UNIVERSITY FOR DEVELOPMENT STUDIES

ADOPTION, TECHNICAL EFFICIENCY AND WELFARE EFFECTS OF ORGANIC VEGETABLE PRODUCTION IN THE NORTHERN REGION OF GHANA

BY

VIVIAN FIATUSEY BOATENG

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VIVIAN FIATUSEY BOATENG

(M.PHIL. AGRICULTURAL ECONOMICS)

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THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE (PhD) IN AGRICULTURAL ECONOMICS

MARCH, 2018

DECLARATION

Student

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

Vivian Fiatusey Boateng	----------------------	------------------
(Name of Student)	Signature	Date

Supervisors'

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

Prof. Samuel A. Donkoh	----------------------	------------------
(Principal Supervisor)	Signature	Date
Prof. Seidu Al-hassan	----------------------	------------------
(Co – Supervisor)	Signature	Date
Dr. Joseph A. Awuni	----------------------	------------------
(Head of Department)	Signature	Date

ABSTRACT

Health concerns with respect to vegetable production have meant that organic farming is gaining popularity in many countries, including Ghana. This study examines the factors influencing the adoption of organic vegetable technology and the effects on output/technical efficiency and welfare (household's per capita expenditure) in the Northern Region of Ghana. A multi-stage sampling was used to select 400 farmers, consisting of 200 adopters (organic vegetable farmers) and 200 non-adopters (conventional vegetable farmers) and data collected through questionnaire administration. Descriptive statistics were used to analyze farmers' perceptions about the benefits and problems associated with organic vegetable production. Heckman's Treatment Effect model was also used to analyse the theoretical factors that influence the adoption of organic farming technology and its effect on output, technical efficiency and welfare of the farmers involved. From the results, the major perceived benefits of organic farming border on low external input requirement, cost effectiveness and sustainable uses of farm land. The major challenge is the labour intensive nature of organic farming. The adoption of organic farming was positive and significantly influenced by the following: education; farming experience; FBO membership; extension contacts; access to credit; training land ownership; farmers' ability and ownership of resources to cultivate throughout the year; and farmers' ability to make their own inputs.

Variables that were found to improve technical efficiency were farmers' engagement in off-farm activities, training in the farming business and access to external credit support. Households' welfare was also positive and significantly influenced by age, sex, education of the head, farm size, engagement in off-farm activities and extension contacts. Organic vegetable farmers were found to have a higher output, technical efficiency and welfare than that of the conventional farmers. In conclusion, organic vegetable farming can be used as a strategy to improve food production and reduce poverty in the Northern region. For a sustained increase in the production of organic vegetables, farmers should be supported through education and unfettered access to extension services, membership of farmers' organisations, and affiliation with agricultural research organisations. Certification of organic vegetables would also go a long way to build consumers' confidence in organic vegetables and consequently increase their demand for the produce.

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DEDICATION

THIS THESIS IS DEDICATED TO GOD ALMIGHTY FOR HIS GRACE, GUIDANCE AND PROTECTION DURING THE PURSUIT OF THIS WORK. IT IS ALSO DEDICATED TO MY HUSBAND DR. B. OWUSU BOATENG AND TO MY CHILDREN, KALVIN, CATHERINE AND FRED.

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LIST OF ABBREVIATIONS

AU	African Union
CAOF	Coalition for the Advancement of Organic Farming
CMP	Conditional (recursive) Mixed Process
CSRC	Community Self-Reliance Centre
DEA	Data Envelopment Analysis
DITC	International Trade and Commodities
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FBOS	Farmer Based Organisations
FIBL	Research Institute on Organic Agriculture
FYM	Farm Yard Manure
GMOS	Genetically Modified Organisms
GNADO	Gia-Nabio Agro-forestry Development Organization
GOAN	Ghana Organic Agriculture Network
GOG	Government of Ghana
GSA	Ghana Standards Authority
GSS	Ghana Statistical Service
HEISA	High External Inputs Sustainable Agriculture
IARC	International Agency for Research On Cancer

IFOAM	International Federation of Organic Agriculture Movements
IMR	Inverse Mills Ratio
ITFC	Integrated Tamale Fruit Company
LATE	Local Average Treatment Effect
LEISA	Low External Inputs Sustainable Agriculture
MMDA	Municipal Metropolitan and District Assembly
MoFA	Ministry of Food and Agriculture
MRV	Modern Rice Varieties
MTDPS	Annual and Medium Term Development Plans
NGO	Non-Governmental Organization
NPASP	Northern Presbyterian Agricultural Services & Partners
NPDS	Northern Presbytery Development Services
PAS	Presbyterian Agricultural Station
PROTA	Plant Resource and Tropical Africa
PSM	Propensity Score Matching
RUAF	Resource Centres on Urban Agriculture & Food Security
SFA	Stochastic Frontier Approach
TE	Technical Efficiency
UNCTAD	United Nations Conference on Trade and Development
UPA	Urban and Peri-urban Areas

USA	United State of America
YHFG	Youth Harvest Foundation-Ghana
ZEFP	Zagslaari Ecological Farms Project
ZOVFA	Zuuri Organic Vegetable Farmers' Association

CHAPTER ONE

INTRODUCTION

1.1 Background

Notwithstanding the recent oil find, the agricultural sector remains imperative to the economic growth and development of Ghana (FAO, 2011). To ensure sustainable growth and development, goals that are purposed towards ending hunger, achieving food security, and improving nutrition with an overall objective of promoting sustainable agriculture must be encouraged. This research, therefore, tackles organic vegetable production, one of the sub-sectors of agriculture, as the focal point.

In Ghana, vegetables are produced under organic or conventional farming systems or both. A recent advocacy of organic foods has led to an increase in the land that has been earmarked for organic farming from an estimated 5,453 hectares in 2003, 19,132 hectares in 2006 to 26,000 hectares in 2010 (IFOAM & FiBL, 2010). Despite these periodic increases, only 0.13 % of arable land in Ghana is used for organic (vegetable) farming (IFOAM & FiBL, 2010). Organic agriculture is considered a momentous farming system worldwide; it is inexpensive to operate and relies mostly on natural and human resources (Dabbert, 2006; Hole, Wilson, Alexander, Grice & Evans, 2005). Mohammed *et al.* (2014) observed that Ghana has a market potential for organic vegetables to about GH¢ 1,991,224 ($1,640, 083) per annum. This means that if organic vegetable farmers can be efficient in producing organic vegetables they stand the chance of raising their farm income and consequently their welfare.

Organic vegetable production does not only benefit the farmer, it also benefits the consumer. For instance, organic vegetables have recently been promulgated as more wholesome than conventional produce as a result of the latter's tendency of being contaminated by the disproportionate use of agrochemicals (Probst, Houedjofonon, Elysée, Ayerakwa, & Haas, 2012; Nouhoheflin, Coulibaly, Andy, Cherry, & Patrice, 2004). For instance, a study conducted to compare organic vegetables with conventional vegetables (Carrington & Arnett, 2014) found much higher levels of cadmium, a toxic metal, in conventional vegetables and pesticide residues that were four times more often than on organic vegetables. Although the higher levels of cadmium and pesticide residue found in the conventional produce were well below regulatory limits, the researchers explained that cadmium accumulates over time in the body and some consumers may wish to avoid this.

1.2 Policies on Fertiliser Subsidy in Ghana

Poor soil attributes and management practices necessitate the need for an increase in inorganic fertiliser use in order to restore and maintain soil fertility (Minot & Benson, 2009). According to Mokwunye (2011), fertiliser in sub-Saharan Africa is the most expensive in the world, thereby, resulting in its underuse at only 3% of global consumption (7 kg/ha application rate) as compared with the more than 150 kg/ha application rate in Asia (Druilhe & Barreiro-Hurlé, 2012).

The low rate of fertiliser application stagnates production, attenuates soil fertility, and heightens food insecurity. The need for enhancing input subsidies to augment food security, therefore, led to the African Fertiliser Summit of 2006, held in Abuja, Nigeria on the theme, 'Abuja Declaration on Fertiliser for Green Revolution'. The summit led to a resolution by member states to increase fertiliser use to 50 kg/ha by 2015 (AU, 2006).

Nearly twenty years without a nationwide fertiliser intervention exercise by the government of Ghana, a national Fertiliser Subsidy Programme was re-introduced in 2008 (FAO, 2015). The essence of the programme was to increase the rate of fertiliser application in the farming systems, and thus, boost food security and standard of living. In spite of the programme, fertiliser usage is still low (FAO, 2015).

The fertiliser subsidy programme in Ghana started with an initial number of vouchers covering 600,000 bags of 50 kg inorganic fertilizers (subsidised cost of US $15 million). The programme subsidised all-size crop farmers, covering approximately 50 percent of fertiliser prices (FAO, 2015). The farmers obtained the subsidy in the form of fertiliser-specific or region-specific vouchers (Banful, 2009).

Government's support to the fertiliser subsidy programme was scaled-up from US$ 10.8 million in 2008 to US$ 63 million in 2012 in spite of the rising fertiliser prices and budgetary constraints. Accordingly, the overall subsidy was reduced from 53.06% in 2008 to 21% in 2013 (FAO, 2015). Up to about GH¢202.5 million has been invested in the Fertiliser Subsidy Programme since its commencement in 2008 (Fearon, Adraki, & Boateng, 2015). Table 1.1 illustrates summaries/averages of investments made in the Fertiliser Subsidy Programme.

Fearon *et al.* (2015) pointed out that almost six years after its inception, Ghana's Fertiliser Subsidy Programme seems ineffective. Their study indicated that little has been achieved in terms of growth in output since the implementation of the programme, and that, the relationship between crop output and budget on subsidy was weak though positive.

Table 1.1: Annual Quantity and Cost of Fertiliser subsidy in Ghana (2008-2012)

Year	Quantity Disbursed ('000 Tons)	Subsidy cost (GH¢ Million)
2008	43.2	20,654
2009	72.8	34,400
2010	91.2	30,002
2011	176.3	78,746
2012	173.8	117,437
Total	**557.2**	**202,493**

Source: MoFA, 2013

The 2012 budget shows an allocation of GH¢ 292,479 million to MoFA out of a GH¢20,581 billion expenditure (GOG, 2013). This represents merely 1.4% of budgetary allocation to agriculture and a deficit of the proposed 10% at the Abuja Summit.

1.3 Statement of the Research Problem

Vegetables are produced nationwide; they are an essential component of Ghanaians diet and a source of income to the peasantry (Amoah, Debrah, & Abubakari, 2014). The consumption of vegetables is widely known to have several nutritional benefits for human health (IARC, 2003; Rapley & Coulson, 2005).

Vegetable production is influenced by a lot of problems including soil infertility, inadequate rainfall or water supply and pest infestation. This has meant that farmers adopt all kinds of unhealthy farming practices such as the adoption of agrochemicals and the use of waste water. Organic vegetable production is devoid of the use of agrochemicals and other unhealthy practices, relying solely on organic fertilisers and bio-pesticides. Thus it requires good agricultural practices which when dully followed can lead to relatively low cost of production, the production of safer vegetables, and protection of the environment as well as improve the livelihood of the farmers (Probst *et al*., 2012). In other words, given that the production of organic vegetables involves local inputs and practices which are known and accessible to the farmers, they (farmers) would be efficient in their production, resulting in increased output to take advantage of the huge market potential, *ceteris paribus*,. The net effect is that farm incomes would rise and farmers welfare would be enhanced. Conventional farming, on the other hand, involves using synthetic fertilisers and pesticides (though farmers can also use some organic fertilisers and pesticides) which may have a lot of adverse health implications. In the study area some farmers are into conventional vegetable production while others are into organic production. The questions that bother many minds are: what socioeconomic factors distinguish organic vegetable production from conventional vegetable production? And does the production of organic vegetable production means a higher output, efficiency and welfare than the production of conventional vegetables? It is important to know the factors influencing the adoption of organic vegetable production so that stakeholders would be well informed as to the angle from which to encourage and support the production of organic vegetables. Notwithstanding its advantages, very few studies on organic farming are available in West Africa (Kristiansen, Taji, & Reganold, 2006; Sodjinou, Glin, Nicolay, Tovignan, & Hinvi, 2015) and Ghana (Nouhoheflin *et al*., 2004; Owusu & Anifori, 2013; Probst *et al*., 2012). It is hoped that this study would add to the limited literature to help give direction for further research and policy formulation.

The specific research questions are as follows:

1. What factors influence the adoption of organic farming among vegetable producers in the Northern Region?
2. What is the effect of organic farming adoption on output of vegetable farmers?
3. What effect does organic farming adoption have on the welfare of the farmers?
4. How efficient are organic and conventional vegetable farmers?
5. What effects does organic farming have on farmers' technical efficiency?

1.4 Research Objectives

The primary objective of the study is to analyse the factors that determine the adoption of organic[1] vegetable farming and the effects of adoption on vegetable output and farmers' welfare. The study seeks to:

1. Identify the factors influencing the adoption of organic farming among vegetable producers in the Northern Region;
2. Determine the effects of organic farming on output of vegetable farmers;
3. Assess the effects of organic farming on the welfare of farming households;
4. Investigate the levels and determinants of technical efficiency in conventional[2] and organic vegetable production; and
5. Examine the effect of adoption of organic farming on the technical efficiency of farmers.

1.5 Justification and Relevance of the Study

Appetite for organic produce is growing worldwide. This paradigm shift is exhorted in response to concerns about the misuse of agrochemical and their potential effects on human health and the environment. Besides, most farmlands have lost their fertility and need fertilisers for replenishment. On the other hand, pests and diseases continue to threaten food crops, compelling the use of costly and even, banned pesticides.

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[1] This refers to vegetable produced solely by relying on organic fertilisers and bio-pesticides.

[2] Conventional vegetables are vegetables produced either by using synthetic fertilisers and pesticides or both synthetic and organic fertilisers and pesticides.

Meanwhile, most Ghanaian farmers are peasants and cannot afford agrochemicals. Organic farming then becomes a convenient alternative to the peasantry because it relies mainly on ecological processes and the use of natural resources. In Ghana and West Africa at large, most farmers are economically handicapped (NPASP, 2012). While this is the prevalent standard of living among the peasantry, organic farming, however, is expected to advance households' resilience (Glin, Mol & Oosterveer, 2013; NPASP, 2012). Moreover, organic farming is known to be viable in maintaining soil fertility (Hulsebusch, Wichern, Hemann, & Wolff, 2007; NPASP, 2012).

It is also considered as a condiment of sustainable development policies, which provides benefits with respect to biodiversity (Hole *et al*., 2005) and climate protection (Skinner, Gattinger, Muller, Mäder, Fliessbach, Stolze & Niggli, 2014). As a result, in developing countries like Ghana, where national development is anchored on agriculture, the role of organic vegetable production in boosting agricultural sustainability and household resilience cannot be overemphasised. Considering the importance of organic farming, it is important to know the factors influencing the adoption of organic vegetable production and its welfare implications. This would help stakeholders to be well informed on how to encourage and support the production of organic vegetables.

Also, an assessment of farm level technical efficiencies in organic vegetable production would help in the formulation of policies to enable farmers to be more productive through an improved efficiency. This study would also provide policy recommendations to various stakeholders such as government institutions (MoFA) and developmental NGOs on organic farming, and also suggest areas for further research.

1.6 Organisation of the Study

This dissertation is organised into eight chapters. Chapter One entails the background, policies on fertiliser subsidy in Ghana, problem statement, objectives, study justification and organisation of the study. Chapter Two provides the history of organic farming in Ghana and its regulatory framework and policies. It is organised as follows: vegetable production in Ghana, basic concepts of organic agriculture, farmers' motivation for choosing organic farming, definition and nature of organic agriculture, and the current status of organic farming in Ghana. Chapter Three presents a review of the literature on theories of adoption and diffusion of agricultural innovations, determinants of technology adoption in agricultural production, effect of adoption on welfare and technical efficiency. Chapter Four presents the study's conceptual and theoretical framework. Chapter five presents the methodology. It is an overview of the study area, the data used by the study and the analytical models employed. The study results are presented in chapters six, seven and eight. Chapter six presents the results and discussion on farmers' characteristics and benefit of organic farming. Chapter seven examines the factors influencing the adoption of organic farming among vegetable producers and the effects of adoption of organic farming on output and welfare of farm household. Chapter eight contains results on the technical efficiency levels of vegetable farming systems and factors influencing the technical efficiency of vegetable farmers. Chapter nine comprises the summary, conclusions, policy implications and recommendations of the study.

CHAPTER TWO

OVERVIEW OF ORGANIC FARMING IN GHANA

2.1 Introduction

This section is a summary of the history of organic farming and a review of its regulatory framework and policies. It is organised as follows: overview of vegetable production, nature of organic agriculture, the current status of organic farming, and regulations in the organic industry.

2.2 Overview of Vegetable Production in Ghana

Vegetable production and consumption in Africa, and for that matter Ghana, is an ancient practice since it has been practiced for centuries. Between the beginning of the 19th and 20th centuries, the Portuguese and other European traders as well as the Christian Missionaries introduced most vegetables into the Gold Coast (Norman, 2007). Since then, the production of vegetable in the country has become a crucial issue in development of the agricultural sector and the entire economy. In view of this, successive governments have encouraged and supported the agricultural sector by empowering farmers with the necessary technologies to increase food supply, achieve food security, and enhance the welfare of farmers.

According to PROTA, about 6,376 useful indigenous African plants exist, out of which 397 are vegetables (PROTA, 2004). Grubben & Denton (2004) reveal about 64 species of tropical African plants considered as vegetables in Ghana, but only a few are grown, consumed, and traded. The most common vegetables grown in Ghana are tomato, hot pepper, sweet pepper, cabbage, lettuce, green beans, cucumber, onion, okra, and garden eggs (Lester & Seck, 2004 cited in PROTA, 2004). Among these, tomato, pepper, onion, okra, and garden eggs are predominant due to their high demand (Osei, Berchie, Ansah, Ankomah, & Gyasi-Boakye, 2003), while leafy vegetables such as Amaranthus (alefu), Roselle (bra), and white jute (ayoyo) constitute staple food in the three northern regions (Northern, Upper East and Upper West).

Due to poor roads, storage challenges, and high demand among urban dwellers, most vegetables are cultivated in the urban and peri-urban areas (UPA) of Ghana. Amoah *et al*. (2007) expound that many developing countries have meagre transportation alternatives with high transport fares and inadequate storage facilities, thereby, leading to the cultivation of most vegetables in the UPA. This enables consumers to easily obtain vegetables, and producers to save the cost of transportation. In Ghana, urban vegetables are mainly cultivated under irrigation in cities including Tamale, Accra, Kumasi, Cape Coast, and Takoradi. Obuobie *et al*. (2006) established that most vegetable farming in urban Tamale is done along wastewater drains, near dams with small reservoirs, or near dugouts due to the lack of natural water supply in the metropolis.

Vegetable consumption has been on the rise with the prevalence of the fast-food catering service in the country (Norman, 2007). They are rich sources of vitamins, minerals, protein and carbohydrate (Lyatuu, Msuta, and Lebotse, 2009; Muhanji, Ralph, Roothaert, and Mwangi, 2011), and are known to improve the human immune systems, control obesity, chronic diseases, cataract formation, stroke, and malnutrition (Habwe, Walingo and Onyango, 2008; Lyatuu *et al*., 2009). Thus, the production and marketing of vegetables are a means of enhanced livelihood to farmers and market women, (Ghimire & Wen-Chi, 2016).

2.3 Production and Basic Concepts of Organic Agriculture (Vegetables)

2.3.1 Meaning and Production of Organic Agriculture

Owusu & Anifori (2013) and Setboonsarng & Markandya (2015) defined organic vegetables as those produced without agrochemicals. Organic vegetables are produced using organic fertilisers such as compost, farmyard manure (FYM), green manure, and animal manure such as poultry droppings, and cow dung to improve and maintain soil fertility, whereas conventional agriculture makes extensive use of agrochemicals for cultivating vegetables (Setboonsarng & Markandya, 2015).

The definition of organic vegetable production, as farming without agrochemicals, is considered by some academics as too concise and does not highlight key characteristics of the farming systems. Organic agriculture follows the logic of a living organism in which all elements such as soil, plants, farm animals, insects, and the farmer himself are closely linked with one another. Organic farming, therefore, must be thorough in its processes (UNCTAD/DITC/COM, 2003). It depends on crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic wastes and biological pests control to improve and sustain the productivity of the soil. These processes are able to replenish plant nutrients, control weeds, pests (especially insects) and other enemies of crop plants (Olutokunbo & Ibikunle, 2011).

The term ‘organic food’ is closely related to ‘safe food’. Safe food refers to hazard free, organic and green foods (Liu, Pieniak & Verbeke, 2013) including vegetables. Hazard free vegetable produce are those that contain limited or no harmful/toxic residues of agrochemicals or heavy metals. Regulations that govern the distribution and use of pesticides without exceeding the regulatory limit have been implemented in developed countries (Huang, Wu, Rong, You & Jiang, 1999; Sangkumchaliang & Huang, 2012), Burkina Faso (Président du Faso, 1998a, 1998b) and in Ghana (Parliament of the Republic of Ghana, 1965, 1996). In this regard, Burkina Faso with their development partners, the Food and Agriculture Organisation, has adopted an integrated pest management programme to redress issues including plant protection in urban farming systems (MoFA & World Bank, 2008; Nacro, 2007; 2008; RUAF Foundation, 2010).

Green foods are those produced in an environmentally friendly manner. The production process of green foods aims at environmental protection and sustainable development wherein the production process must meet environmental protection standards (Zhang, Zhang, Zhao, Shi, He & Zhang, 2002).

Organic agriculture is growing globally with the corresponding extension of arable land allocated for its purpose (Willer, Lernmoud & Home, 2011). In developing countries, the growth in organic agriculture is mainly attributed to the import of organic food from developed countries (Kilcher and Echeverria, 2010; Parrott, Olesen, and Høgh-Jensen, 2006).

Globally, policy makers are attaching more relevance to the production and consumption of organic products due to its safe nature and environmental friendliness. According to IFOAM (2003) and IFOAM & FiBL (2006, 2010), either organic vegetable or conventional vegetable production has increased from an estimated 5,453 hectares in 2003 to 19,132 hectares in 2006 and to 26,000 hectares in 2010. Ghana's main organic export commodities comprise vegetables and fruits (IFOAM & FiBL, 2006). Motivations for venturing organic farming include its high demand in the international market, especially, Europe and US (Osei-Asare, 2009), where there is a high market premium for organic agricultural products, estimated premium price of 9% to 40% on organic products (Owusu & Anifori, 2013).

Norman (2007) and Nouhoheflin *et al*. (2004) found that organic vegetables contribute significantly to job creation, wealth, and poverty reduction in Ghana. It serves as a valuable input for the local food industry, particularly, restaurants and supermarkets throughout the country. Organic crop production requires a few inputs (Dabbert, 2006; Hole *et al.*, 2005; Thapa & Rattanasuteerakul, 2010) and improves soil quality. Unfortunately, in Ghana, conventional agricultural products predominate instead, thereby, rendering consumers susceptible to the health hazards associated with agrochemicals and heavy metals. This situation, however, can be counteracted by promoting organic crop production and fostering technical competence in the subject.

2.3.2 Why Organic Agriculture?

Though the Green Revolution brought a stupendous increase in agricultural yield, it presented an unforeseen downside UNCTAD/DITC/COM (2003) as follows:

a. Salinisation degraded a vast area of fertile land through the application of fertilisers, while weedicide rendered the land bare and prone to erosion. These situations lead to loss of soil fertility;

b. Overexploitation of freshwater resources through the continuous use of agrochemicals and excessive irrigation led to pollution;

c. Destruction of biodiversity (wild and cultivated plant and animal species);

d. Residues of inorganic fertilisers and pesticides in vegetable crops or drinking water pose a health risk to consumers; and

e. High energy consumption from non-renewable resources since the green revolution involved excessive use of external inputs.

UNCTAD/DITC/COM (2003) further established that budget cut in input subsidies in several countries led to a hike in agricultural inputs while prices of produce continuously decreased. As a result, profit margin from conventional produce became unattractive, thereby making organic farming more viable for its growing market demand, its safe esculence, and revigorating nature to farmlands.

2.4 Farmers' Motivation for Choosing Organic Farming

Farmers are motivated by a number of factors to venture organic agriculture, and several studies (e.g. see Kubala, Grodzińska-Jurczak, Cichoń, and Nieszporek, 2008; Flaten, Lien, Ebbesvik, Koesling, & Valle, 2006) attest to this: Kubala *et al.* (2008) pointed out that these studies have shown that the decision of farmers to venture into organic crop production is determined by the following:

Environmental aspects: According to Flaten *et al.* (2006), farmers' concern about threats to the environment, soil, food safety, and consumer health, due to the use of agrochemicals, encourage them to venture organic farming in order to ensure the production of high quality and healthy organic produce (Ceccarelli, 2014; Magnusson, Arvola, Koivisto Hursti, Aberg, & Sjoden, 2003 and Ludin *et al.*, 2014). For these reasons, Lyons & Burch (2008) affirmed that some farmers convert from conventional farming to organic agriculture because it offers new opportunities to retain soil quality and fertility, enhances agricultural productivity and maintains biodiversity.

Economic aspects: Farmers may switch from conventional farming to organic farming because of the increasing market demand for organic produce, its low cost input methods, and the market premium compared with conventional farming (Benge, Banks, Tillman, & De Silva, 2000; Kler, Sarbjeet, & Walia, 2002; Ramesh, Singh, & Roa Subba, 2005; Reganold, Glover, Andrews & Hinman, 2001).

Ideological aspects: Kubala *et al*. (2008) indicate that this motive includes organic philosophy: living in harmony with nature, antipathy to chemicals, and personal satisfaction.

Producers of organic food products are usually motivated by either of the above mentioned or by few case all. For instance, a farmer may be motivated by both environmental and economic aspects. Flaten *et al.* (2006) explained that one motivation factor could change over time; such as from monetary motive (mostly seen among farmers in the process of switching to organic farming) to environmental motive (also usually seen among farmers involved in organic farming for some time).

Other factors include the level of education, technical know-how, management skills, social pressure, attitude toward innovation, bureaucratic procedures regarding certification, among others (Mignouna, Manyong, Mutabazi, & Senkondo, 2011; Setboonsarng & Markandya, 2015). Due to the high cost of inputs in conventional farming and the viable market for organic produce, many farmers switch from conventional to organic agriculture. This is referred to as financial motivation (Padel, 2001). The study also gave technical reasons that refer to farmers' desire to sustain productivity. Setboonsarng, Leung, & Cai (2006) also explained that one influential factor, especially, during the initial and a transition stage of organic agriculture, is an external support to farmers.

Both Lukas and Cahn (2008) and Setboonsarng & Markandya (2015) revealed that motivation factors that influence farmers' decision to adopt or reject organic farming in

Africa are similar to that of farmers in developed countries. To African farmers, producing wholesome and chemical-free products in a sustainable manner and using less expensive inputs with ready market will increase income. Other reasons mentioned by Lyons & Burch (2008) in their study of organic farmers through case studies of four African countries (Ghana, Egypt, Kenya, and Uganda) are high organic premiums, increased chances for communities to become more self-reliant, and new education and economic opportunities. Other studies such as Lukas & Cahn (2008) further explained that farmers in developing countries are usually motivated to go into organic agriculture as a result of their negative experiences with conventional farming. For example, health problems, continuous diseases and pests infestation, degradation of the ecosystem, and high cost of external inputs such as agrochemicals.

2.5 Nature of Organic Agriculture

Organic farming is a form of agriculture that relies on techniques including crop rotation, green manuring, composting, biological pest control, and mulching. The definition of organic farming varies slightly among countries and regions, depending on regulations. Organic Research Organisations have defined organic farming as production practices and principles that transcend the prohibition of agrochemicals or genetically modified organisms (GMOs). Organic farming is one of the numerous approaches to sustainable agriculture. It emphasises land management and maintains the ecological balance between animal life and the natural environment. Currently, only International Codex Alimentarius Guidelines and International Federation of Organic Agriculture Movements (IFOAM) are sources of general principles of organic farming (FAO, 2002).

The Codex Alimentarius Commission defines organic agriculture as a holistic production management system which enhances ecosystem health, including biological cycles and soil biological activities. Organic agriculture is based on minimising the use of external inputs or avoiding the use of agrochemicals. This, however, does not imply that organic farming practices are devoid of residue but is at its barest minimum. Organic food handlers, processors, and retailers adhere to standards to maintain the integrity of organic agricultural products. The primary goal of organic agriculture is to optimise the health and productivity of interdependent communities of soil life, plants, animals, and people (FAO, 2002).

