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

log likelihood value: -25.5276

mean efficiency: 0.3227003

Likelihood ratio test

Model 1: OLS (no inefficiency)

Model 2: Efficiency Effects Frontier (EEF)

```
  #Df  LogLik Df  Chisq Pr(>Chisq)
1   7 -50.654
2  15 -25.528  8 50.252  1.663e-08 ***
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> lrtest(cobb_doug5, translog5)
Likelihood ratio test
Model 1: cobb_doug5
Model 2: translog5
  #Df   LogLik Df  Chisq Pr(>Chisq)
1  15 -25.5276
2  30  -1.7779 15 47.499  3.062e-05 ***
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

APPENDIX D

KNOWLEDGE

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.522[a]	.273	.159	2.59436	.273	2.400	20	128	.002

a. Predictors: (Constant), 22. Who do you sell your product to?, HouseHold Postion, 9.Do you use any form irrigation facility, 6. Do you grow only okra and/garden eggs on your farm?, 6. Marital Status, 8. Main Occupation, 17. What is the source of extension service?, Land Status, _2_What_is_the_size_getable_farm_acres, 18. Do you have acess to credit?, _21_Do_you_belong_to_nization_association, Level Formal Edu, Source of Labor, 3. What is your annual farm income?, 15. If yes to question 14, how many times in a planting season?, 11. Please indicate your household size, 4. How long have you been a vegetable farmer?, 2. Age at last birthday years?, 5. Years of formal education, 1. Gender

ATTITUDE

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.560[a]	.313	.206	1.80725	.313	2.922	20	128	.000

a. Predictors: (Constant), 22. Who do you sell your product to?, HouseHold Postion, 9.Do you use any form irrigation facility, 6. Do you grow only okra and/garden eggs on your farm?, 6. Marital Status, 8. Main Occupation, 17. What is the source of extension service?, Land Status, _2_What_is_the_size_getable_farm_acres, 18. Do you have acess to credit?, _21_Do_you_belong_to_nization_association, Level Formal Edu, Source of Labor, 3. What is your annual farm income?, 15. If yes to question 14, how many times in a planting season?, 11. Please indicate your household size, 4. How long have you been a vegetable farmer?, 2. Age at last birthday years?, 5. Years of formal education, 1. Gender

SKILLS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.596[a]	.356	.255	2.27781	.356	3.534	20	128	.000

a. Predictors: (Constant), 22. Who do you sell your product to?, HouseHold Postion, 9.Do you use any form irrigation facility, 6. Do you grow only okra and/garden eggs on your farm?, 6. Marital Status, 8. Main Occupation, 17. What is the source of extension service?, Land Status, _2_What_is_the_size_getable_farm_acres, 18. Do you have acess to credit?, _21_Do_you_belong_to_nization_association, Level Formal Edu, Source of Labor, 3. What is your annual farm income?, 15. If yes to question 14, how many times in a planting season?, 11. Please indicate your household size, 4. How long have you been a vegetable farmer?, 2. Age at last birthday years?, 5. Years of formal education, 1. Gender

ASPIRATION

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.542[a]	.294	.184	2.87871	.294	2.667	20	128	.000

a. Predictors: (Constant), 22. Who do you sell your product to?, HouseHold Postion, 9.Do you use any form irrigation facility, 6. Do you grow only okra and/garden eggs on your farm?, 6. Marital Status, 8. Main Occupation, 17. What is the source of extension service?, Land Status, _2_What_is_the_size_getable_farm_acres, 18. Do you have acess to credit?, _21_Do_you_belong_to_nization_association, Level Formal Edu, Source of Labor, 3. What is your annual farm income?, 15. If yes to question 14, how many times in a planting season?, 11. Please indicate your household size, 4. How long have you been a vegetable farmer?, 2. Age at last birthday years?, 5. Years of formal education, 1. Gender

COMPETENCIES

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.605[a]	.366	.267	.27622	.366	3.695	20	128	.000

a. Predictors: (Constant), 22. Who do you sell your product to?, HouseHold Postion, 9.Do you use any form irrigation facility, 6. Do you grow only okra and/garden eggs on your farm?, 6. Marital Status, 8. Main Occupation, 17. What is the source of extension service?, Land Status, _2_What_is_the_size_getable_farm_acres, 18. Do you have acess to credit?, _21_Do_you_belong_to_nization_association, Level Formal Edu, Source of Labor, 3. What is your annual farm income?, 15. If yes to question 14, how many times in a planting season?, 11. Please indicate your household size, 4. How long have you been a vegetable farmer?, 2. Age at last birthday years?, 5. Years of formal education, 1. Gender

APPENDIX E

Linear regression

binbenfiting	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
experience	.452	.122	3.72	.001	.207	.697	***
binposition	.248	.234	1.06	.294	-.222	.719	
gender	.215	.151	1.43	.161	-.089	.518	
age	.14	.118	1.19	.242	-.098	.377	
roboticused	-.189	.139	-1.35	.182	-.47	.092	
Constant	.274	.509	0.54	.594	-.753	1.3	

Mean dependent var	1.380	SD dependent var	0.490
R-squared	0.283	Number of obs	50
F-test	3.479	Prob > F	0.010
Akaike crit. (AIC)	64.956	Bayesian crit. (BIC)	76.428

*** *p<.01, ** p<.05, * p<.1*

Tests of endogeneity

Ho: variables are exogenous

Durbin (score) chi2(3) = .426692 (p = 0.9347)

Wu-Hausman F(3,132) = .128089 (p = 0.9433)