An alternative definition by IFOAM considers organic farming is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic farming combines tradition, innovation, and science to benefit the shared environment and promotes fair relationships and good quality of life for the people involved (IFOAM, 2008).

The history of organic farming indicates that before conventional farming methods were introduced during the industrial revolution, indigenous Ghanaian farmers were already practising organic farming because of the following reasons:

Organic farming requires less financial inputs. This is because it involves the use of natural production phenomena such as crop rotation, green manuring, composting, biological pest control and mulching, without the use of agrochemicals. These production methods and inputs require minimum capital and are most appropriate for small scale production, usually, in a mixed cropping or mixed farming system where residues from farm animals and other crops are used to fertilise the soil.

Organic farming offers a cooperative advantage in areas with less rainfall and relatively low soil fertility. This is because, contrary to conventional farming, the methods involved in organic farming (crop rotation, green manuring, composting, biological pest control, mulching, among others) aid in soil and water retention. The organic methods maintain soil moisture (water) for a longer period of time by keeping the soil moist which benefits farmers in areas with less rainfall. These methods also favour the growth of soil organisms (by serving as food for them) and retain soil organic matter which improves soil fertility (Berman, 1994; Carter, 2002; Pimentel, Hepperly, Hanson, Douds, & Seidel, 2005).

Organic farming does not require costly investment in irrigation, energy, and external inputs; it is considered as Low External Inputs Sustainable Agriculture (LEISA) and conventional farming as High External Inputs Sustainable Agriculture (HEISA). As elaborated above, organic farming requires no external inputs such as agrochemicals, GMO, and farm implements, among others. LEISA is a system which is more culturally acceptable, ecologically sound, and economically feasible. Soil and water conservation and crop yield achieved under LEISA are more sustainable than those under HEISA (Berman, 1994; Carter, 2002; Pimentel, Hepperly, Hanson, Douds, & Seidel, 2005).

Organic cultivation prevents mutation of human and animal genetics, which creates deformities, diseases, and other health complications. The consumption of food products produced with agrochemicals poses risk to consumers (Chouichom & Yamao, 2010; Nouhoheflin *et al*., 2004; Sangkumchaliang & Huang, 2012). The risk includes cancer, heart diseases, amoebic dysentery, diarrhoea, and reproductive complications such as impotency, low sperm count and infertility. Additionally, agrochemicals cause environmental degradation (Chou, Chen, & Wang, 2012; Kasim & Ismail, 2012). On the other hand, the consumption of organic product poses no health and environmental problem. Organic produce is considered wholesome as compared with conventional produce. This is because organic crops (especially vegetables) are fresher, tastier and healthier than conventional ones (Liu *et al*., 2013).

2.6 Certified and Uncertified Organic Products

Organic standards and procedures regulate the cultivation of organic vegetables. Organic produce is divided into two categories according to their production processes: uncertified organic products and certified organic products. *Uncertified organic products* are produced organically but are not certified by an organic certification body. On the other hand, *certified organic products* are those grown and processed according to strict standards that are verified by an appropriately constituted certification body or authority. A 2004 report by the United Nations Conference on Trade and Development, suggested that organic certification is designed to certify every step of cultivation including harvesting, handling, storage, processing, transportation and marketing to make sure that the products meet the required standards. Certified organic products have the label 'certified' to indicate that the production process meets the organic standard while 'non-certified' labels refer to organic products that are not subject to organic inspection and certification (Parrott *et al*., 2006).

Ghana is one of the African countries that produce organic products. In general, Africa produces both certified and uncertified organic produce. Uncertified organic production is not well documented and a large percentage of this produce cannot be exported (Kotschi, Bayer, Becker, & Schrimpf, 2003). Organic certification is necessary to elicit confidence in consumers. Developing various organic certification standards to meet consumer demand and public concerns is a strategy to enhance consumers' preferences for organic produce (Antle, 1999 cited in CAOF, 2011). Organic labels vary depending on the certification body. This informs the consumer about the type of standards complied with during production. There are many certification bodies, but most available ones in the world market operate from developed countries. Organic standards have four levels.

- *International voluntary standards* including the Codex Alimentarius and IFOAM guidelines. These guidelines are regularly reviewed, particularly, the criteria for permitted substances and the process by which inspection is carried out and certification issued.
- *National mandatory standards:* The Codex Alimentarius and IFOAM guidelines are considered when developing national organic standards. Most national standards are more country specific, including regulations.

- *Local voluntary standards:* These standards respond to a particular consumer's demands in each country.
- *Accreditation:* Certification bodies can apply the authoritative standards such as voluntary international standards or the national mandatory standards and the procedures will be accredited and given formal recognition (UNCTAD, 2004).

2.7 Organic Farming in Northern Ghana

Although most organic farms in northern Ghana are on small scales, they play significant roles in economic activities contributing to the livelihood of people, especially, farmers. Most of the farmers in northern Ghana are poor and would need an effective agricultural strategy to thrive. Though organic farming has been on quite a wide scale since the early 1960's, the desire to meet the demand of a growing population has led to the introduction of agrochemicals despite the health concerns about consumers and the environment.

Organic farming is confronted with several challenges including the non-availability of exclusive market for organic produce, the absence of premium price in the local market, not creating national recognition for organic produce, and a vague policy direction of the organic farming sub-sector. To redress these challenges, there is the need to have a strong organic Producer and Consumers Network or a coalition that will champion the course of organic agriculture. In 2007, the Coalition for the Advancement of Organic Farming (CAOF) was formed by a number of Civil Society Organisations (NGOs) and individual organic farmers from the Northern and Upper East Regions of Ghana. The coalition's aim was to advocate the identification, development, and promotion of best organic/conservation practices as alternatives to agrochemicals in agricultural production (CAOF, 2011).

CAOF is made up of fifteen (15) organisations, namely, the Zuuri Organic Vegetable Farmers' Association (ZOVFA) in the Bawku Municipality, Community Self-Reliance Centre (CSRC), Youth Harvest Foundation-Ghana (YHF-G), Trade Aid Integrated and TRAX (all within the Bolgatanga Municipality and working in the other adjoining districts of Ghana), Presbyterian Agricultural Stations (PAS) of Sandema, Garu, Langbensi and Mile 7 in the Builsa, Garu-Tempani, East Mamprusi and the Tamale Metropolis respectively, Zagslaari Ecological Farms Project (ZEFP) and Chiira Bisi Farms Project (CBFP) in the West Mamprusi District, PEDIC in the Garu-Tempani District, Gia-Nabio Agro-forestry Development Organisation (GNADO) in the Kassena Nankana East and the Integrated Tamale Fruit Company (ITFC) in the Northern Region of Ghana. These fifteen (15) organisations have been promoting organic/ecological agriculture among smallholder farmers in their respective operational areas.

Some members of CAOF have collaborated with the Northern Presbytery Development Services (NPDS) to embark on an advocacy campaign against the misuse of chemical pesticides in the two (2) regions of Ghana (Northern and Upper East). Though all the NPDS Stations are CAOF members, there are other CAOF members who are not involved in the campaign. In addition to this, a work plan for CAOF was developed and taken to MoFA and other relevant state sector organisations including the District/Municipal Assemblies (where coalition members operate) to lobby them to integrate this plan into their Annual and Medium-Term Development Plans (MTDPs) for implementation (CAOF, 2011).

2.8 Regulations in the Ghanaian Organic Industry

2.8.1 Organic Standards in Ghana

The codes of ethics required for the practice of organic agriculture by the Ghana Standards Authority (GSA) are mainly aimed at promoting food safety and the export of healthy food products. This, however, is not well known among the organic producers. Osei –Asare (2009) indicates that only 14% of producers were aware of the existence of such codes of practice in the country. This revelation is quite significant and therefore requires that organisations such as the Ministry of Food and Agriculture (MoFA), the Ghana Organic Agriculture Network (GOAN), and other stakeholders intensify education on the need to comply with internationally accepted standards of organic farming.

GOAN is a private standard accredited by IFOAM. According to GOAN, a fundamental principle in organic farming is to minimise environmental impacts as much as possible while sustaining an economically viable production by avoiding the use of highly soluble mineral, synthetic fertilisers, pesticides and feed additives while maximising animal welfare. These organic standards in Ghana do not differ by meaning, but execution. The organic sector in Ghana consists of semi organic production (partial standards) and full organic systems. The semi organic production system consists of private individual voluntary standards for specialised markets, international phytosanitary requirement (e.g. Blue Sky), and Global GAP and Conservation agriculture, promoted by NGOs. These groups follow the laid down rules to obtain certification for their produce in order to exploit export opportunities.

On the other hand, full organic systems (IFOAM) in Ghana consist of GOAN and organic production for niche export market (ITFC). However, it is important to note that in Ghana, there are certified and uncertified organic produce. Although GOAN is a full organic system that trains farmers to produce organically, most of the produce by members are uncertified. Willer, Yussefi & Sorensen (2008) suggested that most of the organic agriculture in Africa, and for that matter, Ghana, are uncertified and will continue to remain so in the short term. Therefore, it is important to develop and sustain a local market within African countries for these uncertified products and to find an alternative form of standards and certification within the domestic market. This will create Participatory Guaranteed System (PGS) and an Organic Movement for the continent.

Organic agriculture in Ghana is relatively underdeveloped and there are very few certified organic products produced locally. One of the certified organic groups is ITFC. The ITFC produce certified organic mangoes that have been grown and processed according to strict standards and verified by an appropriately constituted certification body or authority (i.e. The Soil Association – UK). Organic production, in this case, promotes self-sufficiency in food production, improves soil fertility and relies heavily on traditional knowledge, increase agricultural productivity while stabilising returns without harming the environment.

2.9 Opportunities in Organic Farming in Ghana

Charnley (2012) in her study on organic production methods by small scale farmers in Ghana, indicated that organic farming helps to provide a safer and healthier environment by not polluting our groundwater, rivers, lakes, and oceans with synthetic pesticides and chemical fertilisers; it reduces soil erosion, improves soil quality, increases diversity of wildlife on and near farms without exposing farm workers to synthetic pesticides.

Economically, the local and international market for organic products has significant prospects for growth. This could lead to increased income and improved living conditions for the producers and exporters of organic produce. Charnley (2012) suggests that Ghana's investment in organic farming could transform the country's agriculture sector and improve the country's economy dramatically by introducing wholesome produce that is more resilient, encouraging the sustainable use of land and producing more nutritious products that have higher market value.

According to Osei-Asare (2009), there is a huge potential for the organic sector in Ghana for both export and domestic consumption. The prospects for producers are high as most consumers were willing to pay a maximum of 20% premium on organic products. Also, CAOF (2011) suggests that consumers are often willing to pay extra if the produce is certified as organic. On the other hand, the certification costs are very high because certification is often done by foreign organisations. As a result, because the produce is not recognised as organic (according to international standards), they do not attract premium prices. Since most of the organic produce in Ghana are uncertified and will continue to remain so in the short term, it is important to develop and sustain a local market within neighbouring African countries for these uncertified organic products, and also, to establish alternative form of standards and certification within the local context (Willer *et al*., 2008).

2.10 Green Label

The Ministry of Food and Agriculture (MoFA) in collaboration with some private sector agencies are facilitating 'Green Labels' which is similar to the PGS in the Organic Movement and appears to be the latest effort by the ministry to promote organic agriculture in Ghana. This will lead to the production of safe vegetables and other food products in the country. In September 2014, MoFA in collaboration with the GSA, vegetable producers and other stakeholders proposed the initiation of 'Green Labels' for the production of, especially, safe vegetables and other food products in the Ghanaian market (MoFA, 2014). This is to ensure that farmers use the best agricultural practices in the production of vegetables, leading to the trademark for hygienic and wholesome vegetables in the country. This initiative by the ministry according to Keraita & Drechsel (2015) is a good approach to ensuring that only hygienically cultivated vegetables will be certified and labelled as wholesome. Consequently, the initiative will either encourage or compel other producers to adopt appropriate agricultural practices (Keraita & Drechsel, 2015).

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

The chapter is a review of literature on organic vegetable production, its adoption, producer welfare, production efficiencies, and related global studies.

3.2 Theories of Adoption and Diffusion of Agricultural Innovations

In understanding what influences a farmer in Northern Region to adopt organic vegetable production, Rogers (1962) Innovation Diffusion Theory is illuminating. This theory seeks to explain how, why and at what rate new ideas and technologies spread through cultures. The study employs the concept of adoption from diffusion of innovations theory as a framework for understanding the elements of the farmers' adoption decisions.

3.2.1 Adoption of Innovations

Diffusion of innovations theory offers a means to evaluate farmers' decision to adopt organic cultivation. The seminal work on diffusion of innovations by the sociologist, Everett Rogers', in 1995 is important for understanding the concept of diffusion. Diffusion is seen as 'the process by which an innovation is communicated through certain channels over time and among members of a social system.' Stoneman (2002) also defines diffusion as 'the process by which new technologies spread across their potential markets over time'. Both definitions emphasise the process of diffusion as an accumulative product of individuals' decision-making on adopting an innovation. Feder

& Umali (1993) expounds adoption as the acceptance or use of an innovation by an individual whereas diffusion refers to a large scale adoption of the innovation by many individuals.

According to Sunding & Zilberman (2001), diffusion is a macro-level concept that focuses on the rate of factors that affect the spread of innovations across a particular population, while adoption is a micro-level concept that considers the factors that affect an individual’s decision to adopt or use an innovation at a particular time. Therefore, in order to examine the individual farmers’ adoption preference, diffusion of innovation theories must be narrowed to the level of the individual’s intellect.

For decades, researchers (Doss, 2006; Feder, Just, and Zilberman, 1985; Lee, 2005) have tried to explain agricultural technology adoption. In simple terms, adoption is the extent to which new technologies or innovations are used. Rogers (1983, 2003) defined innovation as any idea, practice, or object that is perceived as new to a potential adopter. The decision as to whether or not to adopt a new technology depends on a careful evaluation of a number of technical, economic and social factors. Rogers (2003) and Lee (2005) further explained that adoption or non-adoption of an innovation is a decision made by an individual or group.

Donkoh, Tiffin & Srinivasan (2011) also defined adoption as the level of use of a new technology or innovation. Additionally, Bortamuly & Goswami (2015) defined technology adoption as the implementation of knowledge acquired about a specific innovation. Some farmers perceive organic vegetable production as a new concept in farming. Simin & Janković (2014) argued that ecological (or organic) agriculture has existed as a practice in a traditional peasant society, nonetheless, organic agriculture is indeed a modern agricultural practice based on up-to-date scientific knowledge integrated into the indigenous knowledge of local farming practices and circumstances. Although many of the practices involved in organic farming (manure application, crop rotation, and cultural control of insects) are not new to agriculture, organic farming is an innovation because it represents a complex system of change to most conventional agricultural producers (Padel, 2001). Hoffman (2005) opines that a re-invention of an already existing product is an innovation. Therefore, the introduction of a re-invented product to the target market creates the perception of an evolved product for which all the principles of innovation diffusion applies. Thus, although organic fertilisers already exist, any re-invention activity carried out on them can be considered as an innovation. Compost, for instance, can be considered as an innovation. This is because organic farming involves the implementation and commitment to certain production standards which may be new to potential adopters. For this reason, organic farming can be described using the concept of adoption.

As indicated earlier, though interrelated, adoption and diffusion differ. Adoption is said to have taken place when an individual makes use of an innovation while diffusion means spreading the innovation in a community or worldwide (Feder *et al*., 1985). Studies on adoption and diffusion behaviours were undertaken initially by rural sociologists (Feder *et al*., 1985). In econometrics, the study by Mansfield (1963) on industrial innovation and that of Griliches (1957) on hybrid corn offer a good starting point for examining the development of diffusion theory.

3.2.2 Innovation Decision Process

Innovation decision process is a set of actions taken by an individual to accept or reject a new idea. Nmadu, Sallawu and Omojeso (2015) established that the user's ability to access innovation and use it later affects his/her uptake of innovation. They further established that this depends on cultural, socio-economic, personal, political, and geographical variables. According to Rogers (2003, 1995, 1983), an innovation decision process such as the decision to embark on organic farming is characterised in five stages. They are knowledge about the innovation, persuasion, decision, implementation, and confirmation (refer to Figure 3.1 below).

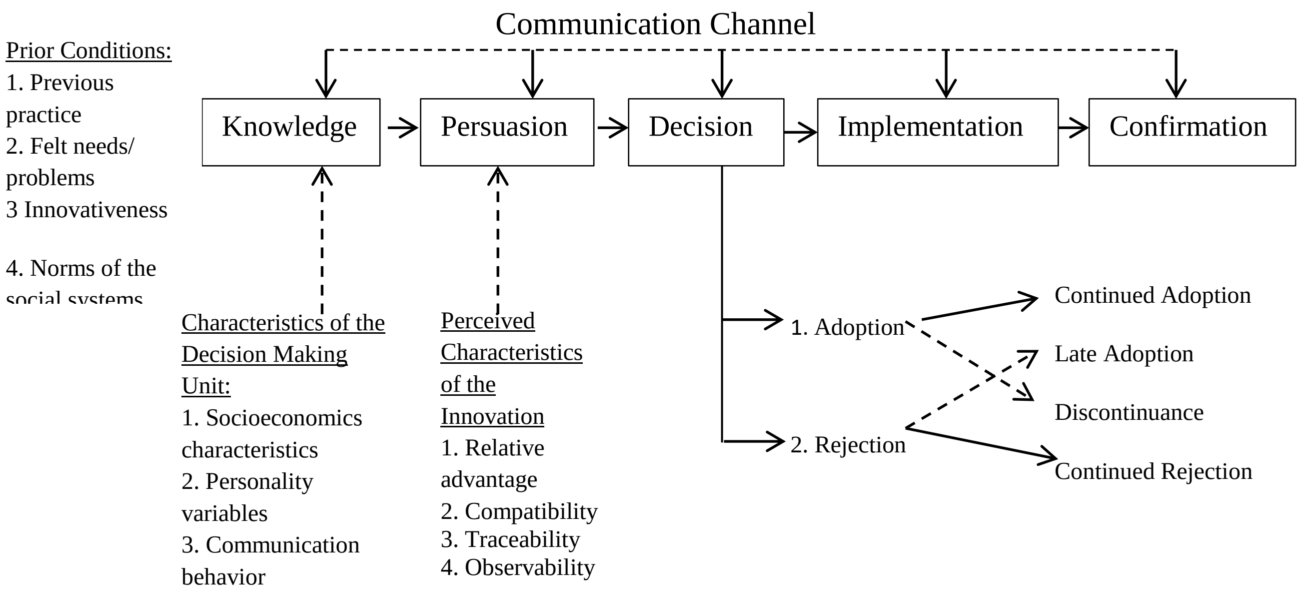

Figure 3.1: Adoption Decision Process (Channels of Communication)

Source: Rodgers (2003)

The knowledge stage is the initial stage when an individual is first exposed to the innovation but does not have enough information about its usefulness. During this stage, the individual learns about the advantages and disadvantages of the innovation and gains some understanding of how it functions. Also at this stage, the individual has not been inspired to find more information about the innovation.

The second stage is the *persuasion stage*. During this stage, the individual gets interested in the innovation and avidly seeks details about it. This occurs when he forms either a favourable or unfavourable attitude towards the innovation, and accordingly, decides to adopt it or not.

The decision stage is when an individual takes the concept of the innovation and weighs the pros and cons of using it and decides whether to adopt or reject it. Prior to the decision stage, the individual engages in activities that lead to a choice to adopt or reject the innovation. Due to the individualistic nature of the decision stage, Rogers (1995) accentuates that it is the most difficult stage to acquire empirical evidence.

Implementation is the fourth stage where the individual puts an innovation to use to a varying degree. During this stage, the individual knows/understands the usefulness of the innovation and may search for further information about it.

Confirmation is the stage at which an individual finalises his/her decision to continue using the innovation and may use the innovation to its fullest potential. He/she consequently makes a decision to adopt or reject it**.**

3.2.3 Individual Innovativeness Theory and Rate of Adoption

According to Rogers (1995), the Individual Innovativeness Theory states that individuals who are predisposed to innovation will adopt an innovation earlier than those who have not been predisposed to innovation. Rogers (2003) uses the concept of individual innovativeness theory to explain who adopts an innovation and when. The author categorised the adopters as innovators, early adopters, early majority, late majority and laggards.

As a new technology is introduced through a communication channel, innovators are normally the first to adopt the new technology, followed by the early adopters. These two groups are the risk takers who would adopt the technology despite the fact that they may not have full knowledge about its prospects. The early majority group usually joins the risk takers when the technology shows positive prospects. The innovators and early adopters convince the early majority and give assurance on the sustainability of the innovation. Farmers in this group deliberate for some time till they gain sufficient experience before adopting. The late majority group is cautious and sceptical people who will not adopt the technology until the large majority group have adopted. The final group is the laggards; they only adopt when they are certain that the technology will not fail; they are usually poor and seldom take risk due to their unstable economic condition. Although some technologies have positive attributes, some farmers may not adopt it. This is because some may not be aware of it, others may not have the means to acquire it, and some would still have some doubts about the technology. Whatever the motivation, they would also have made a decision. It is therefore vital for economists to intensify their studies into farmers' socio-economic, farm characteristics, and other institutional factors that may encourage or discourage the adoption of agricultural innovations.

The third widely-used diffusion theory propounded by Rogers (1995) is the theory of the Rate of Adoption. This theory states that innovations are diffused over time in a pattern that depicts an S-shaped curve when plotted over a period (Rogers, 1995). Bonabana-Wabbi (2002) and Rogers (1983) offer an alternative definition for the rate of adoption. According to Bonabana-Wabbi (2002) and Rogers (1983), the rate of adoption is the relative speed at which an innovation is used continuously and extensively by members of a society. Therefore, innovation goes through a period of slow or gradual growth before experiencing a period of relatively dramatic and rapid growth. An example of how the rate of adoption might typically be represented by an S-curve is shown in Figure 3.2.

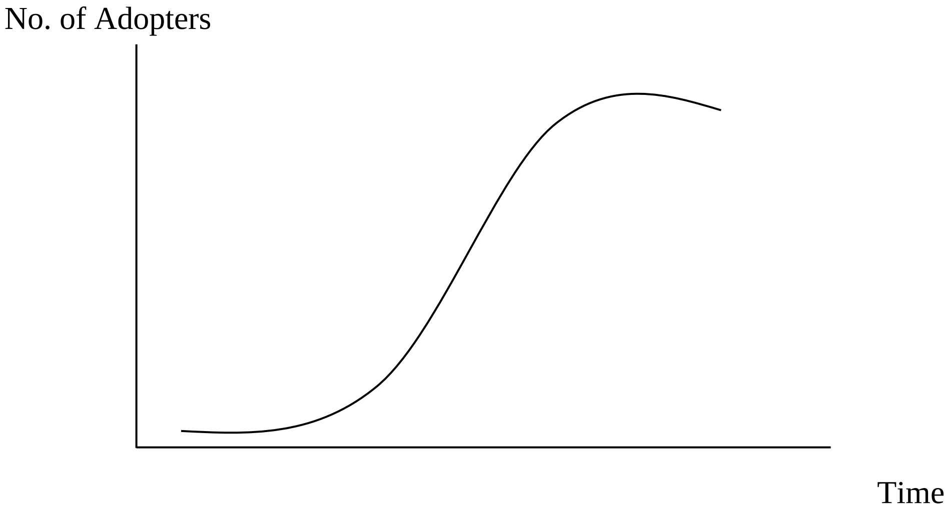

Figure 3.2: The S-Shaped Adoption Curve
Source: Rogers (2003)

The theory further states that, following the period of rapid growth, the rate of innovation adoption will gradually stabilise and eventually decline. This means that when a technology is first introduced, only a few people adopt it at the early stage. Subsequently, as more people adopt it, the rate of adoption increases. This continues until the peak is reached after which the number of adopters begins to decline, leading to a decrease in the rate of adoption. In most cases, the upper limit is reached before all the agents would have adopted. This explains why some people may not adopt an introduced technology at all. Such people may not find the technology to be profitable or feasible. On the other hand, they might have found what they perceive to be more efficient than the technology in question.

3.2.4 Attributes of Innovations

Rogers (1995) identified five characteristics of agricultural innovations, which are important in adoption studies. These attributes are relative advantage, compatibility, complexity, trialability and observability. He further proposes that these attributes help to decrease the uncertainty about innovation.

Organic vegetable production, regarded as an innovation, can be compared with conventional methods of farming in terms of these attributes. The evaluation of these farming methods or technologies should not take into account only the better and easier method to adopt, but also, to consider the farming practices already adopted and its ability to be tried out. Details about these attributes are discussed next.

Relative advantage is the extent to which an innovation is perceived as being better than the existing or previous practice or technology. The concept of relative advantage is often conveyed in economic factors, status aspects, comfort and time issues, incentive payments, and the immediacy of reward. In the case of organic vegetable farming, farmers evaluate the economic factors of organic farming in comparison with conventional farming. Farmers may also perceive a relative advantage in organic farming if they believe an improvement in their social status may result from organic farming. Incentive payments may also influence farmers' adoption by either decreasing the costs of production or increasing income from organic farming. Finally, the duration to realise the benefits of adoption affects potential adopters' perceptions of the innovation's relative advantage.

Rogers (1963) defined compatibility as the degree to which an innovation is perceived to be consistent with the existing values, beliefs, past experiences, and the needs of potential adopters. In terms of agricultural innovations, Yila & Thapa (2008) suggest that farmers' adoption of an innovation is more likely when the innovation is compatible with the farmers' objectives. Because farmers' objectives reflect their values, beliefs, past experiences and needs, there is a relationship between farmers' objectives and farmers' views on the innovation. In the case of organic farming, previous literature calls attention to farmers' values for increasing farm profitability, environmental welfare, health, and animal welfare (Howlett, Connolly, & Cowan, 2002). Farmers who have alluded to these values as motivations for organic farming must have perceived organic farming as a means of achieving their objectives. To these farmers, adoption of organic farming implies meeting their financial, environmental, and health objectives. Additionally, farmers evaluate the innovation of organic farming based on their needs. According to Rogers (1983), potential adopters' needs in relation to the adoption of an innovation may vary with the individual and the specific innovation. With organic farming, several studies indicate that some farmers have adopted organic production as a means to meet their needs of preserving the viability of their farms (Koesling, Flaten, & Lien, 2008; Lauwere, de Buck, Smit, Balk-Theuws, Buurma & Prins, 2004).

Besides the relative advantage and compatibility, simplicity is also an important aspect of adoption. In general, adoption and diffusion occur more rapidly with innovations that are easily understood and used. This is because information about simple innovations is easily obtained in contrast to complex innovation. Adoption rates for simple innovations are usually faster than for complex innovations.

Trialability is the degree to which an innovation could easily be tried by the farmer on his/her farm. Pannel (1999) suggests that farmers' adoption of an innovation is more likely when the innovation is in the pilot phase. This affords the potential adopter to obtain more information about the innovation, and thus, reduce his or her uncertainty concerning the large-scale implementation of the innovation. In the case of organic farming, a farmer may choose to experiment with organic vegetable production by designating only a portion of their farm for the purpose.

Observability is the final attribute of an innovation and it refers to the visibility of an innovation and its results. Higher levels of observability decrease uncertainty about an innovation. Like trialability, observability enables a potential adopter to gather information about an innovation which can be used to make a more informed decision about the technology. For instance, if potential adopters can observe organic farming practices and the effects on neighbouring farms, then they can make more informed decisions about whether or not to adopt organic production on their own farms.

3.3 Determinants of Technology Adoption in Agricultural Production

Uaiene, Arndt & Masters (2009) found that, generally, to explain adoption behaviour and determinants of technology adoption, three paradigms are often used. They are innovation-diffusion model, adoption perception, and economic constraints models. The underlying assumption of the innovation-diffusion model is that the technology is technically and culturally appropriate, but the problem of adoption is one of asymmetric information and very high research cost (Feder *et al*., 1985; Smale, Just, & Leathers, 1994; Shampine, 1998). Diffusion of innovations is also difficult to quantify due to the complex human networks that make it difficult for this theory to account for all the variables which might make one miss the critical predictors of adoption (Damanpour, 1996). The adopters' perception model, on the other hand, suggests that the perceived attributes of the technology modify the adoption behaviour of farmers. This means that even with full farm household information, farmers may subjectively evaluate the technology differently from scientists (Ashby & Sperling, 1995; Kivlin & Fliegel, 1967). Thus, understanding farmers' perceptions of a given technology are crucial in the generation and diffusion of new technologies and farm household information dissemination.

Different factors determine the adoption of different agricultural innovations and technologies (Akudugu, Guo, & Dadzie, 2012). According to Ansah, Eib, & Amoako (2015), demographic factors (such as age, education and religion), economic factors (such as occupation, income), and farm-specific variables (such as firm size, type of enterprise) are important determinants of technology adoption. Mansfield (1963) established that economic factors constitute the most important driving forces affecting technology adoption. Depending on the condition and/or context, certain intrinsic and extrinsic factors, including management and implementation issues may impede adoption of innovations. As a result, economic forces may not necessarily be the major driving forces of technology adoption.

Nmadu *et al.* (2015), Ezeano (2010) and Waqar, Zakir, Hazoor & Ijaz (2008) established that farmers' age, the level of education, farming experience, social status, land ownership, agro-climate, the location of the farm, the size of farm and access to credit affect agricultural technology adoption. Furthermore, the characteristics of the innovation itself such as relative advantage, compatibility, complexity, divisibility and communicability, techniques of communication, the level of participation, and the use of traditional culture also affect agricultural technology adoption. Relative advantage is usually measured in constricted economic terms but non-economic factors such as convenience, satisfaction and social prestige may be equally important. Compatibility with existing practices may also be less important than how they fit in the existing values and norms.

Bonabana-Wabbi (2002), assessed the factors affecting the adoption of agricultural technologies in Kumi District of Eastern Uganda. According to him, factors such as government policies towards a technology, technological change, market forces and environmental influence such as nature of the soil and soil fertility were found to have affected the adoption of agricultural technologies. In addition, the demographic factors such as age and education, and institutional influence such as access to information and the mechanisms for delivering the technology were found to influence the adoption of agricultural technology. Bonabana-Wabbi (2002) also established farm size as the most important factor affecting the adoption of agricultural technologies. This was because farm size affects other determinates of adoption. For instance, farm size affects costs of adoption, risk perceptions in production, labour costs, credit requirements, labour requirements, and land tenure arrangements among others (including: Adesina, Mbila, Nkamleu, & Endamana, 2000; Adesina & Baidu-Forson, 1995; Badgley, Moghtader, Quintero, Zakem, Chappell, Aviles-Vasquez, Samulon & Perfecto, 2007; Bayard, Jolly, & Shannon, 2007; Daberkow & McBride, 1998; Honlonkou, 2004; Javanmard & Mahmoudi, 2008; Karimi, 2011; Nkonya, Schroeder, & Norman, 1997; Place & Dewees, 1999; Ransom, Paudyal, & Adhikari, 2003).

Recent studies include Sodjinou *et al*. (2015) which assessed institutional and socioeconomic factors determining farmers' decisions to adopt organic cotton in Benin. From the results of the study, it is clear that organic cotton farming is more attractive to women as opposed to conventional farming. The study by Sodjinou *et al.* (2015) brought on board, the effect of gender on adoption in a better perspective. Education was also found to be important in the adoption of organic farming. The authors noted that a person who has attained some form of primary education has a higher probability of adopting organic farming, *ceteris paribus*. They also found that older and poorer farmers are more likely to adopt organic farming because they cannot afford external inputs required for conventional production. In addition, the study found that farmers who have their farm near home are more likely to adopt organic farming than those who have their farms afar. They further explained that farmers who have more contacts with advisory and extension services are more likely to adopt organic farming.

Hattam & Holloway (2006), in studying the determinants of adoption of certified organic avocado production in Mexico, highlighted the importance of management, economic, and social factors as determinants of organic avocado production. The result indicated that the adoption of organic farming is positively influenced by the production cost per hectare, whether the inputs were homemade, and whether a farmer belongs to a farmer based association or not.

Kassie, Zikhali, Manjur, & Edwards (2010) investigated the factors influencing farmers' decisions to adopt sustainable agricultural production, with a focus on conservation tillage and compost in a semi-arid region of Tigray in Ethiopia. The results of this study suggest that both socioeconomic and plot characteristics are significant in conditioning the households' decisions to adopt sustainable agricultural production. The researchers also indicate that there was a heterogeneity with regard to factors influencing the choice to adopt compost and/or conservation tillage. They further established that poverty, and access to information, among others, influenced the choice of farming practices significantly. It is also evident from the study that a female farmer is more likely to adopt the use of compost while a male farmer is more likely to either adopt conservation tillage or to combine it with the use of compost.

In other studies, Anderson, Jolly, & Green (2005) examined the factors that influence farmers' decision to adopt organic production. The result indicated that the use of direct marketing, the number of crops and acres, and the age of the farmer are significant determinants of the choice to adopt organic farming. The results of this study also indicated that gross sales revenue positively and significantly influenced the adoption of organic farming. Kubala *et al*. (2008) further added that age, the level of education, farming experience, the size of farm, type of crop being cultivated, economic conditions, among other variables determine whether a farmer will adopt either organic or conventional farming. Koesling *et al*. (2008) and Padel (2001) reported that organic farmers are better educated than conventional farmers, with another study buttressing that in Norway, 73% of organic farmers had obtained agricultural and/or university education.

In Nigeria, Awotide, Karimov, & Diagne (2016) worked on agricultural technology adoption and found that rice farming was dominated by relatively young and less educated people. The variables that positively and significantly influenced the intensity of improved rice variety (IRVs) adoption include income from rice production, membership with a farmers' based organisation, cost of seed, and yield. In this study, the authors also found that distance to the nearest sources of seed and level of training are a driving force in the adoption of agricultural technology. Karki, Schleenbecker, & Hammb (2011) concluded that farmers located at a distance from regional markets, older in age, better trained, affiliated to institutions and having larger farms are more likely to adopt organic farming.

Qualls, Jensen, English, Larson, & Clark (2011) established that off-farm and on-farm income are factors that have been analysed by many adoption studies. The effect of off-farm work on innovation adoption is analysed in multiple studies (including Adesina, 1996; Fernandez-Cornejo, Hendricks, & Mishra, 2005; Jensen, Clark, Ellis, English, Menard, Walsh, and Ugarte, 2007). Jensen *et al*. (2007) found off -farm work to have no effect on the share of acres adopted, Fernandez-Cornejo *et al*. (2005) found it to have a statistically significant positive effect on the adoption of an innovative practice while Norris & Batie (1987) found it to have a statistically significant negative effect on the adoption of an innovation. The effect of on-farm income on innovation adoption has also been analysed by numerous studies (including Ellis, 2006; Jensen *et al*., 2007; Norris & Batie, 1987). Ellis (2006) established that, having a farm income lower than 75,000 dollars had a negative effect on adoption. Jensen *et al*. (2007) postulated that greater on-farm income would have a positive effect on the adoption of a new crop, but on-farm income per hectare would have a negative effect due to the increased opportunity cost of converting hectares to switch-grass. Norris & Batie (1987) shows that income had a positive effect on new conservation techniques.

Age is an important factor that influences the probability of adopting new technologies because it is said to be a primary latent characteristic in adoption decisions. However, there is a contention on the direction of the effect of age on adoption (Akudugu *et al.*, 2012). Ogada, Germano, & Diana (2014) indicate that age has a negative effect on adoption of technologies, while Jensen *et al*. (2007) points out age as an insignificant to the adoption decision making.

Awotide *et al*. (2016) and Simtowe, Asfaw & Abate (2016) came out with similar findings that young people are less risk-averse to adopting innovations than the aged. Other studies stressed that age has been found to be either negatively correlated with adoption, or insignificant to farmers' adoption decisions (Burton, Rigby, & Young, 2003; Hattam & Holloway, 2006; Sodjinou *et al.*, 2015). However, age was found to have positively influenced the adoption of modern rice varieties in Nepal (Ghimire & Wen-Chi, 2016), IPM on peanuts in Georgia (McNamara, Wetzstein, & Douce, 1991), and chemical control of rice stink bug in Texas (Harper, Rister, Mjelde, Drees, & Way, 1990).

Education is considered to enhance the human mentality, and therefore, influences the attitude of an individual towards innovations positively. There are several examples in other studies showing that attaining a higher level of education has a positive effect on innovation adoption (examples: Demiryurek, 2010; Jensen *et al.*, 2007; Mzoughi, 2011). Bortamuly & Goswami (2015), Mariano, Villano, & Fleming (2012) and Paudel & Matsuoka (2008) argued that while education may foster technology adoption, it may also cause people to switch over to some other activities instead of adopting expensive technologies. Akudugu *et al*. (2012) asserted that numerous studies that sought to establish the effect of education on adoption in most cases relate it to years of formal schooling. According to their discussions, education creates a favourable mental attitude for the acceptance of new practices, especially, information-intensive and management-intensive practices.

Other factors underscored in other literature are the complexity of adopting a technology and access to credit. To Akudugu *et al*. (2012), access to funds including credit, is expected to increase the probability of adoption. For instance, it has been reported that most small scale farmers in the country are unable to afford basic production technologies such as fertilisers and other agrochemicals resulting in low crop yield (MoFA, 2010). According to Ehler & Bottrell (2000) and Rogers (1983), technology complexity has a negative effect on adoption and this could only be dealt with through education. Aside the above factors, Cruz (1987) pointed out that the characteristics/attributes of the technology, that of the adopters/clientele, the change agents (extension worker, professional, among others) and the socio-economic, biological and physical environment in which the technology takes place influence the adoption of technology.

The effect of farm size on adoption could be positive, negative or neutral. For example, a number of studies have shown that farm size has a positive effect on adoption and the extent of adopting agricultural innovations (Adesina & Baidu-Forson, 1995; Akudugu *et al*., 2012; Ghimire & Wen-Chi, 2016; Ransom *et al*., 2003). According to Akudugu *et al*. (2012), most empirical studies on adoption have found farm size as the first and perhaps the most significant determinant of technology adoption since it can affect and be affected by other factors influencing adoption. Conversely, Jensen *et al.* (2007) found that farm size did not have an impact on the adoption of switch-grass in Tennessee. Additionally, Yaron, Dinar, & Voet (1992) and Harper *et al.* (1990) found a negative relationship between adoption and farm size. Studies (such as Jensen *et al.* 2007; Ellis, 2006; Fernandez-Cornejo, Beach, & Huang, 1994; Fernandez-Cornejo, Daberkow & McBride, 2001) have analysed the effect of land ownership on adoption. According to them, sole ownership of land influences the adoption of agricultural technology positively.

Analysis of the above literature shows that several studies have been conducted on adoption of organic farming in developed countries, with very little work done in Africa and for that matter Ghana, to the best of the researcher's knowledge. The socioeconomic and cultural environment in the developed countries is obviously different from that of Ghana. Besides, technology adoption is not an end in itself, it is a means to attaining economic wellbeing. It is against this backdrop that this study was undertaken to investigate the location-specific socioeconomic factors that influence the adoption of organic vegetables and the effects on output, technical efficiency and welfare of vegetable farmers in the northern region of Ghana.

3.4 The Effect of Agricultural Technology Adoption on Farmers Welfare

All over the world, technology adoption is seen as a practical means of boosting productivity, enhancing household income, reducing rural poverty and ensuring food security (Abebe, Bijman, Pascucci & Omta, 2013; Adeoti, 2009; Asfaw, Shiferaw, Simtowe, & Lipper, 2012; Fisher & Kandiwa, 2014; Kabunga, Dubois, & Qaim, 2014; Mariano, *et al.*, 2012; Minten & Barrett, 2008; Randela, Alemu, & Groenewald, 2008).

The economic impact evaluation literature has been growing in recent years. This progress is mainly focused on the social sectors where the indicators of its impact tend to be easily identifiable (Winters, Maffioli, & Salazar, 2011). Rigorous impact evaluations of agricultural interventions have, however, been relatively scarce, especially in developing countries (Del Carpio & Maredia, 2009; González-Flores, Bravo-Ureta, Solís, & Winters, 2014; IDB., 2010). The Stochastic Frontier Analysis (SFA) is a widely used econometric technique that estimates the 'best practice' relationship between input and output of the farm households in the sample. In addition, SFA can help identify the levels of efficiency (or inefficiency). Hence, combining SFA with impact evaluation methodologies provides a useful avenue for measuring the productivity impact of agricultural interventions.

Recently, there have been a number of studies that explore the impact of adoption of improved agricultural technologies on either poverty or human welfare, using econometric analysis. For example, Ghimire & Wen-Chi (2016) examined the impact of adoption of new-generation modern rice varieties (MRVs) on family welfare among rural farm households in central Nepal. Their results indicate that rice farmers benefited from the adoption of new-generation modern rice varieties. Similarly, Awotide *et al.* (2016) assessed the determinants of the intensity of adoption of Improved Rice Varieties

(IRVs) and the effect of market participation on farmers' welfare in Nigeria, using the Heckman two-stage models. Their study found that any increase in the farmers' welfare was based on the probability of the farmer participating in the rice output markets. In addition, the study indicates that higher yield, income from rice production, the gender of household head, and years of formal education have a positive impact on households' welfare.

Researchers (such as Awotide, Diagne, Awoyemi, & Ojehomon, 2012; Diagne *et al.*, 2009; Dontsop-Nguezet, Diagne, Okoruwa, & Ojehomon, 2011; Goni, Mohammed, & Baba, 2007; Mendola, 2007) conducted similar studies which reported the impact of agricultural adoption in Africa and found a positive effect on the household welfare of the farmer.

Dontsop-Nguezet *et al.* (2011) explored how the adoption of improved rice technology impacted income and poverty among rice farming households in Nigeria. They found that richer households increased their income substantially by adopting improved varieties of rice as compared with rich non-adopting households. In addition, the authors found that the adoption of improved rice technology had a negative effect on the poor household. Also, Kijima, Otsuka, & Sserunkuuma (2008) in Central and Western Uganda reveal that the adoption of improved varieties of rice had a positive impact on the richer households' welfare, but had a negative effect on the poor household's welfare. Amare, Asfaw, & Shiferaw (2012), Diagne & Demont (2007) and Wu, Ding, Pandey, & Tao (2010) studied the effect of agricultural technology adoption and concluded that the adoption of agricultural technology had a positive and significant influence on yield, farmers’ welfare, and poverty reduction.

In Ghana, Adeoti (2009) adopted Heckman two-stage procedures to measure the impact of irrigation technology adoption on the poverty status of farm households. The results showed that an increase in irrigated area had reduced poverty. Bruce, Donkoh, & Ayamga (2014) analysed the adoption of improved rice varieties on farmers’ output. The study used treatment effect model comprising the production function. The results from the treatment model showed that adoption of the improved rice varieties increased farmers’ output significantly.

Similarly, Adeoye, Olaore, Aliu, & Adeoye (2012), Akinola & Sofoluwe (2012) and Mendola's (2007) use of the Local Average Treatment Effect (LATE) and Propensity Score Matching (PSM) method respectively confirmed the positive effect on household wellbeing, arising from the impact of agricultural technology adoption on productivity and rural rice farmers’ welfare in Nigeria and Bangladesh respectively.

It can be observed from the literature that impact studies of agricultural technology adoption on organic farming are few relative to conventional farming, especially in Africa. This means that to a larger extent organic producers have been left out by most researchers in terms of assessing how technology adoption impacts on their welfare. The evaluation and comparison of the impacts of agricultural technology adoption on welfare of organic farmers and rural poverty reduction is lacking in previous studies, to the best of the researcher’s knowledge.

Although Ghana is one of the African countries with large rural communities and agricultural production, a few studies have focused on the effect of organic vegetable production on farmers' welfare. To understand the potential of organic farming, current understanding of organic vegetable production and its effects on farmers' welfare is crucial. Therefore, it is necessary to examine how organic vegetable production systems currently affect farmers' welfare.

3.5 Review of Empirical Studies on Technical Efficiency

There is vast literature worldwide on the measurement of technical efficiency (TE) but the literature on technical efficiency performance of organic farming is still scanty, as a result of scarcity of organic farming data for analyses. Several studies have suggested that organic farms are less technically efficient as compared with conventional farms (Bayramoglu & Gundogmus, 2008; Guesmi, Serra, Kallas, & Gil, 2012; Madau, 2007; Oude Lansink, Pietola, & Backman, 2002; Ricci Maccarini & Zanoli, 2004). In most of these studies, technical efficiency is reported to be associated with factors such as education, access to credit, farm size, age and gender, among others (Amoah, Debrah, & Abubakari, 2014; Bakhsh, Ahmad, & Hassan, 2006; Binam, Gockowski, & Nkamleu, 2008; Kuwornu, Amoah, & Seini, 2013; Makki, Ferrianta, & Suslinawati, 2012; Masunda & Chiweshe, 2015; Onumah, Brummer, & Horstgen-Schwark, 2010; Shamsudeen, Nkegbe, & Donkoh, 2013). Nonetheless, the findings on the influence of these factors on technical efficiency of farmers vary by study.

Some researchers (Dinar, Karagiannis, & Tzouvelekas, 2007; Dong, Hennessy, Jensen, & Volpe, 2016; Kumbhakar, Tsionas, & Sipiläinen, 2009; Mayen, Balagtas, & Alexander, 2010; Rahman, Wiboonpongse, Sriboonchitta, & Chaovanapoonphol, 2009; Sipiläinen & Lansink, 2005; Solís, Bravo-Ureta, & Quiroga, 2007) have evaluated the impact of technology on TE. Sipiläinen & Lansink (2005) utilised a translog stochastic distance frontier model to analyse TE for organic and conventional farms. The authors suggest that farmers' decision to adopt or not to adopt is not random but rather based on individual self-selection. Statistically, this implies that there is a possible selection bias between organic and conventional farmers.

Several studies have considered sample selection biases in TE measurement and have typically relied on Heckman's (1979) two-step procedure which generates a bias-correcting variable known as the Inverse Mill's Ratio (IMR). Examples include Bradford, Kleit, Krousel-Wood, & Re (2001) for large hospitals, and Sipiläinen & Oude Lansink (2005) for organic and conventional farms. Solís *et al.* (2007) analysed TE levels for hillside farmers in El Salvador and Honduras applying the Switching Regression approach which incorporates the IMR into the frontier model. However, the two-step Heckman procedures utilised by these authors are not suitable for nonlinear functions such as the stochastic frontier.

Mayen *et al*. (2010) used an alternative approach to address self-selection into organic farming by using PSM to compare organic and conventional US dairy farms. The authors found small differences in TE between organic and conventional farms when TE was measured against appropriate technology. Although this study corrected for biases from observed variables, the authors did not account for biases stemming from the unobserved factors.

Rahman *et al*. (2009) used the Greene (2010) model to analyse production efficiency in a sample of rice producers in Thailand, but in this case, the potential bias from observables is overlooked. Bravo-Ureta, Greene, & Solís (2012), also combined PSM with the Greene (2010) model to deal with biases from observables and un-observables respectively. The results show that average TE is consistently higher for beneficiary farmers than the control group while the presence of selectivity bias cannot be rejected statistically. Asante, Villano, & Battese (2014) analysed TE levels for smallholder yam farmers in Ghana. The authors corrected for the endogeneity in adoption and also employed the stochastic frontier analysis to investigate the effect of adoption of the technology on the technical efficiency of production. Their study found average technical efficiencies of 85.4% and 89.2% in the Ashanti and Brong Ahafo regions respectively. Furthermore, the effect of adoption of the technology on the technical efficiency of smallholder farmers was positive and significant in the Ashanti region, but negative in the Brong Ahafo region.

Studies on technical efficiency in relation to organic farming are few, to the best of the researcher’s knowledge. Most technical efficiency studies focus on cereals, root and tuber crops. The extent to which technology adoption impacts differently or similarly on large and small scale farmers is also lacking in previous literature. None of the studies reviewed in this study compared the technical efficiency levels for large scale and small scale farms. The essence of this study is to contribute to the existing literature by applying an empirical framework which corrects for biases arising from both observed and unobserved variables relative to different farm size, for example.

3.6 Summary of literature and research gap

Despite the above limitations, findings from previous studies are relevant to the current study. Many adoption studies have established that adoption and diffusion are interrelated; while adoption is when an individual makes use of a new technology or innovation, diffusion is the spreading of innovation in a community, nation or even globally. An innovation decision process is made of five stages: knowledge, persuasion, decision, implementation, and confirmation. The determinants of agricultural technology adoption are categorized under the following: demographic, economic, social and farm-specific factors; characteristics of the innovation itself; government policies towards a technology; technological change; market forces; and institutional supports. Depending on the commodity, study area, the time and other factors, the directions of these factors may vary. As a result it is important to constantly do research, using the laid down procedures to identify the technology, time and location-specific factors that influence technology adoption and its effects/impacts. The commonly used models to assess the impacts of technology adoption on productivity and technical efficiency are the Stochastic Frontier Analysis (SFA), Heckman two-stage model (Treatment effect model), and Propensity Score Matching (PSM) method.

CHAPTER FOUR

CONCEPTUAL AND THEORETICAL FRAMEWORKS

4.1 Introduction

In this chapter, the conceptual and theoretical frameworks that are relevant to the research are provided.

4.2 Conceptual Framework

In this section a schematic presentation of the study's conceptual framework is depicted in Figure 4.1, showing the relationships among the adoption of organic farming technology, technical efficiency, output, and welfare of farm households. While the adoption of organic farming is influenced by farmers' demographic characteristics, farm-specific characteristics, and some institutional or policy variables, adoption itself leads to increased farm output and technical efficiency which also lead to increased welfare of the farm household. However the socioeconomic, farm characteristics and institutional variables also influence technical efficiency and welfare.

Taking into account the impecunious livelihood of farmers in the Northern Region of Ghana, organic farming is expected to not only contribute towards poverty reduction but also to strengthen farmers' resilience (Glin, Amol & Oosterveer, 2013).

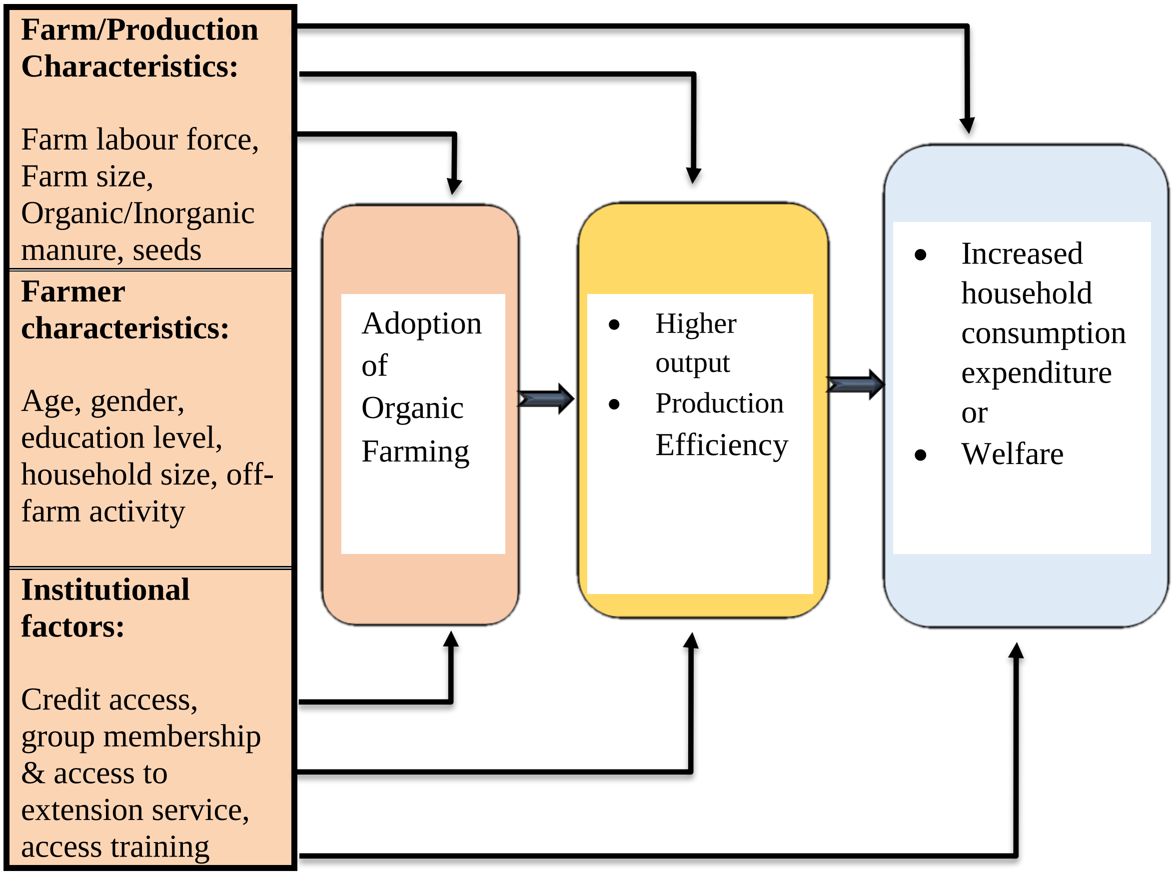

Figure 4.1: A Conceptual Framework of Organic Vegetable Production, Technical Efficiency and Welfare Effect
Source: Author's illustration based on theory and empirical review

Besides the adoption of the organic farming technology, organic vegetable production is known to improve soil fertility and ensure constant production with a relatively low risk of harvest loss (Hulsebusch *et al*. 2007).

The concept of efficiency in production stems from the ability of the farmer to attain the maximum output from a given set of inputs. Thus, as shown in Figure 4.1, the farm's production efficiency is influenced by the farmers' characteristics, the farm or production characteristics, and institutional factors. This is supported by the notion that for a production process to be effective, the manner in which farm resources are utilised is crucial. The availability and distribution of these factors may in-turn influence output. It is expected that the more inputs used by the farmer efficiently, the higher the vegetable output per acre. Increased vegetable output also has the tendency of improving the farmers' income and food security, and are expected to translate to a higher consumption expenditure which is an indication of a better household welfare. It is noteworthy that the conceptual framework in Figure 4.1 does not tackle the theoretical issues of the adoption of organic farming technology. It basically illustrates the relationship between the adoption and effects of organic farming technology on technical efficiency, vegetable output, and welfare. The theoretical linkage between the adoption of organic farming technology and its effects on output and welfare are described in the next section.

4.3 Theoretical Framework and Estimation Techniques

There are three main theoretical foundations that support this study. The first objective, which aims to examine the factors that influence organic farming among vegetable producers, is drawn from the theory of utility maximization and for that matter, the random utility theory. Numerous reasons exist as to why the adoption of organic vegetable production may influence outcomes such as output and household welfare. However, it is difficult to attribute the observed difference in the outcomes of adopters and non-adopters solely to the adoption of the technology. This introduces a sample selection bias into the process. The standard approaches for dealing with the problems of self-selection are the Heckman selection–correction approach (Heckman, 1979). The study also draws from stochastic frontier theory to analyse technical efficiency in different farming systems (organic and conventional vegetable farms). The relevant theories are explained in the following sections.

4.3.1 Producer Decision Theory

A farmer's decision to grow or not grow organic vegetables falls under the framework of choice modelling. Usually, the concept of choice is studied using the utility maximisation framework. In the production decision making process, the vegetable farmer is assumed to be a rational being with an economic objective. Given a choice among two alternative activities, such as organic and conventional vegetable production, the rational producer aims at choosing the option that yields the maximum benefit, referred to as utility. Therefore, to examine the factors that influence organic vegetable production will require the concept of utility maximisation.

4.3.1.1 Farm Technology Adoption Decision

The neoclassical microeconomic theory is concerned with an individual farmer, making production decisions. The production decision is purely a choice between two alternatives: organic and conventional production methods. As such, choice models developed in consumer theory have been used to motivate production decision model. In this background, vegetable farmers are assumed to make decisions by choosing the alternative that maximises their perceived utility (Fernandez-Cornejo, Beach & Huang, 1994). Thus, a farmer is likely to produce organic vegetable if the expected utility $(\mathrm{E}(\mathrm{U_{i1}}))$ of organic production is higher than producing an alternative a conventional vegetable, $\mathrm{E}(\mathrm{U_{i0}})$ [i.e. $\mathrm{E}(\mathrm{U_{i1}}) \geq \mathrm{E}(\mathrm{U_{i0}})$]. Because there are errors in optimisation and perception, the utility function is assumed to be random (McFadden, 1974). However, only the binary random variable (taking the value of 1 if the farmer makes the decision to produce organically, and 0 if not) observed as utility is unknown to the researcher, and as such, treated as a random variable (Ben-Akiva & Lerman, 1985; Greene, 2008). In the context of making a decision to produce organic vegetables, the linear random utility function may be expressed as

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{4.1}$$

where U_{ij} is the utility of the farmer *i* in choosing an alternative j, V_{ij} is the systematic component of U, relating to the utility of producing organically $(j = 1)$ and not producing $(j = 0)$, and ε_{ij} is the random error. V_{ij} becomes the explanatory part of the variance in the alternative chosen, which is used to explain and predict farmers' choices and a vector of individual farmer attributes. V_{ij} can be expressed as a linear function of *n* characteristics for a specific alternative as follows:

$$V_{ij} = \beta_1 \chi_1 + \beta_2 \chi_2 ...... + \beta_n \chi_n \tag{4.2}$$

where x_n is a vector of variables representing the characteristics of the decision maker in choosing an alternative j, and β's are unknown parameters associated with characteristics. The fundamental assumption is that, an individual farmer *i* will choose an alternative *j* over another alternative *k* if only the expected utility associated with *j* is greater than the expected utility from alternative *k*, given $j, k \in C$ where *C is* the set of alternatives, called the choice set and written as

$$U_{ij} > U_{ik} \text{ for all } j \neq k \tag{4.3}$$

Substituting equation (4.1) into (4.3) and expanding yields equation (4.4) as follows

$$V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik} \tag{4.4}$$

Rearranging equation (4.4) into observable and unobservable (random) components gives:

$$V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij} \tag{4.5}$$

The left-hand side of the inequality is comparing the expected levels of utility or profit of the two options. The right-hand side compares the error terms. However, in practice, it is difficult to observe $(\varepsilon_{ik} - \varepsilon_{ij})$, and hence, one cannot determine whether $V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij}$. Since the true utility function cannot be observed, the probabilistic utility function is often used in the estimation process. Hence, the probability of choosing alternative *j* (that is if the farmer decides to produce organic vegetables) follows Verbeek (2004), given by:

$$P_r(j) = P_r(Q_i = 1) = P_r(V_{ij} > V_{ik})$$

$$P_r(j) = P_r(V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij})$$

$$P_r(j|C) = P_r(V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij}) \qquad \forall j \neq k \in C \tag{4.6}$$

In this study, there are two categories of producers: those producing organic vegetables and those producing conventional vegetables. It is assumed that those that produce organic vegetables maximise their expected utility. On the other hand, those that are not producing organic vegetables have inherent reasons behind their choice. What are these reasons or factors?

From equation (4.6), the probability of choosing alternative k (producing conventional vegetables) can be derived by

$$P_r(k) = 1 - P_r(j) \tag{4.7}$$

Utility models are obtained by specifying a probability distribution of the two disturbances $\varepsilon_i = (\varepsilon_{ik} - \varepsilon_{ij})$. The two most commonly used forms are the normal distribution and logistic distribution. Assuming that the disturbance (ε_i) is identically and independently distributed as a Weibull distribution, then this follows the logistic distribution, resulting in the logit model (Maddala, 1983). If it is assumed that the disturbances (ε_i) are independently and identically distributed normally, then their difference $(\varepsilon_{ik} - \varepsilon_{ij} = \varepsilon_i = u)$ will also be normally distributed and the probit transformation can be used to model farmers' decision to produce organic vegetables. Both models have symmetric and bell-shaped densities, although the logistic density has heavier tails than the standard normal. The logit and probit models are both used for analysing dichotomous choice models (Greene, 2008) and since the distributions are similar, the results derived using the two models are quite similar, making it difficult to make a choice between the probit and logit on theoretical bases (see Greene, 2003; Hill, Griffiths, & Lim, 2008; Maddala, 1992; Stock & Watson, 2007). Thus, the probability that a given farmer is an adopter of organic vegetable production is given as

$$P_r\,(j) = P_r(Q_i = 1) \;=\; F(\beta_j{}'X_j) \tag{4.8}$$

where F (•) denotes the cumulative normal distribution, P_r the probability, β, a coefficient estimate, and X, a vector of explanatory variables. The parameters in the above equation (4.8) are estimated by maximum likelihood methods. This is because the dichotomous dependent variable in the probit regression (4.8) cannot predict a numerical value and violates the assumptions of homoscedasticity, linearity, and normality. As a result, the use of ordinary least squares (OLS) estimates for the best fit approach of minimising the sum of squared distances is inefficient (Maddala, 1983). To overcome inefficient parameter estimates, the maximum likelihood estimation, which maximises the log-likelihood, is applied in the probit model to estimate the regression coefficients (β). The likelihood function for the model is given as:

$$L = \prod_{Q_i=1} P_r \prod_{Q_i=0} (1 - P_r) \text{ (Maddala, 1983)} \tag{4.9}$$

The goal of this research is to examine the effect of organic farming adoption on farmers' output/technical efficiency and welfare. To determine this, the impact assessment theory was used. The concepts and the varieties of impact assessment are described in the next section.

4.3.2 Theoretical Framework for Impact Assessment

Many reasons exist as to why the adoption of agricultural technology may influence outcomes such as output and household welfare. However, it may be difficult to attribute the observed difference in the outcomes of adopters (organic vegetable farmer) and non-adopters (conventional vegetable farmer) solely to the adoption of the technology. Preferably, experimental data gathered through randomisation would provide information on the counterfactual situation that would solve the problem of causal inference. Since this is not the case, any attempt to attribute specific outcomes to specific agricultural technology interventions faces the fundamental problem of missing data (Blundell & Costa Dias, 2000). Consequently, many researchers are compelled to resort to drawing conclusions on the direct effects of technology adoption using the difference in outcomes across the farm households. Meanwhile, producers make adoption decision themselves; hence randomisation requirement is not fulfilled. In this case, estimation processes that do not account for self-selection may lead to biased results.

The standard approaches for dealing with the problem of self-selection are the two-step Heckman treatment effect model, the instrumental variable (IV), randomised designs, the double difference estimator, propensity score matching, regression discontinuity, and pipeline methods (Abadie, 2003; Cameron & Trivedi, 2005; Heckman & Vytlacil, 2007; Imbens & Angrist, 1994; Imbens & Wooldridge, 2009). In this study, Heckman's treatment effect procedure was adopted to estimate the effects of organic farming adoption on output and household welfare of vegetable producers in the study area. The choice of Heckman's estimation for this study was motivated by the fact that it is a more suitable approach that corrects self-selection and accounts for simultaneity problems. Sample selectivity bias and Heckman estimation procedure are described in the next section.

4.3.2.1 Sample Selection Bias

Sample selection bias arises when a selection process influences the availability of data, and that process is related to the dependent variable. Sample selection induces correlation between one or more regressors and the error term, leading to bias and inconsistency of the estimator. Barnow, Cain, & Goldberger (1980) noted that selectivity bias arises in programme evaluation when the control (or treatment) status of the subjects is related to unobservable or unmeasured characteristics that are themselves related to the programme outcome under study. Researchers define the term ‘bias’ as potential mis-estimation of an effect of a treatment or programme on an outcome. In this study, sample selectivity bias can arise when organic vegetable production is related to unmeasured or unobservable characteristics like farmers’ competence, managerial skills, and entrepreneurial skills which may affect organic vegetable production, but correlate with income from vegetable production and consumption expenditure of household.

Several studies (Breen, 1996; Heckman, 1979; Winship & Mare, 1992) have explicated sample selection bias. According to them, there are basically two versions of the selection bias problem. The first one is when information on the dependent variable for part of the respondents is missing, and the other is when information on the dependent variable is available for all respondents. However, the common method of the sample selection that is linked to this research is where information on the dependent variable is available for all respondents, but the distribution of respondents over categories of the independent variable of interest has taken place in a selective way.

Assuming that an ordinary least squares (OLS) model is used to estimate the effect of organic farming on vegetable output and household welfare as given below;

$$Y_i = \gamma X_i + \delta D_i + \varepsilon_2 \tag{4.10}$$

$$W_i = \gamma X_i + \delta D_i + \varepsilon_3 \tag{4.11}$$

where Y_i and W_i are annual vegetable output and household welfare respectively, D_i is a dummy (1 = organic vegetable farming; 0 = conventional vegetable production), X_i is vector of farmer and farm characteristics, γ and δ are vectors of parameters to be estimated, and ε_2 and ε_3 are the error terms with $N(0, \sigma^2_v)$.

The effect of adoption on the outcome (vegetable output and household welfare) variables are measured by the estimates of the parameter δ. However, if δ is to accurately measure the effect of organic farming adoption on vegetable output and household welfare, then farmers should be randomly assigned to organic vegetable farming (adoption) or conventional vegetable farming (non-adoption) (Faltermeier & Abdulai, 2009; Kassie, Shiferaw, & Muricho, 2011; Stefanides & Tauer, 1999). Furthermore, the farmers themselves decide (self-selection) whether to adopt organic vegetable farming, and thus, the adoption decision is likely influenced by unobservable characteristics that may be correlated with the outcome of interest (such as annual vegetable output and household welfare indicator). For example, if organic farmers tend to be more industrious or more skilful than non-organic vegetable farmers, they would have higher output vegetable and better consumption expenditure regardless of whether or not they participated in organic vegetable farming. In this case, the coefficient on the participation dummy variable would include the effect of these unobservable characteristics in addition to the effect of organic farming, thus overestimating the effect of organic vegetable farming. Therefore, if unobservable characteristics are correlated with either dependent variables or error terms (of annual vegetable output and household welfare), then, the estimation of Eqn. (4.10) and Eqn. (4.11) does not account for this self-selection and may lead to biased results. This selection bias can be accounted for by assuming a joint normal error distribution with the form:

$$\frac{\varepsilon_{1i}}{\varepsilon_{2i}} \sim N\left(\begin{bmatrix}0\\0\end{bmatrix}, \begin{bmatrix}1 & \rho\\ \rho & \sigma^2\end{bmatrix}\right)$$

$$\frac{\varepsilon_{1i}}{\varepsilon_{3i}} \sim N\left(\begin{bmatrix}0\\0\end{bmatrix}, \begin{bmatrix}1 & \rho\\ \rho & \sigma^2\end{bmatrix}\right) \tag{4.12}$$

And by recognising that the expected output and welfare of choosing organic vegetable production, given as:

$$E\,[Y_i|Q_i = 1] = Z_i\beta + \delta + E[\varepsilon_{2i}|Q_i = 1] \quad = Z_i\beta + \delta + \rho\sigma\lambda_i$$

$$E\,[W_i|Q_i = 1] = Z_i\beta + \delta + E[\varepsilon_{3i}|Q_i = 1] \quad = Z_i\beta + \delta + \rho\sigma\lambda_i \tag{4.13}$$

Where

$$\lambda_i = \frac{\emptyset(\rho + x_i'\beta)}{\Phi(\rho + x_i'\beta)} \tag{4.14}$$

And $\emptyset$ and Φ are the density functions of a standard normal and cumulative distribution function of a standard normal distribution respectively. Inverse Mills Ratio (IMR) is denoted by a symbol λ and describes the ratio of the ordinate of a standard normal to the tail area of the distribution (Greene, 2003). If λ_i is not statistically significant, then sample selection bias is not a problem (Heckman, 1979, 1980). Besides, if the finding of λ_i is statistically significant in the vegetable output and household welfare equations, then, this would suggest that an important difference exists between the farmers that adopted organic vegetable farming and those that did not adopt. This difference needs to be taken into consideration in estimating the equations. Also, equation (4.14) implies that in estimating equation (4.10) and (4.11) without the Inverse Mills Ratio (IMR), the coefficients β and δ will be biased. Hence, the standard approach for dealing with the problem of self-selection is the treatment effects model (also called the Heckman selection–correction model).

4.3.2.2 The Treatment Effects Model

Heckman's sample selection procedure controls the self-selection that normally arises when technology adoption is not randomly assigned and self-selection into adoption occurs. According to literature (Awotide *et al.*, 2016; Heckman, 1976; 1979; Hoffman & Kassouf, 2005; Siziba, Kefasi, Diagne, Fatunbi, & Adekunle, 2011), Heckman correction model is commonly used to account for this bias. This method involves, first, the estimation of the selection equation which uses the probit model (which are the factors that influence the adoption of organic farming among vegetable producers; equation (4.8)) and second, the estimation of the substantive equations (in this case vegetable output equation (4.10) and welfare equation (4.11)).

As mentioned above, the idea behind the Heckman's treatment effect procedure is to estimate a probit model and use the predicted values of organic vegetable production to calculate the IMR. The IMR is then included in the vegetable output or welfare model as an additional explanatory variable. The treatment effect model is a special case in which the adoption variable appears as an additional explanatory variable. The treatment model also offers the opportunity to the researcher to estimate the adoption and output or welfare equations simultaneously. This computation corrects possible selection bias and yields unbiased and consistent estimates in the output or welfare models. Consequently, according to Maddala (1983), equations (4.10) and (4.11) respectively take the form:

$$lnY_i = \beta'(\Phi_i \, lnZ_i) + \delta\left(\Phi_i Q_i\right) + \sigma\emptyset_i + \varepsilon_{2i} \qquad (4.15)$$

$$lnW_i = \beta'(\Phi_i \, lnZ_i) + \delta\left(\Phi_i Q_i\right) + \sigma\emptyset_i + \varepsilon_{3i} \qquad (4.16)$$

where $\Phi_i \equiv \Phi(w_i \gamma)$, δ measures the effect of organic farming on the natural logarithm of gross income from vegetable Y_i or natural logarithm of per capita consumption expenditure W_i respectively; ε_{2i} and ε_{3i} are also two-sided error terms. X_i is a vector of independent variables affecting farm income, Q_i is a binary variable representing adoption of organic vegetable farming, γ, δ, and β are parameters to be estimated.

To estimate the three equations (the adoption of organic vegetable production, the effects of adoption on vegetable output and household welfare) mentioned above, the study also utilised the Conditional (recursive) Mixed Process (CMP) estimator which is described in the next section.

4.3.3 Estimation Approach using Conditional Mixed Process

The adoption of organic vegetable production and vegetable output are potentially endogenous due to sample selection. However, welfare could also potentially affect both adoption and output through several mechanisms. Any potential endogeneity has the possibility of leading to under- or overestimation of the impacts of adoption on output and welfare. Therefore, to account for the potential endogeneity among the dependent variables, the study modelled the adoption of organic farming, output and welfare jointly as a system of simultaneous equations.

Owing to the recursive nature of the adoption of organic farming and the vegetable output and welfare equations that are dealt with in this study, one possible way of estimation is through Zellner's Seemingly Unrelated Regressions (SUR) (Zellner, 1962) to ensure that correlations across equations are exploited, and estimation is efficient. However, the fact that the equation system had a mix of dichotomous and continuous dependent variables implies that SUR may not be the most appropriate technique since it would treat the dummy variable in the adoption of vegetable production equation as continuous. This leads to the use of the conditional mixed process (CMP) modelling (Roodman, 2011) which is a highly flexible way to estimate joint equations, especially, where the dependent variables are measured on different scales. In this case, the adoption of organic vegetable farming is dichotomous, while output and welfare are continuous variables.

The Roodman's CMP estimator estimates the equations together and does not make any assumptions about the nature of the dependent variables (Roodman, 2007). The CMP approach uses a simulated maximum likelihood approach for evaluating the multivariate normal distribution functions based on the Geweke-Hajivassiliou-Keane (GHK) algorithm. The estimation based on the simultaneous equations system approach makes the possibility of accounting for unobserved factors that may affect two or more of the dependent variables under consideration. This helps to improve the efficiency of the estimates when indeed there is a correlation between the error terms of the three equations in the system.

In this study, we applied the CMP to jointly estimate a three-equation model of vegetable production involving a dichotomous dependent variable for the adoption of organic farming, a continuous dependent variable for vegetable output, and a continuous dependent variable for household welfare. The flexibility of the CMP model rests upon its ability to deal with a large family of multi-equation systems where the dependent variable of each equation may have a different format (for example, binary, categorical, and bounded and unbounded continuous). The most salient features of this tool are that the data-generating processes within the multi-equation system can mix different samples and can be used for different models within the system. It also takes into account both simultaneity and endogeneity and produces consistent estimates for recursive systems.

4.3.4 Theoretical Framework for Measuring Efficiency in Vegetable Production

Efficiency is the ability to produce output at the lowest possible cost (Farrell, 1957). The three dimensions of efficiency are technical, allocative, and economic efficiencies (Williams, Kareem, Adiegu, & Dipeolu, 2012). However, most researchers are of the view that allocative and technical efficiencies are components of economic efficiency (Coelli, Prasada Rao, O'Donnel, & Battese, 2005; Williams *et al*., 2012). Economic efficiency is the ability of a producer to produce a given quantity of output at minimum cost at a given level of technology (Worthington & Dollery, 2000). Economic efficiency is also known as cost efficiency in the input-oriented case. Thus, when a firm uses all its resources in an allocatively and technically efficient manner, then, it is said to be economically efficient or cost efficient. Allocative efficiency measures the ability of the producer to use inputs in optimal proportions, given their respective price and production technology. It is concerned with choosing between different technically efficient combinations of inputs that are used to produce maximum feasible outputs (Siry & Newman, 2001).

This is achieved by producing as many outputs with available inputs, or by using as little inputs as possible in producing a given quantity of outputs. In other words, technical inefficiency reflects deviations from the frontier isoquant, and allocative inefficiency is related to deviations from the minimum cost input ratios (Farrell, 1957; Kopp & Smith, 1982). Farrell (1957) presented a seminal on the measurement of technical efficiency (or productive efficiency) which has inspired several studies.

The basic idea underlying the Farrell approach to measuring efficiency is shown in figure 4.2. In this case, it is assumed that the vegetable producer uses only two inputs (X_1 and X_2) in producing a single output (Y).

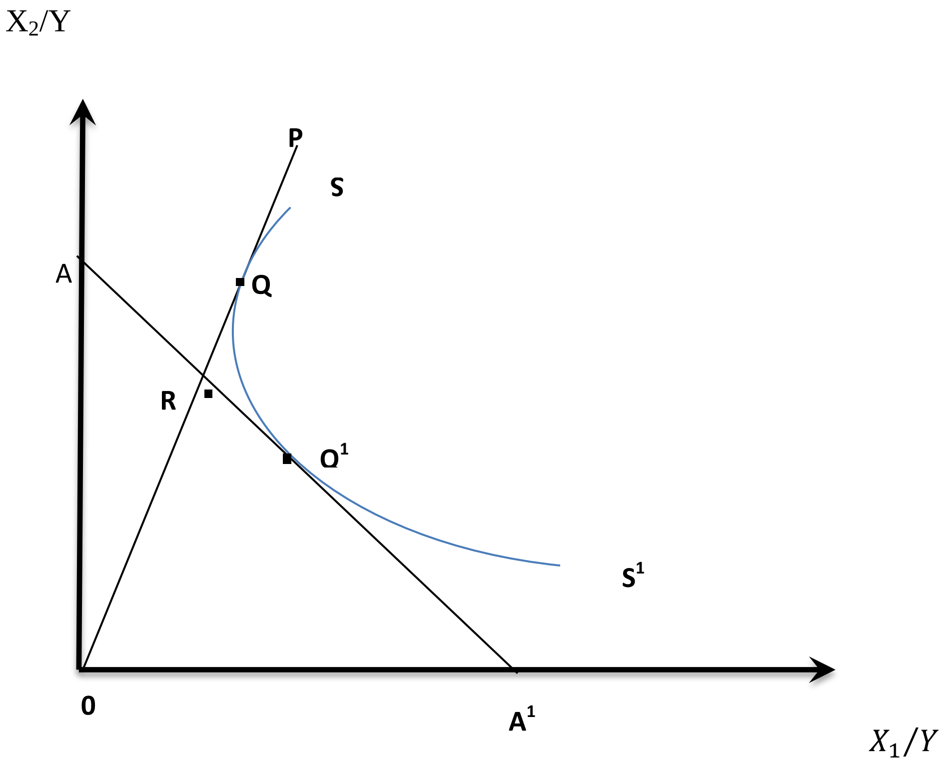

Figure 4.2: Measure of Technical and Allocative Efficiencies of Production
Source: Ajibefun (2008)

This is also under the assumption of constant returns to scale. AA^1 and SS^1 represent allocative and technical efficiencies respectively. 0P is the quantity of inputs used for production. X_1/Y represents the ratio of first input to output while X_2/Y is the ratio of the second input to output. At any point on the isoquant SS^1, the producer is technically efficient. Point Q is also technically efficient because it is on the isoquant SS^1. This means that any point on P that is not on SS^1 is not technically efficient. Technical efficiency is computed as $0Q/0P$. Since a value of one means the farmer is fully technically efficient, the technical efficiency of the farmer is expressed as $1 - 0Q/0P$. Technical efficiency takes a value between 0 and 1. Any point on AA^1 shows that the producer is using his resources technically and in an allocative efficient manner. At point R, the producer uses his resources in an allocative efficient manner since it is on the curve AA^1, but it is not technically efficient since it is on SS^1. Allocative efficiency is computed as $0R/0Q$.

Again, at point Q^1, the producer uses his resources technically and in an allocative efficient manner since it is on both SS^1 and AA^1. As a result, on Point Q^1 the vegetable producer is said to be economically efficient. Economic efficiency is calculated as $OQ/OP \times OR/OQ$. Hence, economic efficiency is a product of technical and allocative efficiencies.

Information about production and technical efficiency differences between conventional and organic farms is a significant tool for governments who are considering alternatives to improve the performance of organic agriculture. In this regard, there is the need to also estimate the potential organic vegetable production levels in order to make an informed decision.

4.3.4.1 Estimation of the Production Frontier and Technical Efficiency

It is assumed that an organic farmer aims at maximising output, given the resources available. In an attempt to maximise output, the farmer must consider certain factors that can influence the efficiency with which to realise the output. These factors are both those within the control of the farmer and those beyond his control. The researcher's interest is to model factors that are within the control of the farmer and how these factors influence the farmer's technical efficiency (TE). Technical efficiency estimates the success in producing maximum output from a given input.

Two main approaches are widely used to estimate technical efficiency (TE): non-parametric methods (data envelopment analysis - DEA) and parametric (Stochastic Frontier Approach - SFA). The non-parametric techniques are more flexible than parametric approaches and can be implemented without knowing the true specification of the functional form that characterises the production technology. Nonetheless, they do not allow the investigator to isolate inefficiency effects from random noise (Coelli, 1995; Cooper, Seiford & Tone, 2006; Sharma, Leung & Zaleski, 1999; Wadud & White, 2000). To overcome the shortcoming exacted by non-parametric models, an alternative method known as the Stochastic Frontier Approach **(**SFA) is required.

This approach distinguishes between exogenous shocks outside the farmer's control and inefficiency. Contrary to DEA and deterministic frontier analysis, SFA accounts for random noise. Alternatively, SFA requires the specification of a distributional form for the inefficiency term and a functional form for the production function. Some researchers (Chakraborty, Biswas, & Lewis, 2001; Coelli, 1995; Oude Lansink &

Jensma, 2002), reported that agricultural production outcomes are stochastically determined due to random weather effects, and since agricultural production studies are likely to be affected by measurement and variable omission errors; it is important to choose a robust model that resolves these issues. Accordingly, this study selects SFA as a method to correctly and consistently estimate TE.

4.3.4.2 The Stochastic Production Frontier Model

Following the pioneering work of Farrell (1957), various modifications and improvements have been made to this model. Aligner & Chu (1968) translated Farrell’s frontier into a production function and later Aigner, Lovell & Schmidt (1977) and Meeusen & Van den Broeck (1977) suggested the stochastic frontier approach. The stochastic production frontier approach comprises a production function of usual regression type with a composite disturbance term equal to the sum of two error components. The first element in the composite error, v_i, accounts for such random disturbances as measurement error in output variable, weather, topography, distribution of supplies and the combined effects of unobserved inputs on production, among others, which influence farmers’ decisions and can take on both positive and negative values. The other error term, u_i, captures the existence of technical inefficiency, accounting for technical and managerial constraints of the farmer and assumes only nonnegative values. Technical inefficiency arises when the actual or observed vegetable production value from a given resource mix is less than the maximum possible.

Researchers (e.g. Battese & Coelli, 1995; Kumbhakar, Ghosh, & McGuckin, 1991; Wang & Schmidt, 2002) modified and extended the stochastic production frontier model by suggesting a simultaneous estimation of the production frontier and inefficiency effects. Following Battese & Coelli (1995), the following stochastic frontier production function and inefficiency effects model can be estimated simultaneously. The stochastic production frontier model is represented as

$$q_i = h(x_i; \beta)\, exp\, (\varepsilon_i) \qquad (4.17)$$

q_i is the output of the i^{th} farmer, x_i is a $(1 \times k)$ vector of farm inputs, β is a vector of unknown parameters to be estimated, $h(\cdot)$ is the best production functional form for the frontier (e.g. Cobb-Douglas, translog), and ε_i is a random disturbance. Following Aigner *et al*. (1977) and Meeusen & Van den Broeck (1977), the disturbance term consists of two components;

$$\varepsilon_i = v_i - u_i \qquad (4.18)$$

where the component v_i is a symmetric, identically and independently distributed (*iid*) error term representing random variation in output due to random exogenous, measurement errors, omitted explanatory variables, and a statistical noise beyond the control of the producing unit. On the other hand, the element u_i is a nonnegative error term representing the stochastic shortfall associated with farm-specific factors which leads to the i^{th} farm not attaining maximum efficiency of production; u_i is the technical inefficiency of the farm and ranges between zero and one.

Estimating parameters in equation (4.17) is reinforced by distributional assumptions concerning the two error terms. The v_i is independently, identically, and normally distributed with zero mean and constant variance, and σ_v^2, $[v_i \sim N\ (0, \sigma_v^2)]$ is independent of the u_i. The term u_i has an asymmetrical distribution and is assumed to be independently and identically distributed *(i.i.d)* and truncated (at zero) under normal distribution with a mean of μ, and variance σ_u^2 $[u_i \sim N\ (\mu, \sigma_u^2)]$ such that the mean is defined as

$$\mu_i = Z_i \delta \tag{4.19}$$

where Z_I is $(n \times 1)$ vector of explanatory variables associated with the technical inefficiency effects which could include socioeconomic and farm management characteristics. δ is a $(1 \times n)$ vector of unknown parameters to be estimated. This may follow a half-normal, truncated normal, exponential or gamma (Aigner *et al.*, 1977; Meeusen & van den Broeck, 1977; Stevenson, 1980). Following (Jondrow, Lovell, Materow, & Schmidt, 1982) technical inefficiency for each observation is calculated as the expected value of u_i conditional on $\varepsilon_i = v_i - u_i$

$$E(U_i / \varepsilon_i) = \frac{\sigma_u \sigma_v}{\sigma}\left[\frac{g(\varepsilon\lambda/\sigma)}{1 - G(\varepsilon\,\lambda/\sigma)} - \frac{(\varepsilon\lambda)}{\sigma}\right] \tag{4.20}$$

where E is the expectations operator, $g(\bullet)$ and G $(\bullet)$ are the standard normal density and cumulative distribution functions respectively and evaluated at $\sigma^2 = \sigma_u^2 + \sigma_v^2$, and $\lambda = \frac{\sigma_u}{\sigma_v}$. λ is the ratio of the two standard errors as used by Jondrow *et al.* (1982) and it explains the total variation of output from the frontier which can be attributed to technical efficiency and lies between zero and one.

Technical efficiency of an individual firm or farm can be expressed as the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm. The estimation for the TE of each producer can be calculated as

$$TE_i = \frac{q_i}{q_i^*} = \frac{f(\chi_{i,}\beta)\exp(V_i - U_i)}{f(\chi_{i,}\beta)\exp(V_i)} = \exp(-U_i) \tag{4.21}$$

where q_i is the observed value of vegetable output and q_i* the frontier value of vegetable output. This expression shows that the difference between q_i and q_i^* is embedded in u_i. If $u_i = 0$, then $q_i = q_i^*$ implying that the production lies on the frontier, and hence, technically efficient and the farm obtains its maximum potential output given the level of inputs. However, if $u_i > 0$, production lies below the frontier and the farm is technically inefficient. Therefore, the technical efficiency (TE) of a farm is defined as $TE_i = \exp(-u_i)$. Following Jondrow *et al.* (1982), the maximum likelihood estimation of equation (4.17) and (4.18) and the farm- specific TE_i defined by equation (4.21) are attained in terms of parameterisation: $\gamma = \sigma_v^2/\sigma^2 = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The maximum likelihood estimation of equation (4.17) yields consistent estimators for β, γ and σ^2, where $\sigma^2$is a vector of unknown parameters. This study considers the parameter γ to be bounded between zero and one. The value of $\gamma = 1$ indicates that the deviation from the frontier is entirely because of technical inefficiency, whereas the value $\gamma = 0$ means the deviation from the frontier is entirely because of noise effects. Thus, for $0 < \gamma < 1$, output variability is characterised by the presence of both technical inefficiency and stochastic errors.

CHAPTER FIVE

METHODOLOGY

5.1 Introduction

This section provides an overview of the study area, research design and data, sampling procedure and the methods used to analyse the data.

5.2 Study Area

The research was carried out in the Northern Region of Ghana. The Region is the largest Region in the country. It is bordered to the west by Cote d'Ivoire, to the east by Togo, to the north by Upper East and Upper West Regions and to the south by Brong Ahafo. The topography is flat with 4.350 feet elevation. Its vegetation is mostly Guinea Savannah woodland mixed with grasses, shrubs, short trees and a few species of tall trees. The area is dominated by the Dagomba ethnic group and other tribes including the Mamprusis, and Kokombas.

Agriculture is the main economic activity of the people. It has an estimated land area of 70,384 km^2 of which 75% is available for cultivation. The area has a very high agricultural prospect. It is for this reason that the area was chosen for this study as well as the convenience in obtaining the target group of farmers. Figure 4.3 is a map showing the main vegetable production sites in Northern Region that were selected for the study. The major crops grown in the study area include cereals, legumes, and tuber and are increasingly integrated with small ruminants, fowl, and occasionally, cattle rearing.

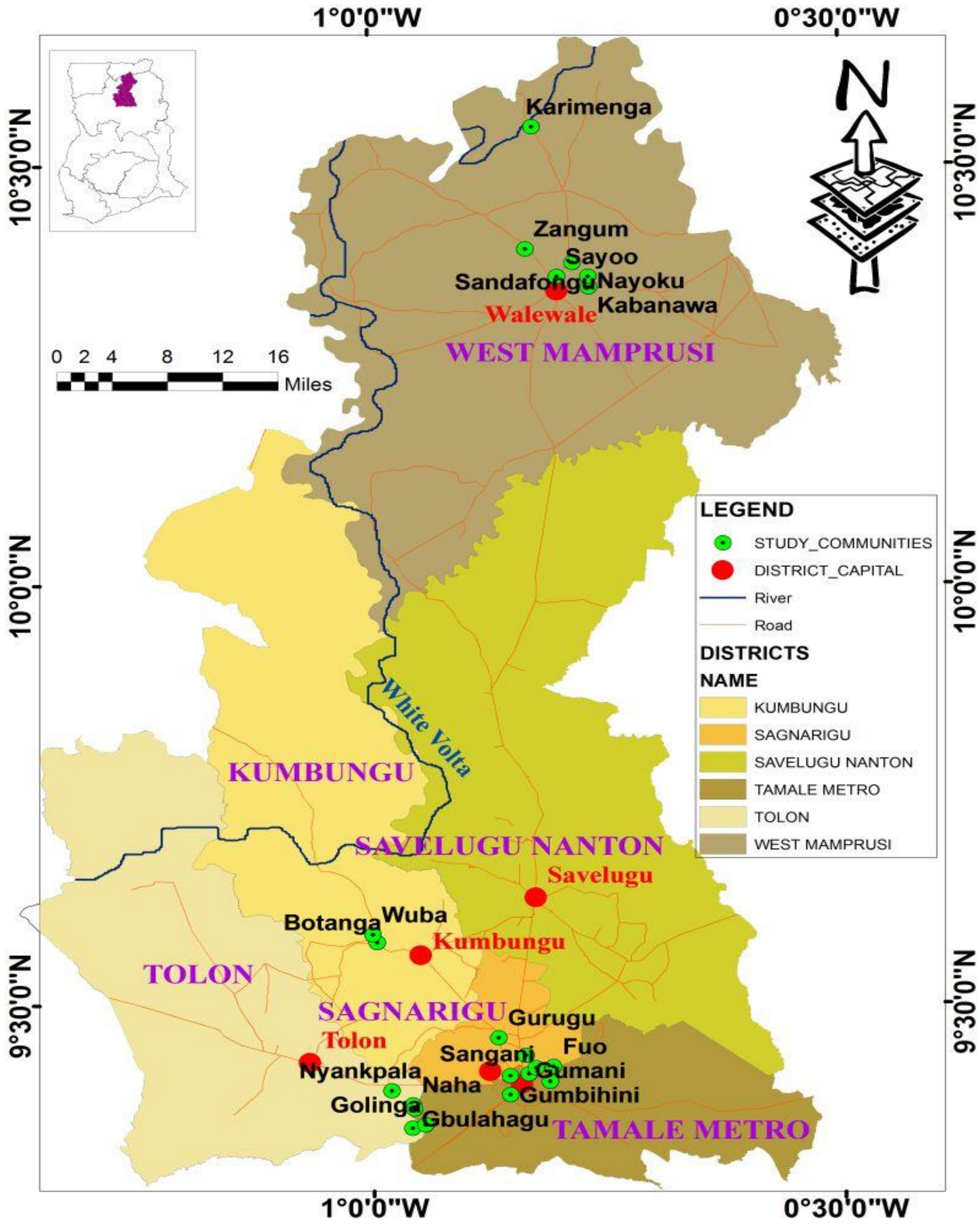

Figure 5.1: Map of the Northern Region showing the study area

Vegetable farmers in the research area grow a wide range of exotic and indigenous vegetable crops, including tomatoes, cucumbers, sweet and hot pepper, green beans, carrots, cabbages, spring onion, okra, Amaranthus, Roselle (bra), white jute (ayoyo), okra, spring onion, among others. The climate of the region favours vegetable cultivation. The region experiences two major seasons, namely, the dry season and the wet season.

During September, there is a break in the rainy season and then the dry season occurs between early November and late March/early April. The average annual temperature varies from 18^{o}C to 41^{o}C. The study area is characterised by a uni-modal rainfall pattern (April to November) with a mean rainfall of 1,100mm and a minimum of 670mm.

5.3 Research Design and Data

The bulk of data used in the study was collected from farmers growing vegetables on small scale, either using organic or conventional farming systems. As a result, the study mainly used primary data collected through a survey, group discussions, and key informants' interviews for the 2014/2015 cropping season. Prior to conducting the survey, a pre-test of the questionnaire was conducted in June 2014 to evaluate the clarity, consistency and appropriateness of the survey questions. Based on a review of the pre-test sample, the survey questions were amended. Ten extension officers who understood the vernacular of the study area were trained on data collection techniques prior to the survey.

The survey's field work lasted for a year. Both qualitative and quantitative primary data were collected from selected organic and conventional vegetable farmers. The respondents of the sampled population were interviewed using a semi-structured questionnaire; comprising both closed- and open-ended questions (see Appendix A). The questionnaire included several categories of questions such as demographic information, information on general farming practices, and farmers' knowledge of organic farming. The questionnaire also asked for extensive information on credit access, seeds, land holding, assets, expenditure, household income sources, extension contacts, and membership with farmer based organisations. Information on average input prices was also taken from the respondents. Supplementary primary information was collected from a group discussion with the farmers, and also from the semi-structured interviews of three government agriculture extension agents and six officials from some NGOs.

Based on the reconnaissance survey, it was observed that the farmers in the study area were cultivating several types of vegetables including cabbage, cucumber, garden egg, carrots, green pepper, lettuce, pepper, okra, amaranthus (alefu), bitter leaf, onion, white jute (ayoyo), spring onion, beans leaf, and green beans. Notably, cabbage, carrots, green pepper, lettuce, cucumber, hot pepper, okra, Amaranthus, Roselle (bra), and white jute (ayoyo) were the predominant, in terms of the area size being cultivated.

In this study, adopters are classified as farmers who grow vegetables using only organic fertilisers and bio-pesticides, and non-adopters are those who grow vegetable using only synthetic fertilisers and pesticides or both. As the 'adoption of organic vegetable farming' is a dichotomous or binary dependent variable with the option of either 'adoption' or 'non-adoption', probit regression was considered to be the most appropriate analytical tool with which to investigate the factors determining adoption. After obtaining the factors influencing adoption of organic vegetable farming, the study found out whether the adoption has the potential to improve the farmers' output or household welfare. Household per capita consumption expenditure was used to measure household welfare in this study. First, output prices were gathered from organic and conventional vegetable farms. All vegetables produced on the sample organic and conventional vegetable farms were aggregated into one output valued in Ghana cedis (GH¢), which was the dependent variable. Secondly, consumption expenditures capture seven major categories, including food, energy, water, education, medical expenditure, transportation, fuel/maintenance, and other social activities over the twelve months divided by the household size.

5.4 Sampling Procedure

A multi stage sampling procedure was used to select vegetable farmers for this study. In the first stage, Northern Region was strategically or purposively selected for the study due to the highest concentration of vegetable farmers in the Northern Region. Four (4) Municipal Metropolitan and District Assembly (MMDA) of the region, namely: Tamale Metropolis, Tolon, Kumbugu and West Mamprusi were also purposively selected for the study in view of the high concentration of organic as well as conventional vegetable production. This was followed by Probability Proportion by Size (PPS) sampling to random sampling of three (3) to seven (7) communities from each MMDA's depending on the concentration of organic vegetable farmers in the MMDA. In all, twenty (20) communities were subsequently selected for the study.

In the second stage, vegetable farmers in each selected MMDA were stratified into two, namely organic vegetable farmers (adopters) and conventional vegetables farmers (non-adopters). Prior to the conduct of the survey, a list of organic farmers was obtained from private organization monitoring organic farmers (Coalition for the Advancement of Organic Farming, 6.1a), farmers and farmer groups of the MMDA. The list revealed 514 farmers from the 4 MMDA of the region that grow organic vegetables. In view of the small number of farmers practicing organic vegetable farming, it was not deemed necessary to determine the sample size using the standard statistical method. Two hundred (200) farmers were randomly selected, accounting for about 39% of the total farmers in organic vegetable farming, spreading over the 4 MMDA of the region. The non-adopters (conventional vegetable farmers) were also distributed throughout the selected MMDA. Two hundred (200) conventional vegetable farmers with similar characteristics were also randomly selected to match the selected organic farmers for the study. Thus, equal numbers of organic and conventional vegetables producers were randomly selected from each stratum for the study. From each selected community, 20 respondents made up of 10 of organic and conventional vegetable producers each were randomly sampled, giving a total of 400 sample farmers in all for the interview.

5.5 Analytical Framework and Empirical Models

This section outlines the various analytical approaches used in attaining each specified objective. It also outlines how the variables were measured in the study.

5.5.1 Factors Influencing Adoption of Organic farming and its Effect of Output and Household Welfare: Treatment-Effect Model

Investigating the effect of adoption of organic farming on vegetable output or household welfare might be subject to selection bias. This requires a multivariate analysis. For instance, assuming that, an ordinary least square (OLS) model was used to estimate vegetable output or household welfare as a function of farmer and farm characteristics and a dummy variable representing the effect of adopting organic farming and the error term. If all factors assumed to affect organic farming and are not correlated with error term, then Ordinary Least Square (OLS) will produce consistent and unbiased estimates. In that case, the coefficient will measure the true impact of organic farming on the output and welfare of smallholder farmers.

Nonetheless, as stated earlier, the decision of vegetable farm household to adopt organic farming is potentially endogenous and failure to account for this will lead to biased and inconsistent estimates which will subsequently lead to wrong policy recommendations. The issue of endogeneity arises due to voluntary nature of organic vegetable farming. Thus, farmers ‘self-select’ themselves into organic vegetable farming. Also, the observed characteristics of adopters may be systematically different from non-adopters. For example, if organic farmers tend to be more industrious or more skillful than non-organic vegetable farmers, they would have higher output and better consumption expenditure regardless of whether they participated in the organic vegetable farming. In this case, the coefficient on the participation dummy variable would include the effect of these unobservable characteristics in addition to the effect of organic farming, thereby overestimating the effect of organic vegetable farming. In econometric terms, if unobservable characteristics are correlated with the dependent variable (vegetable output or household welfare) and a regressor (adoption of organic vegetable production), then, the coefficient on that regressor will be biased and inconsistent. To rectify this problem, the treatment model, also called the two-stage Heckman's procedure was used in this study. This model is appropriate because it rectifies simultaneity problems.

In this study, two – stage estimation procedure is involved; first, the estimation of the selection equation using a probit model (which was used to identify the factors that influence adoption decision of organic vegetable production) and second, the estimation of the average vegetable output or welfare of households (annual consumption expenditure) equations.

5.5.1.1 Empirical Model for Estimating Factors Influencing Organic Vegetable Production Decision

Farmers' decision on whether to adopt an innovation or not has been studied in a wide range of literature (Afolami, Obayelu, & Ignatius, 2015; Kontogeorgos, Sergaki, Migdakos, & Semos, 2008; Manda, Alene, Gardebroek, Kassie, & Tembo, 2015; Sodjinou, *et al*., 2015). In practice, the probit or logit models are used to determine the probability that smallholder farmers will adopt a technology or not. In this study, as the 'adoption of organic vegetable farming' is a dichotomous or binary dependent variable with the option of either 'adoption' or 'non-adoption', the probit model was considered to be the most appropriate analytical tool because it allows for the estimation of marginal effects and its fitness to the data. Therefore, as specified in the theoretical model in equation (4.8), the farmers' organic vegetable adoption decision was specified as follows:

$$P_r\,(j) = P_r(Q_i = 1|X) \;\; = F(Z_i) = (F(X'\beta) \qquad (5.1)$$

Where $F(\cdot)$ corresponds to the cumulative distribution function of the normal distribution. P_r is the probability and X denotes the vector describing the farmers' socio-economic characteristics, and farm characteristics. β is the vector of parameters to be estimated, and $\beta' X$ is the index function that permits the estimation of the probability of adoption. The parameters in the above equation (5.1) are estimated by maximum likelihood methods. According to Greene (2008) and Maddala (1983), in the case of the normal distribution function, the model to estimate the probability of observing a farmer producing organic vegetables can be stated as

$$P_r(Q_i = 1|X) \; = F(Z_i) = \int_{-\infty}^{X'\beta} \Phi(t)\, dt = \; F(X'\beta) \qquad (5.2)$$

where, Φ (·) is the normal density function, and its derivative is given as

$$\Phi(t) = \frac{1}{\sqrt{2\pi}} exp^{-0.5t^2} \qquad (5.3)$$

Since the estimated coefficients (*β's*) do not have simple interpretation, except that they tell how the explanatory variables are related to the dependent variable (Greene, 2003; Hill, *et al*., 2008; Stock & Watson, 2007), the model is best interpreted by computing the marginal effects as follows:

$$\frac{\partial E(Q|x_i)}{\partial x_i} = \; F(Z_i)\beta_j \qquad (5.4)$$

where

$$Z_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \varepsilon_i \tag{5.5}$$

The marginal effect shows the effect of an increase in x_i on P_r and this effect depends on the slope of the probit function which is given by $F(Z_i)$ and the magnitude of the parameter β. In order to estimate the probabilities of farmers making a decision to adopt or not to adopt organic farming as a function observed characteristics (X_i) and unobserved characteristics (ε_1), that is:

$$Q_i^* = X_i'\beta + \varepsilon_1 \tag{5.6}$$

where Q_i^* is a latent variable which is unobservable, and what is observed is the organic vegetable production decision that can be related to the observable binary variable Q, through the expression;

$$\begin{cases} 1 \; if \; Q_i^* > 0 \\ 0 \; if \; Q_i^* \leq 0 \end{cases} \tag{5.7}$$

Equation 5.6 can be expanded as

$$\begin{aligned} Q_i &= \beta_o + \beta_1 AGE + \beta_2 HSIZE + \beta_3 EDU + \beta_4 FEXP + \beta_5 FSIZE + \beta_6 AECS + \beta_7 OFFACT \\ &+ \beta_8 EXT + \beta_9 FBO + \beta_{10} TRAIN + \beta_{11} AMOI + \beta_{12} ARCAY + \beta_{13} LOWN + \varepsilon_1 \end{aligned} \tag{5.8}$$

where: Q_i is the 0-1 outcome with 1 corresponding to farmers who produced vegetable under organic production methods for the period of 3 years and above and 0 relating to farmers who produced vegetable using conventional method. $\beta_1 - \beta_{13}$ are the parameters to be estimated, and ε_1 is the error term which is assumed to follow a standard normal distribution with mean zero and variance 1. Table 5.1 presents a summary of the explanatory variables in the equation (5.8).

5.5.1.2 Empirical Model for Estimating the Effect of Organic Farming on Vegetable Output and Household Welfare

As mentioned above, from the probit model (i.e. selection equation), the predicted values are then used to form an inverse mills ratio (IMR). This IMR appears as an additional explanatory variable in the substantive or outcome equations of vegetable output and household welfare respectively. These accounts for potential selection bias (Chang & Mishra, 2008). The second stage (outcome equation), which assesses the effect of organic farming on vegetable output and welfare of households (annual consumption expenditure), are estimated empirically as follows;

$$Y_i = \alpha X_i + \delta Q_i + \varepsilon_{2i} \tag{5.9}$$

$$W_i = \gamma X_i + \delta Q_i + \varepsilon_{3i} \tag{5.10}$$

Where Y_i and W_i are vegetable output and welfare of the farm household respectively; X_i represents socioeconomic, farm-specific and institutional/policy variables and Q_i is a binary variable and represents the adoption of organic farming variable. $\gamma \text{ and } \alpha$ are parameter estimates for X_i and δ is a parameter estimate measuring the effect of organic farming on output and household welfare.

Specifically, expanding the empirical model for estimating the effects of organic farming on vegetable output is given as

$$Y_i = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \delta_i Q + \varepsilon_1 \qquad (5.11)$$

Similarly, the model for estimating the effects of organic farming on household consumption expenditure is specified as

$$W_i = \varphi_0 + \varphi_1 AGE + \varphi_2 SEX + \varphi_3 \, EDU + \varphi_4 FSIZE + \gamma_5 EXT + \varphi_6 OFFACT + $$
$$+ \varphi_7 \mathrm{LOWN} + \delta_i Q + \varepsilon_3 \qquad (5.12)$$

The detailed definitions of the variables used in the empirical models (5.11) and (5.12) are provided in Table 5.1.

5.5.2 CMP (Joint) Estimation Model for Adoption and Effect of Adoption on Output and Household Welfare

The study used CMP to jointly estimate a three-equation model for vegetable production involving a dichotomous dependent variable for the adoption of organic farming, a continuous dependent variable for vegetable output, and a continuous dependent variable for household welfare. The adoption of organic vegetable production and vegetable output are potentially endogenous due to sample selection. However, welfare could also potentially affect both adoption and output through several mechanisms. Any potential endogeneity has the possibility of leading to under- or overestimation of the impacts of adoption on output and welfare. This potential for endogeneity raises the concern that if each equation is estimated separately, then, there would be an unobserved correlation between the error terms. Therefore, this study adopts CMP estimation techniques that use more information, leading to more precise parameter estimates. The underlying assumption of the CMP framework is the joint modelling of two or more equations and allowing for cross- equation correlation of the error terms. This justifies its use in this study. The equation system is made up of a probit and two Heckman selections models. Essentially, three equations are estimated together and the endogenous variable Q_i^* appears as a predictor in equation 5.14 and 5.15. The study simultaneously estimates the following three equations:

$$Q_i^* = X_i'\beta + \varepsilon_1 \tag{5.13}$$

$$Y_i = \gamma X_i + \delta Q_i + \varepsilon_2 \tag{5.14}$$

$$W_i = \gamma X_i + \delta Q_i + \varepsilon_3 \tag{5.15}$$

Where Q_i, Y_i and W_i are dummy variable indicating the choice of organic farming, vegetable output and welfare of the farm household respectively; X is the set of variables hypothesised to influence Q, Y and W. The dummy variable (adoption of organic farming) enters equations 5.14 and 5.15 as an endogenous factor estimated by δ.

Moreover, the trivariate error variance ε is assumed to be normally distributed with mean zero and variance $\sum$:

$$\varepsilon = (\varepsilon_1, \varepsilon_2, \varepsilon_3)' \sim N(0, \Sigma)$$

$\sum$ captures the correlation ρ between the omitted factors explaining the adoption of organic farming Q_i and the effect of adoption on output (Y_i) and welfare (W_i).

$$\sum = \begin{pmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix} \tag{5.16}$$

where ρ_{ij} with j, k = 1, 2,3 $\forall$ $i \neq j$ is the correlation between the error terms. Unobserved heterogeneity can be allowed with the potentially non-zero values of the off-diagonal elements of the matrix. The three equations (Eqs. 5.13 to 5.15) above are estimated simultaneously using Conditional (recursive) Mixed Process (CMP) framework introduced by Roodman (2011). This system is estimated by maximum likelihood, allowing the system error terms $(\varepsilon_1, \varepsilon_2 \; and \; \varepsilon_3)$ to be freely correlated so as to account for unobserved common factors that impact simultaneously on adoption, output and welfare.

5.5.3 Functional Forms of the Stochastic Frontier Model

The study used the stochastic frontier approach because vegetable production is largely influenced by external factors. This approach specifies some functional form to represent the relationship between output and input. Among the parametric functional specifications of the production function, the Cobb-Douglas and the transcendental logarithmic (translog) function developed by Christensen, Jorgenson, & Lau (1973) are widely used in econometric estimation. The Cobb–Douglas functional form is not only simple but it is self-dual and has been widely applied in agricultural production technologies in many developing countries (Battese *et al*., 1993; Lindara *et al*., 2006). However, the translog frontier function is flexible, and permits combination of square and cross product terms to improve the fit of the model (Coelli, 1995). But, it can cause multi-collinearity problems (Dawson *et al*., 1991). As specified in the theoretical model (Equations 4.17), the study considered both functional forms to represent each of the vegetable production systems. However, the study employed the Cobb-Douglas production function based on the preliminary test that suggested that Cobb-Douglas is the best fit for the data.

This study followed a three-stage estimation procedure to measure the technical efficiency of conventional farms, organic farms, and both (pooled farm). The first stage involved the use of a one-stage stochastic frontier analysis to generate technical efficiency and the determinants of technical inefficiency for each farming system.

Following Abotsi (2016), Battese & Coelli (1995), Bozoglu & Ceyhan (2007) and Coelli, Rao & Battese (1998), Cobb-Douglas production function can be specified as follows:

$$\ln T_i = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + V_i - U_i \tag{5.17}$$

where *ln* represents logarithm to base *e*, T_i represents the dependent variable (for conventional or organic vegetable farms) is the value of vegetable output (in Ghana cedis)3, X_1 is the total area under organic or conventional vegetables measured in acres, X_2 is the quantity of seeds used for planting (in kg), X_3 is the cash expenditure on synthetic fertilisers used (in organic farming, this refers to organic fertiliser and biological pests control) and X_4 is total quantity of labour (persons day).

Battese & Coelli (1995) and Coelli *et al*. (1998) extended the stochastic production frontier model by suggesting that the inefficiency (u_i) effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics, demographic characteristics, and a random error. The research utilises this model and is given as follows;

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \alpha_9 Z_9 + \alpha_{10} Z_{10} + \alpha_{11} Z_{11} + \alpha_{12} Z_{12} + \alpha_{13} Z_{13} + w_i \tag{5.18}$$

where α_i $(i = 0, 1, \ldots, 13)$ are unknown parameters; Z_1 is the sex of the farmer (categorised as 1 for male and 0 for female); Z_2 is the household size (number of the

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3 In this study the value of output was used instead of physical quantity because several vegetables with different weights are involved and we could not have aggregated them. Value of output is given as the physical quantities of output multiplied by a standardized price computed based on the market prices given. Similar studies that have used the monetary value as the dependent variable include Abotsi (2016); Battese & Coelli (1988); Bozoglu & Ceyhan (2007); Kramol, Villano, Kristiansen, & Fleming (2013). According to Coelli *et al*. (1998; p.213), where the dependent variable in the frontier function is value of output rather than physical output, the inefficiency effects in the model may be influenced by allocative inefficiencies, in additions to technical inefficiencies of production.

people in the household), Z_3 is numbers of year in school; Z_4 is farming experience (years); Z_5 is the number of agricultural extension visits for 2014/2015 cropping season ; Z_6 is off- vegetable farm work (1, if farmer engaged in off- vegetable farm work and 0 if otherwise); Z_7 is access to external credit support (1, if the farmer received credit support and 0, if otherwise); Z_8 is the farmer's ability to make his/her own inputs (yes =1 and 0= otherwise); Z_9 is access to training in vegetable farming (1, if the farmer had access and 0, if otherwise); Z_{10} is farmers' capacity and resource to cultivate all year (1, if the farmer has the capacity and resources to cultivate all year and 0, if otherwise); Z_{11} is farmers' membership in famer based organization (1, if farmer is a member of a FBO and 0 otherwise) and Z_{12} is farm land ownership (1, if the farmland is owned by the farmer and 0 if otherwise). The technical inefficiency model was estimated for both organic and conventional farming systems. Following Battese & Coelli (1995), the parameters for both the stochastic frontier and the inefficiency effects model in equations (5.17) to (5.18) were consistently estimated by maximum likelihood (ML) procedure, which yields estimates for α, β, γ and σ_u^2.

5.5.3.1 Empirical Model for Estimating the Effect of Organic Farming on Technical Efficiency

Agricultural technologies or innovations such as adoption of organic vegetable farming can help increase farm efficiencies and output (Becerril & Abdulai, 2010; Minten & Barrett, 2008; Moyo, Norton, Alwang, Rhinehart, & Demo, 2007). However, any attempt to attribute specific effects to specific interventions will face the fundamental problem of attributing the observed difference in the outcome of adopters and non-adopters, owing to the inability to observe the counterfactual corresponding to any change induced by an intervention (Cameron & Trivedi, 2005; Imbens & Wooldridge, 2009). This challenge makes attribution of the effects difficult because it is necessary to observe the counterfactual in order to measure the effect of the change on any target population. In the following paragraphs, these challenges (often described as selectivity bias) and ways of addressing it are discussed.

In estimating the effect of any agricultural innovation or technology on TE of a farmer, for example, most of the studies (Kramol *et al.*, 2013; Kumbhakar *et al.*, 2009; Tzouvelekas, Christos & Christos 2001) have adopted two separate frontier production functions for organic and conventional processes. But the basic assumption is that organic farming induces minor productivity and the two techniques lie on different frontiers. On the contrary, Kumbhakar *et al*. (2009), Madau (2007), and Sipiläinen & Lansink (2005) used a single stochastic frontier analysis for both organic and conventional farms by including a dummy variable that reflects adoption. This estimation method was biased and inconsistent because farmers should be randomly assigned to the organic vegetable farming system (adoption) or conventional vegetable farming (non-adoption). This, therefore, means that the estimation methods that pool all sampled observations to estimate production/output functions with adoption as a determinant might not be appropriate, because of endogeneity problems. Hence, in this study, an important consideration is to deal with the problem of endogeneity so that unbiased and consistent estimates can be used to measure the impact of adoption on productivity and efficiency.

There are several approaches to overcome the problem of endogeneity when measuring the effect of farm technology adoption, programmes, or an intervention. The traditional approach is to use two-stage estimation procedure. The first stage involves the use of binary models (logit or probit) to obtain a matched sample for each of the groups (treated and non-treated). In the second stage, separate stochastic frontiers were obtained for each group using the matched samples, and the mean technical efficiency differences were used to evaluate the impact of the treatment on efficiency. This approach also has a shortcoming since it is unable to account for selectivity bias associated with observed and unobserved variables. A recent approach proposed by Greene (2010) simultaneously estimates both the matched sample and a single stochastic frontier model. This procedure jointly estimates the probit model, propensity scores, and the technical efficiency scores; hence, it takes into account both observed and unobserved bias (Bravo-Ureta, Almeida, Solís & Inestroza, 2011).

To evaluate the effect of organic vegetable farming on technical efficiency of vegetable farmers, the study attempted using the Greene approach. However, the study could not fully apply the Greene's approach due to data limitations. The raw uncompleted results are placed in appendix B (I and II) for verification. Hence, the mathematical procedure with respect to this approach has been left out.

The study, therefore, adopted the approach used by Oduol, Binam, Olarinde, Diagne & Adekunle (2011) and explained in Asante *et al*. (2014). This approach also involves two-stage estimation. First, the adoption of organic farming is estimated and the predicted probabilities score of adoption are generated. The adoption model is therefore expressed as

$$Q_i = X^{'}\beta + \varepsilon_1 \tag{5.19}$$

Where Q_i is the dependent variable, the adoption status of the producer, 1 for farmers who adopt organic vegetable, and 0 for farmers who do not adopt it while X_i represents socioeconomic, farm-specific and institutional/policy variables. β is parameter of the X_i variables and ε_1 is the random error term in the probit model.

In the second stage, the predicted values of adoption are included as an explanatory variable in the frontier model. The positioning of the adoption variable in the model will be determined based on Akaike Information Criteria (AIC) model selection criteria. In other words, the predicted probability scores of adoption variable (from equation 5.19) is then included as explanatory variable together with other variables in the stochastic frontier model in equation (5.17) and/or inefficiency effect model (equation 5.18) to measure the real effect of adoption of organic vegetable production. This approach corrects for endogeneity in the adoption before incorporating it into the technical efficiency estimation (Asante *et al*., 2014).

The stochastic frontier production function which includes the effect model is then specified as:

$$T_i = \beta_i X_i + \phi_i A_i + V_{i\,i} \qquad (5.20)$$

$$\mu_i = \delta_i X_i + \phi_i A_i + \varepsilon_i \qquad (5.21)$$

where, A_i is predicted adoption variable and ϕ_i is a parameter estimate measuring the impact of organic vegetable farming on technical efficiency. The rest of the variables are defined earlier.

5.5.3.2 Test of Hypotheses

In this study, four hypotheses were tested in the stochastic frontier model using the generalised likelihood ratio test. The formula for the generalised likelihood ratio test is as follows:

$$LR = -2\left\{ln\left(\frac{LH_0}{LH_1}\right)\right\} = -2\,\{\ln[L(H_0)] - \ln[L(H_1)]\} \qquad (5.22)$$

where $LL(H_0)$ and $LL(H_1)$ denote the maximum value of restricted and unrestricted log-likelihood functions respectively. The LR is assumed to be mixed chi-square distributed. If the null hypothesis is true, the test statistic has approximately a mixed chi-squared distribution with degrees of freedom equal to the difference between the numbers of the parameters involved in the alternative and null hypotheses. The following hypotheses were tested:

- $H_0: \beta_{jk} = 0,$ coefficients of the second order variables are zero, which implies that the Cobb Douglas function is the statistically best fit for the data.
- $H_0: \gamma = \alpha_0 = \alpha_1 = \cdots . = \alpha_{14},$ inefficiency effects are absent from the model at all levels.
- $H_0: \gamma = 0,$ inefficiency effects are non-stochastic. Thus, stochastic frontier model minimises to the original average response function.
- $H_0: \beta_5 = 0,$ meaning that there is no effect of organic vegetable farming adoption on output.

5.5.4 Description of the Variables and their *A priori* Expectations

The study considers a set of independent variables that relate to the theoretical framework in the vegetable production adoption decision as described earlier in this chapter. These variables include farmer characteristics, farm/production factors, economic factors, and institutional factors. Below are brief descriptions, measurement and a priori expectations of the explanatory variables used in the model (Table 5.1).

Table 5.1: Description, Measurement and a priori Expectations of the Study Variables

Variable	Description	Measurement	Expected Sign
Dependent variable			
Q_i	Adoption status	Dummy (1 = adopter of organic vegetable farming; 0 = non-adopter/ conventional vegetable farming)	
Y_i	Natural logarithm of vegetable output	Ghana cedis	
W_i	Natural logarithm of per capita consumption expenditure	Ghana cedis	
Independent variables			
x_1	Natural logarithm of farm size	Acres	+
x_2	Natural logarithm of labour	Persons days	+
x_3	Natural logarithm of fertilizer/manure cost	Cedis	+
x_4	Natural logarithm of seeds	kilogram	+
AGE	Age of the farmer	Years since birth	-/+
HSIZE	Number of household members	Number of people	+
EDU	Education level of the farmer	Schooling years	+/-
FYEXP	Experience of the farmer	Years	+
FSIZE	Farm size	Acres	+/-
EXT	Access to Extension service	Number of visit	+/-

Table 5.1: Description, Measurement and a Priori Expectations of the Study Variables (continued)

Variable	Description	Measurement	Expected Sign
ARCAY	Ability and resources to cultivates all year	1 if farmers have the ability and resources to crop all year round; 0 if otherwise	+
AECS	Access to external credit support	Yes = 1; No = 0	+
OFFACT	Engagement in off- farm activities	Yes = 1; No = 0	+
FBO	Membership in farmer associations	Yes = 1; No = 0	+
AMOI	Ability and resource to make own inputs (fertilizers & pesticides)	Yes = 1; No = 0	+
LOWN	Sole owner of land	Yes = 1; No = 0	+

i. ***The age of the farmer:*** The relationship between a farmer's age and the decision to adopt an innovation or technology is not clear in the literature. While some researchers found that older farmers are more likely to adopt an innovation (Donkoh & Awuni, 2011; Sodjinou *et al*., 2015), others found that young people are more open to adopting new technologies (Ogada *et al*., 2014). Thus, in this study, we expect that the sign of the variable age can be positive or negative. Besides, Sodjinou (2011) argued that producers might be opened to new technologies till a certain age after which they become less open until they reach old age. The opposite may also occur in some cases.

ii. ***Gender of the producer:*** A dummy variable is included to capture gender differences, with 1 for male and 0 for female. The hypothesis is that males are more likely to adopt an innovation or technology than females (Asmah, 2008; Mugonolaa, Deckersa, Poesena, Isabiryec, & Mathijsa, 2013; Nunoo, Asamoah, & Osei-Asare, 2012). As a result, the variable gender is supposed to have a positive influence on the organic vegetable adoption. This means that male farmers will be more likely to adopt organic vegetable production than female farmers.

iii. ***Household size:*** It is a continuous variable which indicates the number of persons living in the house of the farmer for their livelihood. The production of organic vegetable is more labour-intensive than conventional vegetable farming, especially, for transportation, application of organic inputs (pesticides, fertilisers, etc.), and weed control. This means that farmers with large family sizes will generally have a greater labour force for timely operation of farm activities. This implies that this variable may have a positive sign.

iv. ***Educational level:*** It is well expected that the more educated a farmer is, the likelihood he will seek innovation to overcome production constraints. Therefore, education might also enhance farmers' ability to efficiently allocate inputs across competing uses and to gain more knowledge about adverse effects of conventional crop farming (Polson & Spencer, 1991). As a result, it is expected that education will have a positive effect on the probability to adopt organic vegetable farming.

v. ***Off-farm activity level:*** Off-farm activity might have a positive influence on organic vegetable adoption since income from off-farm employment relaxes the liquidity constraints. Farmers involved in subsistence agriculture usually have low farm income, so they rely heavily on off-farm sources of income and devote considerable amounts of time to off-farm activity. It is expected that the availability of off-farm activity will relate positively to adoption decision since farmers who engaged in off-farm activities earn additional income to purchase initial seeds or other essential agricultural inputs (Beshir, Emana, Kassa, & Haji, 2012).

vi. ***Farming experience:*** Farmers' experience in vegetable production is likely to have a range of influence on adoption. Farmers with long years of experience appear to have better knowledge and are able to evaluate the advantage of the technology. Hence, it was hypothesised to affect adoption positively (Lapple, 2010; Ojo & Ogunyemi, 2014; Ramesh *et al.*, 2010).

vii. ***Farm size:*** The size of the farmland is often argued to be important to the adoption decision. Farmers with smaller farm size are more likely to adopt organic farming; the reason is that, they can easily mobilise the needed organic inputs (such as organic manure) and labour for their small farm operation. This means that the larger the farm size, the more difficult it is to manage under organic farming systems. Sodjinou (2015), however, explains that farmers with large land area could easily adopt certain practices of soil fertility improvement such as inter-cropping, crop rotation, agroforestry and improved fallow. In this respect, farmers who have large farmland will be more likely to adopt these organic technologies. This means that farm size will have either a positive or negative sign.

viii. ***Access to external credit support:*** This is a dummy variable which takes a value of 1 if the farmer had access to cash credit or kind credit and 0 if otherwise. Access to credit, generally, has a positive effect on innovation adoption. Indeed, farmers who have access to credit are more likely to adopt improved technology than those who have no access to credit (Akudugu *et al.*, 2012; Beshir *et al.*, 2012; Saleem, Muhammad, & Latifullah, 2011). Nevertheless, the condition is quite different in the case of organic farming where farmers rely on locally available or farm derived resources instead of market-based inputs. This suggests that organic farming is less dependent on credit compared with conventional farming. In this study, access to credit is expected to have a negative influence on the adoption of organic vegetable production.

ix. Extension contact: Extension service will help the farmers to understand the importance of modern technology and enhance the efficiency in the implementation of the technology. The farmers who received more services from extension agents are more likely to adopt organic farming and also improve their productivity.

x. ***Membership in farmers associations***: Membership with farmers' associations is likely to relate positively to adoption decisions. Producers belonging to farmer based organisation can easily get in touch with their colleagues. This grants them the opportunity to not only exchange new technologies but also to have access to agricultural inputs. Accordingly, belonging to a producer organisation is expected to have a positive influence on the adoption of organic vegetable production.

xi. ***Capacity and resource to crop all year round* (ARCAY):** This is a dummy variable which takes a value of 1 if the farmer has the ability and resource to produce vegetable throughout the year, and 0 if the farmers have the ability and the resources to cultivate once in a year (i.e. either in the raining or dry seasons). For this reason, it is expected that an all year round production will have a positive effect on the probability to adopt organic farming.

xii. ***Capacity and resource to make own inputs (Manure & Pesticides):*** Promoting homemade inputs will reduce production costs while helping to positively influence adoption. This variable was treated as a dummy variable. That is, if the farmer makes his/her own inputs, it is coded as 1, and 0 if otherwise.

xiii. ***Land ownership:*** The benefits of investing in organic farming accrue over time. This implies that secure land access will impact positively on adoption decision. In the study analysis, land ownership was used as a proxy for assured land access. This takes the value of 1 if the land for the vegetable farming operation is solely owned by the farmer, and 0, if otherwise**.**

CHAPTER SIX

FARMERS' CHARACTERISTICS AND BENEFITS OF ORGANIC FARMING

6.1 Introduction

This section presents the results and discussion of the data analysis. It includes organic vegetable production, its perceived benefits and socio-economic characteristics of the respondents.

6.2 Socio-economic Characteristics of Smallholder Vegetable Farmers

The study was conducted in twenty (20) communities in the Northern region of Ghana. It involved a total of 400 respondents, comprising 200 each of organic and conventional vegetable producers. It is important to recall that conventional vegetable farmers are those who used only synthetic inputs or a mix of synthetic and some organic inputs together. This was made so because products from such production systems are classified as non-organic. The study sourced information about vegetable farmers: age, gender, experience in vegetable production, total farm size under cultivation, extension visits, farmers' ability and resource to cultivate all year round and membership with farmer association.

The majority of the respondents (41.5%) fell within the modal age group of 35-44 years, out of which 42% adopted organic vegetable farming, and 44% were non-adopters (conventional farmers). Organic vegetable farmers had an average age of 38.2 years, whereas the average age of conventional farmers was 37.8 years, placing both in the middle-age class (Table 6.1a). The difference in the ages of both organic and conventional vegetable farmers was, however, not statistically significant (Table 6.1a).

From the study, the youngest farmers were in their mid-20s and late 30s. It can then be inferred that most farmers in the study area are within their prime productive agricultural age and are capable of providing active self-labour for their vegetable production. This is in sync with the findings of Afolami *et al*. (2015) and Sodjinou *et al*. (2015) who stated that farmers that are in their productive age usually experience high farm output and enhance the spread of innovation. This is also consistent with the observations made by FAO (2005) that the average age of Ghanaian farmers clearly indicates that farming is something middle-aged and older people do for living.

On the average, the household size was found to be relatively high; with 59.3% of the respondent farmers having household sizes that ranged between 5 and 10 members. Yet, there was no statistically significant difference in the household size between organic and conventional vegetable farmers as shown in Table 6.1a. Household size plays an important role in family labour supply which is a major characteristic of small scale agriculture in Ghana. These larger households usually tend to be a source of cheap and affordable labour in vegetable production. It thus, contributes to the adoption of organic farming by the farmers since having large household size offers an opportunity to expand the farm size, generate more revenue and meet the welfare needs of the households.

Table 6.1a: Farmers' socio-economic characteristic

		Conventional farmer (200)			Organic farmer (200)			Total (400)			
Variable	**Category**	**N (%)**	**Mean**	**Std. Dev.**	**N (%)**	**Mean**	**Std. Dev.**	**N (%)**	**Mean**	**Std. Dev.**	***Statistical test***
Age			**37.81**	**8.44**		**38.24**	**8.18**		**38.02**	**8.30**	***t= -0.518***
	Less than 25yrs	5 (2.5)			5(2.5)			10 (2.5)			
	25-34	67(33.5)			60(30)			127(31.9)			
	35-44	82 (44)			84(42)			166(41.5)			
	45-54	34(17)			43(21.5)			77 (19.3)			
	more than 54	12(6)			8(4)			20 (5)			
Household size			**8.76**	**3.17**		**8.79**	**3.87**		**8.77**	**3.53**	***t=-0.706***
	less than 5 members	12 (6)			24(12.2)			36 (9.00)			
	5-10 members	125(62.2)			110(55.8)			237(59.3)			
	more than10 members	64 (31.8)			63 (32)			127(31.8)			
Education	*Years of schooling*		**5.13**	**4.57**		**6.12**	**5.03**		**5.13**	**4.90**	***t=--5.184******
	Primary	32 (16)			48 (24)			80 (20)			
	junior high	25 (12.5)			39 (19.5)			64 (16)			
	Secondary	6(3)			30(15)			36 (9)			
	Teacher/nursing training	1 (0.5)			1 (0.5)			2 (0.25)			
	vocational/technical	2(1)			2 (1)			4 (1)			
	Tertiary	3 (1.5)			7 (3.5)			10 (2.5)			
	no formal education	131(65.5)			73(36.5)			204 (51)			

Source: Field Survey, 2015, *** significant at <=1% level, t = T-test statistics

More than half of the respondents (51%) in this study did not have any form of formal education. Out of this, 32.8% were into conventional farming while 18.3% were into organic vegetable farming. The results indicated that the respondents as a whole attained an average of 5.1 years of formal education which corresponds to primary education. However, the level of education of the conventional vegetable farmers was found to be relatively low (5.1 years) compared with the organic vegetable producers (6.1 years). Their mean difference was also statistically significant at 1% level. This offers a plausible explanation why all the organic farmers adopted at least one of the sustainable organic agricultural practices.

The mean distribution of the farm size for organic vegetable adopters was 1.65 acres and 1.69 acres for non-adopters. The results showed no statistically significant difference in farm size between organic and conventional farms. Table 6.1b indicates that more than half (53.8%) of the sampled farmers did not have access to extension services while 46.3% had access. But a significant number (28.8%) of organic vegetable farmers had information from extension agents (MOFA and NGOs agents) whereas only 17.5% of the conventional farmers had access to extension services.

The study found the number of years of experience in vegetable production to be relatively high for the producers of organic vegetable compared with conventional vegetable producers. The paired sample mean comparison test indicates that there is a statistically significant difference in farming experience between organic and conventional farmers at the 10 percent level.

Table 6.1b: Cont'd. Farmers' socio-economic characteristic

Conventional farmer (200)					**Organic farmer (200)**			**Total (400)**			
Variable	**Category**	**N (%)**	**Mean**	**Std. Dev.**	**N (%)**	**Mean**	**Std. Dev.**	**N (%)**	**Mean**	**Std. Dev.**	***Statistical test***
Farm size			**1.69**	**0.93**		**1.65**	**0.69**		**1.67**	**0.82**	***t*** **= 0.4370**
	Less than 1 acre	16 (8)			10 (5)			26(6.5)			
	1-1.9 acres	131(65)			132(66)			263 (65.8)			
	2-2.9 acres	53(26)			58(29)			111 (27.8)			
	More than 2.9 acres	0			0			0			
Farming experience			**16.27**	**9.17**		**18.67**	**7.57**		**17.47**	**8.48**	***t*** **= -2.8540****
	Less than 6 years	21 10.5)			3(1.5)			24 (6)			
	6-15 years	92 (46)			86 (43)			178 (44.5)			
	16-25 years	61(30.5)			83(41.5)			144 (36)			
	>25 years	26(13)			28 (14)			54 (13.5)			
Access to extension service			**1.12**	**1.64**		**2.93**	**3.80**		**2.04**	**3.05**	***t*** **= -6.0841*****
	Less than 2 times in production year	130 (65)			92 (46)			222 (55.5)			
	2-4 time in production year	67(33.5)			60 (30)			127 (31.8)			
	>4 times in production year	3 (1.5)			48 (24)			51 (12.8)			

Source: Field Survey, 2015, *** significant at <=1% level, ** significant at >1&<=5% level, *t* = T-test

This difference suggests that the organic farmers in the study sample have been cultivating vegetables for longer periods as compared with conventional farmers. Consequently, though the majority of the respondent farmers were still in their productive age, they were very experienced in vegetable production.

Furthermore, 24% of the organic vegetable farmers had frequent contacts with the extension agents (i.e. more than four times in one cropping season) than the conventional vegetable farmers (1.5%). This provided them with a better opportunity to adopt an innovation since contacts with the agricultural extension agents help farmers to access a more precise and technical information on organic farming systems as observed by Sodjinou *et al*. (2015).

As shown in Table 6.2a, the majority of the farmers (81.5%) are male and 18.5% female. The result also indicates that the male organic vegetable producers (87.5%) are more than conventional vegetable farmers (76%). Their difference was statistically significant at 5% probability level, suggesting that vegetable production was common among male farmers in the study population. The higher number of male respondents among the farmers could be the result of males having greater access to farm resources than their female counterparts. This is in sync with Asmah (2008) and Nunoo *et al*. (2012), who attributed the low number of female in farming to land ownership.

Furthermore, the analysis presented in Table 6.2a indicates that all the organic vegetable growers have the capacity and the resource to prepare almost all their inputs as compared with only 6.5% of conventional vegetable farmers.

Table 6.2a: Farmers' Socio-Economic Characteristic

		CVF (200)	OVF (200)	Total Sample(400)	*Statistical test*
Variable	**Category**	**N (%)**	**N (%)**	**N (%)**	
Sex					**x^2=- 0.86****
	Male	152 (76)	175 (87.5)	327(81.8)	
	Female	48(24)	25 (12.5)	73 (18.2)	
Farmer's ability and resource to make own input					**x^2= -148.2****
	Yes	13 (6.5)	200(100)	213(53.3)	
	No	187(93.5)	0(0)	187(46.7)	
Membership in FBO					**x^2= -12. 9*****
	Yes	45(22.5)	71(35.5)	116(29)	
	No	155(83)	129(64.5)	284 (71)	
Farmer's capacity and resources to cultivate					**x^2= -93.1*****
	Once a year	143 (71.5)	39(19.5)	182(45.5)	
	All year around	57 (28.5)	161(80.5)	218(54.5)	
Off-vegetable farm activity participation					**x^2= -0.01**
	Yes	107(53.5)	108(54)	215(53.8)	
	No	92(46)	93 (46.5)	151(46.2)	

Source: Field Survey, 2015, *** significant at <=1% level, ** significant at >1&<=5% level. Figures in Parentheses are the standard deviation, Chi-square = χ^2 values; CVF= conventional vegetable farmer; OVF= organic vegetable farmer.

Organic farmers also used crop residues and animal droppings for compost and farmyard manure (FYM) to improve soil fertility. This is because they find it affordable, easy to apply, sustainable and environmentally-friendly.

Membership to farmer based organisations (FBOs) is more pronounced among organic vegetable farmers (17.8%) than conventional vegetable farmers (11.3%). It was also observed that organic vegetable farmers engaged in off- farm activities more than the conventional farmers. It is therefore not surprising to find that 67.5% of organic farmers earned more off-farm income than conventional farmers (57%). The major sources of off-farm income include trading, driving, employment as civil servants, artisanal, butchery, among many others.

Almost all the farmers in this study were found to finance their farming operations through personal savings. However, approximately 20% of the sampled farmers had received agricultural credit support to finance their production. A good proportion of the organic vegetable farmers (80.5%) in the study area have the ability and resources to cultivate vegetables throughout the year as compared with 28.5% of the conventional farmers (Table 6.2a). The organic farmers attributed their ability to farm throughout the year to the presence of organic matter in the soil. According to them, the organic matter in the soil retains enough moisture to support plant growth, even in the dry season. This afforded them the opportunity to invest in simple irrigation systems that cost less while assuring them the ability to produce, even in the dry season. Another motivation for the all year production was the continuous high demand and the ready market for the organic vegetables. This finding is corroborated by results from studies by Berman

(1994), Carter (2002) and Pimentel *et al.* (2005), who posited that soil organic matter enhances soil water-holding capacity, regulates air and maintains plant nutrients. Some other studies also report that organic matter used in organic agriculture offers a comparative advantage in areas with less rainfall and relatively low natural and soil fertility levels (Dabbert, 2006; Hole *et al*., 2005; Ramesh *et al*., 2005).

Table 6.2b: Cont'd. Farmers' Socio-economic Characteristic

		CVF (200)	**OVF (200)**	**Total sample (400)**	***Statistical test***
Variable	**Category**	**N (%)**	**N (%)**	**N (%)**	
Landownership					**x^2=0.11**
	Leased	38(19)	38(19)	76(19)	
	partnership	6(3)	5(2.5)	11(2.75)	
	Rent	13(6.5)	17(8.5)	30(7.5)	
	sole owner	143(71.5)	140(70)	283(70.75)	
Access to external credit support					***x^2=63.78****
	Yes	11(5.5)	69(34.5)	80(20)	
	No	189(94.5)	131(65.5)	320(80)	
Training					***x^2=97.37****
	Yes	14(7)	104(52)	118(29.5)	
	No	186(93)	96(48)	282(70.5)	

Note: *** significant at <=1% level, Chi-square = χ^2 values; CVF= conventional vegetable farmer; OVF= organic vegetable farmer

The study further reveals that small proportion of farmers (29.5%) had training. Out of this, a significant percentage (26%) of the organic farmers received training on their farming businesses, compared with 3.5% of conventional vegetable growers. Similarly, 33.8% and 28.5% of organic and conventional vegetable producers respectively engaged in full-time farming. As indicated in Table 6.2b, in the pooled sample, the majority (70.8%) of the respondents are sole owners of their farmland. Also, 71.5% and 70% of the respective adopters and non-adopters own their farmland. This suggests that access to farmland is not a constraint to vegetable production and adoption of organic farming in the study area. The use of Farmyard Manure (FYM) and compost in vegetable farming has been highly advocated by environmental activists as a way to improve soil fertility without producing negative externalities to the environment.

Results presented in Table 6.3, show that 39% of the conventional farmers had used both natural and synthetic fertilisers to grow vegetables, and are referred to as ‘conventional’ farmers in this study whereas organic vegetable farmers used farm yard manure (FYM), compost, crop rotation, among others for cultivation. FYM was the most common type of organic fertiliser used by all (100%) organic farmers, and 38.5% of the conventional farmers. From the survey, farmers obtain FYM from their own pens and kraals or buy the FYM from their fellow farmers (within the study area or from Sunyani and Kumasi). Compost was the second most popular organic fertiliser used by 98.5% and 6.5% of organic and conventional farmers respectively.

Table 6.3: Quantity used and Costs (GH¢) of Inorganic and Organic Fertilisers

	CVF		**OVF**		**Total sample**		**Mean Difference**
Variables	**N (%)**	**Mean**	**N (%)**	**Mean**	**N (%)**	**Mean**	
Inorganic fertiliser (kg)		**211.5 (164.8)**				**211.5 (164.8)**	
Synthetic fertiliser	200(100)				200 (50)		
Organic fertiliser (kg)		**561.8 (165.3)**		**2672.9 (1472.7)**		**1617.3 (1487.4)**	**2111.13*** **
Farm yard manure	77(38.5)		200(100)		277 (69.3)		
Compost	21(10.5)		197(98.5)		218(55)		
Others			21(10.5)		21(10.5)		
Fertiliser cost		**232.2 (93.2)**		**79.2 (60.4)**		**155.7 (119.2)**	**152.97*** **

Source: Field Survey, 2015, *** significant at <=1% level. Figures in Parentheses are the standard deviation, N= number of farmer, CVF= conventional vegetable farmer; OVF= organic vegetable farmer

Notably, the analysis presented in Table 6.3 reveals significant differences in the quantity and cost of natural/synthetic fertilisers between farmers who adopted organic vegetable farming and those who still produced vegetable by conventional methods. The adopters of organic farming had used significantly higher quantities of organic manure than non-adopters (conventional farmers). For instance, the organic farmers used

2610.63 kilograms per acre of organic manure in 2014/15 production year compared with 561.75 kilograms/acre for the non-adopters. The disparity between the quantity of inorganic and organic fertilisers is obviously due to the differences in nitrogen levels between the inorganic and organic fertilisers. The compound fertiliser NPK (15-15-15) used by farmers contain 15 % nitrogen whereas most organic fertilisers, ranging from compost to poultry manure, only have between 1- 4 % nitrogen. This means that higher amounts of the organic fertilisers are required in vegetable production as compared with inorganic fertilisers to meet crop nutrient demands (Ahmed, Idris, & Syed Omar, 2007; Amanullah, Sekar, & Muthukrishnan, 2010; Gao, Liang, Yu, Li, & Yang, 2010; Munawar & Riwandi, 2010; Yun Zhang & yang He, 2006). This result also suggests that any policy intervention that would encourage further research into the improvement in nitrogen level of organic manure can encourage an increased interest in adoption. Although organic farmers use huge quantities of organic fertiliser, the annual cost associated with the use of the organic fertiliser was GH¢79.18 per 2610.63kg per acre in 2014/15. This was relatively low compared with the GH¢232.15 per 211.5kg of synthetic fertiliser used by conventional farmers.

The average cost of seeds per acre for organic farms was higher than that of conventional farms. However, the difference between the two groups is not significant even at 10% level. Similarly, labour costs (family plus hired labour) in organic farms are higher as compared with conventional farms (Table 6.4). The t-test result suggests that there is a significant difference in the cost of labour used by adopters of organic farming and non-adopters. This means that organic vegetable farmers utilise more labour than non-adopters.

Table 6.4: Summary statistics of average seeds and labour cost (GH¢) per acre in 2014/2015

Variable	Conventional Farms			Organic Farms			
	Mean	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean difference**
Labour cost	232.59 (114.4)	60	645	293.27 (104.07)	77	650	-60.69***
Seeds	8.813 (4.01)	1.76	37.5	9.10 (5.30)	2	50	-0.29

Source: Field Survey 2015 *** significant at <=1% level, Note: Figures in Parentheses are the standard deviation, Min = minimum and Max = maximum

This could be explained by the fact that organic vegetable production is more tedious and laborious, owing to the fact that organic farming depends solely on natural materials (such as compost, FYM, plants repellent, among others) for soil fertility and pest management. Also, more laborers are needed for weeding and the preparation and spreading of manure on the farm. This can further be explained by the findings of this study that 80.5% of the organic farmers cultivated throughout the year (as reported in Table 6.2a), expending more labour and capital thereof. The result also confirms the findings of Badgley *et al*. (2007) and Pimentel *et al*. (2005), who found organic farming systems to be more labour intensive in comparison with conventional farming in Thailand.

The farmers in the Northern Region grow a wide range of vegetable crops, including tomatoes, pepper, cabbages, lettuce, carrot, onion, cucumbers, green pepper, amaranthus (alefu), white jute (ayoyo), Roselle (braa), okra, and beans leaf (suule). Vegetable yield, gross margin, and the price of vegetables widely produced in the research area are presented in Table 6.5.

About 96% of farmers (organic and conventional farmers) indicated that they preferred alefu (Amaranthus *species)* because it is easy to manage and takes short time to mature; hence yields quicker returns. Also, amaranthus can be harvested 4 weeks after sowing; thus, a farmer has an opportunity of sowing and reaping about 9 times a year. Lettuce was the second most grown vegetable by the organic growers and it can be cultivated on the average of 8 times a year. This is because it has a high market demand most often for food joints and restaurants. This is consistent with the finding of Obuobie *et al*. (2006) who stated that 98% of all lettuce traded in Ghana are bought by food vending businesses. It also requires 4-6 weeks to manure. Ayoyo (Corchorus *olitorius*) and okra were also among the most grown vegetables.

Conventional vegetable growers, on the other hand, frequently grow cabbage and pepper. Cabbage, for instance, is readily saleable in their neighborhood and farm gate. There is a reasonable demand from the community and outside, and thus, motivates conventional farmers to produce more. Another reason for their frequent production may be due to the fact that cabbage is an exotic crop which is prone to pest infestation, but is easily controlled with synthetic pesticides to reduce the risk of harvest and income loss.

With the exception of cabbage, organic vegetable growers have higher output in kilogram for the various vegetable crops than the conventional vegetable; with pepper, cucumber, and okra recording a significant mean difference of 482.25kg, 348.43kg, and 292.86kg at 10% and 5% levels of significance respectively (Table 6.5). Similarly, studies conducted in Punjab and Ethiopia shows that organic farming gave a higher or equal output as compared with conventional farming, Kassie *et al*., 2010, and Kler *et al*., 2002).

Okra and green beans had the highest gross margins of GH¢3,237.14 per acre and GH¢4,992.904 per acre for conventional and organic farms respectively. Considering output prices, carrot had the highest price and amaranthus had the lowest (Table 6.5). The average annual gross income of the organic vegetable farmer (adopters) was GH¢37,091.66 per acre while that of conventional farmers was GH¢ 27,144.16 per acre with a significant mean difference of GH¢9,947.50 per acre, indicating that the adopters have higher vegetable output than the non-adopters (conventional vegetable farmers). The average output difference between organic and conventional farms was statistically significant at 1% level. As shown in the results, the use of organic method can lead to significantly higher vegetable output, meaning that the adoption of organic farming yielded multiple benefits in in terms of reduced production costs and increased output.

Table 6.5: Average yield and gross revenues of vegetable in 2014/15 cropping seasons

		Conventional farmer		**Organic farmer**		**Pooled sampled**		
Species	**Output price (¢/kg)**	**Yield (kg)**	**Gross margin (¢/Acre)**	**Yield (kg)**	**Gross margin (¢/Acre)**	**Yield (kg)**	**Gross margin (¢/Acre)**	***Mean Difference of yield (Kg)***
Tomatoes	3.47	980.43	3402.09	1057.5	3669.51	1011.55	3510.09	77.07
Pepper	1.72	606.75	1043.6	1089	1873.08	846.16	1455.4	482.25*
Cabbage	1.92	1384.88	2658.98	1175.42	2256.81	1222.24	2346.7	209.47
Lettuce	1.94	1163.54	2257.28	1190.49	2309.56	1183.4	2295.8	26.95
Carrot	12.13	223.18	2707.15	397.93	4826.88	350.27	4248.77	174.75
Onion	2.1	1135.57	2384.69	1378.07	2893.95	1250.85	2626.79	242.5
Green beans	9.87	308.67	3046.54	505.87	4992.9	407.27	4019.72	197.2
Cucumber	6.51	283	1842.33	631.43	4110.58	390.21	2540.25	348.43**
Sweet pepper	5.18	282.7	1181.69	502.58	2100.8	429.29	1794.43	219.88
Alefu	0.7	907.98	635.919	969.97	678.976	933.85	653.964	61.99
Ayoyo	3.47	456.47	1583.95	531.78	1850.51	478.83	1661.61	75.31
Bra	2	385.57	771.134	407.53	815.061	392.32	784.65	21.96
Okra	3.35	966.31	3237.14	1259.17	4218.23	1172.75	3928.73	292.86**
Bean leaf(sulee)	1.1	356.06	391.665	449.83	494.815	408.96	449.852	93.77
Average			**27,144.16**		**37,091.66**		**32316.76**	

Source: Field Survey Note: ** significant at >1&<=5% level, * significant at >5&<=10% level

Household expenditure is usually used as a measure of household welfare because it reflects a lot of information on effective consumption of households. Household expenditure includes expenditure on food shelter, clothing, education and health, among others and therefore can have relevance for the long-term average well-being of the household (Afolami *et al.*, 2015). A comparison of household expenditure was made between adopters and non-adopters of organic farming in the study area. The result of the analysis is presented in Table 6.6. Many of the respondent farmers (constituting 59.5%) were found to have spent their income on food and its related items. This is because food is an important need of every household, particularly in Ghana, and it accounts for the larger percentage of household budget. This is evident in a previous study conducted by Donkoh, Alhassan & Nkegbe (2014) who found that food accounts for almost 40% of household expenditure. Similarly, expenditure on transportation/fuel/maintenance and others (such as rents, farm implements, social contributions, among others) constitutes 11.9 % and 10.4 % respectively of farmers' household expenditure.

Also, the results presented in Table 6.6 reveal that organic vegetable farmers have higher and statistically significant expenditure on water than conventional farmers. This might probably be due to the fact that most organic vegetable farmers grow vegetables throughout the year (as reported in Table 6.2a), and thus, use water in the dry season. This, however, resulted in higher outputs which led to higher income and better welfare. Equally, the average annual per consumption expenditure of the adopters is GH¢ 453.13 while that of non- adopters was GH¢ 293.24 with a significant mean difference of GH¢

159.89, indicating that the adopters had higher annual per consumption expenditure than non-adopters. Since consumption expenditure was used as a measure of welfare, it can be explained that organic vegetable producers had a better welfare than the conventional vegetable producers. This finding is consistent with Afolami *et al*. (2015) and also Kassie *et al*. (2011) who reported that farmers who benefited from agricultural technologies reduced poverty levels significantly.

Table 6.6: Farm Households' Per Consumption Expenditure for 2014 /2015

	CVF	**OVF**	**Pooled Sample**		
Variable	**Mean**	**Mean**	**Mean**	**Av.%**	**Mean Difference**
Electricity expenditure	12.4	20.19	16.30	**4.37**	-7.78***
Water expenditure	3.48	9.19	6.34	**1.70**	-5.71***
Food expenditure	159.87	284.54	222.20	**59.54**	-124.67***
Medical care	11.609	10.44	11.02	**2.95**	1.17
Transportation/fuel/ maintenance	40.83	48.55	44.69	**11.98**	-7.71*
Education expenditure	28.64	39.23	33.94	**9.09**	-10.59*
Other expenditure	36.5	40.98	38.74	**10.38**	-4.48*
Total	**293.24**	**453.13**	**373.18**	**100**	

Source: Field Survey, 2015, The T-test was used to test for differences in household expenditure variable between organic and conventional vegetable producer. * Significant at 10%; ** significant at 5% and *** significant 1%, CVF and OVF refer to the conventional vegetable farmer and organic vegetable farmer respectively.

From the above results (Table 6.5 and Table 6.6), the adopters of organic farming had higher vegetable output than the non-adopters. However, these comparisons did not account for the effects of other characteristics (such as managerial skills and entrepreneurial skills) of the farmers that could influence these outcomes. Hence, these observed differences in the mean vegetable output and household welfare cannot be attributed entirely to the adoption of organic vegetable farming (Becerril & Abdulai, 2010; Kuhlgatz & Abdulai, 2011). The Heckman (1979) treatment effect model was used in subsequent section to assess the effect of organic vegetable production on output and household welfare (household consumption expenditure).

6.3 Organic Vegetable Production and Perceived Benefits

Information about organic vegetable farming is very important to farmers in order to gain insight into its production and marketing processes. In Ghana, only a few farmers have adopted organic farming since its introduction. The reason is that most farmers have no insight into the practice and have limited access to information thereof (COAF, 2012; Osei-Asare, 2009). According to Coleman (1985), organic farming is an information based production system because of its dependence on management rather than capital input. For instance, soil fertility maintenance in organic farming relies mainly on crop rotational strategy and the conservation of soil nutrients, rather than synthetic fertiliser application as in conventional farming. In this study, organic farmers were asked to cite their sources of information pertaining to their production processes. Their responses are summarised in Table 6.7 as follows.

Table 6.7: Farmers' Sources of Information on Organic Farming (%)

Information	**Most helpful**	**Helpful**	**Not helpful**	**Mean**	**Overall rate**	**Rank**
Friends & Neighbours	70.1	25.8	5.1	1.34	**MH**	**1st**
Extension Agents & NGOs	68.1	15.7	16.2	1.48	**MH**	**2nd**
Traders	59.9	31.9	8.2	1.48	**MH**	**2nd**
Profitability of the Venture	38.1	41.6	20.3	1.82	**H**	**4th**
Radio & TV programmes	37.6	26.9	35.5	1.98	**H**	**5th**
Talks & Seminars	24.4	19.3	56.3	2.32	**H**	**6th**
Articles and Books	5.1	16.7	78.2	2.73	**NH**	**7th**
Internet	2.5	12.2	85.3	2.83	**NH**	**8th**

Source: Field Data, 2015, Note: MH=Most Helpful, H=Helpful, NH=Not Helpful

The foremost source of information to the organic farmers interviewed for this study is friends and neighbours. Farmers who had not yet adopted an innovation as organic farming sought advice and recommendation from their friends and neighbours, which they regarded more credible than any advice given by outsiders (Jintrawet, 1995). This finding was noted during discussions with the farmers where many of them disclosed that they were enticed into organic farming by their fellow farmers.

Traders, extension agents and NGOs were ranked second to friends and neighbours. A little more than half of the farmers stated that they ventured organic vegetable production upon demand for organic produce by traders and consumers. The farmers noticed that the traders had a preference for organic vegetables to conventional ones due to their longer shelf life as compared with conventional vegetables. The service of extension agents and NGOs as information sources to farmers can be attributed to the sessions of organic farming training they conduct for the farmers. The training included the cultivation and proper care for organic vegetables. The results in Table 6.7 indicate that the organic vegetable growers (68.1%) ranked the information received from extension agent and the NGOs as the second most helpful because it actually convinced them to venture organic vegetable production. The internet, articles, and books were not helpful to the respondents in this study, perhaps due to the high level of illiteracy among them. Respondents also found talks, seminars, radio and television programmes, and profit incentives the least helpful.

Farmers had several motives as to why they adopted organic farming in their vegetable production system. The major reason is about health concerns associated with the conventional vegetable production. There has also been an increase in the demand for organic vegetables by the growing population. As farmers attempt to meet this increasing demand, they are also challenged by pests, diseases, and soil fertility, which conventional farmers tackle with synthetic fertilisers and pesticides (Lund *et al*. 2010; Williamson *et al*., 2008).

Furthermore, conventional farmers often misuse agrochemicals such as aldrin, dieldrin, endosulfan, lindane, DDT, methylbromide and carbofuran which are either prohibited or labelled for restricted use (Boadi, 2004; Lund *et al.*, 2010; Ntow *et al.*, 2006). This practice has raised concerns about the negative health effects on both farmers and consumers. Due to this, farmers cited health concerns associated with the use of agrochemicals as their paramount reason for venturing organic farming (Table 6.8). This was confirmed by field observation that more than half of the conventional farmers (51%) sprayed their farms without wearing protective clothing. As a result, 43% of them complained of terrible body reactions upon the usage of agrochemicals on their farms.

From Table 6.8, reliable and stable income was the second reason why farmers adopted organic vegetable farming. The majority of the organic vegetable farmers (80.5%) in the study area have the capacity and resources to cultivate vegetables throughout the year as compared with the smaller percentage (28.5%) of conventional farmers shown in Table 6.2a. The organic farmers attributed their ability to cultivate vegetables throughout the year to the advantage in using organic manure which retains enough moisture in the soil to support plant growth, even in the dry season. This finding is corroborated by Berman (1994), Carter (2002) and Pimentel *et al.* (2005) who reported that soil organic matter enhances soil water-holding capacity.

Table 6.8: Motivation for Cultivating Organic Vegetables

	Percentage response (Yes = 1)						
Reasons	**Kum-bungu**	**Tamale**	**Tolon**	**West Mamprusi**	**Total Average**	**Mean**	**Rank**
Ill-health problems	30	48.75	40	56	51	2.47	**1st**
Reliable and stable income	30	48.75	40	52	49	2.77	**2nd**
Sustainable and environmental friendly	100	88.75	70	92	91.5	3.07	**3rd**
Advice from vegetable trader/consumer	30	70	80	63	65	4.31	**4th**
Advice from neighbour/friend	60	46.3	40	31	39	4.66	**5th**
Increasing cost of chemical inputs	40	38.75	30	43	40.5	4.86	**6th**
Maximum profit	100	53.75	70	47	53.5	4.89	**7th**

Source: Computed From Field Data, 2015

Since organic vegetable production relies mainly on farm-derived resources, it normally leads to a reduction in the variable cost and the cost of irrigation during the dry season (Figure 6.1). The income of the respondent farmers was found to have increased with sales through continuous production. According to the respondents, income from organic vegetable production is stable because consumers are showing more preference for organic products.

Figure 6.1: Drip irrigation for organic vegetable production in the dry season

Organic farms differ from conventional farms in terms of nutrient management strategies: The organic systems adopt management options with the prime aim of developing the whole farm. The nutrient cycle is closed as much as possible, and thus, the only nutrient exported out of the farm is what is contained in the harvested vegetable crop. Burning of the vegetable residues is usually prohibited and seen by the majority of the respondents as a major contributory factor to making organic farming systems more sustainable. Environmentally friendly methods are ranked next to reliable and stable source of income as a reason for the adoption of the organic vegetable farming system. This is because organic manure used by the farmers is a renewable source of nutrient that ensures more sustainable production. This position is supported by other studies including Ceccarelli (2014) and Ludin *et al.* (2014). It also allows farmers to obtain a more sustainable and environmentally friendly vegetable supply chain that increased the vegetable yield without over-reliance on costly external input, yet, earning farmers a higher income. Sustainable and environmentally friendly nature of this type of production stems from the fact that farm land and biodiversity are protected to ensure all year-round production.

The study also found that advice from vegetable traders or consumers inspired to adopt organic vegetable production. With these advices, the producers have the assurance of a ready market for their produce. This can also be attributed to the fact that vegetables produced organically are known to have a long shelf life after harvest (Reganold *et al*., 2001), and that, traders and consumers consider it an opportunity to keep stock of their vegetables with little concern about losses due to decay. For this reason, the majority of the organic farmers (91%) attested to the fact that they sell their produce before harvest is due. Other reasons which motivated respondent farmers to adopt organic farming (Table 6.8) include advice from neighbours or friends (39%), the increasing cost of chemical input (40.5%), and maximum profit.

Farmers make decisions on their choice of a particular production method based on its perceived advantages and disadvantages as compared with an alternative. For this reason, their perceptions of the advantages of organic farming were sought with an open-ended question. The producers’ views on the advantages of organic farming were analysed based on four factors: *economic, environmental, productivity, and health concerns*.

The *economic factors* were categorised as low input methods of farming, an appreciable level of profit with less damage to the environment, cost effectiveness, and extended shelf life of organic produce. Table 6.9 shows the advantages of organic vegetable farming as mentioned by the respondents in the study area. The study results indicate that approximately 62% and 61% of organic vegetable farmers cited low inputs and cost effective method of farming respectively as the main economic advantages. This finding can be attributed to the fact that the farmers replaced costly external input with farm-derived resources which resulted in the reduction in the variable input costs in organic vegetable farming. Similar findings were also reported by Thapa & Rattanasuteerakul (2010) which show that the expenditure on fertilisers and pesticides are substantially lower in organic farming than conventional farming.

As shown in Table 6.9, the respondents found organic farming to be more profitable. This is because the farmers prepared their own organic manure and pesticides, using less external input and also engaging their families in farm work in order to reduce production cost. The study found that majority of the organic vegetable farmers farmed throughout the year (see Table 6.2a). The finding is consistent with Ramesh *et al.* (2005) and Reganold *et al.* (2001) who reported that organic farmers have control over water usage on their farms, therefore, can produce all year round and obtain high profit. The stable and consistent production, together with the market demand for organic vegetables, were found to be major contributory factors to the increased sales value which made it more profitable than conventional vegetable farming.

Table 6.9: Farmers' Perception of Advantages of Organic Farming

Advantages of organic farming	**West Mamprusi** %	**Tolon** %	**Tamale** %	**Kumbungu** %	**All** %	**Pooled/ Average %**
Environmental factors						**35.6**
Organic farming conserves soil moisture as compared with conventional farming	12	5	12.8	2.5	32.3	
Organic farming encourages sustainable use of the farm land	8.8	22.5	13.1	10	54.4	
Organic farming maintains microbial life in the soil	3.25	2.5	2.8	5	13.6	
Organic farming reduces soil erosion	16	7.5	6.6	12.1	42.2	
Economic factors						**46.5**
Low input method of farming	9.75	15	14.8	22.5	62.1	
Appreciable level of profit with less damage to the environment	7.5	10	6.6	10	35.1	
Cost effectiveness	17	12.5	16.9	15	61.4	
Extended shelf life	4.5	2.5	8.8	12.5	28.3	
Productivity factors						**11.8**
Organic farming contributes to humus; thus, it improves soil fertility	15.5	12.5	10	2.5	39.3	
Organic farming is drought resistance	2.5	2.5	2.5	0.5	8	
Health concerns factors						**6.2**
Organic farming poses less health hazard as compared with conventional farming	3.3	2.5	2.8	5	13.5	
Healthy and tasty vegetables are produced in organic farming	1.3	5	2.5	2.5	11.3	

Source: Computed from Field Data, 2015

This observation corroborates the findings of Chouichom & Yamao (2010) and Pimentel *et al*. (2005) who argue that replacing external input with farm made input and using two-wheeled tractors could reduce the need for hired manpower, resulting in the reduction in the input cost, Other Similar studies have shown that organic agriculture has lower input cost and price premiums that can compensate for the low yield (Benge *et al*., 2000; Ramesh *et al*., 2005; Reganold *et al.*, 2001). On the whole, the economic gain was the most important advantage to all the respondent farmers in the study area.

Another important advantage suggested by the farmers is the extended shelf life of the organic vegetables. The farmers explained that, as compared with the conventionally produced vegetables, the organic vegetables are less prone to decay. Accordingly, most traders are willing to pay higher for the organic vegetables. This is consistent with the findings by Ramesh *et al*. (2005) and Reganold *et al*. (2001); which indicate that the quality of organic produce after storage is higher than conventional produce. Regarding the *production factor*, the organic farmers used organic manure (such as compost, FYM, crop rotation) to enhance soil fertility. The organic manure was noted to be readily available either on their farms or in the communities. According to the study, 39% of the farmers indicated that the organic farming practices improved the soil fertility. They attributed this to the ease of converting their farm waste into organic manure at a very cheap cost in comparison with inorganic fertilisers. The presence of organic matter was also found to improve soil texture and temperature in order to promote microbial activities. The optimal microbial activity resulted in the further breakdown of the organic material in the soil to release the needed nutrients for ideal vegetable growth. Research conducted by Baconguis & Cruz (2005), Mohan (2003) and Ramesh *et al.* (2005) reveal that the application of organic materials in agriculture has contributed immensely in converting poor lands of the world into stable productive ecological zones.

Only 8% of the respondents in the study area found vegetable cultivation under the organic farming system to be less affected by drought. This therefore afforded them the opportunity to cultivate their land throughout the year. From the findings 80.5% of the organic farmers were also found to engage in vegetable farming throughout the year. Similarly, a number of studies have shown that under drought conditions, crops produced by the organic agricultural systems have a higher yield as compared with conventional ones as reported by Kristiansen *et al*. (2006) and Ramesh *et al*. *(*2005).

The results also show that the farmers perceived the organic farming system more environmentally friendly as compared with conventional farming. Thus, 54.4% of the respondents thought that organic farming encouraged sustainable farmland use while 42.2% of them indicated that it reduced soil erosion. The reduction in soil erosion was attributed to the presence of organic matter in the soil which encouraged the formation of crumbly soil structure, resulting in improved soil drainage, infiltration and aeration. Another reason for the perceived advantage of organic farming was that it helped to retain soil moisture which kept the soil in good condition for plant growth, even in the dry season, as a result, it helped to protect the topsoil. The respondent farmers stressed that farmland is a fixed natural resource that is easily susceptible to deterioration from inappropriate application of agrochemicals. Moreover, these inputs are expensive and have long-term detrimental effects on the wellbeing of the farms. This assertion has been corroborated by the findings of Chouichom & Yamao (2010) and Pimentel *et al.* (2005); which show that soil organic matter was higher in organic farming systems and thus provided considerable benefits to the sustenance of the environment.

The respondent farmers also perceived the relatively few *health concerns* associated with organic vegetable production as an advantage. As reported in Table 6.9, 13.5% of the respondents perceived organic farming as less hazardous while 11.3% stressed that organic farm produce was tastier and healthier. In recent times, consumers and growers worldwide have come to regard organic products as comparatively healthier (Magnusson *et al*., 2003). Furthermore, the respondent farmers indicated that they were encouraged to venture into organic farming because of the growing market demand for organic vegetables. These findings suggest a perceived increase in consumer demand for organic vegetables which might be driven to a large extent by the perception of its health benefits compared with conventional vegetables. This result is consistent with studies by Osei-Asare (2009) and Reganold *et al*. (2001) who argued that vegetables produced organically are healthier, taste better and contain a better balance of vitamins and minerals than conventionally grown vegetables.

In spite of the many advantages of organic farming outlined, only few farmers are engaged in organic farming compared to conventional farming. The results presented in Table 6.10 show reasons why only a few farmers adopted organic vegetable farming.

The labour intensive nature of organic farming was the reason why 45% of the respondent farmers found it less attractive. The reliance on natural resources and materials (compost, FMY, neem tree seeds and leaves) for soil fertility and pest management makes it labour intensive, especially, to most of the respondents who are peasants.

Table 6.10: Percentage Distribution of Reasons for Low Production of Organic Vegetables

	Conventional Farmer	Organic Farmer	Pooled Data	
Reasons	**N (%)**	**N (%)**	**N**	**Ave. %**
Labour intensive	86(43)	94(47)	180	45
Lack of government policy support	27(13.5)	31(15.5)	58	14.5
Lack of exclusive market and low price incentives/certification	21(10.5)	33(16.5)	54	13.5
Lack of appropriate information and education	7(3.5)	11(5.5)	18	4.5
Inadequate availability of organic material for composting	59(29.5)	31(15.5)	90	22.5
Total	**200**	**200**	**400**	**100**

Computed from Field Data, 2015

Organic farming systems are laborious, involving, manual weeding and the preparation and carting of compost to the farm. Thus, there is usually the need to employ extra labour for effective work on organic farms. For instance, some of the farmers' sourced for organic materials outside their farms, thereby inadvertently introducing new weed species from other farms into their farms. Consequently, these farmers often required frequent weeding of their farms which necessitated the hiring of more labour. This is consistent with the findings of Karimi (2011), Javanmard & Mahmoudi (2008) and Sodjinou *et al*. (2015).

Approximately 23% of the respondents attributed their non-participation in organic farming to their inability to produce the requisite organic materials or inputs, and the tedious nature of the procedures. The bulky nature of organic fertilisers makes it difficult to transport and apply, compared with inorganic fertilisers. According to the farmers, so many hours are spent, sourcing organic material. The farmers also noted that due to the limited supply of organic material during the raining seasons, vegetable growers have to compete with other crop farmers for organic manure (especially for poultry droppings). Direct field observation found heaps of the organic fertilisers being stored by most of the farmers. The study found this challenge as a contributory factor to the unattractiveness of organic farming to some of the respondent farmers. However, the farmers were quick to suggest that mass commercial production of organic manure would improve the situation, and thereby, encourage more farmers to adopt organic farming.

Most farmers found it a bit more challenging to cultivate organic vegetables due to the lack of exclusive market, low price incentives, and lack of certification in Ghana. This was considered as an obstacle because although organic vegetable production was found to be profitable, the process is tedious and highly laborious; however, these farmers do not have any *guaranteed* significant farm-gate price difference over non-organic vegetables *that are influenced by sector specific policies*. Both the organic and conventional farmers revealed their expectation from the government to introduce a policy which would be directed at addressing this concern. A study by Osei-Asare (2009) concluded that consumers are willing to pay a maximum of 20% premium for organic produce.

On the other hand, in 2011, a report by the Coalition for the Advancement of Organic Farming (CAOF) suggested that consumers are more willing to purchase organic produce if they are certified. Unfortunately, there is no such certification authority in Ghana, and the farmers' only recourse is an international certification authority, but this is very expensive and more than 60% of farmers in Ghana cannot afford. This corroborates the finding of Willer *et al.* (2008) who reported that most organic produce in Africa and for that matter Ghana, are uncertified and will continue to remain so in the short term. There is the need to develop and sustain a local market within the country for these uncertified organic products and to find alternative forms of standards and certification within the domestic market that would encourage more production. In fact, most producers are either not well educated, not well informed, or lack the knowhow to accessing information on organic production and its benefits (Charnley, 2012).

CHAPTER SEVEN

ORGANIC FARMING ADOPTION AND EFFECTS

7.1 Introduction

This section presents econometric results and discussion of the data analysis. It includes factors influencing farmers' adoption decision and the effect of organic farming adoption on farmers' vegetable output and household welfare.

7.2 Factors Influencing Farmers' Choice of Vegetable Production

The first objective of the study was to identify the factors influencing the adoption of organic farming among vegetable producers in the Northern Region. The factors that influenced the adoption of organic vegetable farming were examined using the binary probit regression model. Farmers that had adopted, at least, one of the organic farming practices without the use of chemical inputs are classified as adopters, and those using synthetic inputs or both organic and synthetic inputs are referred to as non-adopters or non-organic farmers.

The results for the adoption model, capturing the factors affecting the probability of adopting organic vegetable farming are presented in Table 7.1. The diagnostics tests, such as likelihood ratio (LR) chi-square statistics, the probability of chi-square, and pseudo R-square values are also reported at the bottom of the table. The LR chi-square of 152.50 is statistically significant at 1% and shows that the selected explanatory variables in the model contribute to explaining the variation in the probability of adoption of organic vegetable farming. In other words, the explanatory variables in the probit model together explain the probability of organic vegetable production. The pseudo R-squared estimate (0.61) further demonstrates that approximately 61% of the variation in farmers' decision to adopt organic vegetable production in the study area was jointly explained by the explanatory variables. Overall, the age of farmers, farmers' capacity and resources to cultivate all year round, FBO membership, farming experience, extension services, farmers' ability of making own inputs, off- vegetable farm activity, education, farm size, and land ownership exert a positive influence on organic vegetable production while household size and credit access influence organic vegetable production negatively.

From the result presented in Table 7.1, the age of respondents had a positive effect on the adoption of organic vegetable farming technology but was not significant. Thus, the finding does not provide strong suggestion to support the hypothesis that the older a farmer is, the higher the probability that he will be innovative. The finding concurs with that of Akinola & Sololuwe (2012).

Household size was positive as expected, but did not have a statistically significant influence on the adoption of organic farming. This result does not support the finding of Feder *et al*. (1985) who maintain that families with large members facilitate the adoption of technology that is labour intensive. Off-farm activity was also not significant and was positively related to the probability of adoption of organic vegetable technology by farmers in the study area. These results confirm that of Akinola & Sololuwe (2012).

Table 7.1: Maximum Likelihood Estimation results of factors influencing organic vegetable production

Variables	Coefficients	Standard Error	Marginal Effects	Standard Error
Age	0.012	0.011	0.005	0.004
Household size	-0.018	0.029	-007	0.011
Education	0.059***	0.020	0.024***	0.008
Off- farm activity	0.022	0.198	0.009	0.079
Farming Experience	0.033***	0.012	0.013***	0.005
Farm size	-0.020	0.124	-0.008	0.049
ARCAY	1.262***	0.202	0.468***	0.066
FBO	0.454**	0.249	0.179**	0.096
Extension	0.095**	0.043	0.038**	0.017
AECS	1.816***	0.330	0.569***	0.06
AMOI	2.631***	0.345	0.727***	0.04
Training	1.418***	0.252	0.510***	0.071
Land ownership	0.371**	0.202	0.146**	0.078
Constant	-5.068***	0.732		
Log likelihood function	-109.069			
Number of observation	400			
Wald chi^2(13)	152.50***			
Pseudo R^2	0.61			

Source: Field Survey. Note: *** significant at <=1% level, ** significant at >1&<=5% level. ARCAY, AMOI, FBO and AECS refer to ability and resources to cultivate all year, the ability to make own inputs, farmer base organisation, and access to external credit support respectively.

Similarly, farming experience had a positive and significant influence on adoption of organic farming among vegetable producers in the study area. This suggests that a year increase in farming experience tends to increase the probability of adoption by approximately 1.3%. This result corresponds with the findings of Afolami *et al.* (2015), Lapple (2010), Ojo & Ogunyemi (2014) and Ramesh *et al.* (2010) who found the years of farming experience as an important determinant in adoption model. Also, it seems that farmers who have adopted organic vegetable production are more experienced because they may have used both methods of production (organic and conventional vegetable) in the past, and therefore, had learned from experience the benefit of organic farming and the need to adopt organic farming methods for a change.

Furthermore, institutional factors such as access to extension services, membership in FBOs, access to extension services and credit, influence the adoption of organic farming in the study area. Access to information is vital in creating awareness and favourable attitude towards the adoption of technology (Place & Dewees, 1999). Notably, access to extension service is often used as an indicator of access to information (Adesina *et al*., 2000; Honlonkou, 2004). The study found that access to agricultural extension services was positive, and influenced the adoption of organic vegetable farming significantly. This means that those who have access to extension services are more likely to adopt organic farming than otherwise. Farmers who access extension services become informed on organic farming or sustainable agricultural production and are guided by improved inputs and other organic vegetable husbandry practices and market information (Langyintuo & Mekuria, 2005), which are important for promoting organic vegetable farming adoption.

These findings corroborate Asfaw *et al*. (2012), Mariano *et al*. (2012) and Yaron *et al*. (1992) who contend that access to extension services is critical in promoting the adoption of modern agricultural production technologies. This is because it can counterbalance the negative effect of lack of formal education in the overall decision to adopt new technologies.

Caviglia & Kahn (2001) argue that farmers' associations and unions constitute one of the important sources of information to farmers. The results of this study confirm that membership in FBOs has a positive and statistically significant influence on farmers' probability of producing organic vegetables. Farmers who belonged to FBOs had 0.18 greater probability of adopting organic farming than those who did not belong to an FBO. These research findings correlate with other studies such as Bayard *et al*. (2007), Hattam & Holloway (2006) and Uaiene *et al*. (2009). They suggest that the normal channels of information flow (via the extension agent) are not suitable for producers. However, if farmers are associated with FBOs, they learn more, gain a better understanding, and make informed decisions. This is because FBOs groups offer platforms for the farmers to learn and share knowledge among themselves for the promotion of any agricultural innovation such as organic farming.

Jintrawet (1995) observed that farmers who have not yet adopted an innovation such as organic farming seek advice and recommendations from their fellow farmers, which they usually consider more convincing and reliable than any advice given them by outsiders, including extension officers and NGO officials. Particularly in developing countries like Ghana, where extension services have not been very effective, FBOs can play a key role in promoting the adoption of agricultural innovation (Adesina & Baidu-Forson, 1995; Bewket, 2007; Scoones & Thompson, 1994). The estimation result confirms the views of some respondents that they decided to venture into organic vegetable production after having been convinced by their fellow farmers.

Access to external credit support was significant and was positively related to the probability of adoption of organic farming by vegetable farmers in the study area. The more credit support a farmer had, the more likely he or she was to adopt organic farming. There is a relationship showing that having access to more credit support increases the probability of investing in organic production compared to those who had no support. This finding concurs with the findings of Awotide *et al*. (2016) and Abayneh & Tefera (2013) in Nigeria and Ethiopia respectively, but contrasts that of Ogada *et al.* (2014) and Afolami *et al*. (2015) who found a negative relationship between access to credit and the diffusion of improved agricultural technology.

The level of formal education attained by farmers was found to have a positive relationship with the probability of adoption and was significant at 1 percent level. The marginal effect of education was 0.024 and means that a year more in school increases the probability of a farmer producing organic vegetables by 0.02. Like previous studies (such as Doss, 2001; Mariano *et al*., 2012; Paudel & Matsuoka, 2008), this result suggests that adoption depends on the decision-makers' level of education and access to information. This could also mean that organic farming is relatively knowledge intensive, and thus, management skills are vital in its implementation. Beshir *et al. (*2012), Demiryurek (2010), Mignouna *et al.* (2011) and Uaiene *et al*. (2009) reported a similar finding that reveals that education increases a farmer's ability to acquire and use information that encourages the adoption of technology.

The farmers with the ability and resources to farm throughout the year (ARCAY) had a greater probability (0.47) to adopt organic vegetable production than their resource constrained counterparts. This suggests that if a technology, such as organic farming, gives the vegetable farmer the chance to cultivate their farmland throughout the year, then this would increase the farmer's probability of adopting such technology. Also, the organic farmers attributed their ability to grow vegetables throughout the year to the presence of organic material in the soil. According to the farmers, the organic material in the soil retains enough moisture to support plant growth, even in the dry season. As a result, relatively resource endowed farmers have invested in simple irrigation systems that support vegetable production throughout the year. This finding is corroborated by results from studies by Carter (2002) and Pimentel *et al*. (2005) who reported that soil organic matter enhances soil water-holding capacity.

In a similar way, a related variable is 'farmer's ability to making their own input' (AMOI), was found to be very important since it had the highest and significant marginal effect on adoption of organic vegetable farming among other parameters. This indicates that farmers who have the ability and resource to make their own inputs (homemade input) tend to have a higher probability of adoption because growers are able to reduce costs associated with organic vegetable production. Such inputs include compost and locally made insecticides which are used in spraying the vegetables against insecticide and pesticide attacks. For sustainable production of vegetables in Ghana it is important, from this finding that efforts are made to empower farmers to make their own inputs from local resources. Hattam & Holloway (2006) had a similar finding.

The marginal effect of land ownership also shows a positive significant effect on vegetables production, implying that farmers who owned their land had 0.15 greater probability of going into organic vegetable production than those who rented or borrowed it from relatives. This is plausible because organic farming requires permanent development of farmland for sustainable production. Therefore, a farmer who does not own his/her land permanently may be unwilling to spend a lot to improving its long term fertility. To ensure sustainable organic vegetable production, it is important that the present land tenure arrangements are re-structured in favour of willing and committed farmers with longer term visions.

Training farmers on improved ways of growing vegetable were paramount in influencing their decisions to adopt organic vegetable farming. This was indicated by a marginal effect of 0.51 which implies that farmers who had received training in vegetable production had 0.51 greater probability of adopting organic vegetable production than those who did not receive any training. This finding is in agreement with the finding of Awotide *et al.* (2016) in commercialisation of smallholder agriculture in Nigeria. Farm size was also found to be positive, but not significantly related to the probability of adoption of organic farming.

7.3. Effect of Organic Farming on Vegetable Output and Household Welfare

The study also sought to find out whether the organic vegetable producers had a higher output (measured in Ghana cedis) than the conventional vegetable farmers, and whether the higher output translates into better welfare, *ceteris paribus.* This measurement was done using the treatment effects model of Heckman (1979). As described in the methodology chapter, this model involves two equations: the selection equation estimates the probability of adopting organic vegetable production and the outcome equation estimates output or household welfare. The IMR, calculated from the selection equation, adjusts the outcome equation for the selection bias associated with the fact that organic vegetable farmers and conventional farmers may differ in unobservable characteristics (such as industriousness, skills, or intelligence). The study implements this analysis with maximum likelihood estimation in which all parameters are estimated simultaneously rather than in a two-step process.

7.3.1 The Effect of Adoption of Organic Farming on Vegetable Output

The study explores the effects of organic vegetable farming adoption on farmers' vegetable output (measured in Ghana cedis). The empirical results of the effect of organic vegetable production on farmers' vegetable output are presented in Table 7.2. The parameter 'lambda (λ)', as shown in Table 7.2, is equivalent to the IMR which measures the correlation between the error terms in the selection equation and the outcome equation. The fact that this parameter(λ) was negative and statistically significant suggests that there is a selectivity bias.

Table 7.2: Maximum Likelihood Estimation results of Heckman's Treatment Effect model of the effects of Organic Vegetable Production on Output

Variables	Coefficient	Standard Error
Constant	10.652	0.517
Ln seeds	0.087	0.138
Ln Farm size	0.486***	0.160
Ln labour	-0.040	0.041
Ln manure	-0.144**	0.068
Adoption	0.802***	0.200
λ (IMR)	-0.329**	0.139

Source: Authors' estimation based on Field Survey data (2015). Note: *** significant at <=1% level, ** significant at >1&<=5% level. Number of observation = 400, likelihood = -7776.886, Wald Chi^2 (5) = 51.03***

This indicates that if this bias had not been corrected, the estimated coefficients, including the adoption variable, would have been bias, meaning that the effects of the explanatory variables on vegetable output could not be measured. Hence, it was vital to estimate vegetable income function using the treatment effects model to overcome the selectivity bias problem in order to ensure that the estimated coefficients were corrected from the effects of unobserved factors that correlated with the adoption variable.

As seen in Table 7.2, the adoption of organic vegetable farming had the expected positive sign and statistically significant effect on vegetable output. The empirical results show that adoption of organic vegetable farming had increased vegetable output levels. The findings are consistent with Bruce *et al.* (2014) who reveal that the adoption of improved variety had a positive and significant effect on farmers' output in rice production in Ghana. Increase in farmers' vegetable output in the study area can be attributed to the benefits that came along with organic farming. The research revealed that the organic vegetable farmer had better access to technical advice that improved their production in terms of quality, and influenced their decision making positively.

Also, this could be due to the fact that most of the organic vegetable farmers in the study area had access to a ready market for their produce, which reduced post-harvest losses. Almost all the organic vegetable farmers (98.5%) reported that they had a ready market for their vegetable whenever they produced. Similarly, under the organic farming system, the organic material in the soil retains enough water for plant growth, even under dry conditions because it does not require any cost in irrigation input (Pimentel *et al*., 2005; Ramesh, 2005). This allows the farmers to produce throughout the year thereby realising a higher output than those relying on conventional farming only. Developing mechanisms to help promote organic farming among poorer households may be a reasonable policy instrument to generate higher income.

Results in Table 7.2 indicate that expenditure on seed and labour had a positive and negative effect on vegetable output respectively. However, these effects were statistically insignificant. Lack of statistical significance of these variables implies that the coefficients of these variables are statistically not different from zero. From the results above, the area under vegetable production (0.486) was found to be significant at 5% level and positive. Hence, the more farmland a farmer allocated to vegetable farming, the higher the output obtained−which is consistent with similar findings by Bruce *et al*. (2014), Goni *et al*. (2007) and Randela *et al*. (2008). The reason for this might partly be due to the fact that farmers' effective utilisation of farmland may enhance production, leading to higher output. Results in Table 6.2a provided some evidence for this linkage. Table 5.2a shows that the farmers who have the capacity and resources to cultivate the land throughout the year obtained a higher output which to some extent, lowers the average cost associated with vegetable production.

The coefficient of manure with respect to vegetable output was negative and statistically significant at 5% level. A hundred percent increases in the cost of manure used in vegetable production would be associated with about 15% decrease in vegetable output. As reported in Table 6.3, farmers used larger quantities of manure (2672.9kg/acre). The manure preparation, transportation, and use are laborious, suggesting that more labour input, particularly, hired labour increases the cost of production. Thus, the additional cost associated with the use of larger quantities of manure in vegetable production most likely outweighed the marginal value, leading to the observed negative relationship between increased manure use and vegetable output.

7.3.2 The Effect of Adoption of Organic Farming on Annual Household Consumption Expenditure

The effect of adoption of organic vegetable production on household welfare was also measured using a treatment effect model. Following Asfaw (2010) and Afolami *et al*. (2015), the welfare of the vegetable farmer is proxied by total household annual consumption expenditure, and the results are shown in Table 7.3. Among all variables, age, gender, education, farm size, and off-farm activity had a positive and significant effect on consumption expenditure whereas land ownership was negative and not important in determining farmers' welfare (consumption expenditure). The direction of the effects of all the predictor variables turned out to be consistent with expectations.

The 'lambda (λ)' coefficient in Table 7.3 is positive and significantly different from zero, indicating the presence of selectivity bias in the sample. This means that the error terms of the adoption and household consumption expenditure models are positively correlated. So, it was important to estimate household consumption expenditure using the treatment effects model.

The result further indicates that the adoption of organic vegetable farming had a positive and statistically significant effect on the annual household consumption expenditure of the farmers at the 5% (Table 7.3). It implies that organic vegetable farming adoption increases consumption expenditure by 10% relative to that of conventional farming. This shows that adopters (organic vegetable farmers) benefited economically from organic farming.

Table 7.3: Maximum Likelihood Estimation results of Heckman's Treatment Effect Model of the effects of Organic Vegetable Farming on Household Expenditure

Variables	Coefficient	Standard Error
Constant	6.608	0.321
Age	0.209**	0.088
Gender	0.158***	0.050
Education	0.011***	0.004
Farm size	0.180***	0.047
Off- farm activity	0.160***	0.039
Land ownership	-0.050	0.040
Extension contact	0.024***	0.008
Adoption	0.100**	0.056
λ (IMR)	0.366**	0.146

Source: Field Survey *** significant at <=1% level, ** significant at >1&<=5% level. Note: number of observation = 400, likelihood = -280.59, Wald Chi^2 (8) = 84.70***

Probably because organic vegetable farming promotes the use of sustainable agricultural production practices that create a situation where farmers are able to reduce production cost (by relying on local or farm renewable resources such as farmyard manure, crop residue, neem seeds, etc.). This suggests that the real income for consumption is increased, hence, higher welfare of these households. This might also explain the reasons why adopters (organic vegetable farmers) had higher consumption expenditure which affords them a better welfare. This finding harmonises with previous studies such as Becerril & Abdulai (2010), Kassie *et al*. (2011), Ghimire & Wen-Chi (2016) and Wu *et al*. (2010).

The gender variable was positive and statistically significant, indicating that male vegetable farmers have better welfare than female vegetable farmers. This is because traditionally, males are considered to be heads of the household unit in Ghana. Hence productive inputs owned by the family are likely to be in the name of the head of the family. This suggests that males have better access to these productive inputs. Asmah (2008) explains that women, usually, do not have access to assets as men do, determining the extent to which a farmer, based on gender, will participate in vegetable production. Chikuvire, Moyo, Murewa, Mutenje, & Nkyakudya (2006) also reported that women in Sub Saharan Africa are disadvantaged in production because of unequal distribution of resources with men and other cultural barriers. In addition, women also spend much of their time doing household chores and allocate less time to farm work.

The coefficient of age was positive and statistically significant at 5% level, showing that older farmers have higher consumption expenditure. This could be due to the fact that older farmers may have a large family size, connoting a greater consumption expenditure. Since vegetable farming is highly dependent on farmers' experience, then it is commonly believed that age can serve as a proxy for farming experience. This then suggests that older farmers have greater farming experience, which translates into proper management of their farm to ensure higher production, higher profits and better welfare.

A farmer's level of education was found to correlate with household expenditure. The estimated coefficient for years of schooling (education) was 0.011; it maintains a positive sign as expected and it is statistically significant at 1% level. This implies that household consumption expenditure increases as the farmer's years of schooling increases. This is not surprising, because educated farmers are more likely to enhance their capacity to adapt to change, understand new practices, modernise their principles about technologies and follow the procedures relating to the use of the technology. By so doing, they become more knowledgeable in resource allocation for maximum productivity, thereby, leading to a better welfare than their uneducated counterparts. This result is consistent with Adeoti (2009) and Awotide *et al*. (2016) who reported that educated farmers are more likely to understand the benefits of technology in modern agricultural production and its usage.

The farm size was positive and significant at 1%. A unit increase in cultivated area per acre led to 18% increase in household consumption expenditure. An increase in farm size will increase vegetable output, generate income, and improve farmers' welfare. This result is consistent with previous findings (Mendola, 2007; Takahashi & Barrett, 2014) that explain the possible relationship between the ownership of cultivated land and welfare.

Additionally, the results indicate that off-farm activities had a positive effect on farmers' welfare, as hypothesized, and it was significant at 1% level. A hundred percent increase in off-farm activities led to 16% increase in household consumption expenditure. It was observed from the survey that, off-farm activities are engaged by most farmers as a compliment to farm income. The farmers noted that off-farm activities provide an extra income that is directly used for consumption expenditure or re-invested in vegetable farming. Farmers with such earnings show a higher farm productivity or marketable surplus, thereby, increasing consumption expenditure which then provide better welfare. Similar findings were reported by Lopez (2008) and Waluse (2012). The findings, however, contrast the observations by Awotide *et al. (*2016) and Ghimire & Wen-Chi (2016) which attest that household farm income decreased when farmers had higher off-farm work.

Extension services, as indicated by whether or not the farmer had contact with an extension agent, had a positive and significant effect on households' welfare. Vegetable farmers benefit from intensive extension services from NGOs, development organisations and Ministry of Food and Agriculture (MOFA) which are the major supporters of organic agriculture in Ghana. Organic farming is knowledge intensive and requires regular interactions between farmers and extension services. This suggests that farmers who had contacts with extension agents had the opportunity to learn new innovations in vegetable production. This confirms our expectations on the significance of extension service on household welfare. Other researchers who had similar findings are Awotide *et al. (*2016) and Ghimire & Wen-Chi (2016).

7.4 CMP Estimation results of Adoption and its Effects on Output and Household Welfare

Table 7.4 presents results from joint estimation of factors influencing the adoption of organic farming and its effects on output and welfare of farm household. Joint estimation of the system of equations allows us to control endogeneity bias created by the selectivity bias of organic farming adoption in the equations of output and welfare of farm household.

The joint estimation results presented in Table 7.4 indicates that organic farming adoption has a positive and significant effect on vegetable output and the welfare of farming household in the study area. The CMP method, which was used simultaneously to determine factors influencing the adoption of organic farming, its effects on output and welfare, gives similar results as those of the probit and Heckman treatment results presented in Tables 6.1, 6.2 and 6.3 respectively. However, except for the coefficients on farming experience and land ownership variables, the CMP joint estimation results are similar to the probit and Heckman treatment results in Tables 7.1, 7.2 and 7.3 respectively. The importance of unobserved factors which simultaneously affect the adoption of organic farming, its output, and household welfare can be evaluated by examining the estimates of the correlation coefficients between the error terms of the three equations- measured by the rho parameters. The result shows that the correlation coefficients of the three equations are statistically significant.

Table 7.4: CMP Estimation results of Adoption and its Effects on Output and Household Welfare

	Adoption	**Vegetable Output**	**Household Welfare**
Variables	**Marginal Effects**	**Coefficient**	**Coefficient**
Adoption		0.840(193)***	0.113(0,054)**
Age	0.002(0.002)		0.146(0.085)*
sex			0.523(0.50)
Household size	-0.004(0.004)		
Education	0.009(0.003)***		0.010(0.004)**
Off-vegetable farm activity	0.040(0.029)		0.123(0.038)***
Farming Experience	0.002(0.002)		
Farm size	0.002(0.019)		
ARCAY	0.162(0.025)***		
FBO	0.076(0.032)**		
Extension	0.019(0.569)**		0.222(0.008)***
AECS	0.232(0.0569)***		
AMOI	0.408(0.490)***		
Training	0.227(0.036)***		
Land ownership	0.044(0.029)		-0.152(0.0386)
Ln seeds		0.014(0.050)	
Ln Farm size		0.344(0.163)**	0.152(0.048)***
Ln labour		-0.058(0.039)	
Ln manure		-0.117(0.064)**	
Constant		10.772(0.438)***	6.934(0.314)***
rho_12	-0.321(0.116)**		
rho_13	0.336(0.124)**		
rho_23	0.300(0.058)***		
observation	400		
LRchi^2	388.12***		
Log likelihood	-931.032		

Source: Computed from Field Survey, 2015. Note: *** significant at <=1% level, ** significant at >1&<=5% level, * significant at >5&<=10% level. ARCAY, AMOI, FBO and AECS refer to ability and resources to cultivate all year, the ability to make own inputs, farmer base organisation, and access to external credit support respectively.

The correlation coefficient between the errors of the factors influencing the adoption of the organic farming equation and that of the vegetable output equation was negative and statistically significant. This indicates the existence of unobserved factors that exert a positive effect on factors influencing the adoption of organic vegetable production and which simultaneously reduces vegetable output. These confirm the significance of the IMR in the Heckman parameter effect. Interestingly, there was a positive and statistically significant correlation coefficient between errors in the adoption of the organic farming equation and the welfare equation; and may show that the effects of some unobservable factors in the adoption of organic farming and welfare of farm household are in the same direction. This implies that farmers who have a higher propensity to adopt organic farming technology in their vegetable production are of a better welfare. Furthermore, the correlation between the error terms of the equations for vegetable output and welfare is positive and statistically significant. This corresponds with the evidence that suggests the existence of unobserved factors that jointly increase the vegetable output and the welfare of farm household.

CHAPTER EIGHT

PRODUCTIVITY OF VEGETABLE FARMING SYSTEMS

8.1 Introduction

This chapter of the study examines the technical efficiency level and factors affecting technical efficiency of farmers in the vegetable production systems. The section also presents and discusses the effects of organic farming adoption on vegetable output/technical efficiency.

8.2 Results of the Hypotheses Tests in the Stochastic Frontier Model

This section presents and discusses the results of the four main hypotheses tested using the generalised likelihood-ratio (LR) test technique. These were performed to examine the appropriateness of the model, the existence of inefficiencies, the effects of the explanatory factors on inefficiencies and the appropriateness of the inclusion of the adoption factor in the output model.

The results in Table 8.1 show that the LR chi square statistics for the first hypothesis is not significantly different from zero. However, the other three are significantly different from zero. This means that we fail to reject the null hypothesis of the first one but reject that of the other three. The first claim that the Cobb-Douglass production function is an ideal specification for the data compared to the transcendental (translog) production function for the three (conventional farms, organic farms and the pooled sample) is upheld. This further suggests that the coefficients of the squared terms and the interactive terms in the translog production function are statistically not different from zero in explaining the variation in vegetable output of farmers, (in particular conventional and organic farmers) in Northern region.

Table 8.1: Results of Hypotheses Tests in the Stochastic Frontier Model for Vegetable Producers

	Conventional farms	**Organic farms**	**Pooled sample**	
Null hypothesis	LR-statistic (p-value)	LR-statistic (p-value)	LR-statistic (p-value)	Decision
$H_0 = \beta_{jk} = 0$	12.42 (p>0.10)	11.37(p>0.10)	4.92 (p>0.10)	Accept H_0
$H_0 = \Omega = \delta_0 = \delta_1,\ldots,\delta_k = 0$	33.18 (p<0.05)	65.33 (p<0.01)	125.06 (p<0.01)	Reject H_0
$H_0 = \gamma = 0$	14.48(p<0.01)	12.33 (p<0.01)	27.44 (p<0.01)	Reject H_0
$H_0 = \beta_5 = 0$			9.25 (p<0.01)	Reject H_0

The second null hypothesis tested was that the entire coefficients of the explanatory variables in the inefficiency model are not significantly different from zero. If this is true, then the explanatory variables have no effects on the technical inefficiency of both conventional and organic vegetable production and the pooled data. However, this null hypothesis was rejected at 5% for conventional farms and 1% for organic farms and the pooled sample respectively, implying that the socioeconomic and farm-specific characteristics significantly influence vegetable production in all the farming systems. This means that inefficiencies exist and vegetable farmers might not be producing at a technically efficient level, further supporting the appropriateness of the stochastic frontier model as opposed to the average response model.

The third hypothesis tested was that there are no technical inefficiencies in the production of vegetables. However, the results in Table 8.1 suggest that the null hypothesis of no technical inefficiencies was rejected in all the systems of vegetable production. This implies that the inefficiency component of the disturbance term (u) is significantly different from zero. This implies that the traditional average response function is not an adequate representation of the data compared to the stochastic frontier model, given that inefficiencies exist and are stochastic.

The final null hypothesis tested was that the probability of adopting the organic vegetable farming had no effect on the efficiency of vegetable farmers. The null hypothesis was rejected. The results, however, concluded that adoption of organic farming had a significant effect on the technical efficiency of vegetable farmers in the study area. This also suggests that the inclusion of the predicted adoption factor in the outcome model is statistically appreciable.

8.3 Estimated Parameters in the Stochastic Frontier Model

The objective of this section is to estimate the effect of adoption on technical efficiency of vegetable farmers. Empirical studies such as Asante *et al.* (2014) showed that adoption influences both the production output (frontier) and the technical efficiency of the farmer. Therefore, an Akaike Information Criteria (AIC) test was conducted to determine the appropriate position of adoption in the model. A lower AIC indicates a better fit for the model. From the test result, the AIC when adoption was placed in both parts of the model was lower (1235.479) than when placed only in the output model (1248.909) or only in the inefficiency model (1249.304). By the rule, the model with the smaller AIC value is considered to be better. Hence, this study estimated a production frontier with adoption in both parts of the model.[4]

The maximum likelihood estimates of the parameters of the Cobb-Douglas stochastic frontier production function for the conventional, organic and pooled vegetable farms are presented in Table 8.2. The log likelihood test values for the fitted models were -300.061, -306.420 and -595.271 and the Wald chi-square statistics of the models were statistically significant at 5% levels for conventional (χ =12.42) and organic (χ =11.37) farms and 1% for pooled sample (χ =102.95), respectively in the study area. These mean that the estimated results for all the models were significant and the explanatory variables used in the model were collectively or jointly able to explain the variations in vegetable production.

Most of the variables in the Cobb-Douglas stochastic frontier model were found to be statistically significant either in the conventional, organic or pooled stochastic frontier

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[4] It must be recalled that in section 7.3.1 under chapter 7, the effect of adoption on output was measured. However, that involved the estimation of an average response model. The average response model is estimated on the assumption that there are no technical efficiency effects. Where technical efficiency effects are present in the model, the stochastic frontier model must be estimated. One would therefore ask why, in this study, the average response model was estimated knowing that a stochastic frontier model would be estimated. We estimated the former model because of the fact that the average response model, which involves the estimation of a production function, augurs well for Heckman's (1979) method of correcting for sample selection problems, in the same way that we did for the welfare (per capita consumption) model. In the case of the stochastic frontier model, as mentioned earlier, the composed error term does not permit the usual way for correcting for sample selection. This perhaps is one of the reasons why the estimation results vary, despite the fact that they are both maximum likelihood estimates.

models, respectively. These were farm size, quantity of labour, manure/fertiliser and quantity of seeds planted. It must be noted that on the whole, the parameter estimate for quantity of fertiliser in the conventional and organic farms model were almost similar, even though organic farmers turn to use different kinds of fertilisers or manures from the ones used by conventional farmers.

Table 8.2: Maximum likelihood estimates of the Cobb-Douglas Stochastic Frontier

Variable	**Parameter**	**Conventional farms Coef. (Std. Err)**	**Organic farms Coef. (Std. Err)**	**Pooled sample Coef. (Std. Err)**
Constant	β_0	12.379***	12.697***	12.659***
		(0.672)	(0.702)	(0.497)
ln labour	β_1	-0.097**	-0.068	-0.096***
		(0.041)	(0.050)	(0.030)
ln fertilizer	β_2	0.162***	0.166*	0.217***
		(0.062)	(0.089)	(0.044)
ln seed	β_3	0.060	0.082	0.045
		(0.105)	(0.124)	(0.563)
ln farm size	β_4	0.033	0.524**	0.259*
		(0.176)	(0.226)	(0.134)
Adoption	β_5			0.630***
				(0.207)
Returns to scale		*0.159*	*0.703*	*0.425*
Number of obs.		*200*	*200*	*400*
Wald chi2		*12.420*	*11.370*	*102.950*
Prob>chi2		*0.015*	*0.023*	*0.000*
Log likelihood function		*-300.061*	*-306.420*	*-595.271*

Source: Computed from Field Survey, 2015; Note: Figures in parenthesis are standard errors; ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively.

From the production parameter estimates, the output structure was calculated for each farming method and pooled farming method as shown in Table 8.2. Since the Cobb–Douglas models coefficients have an elasticity interpretation (represent output elasticities of the corresponding inputs), the value of the parameters for all the farming systems can be taken as a measure of elasticity.

Consequently, there is no reason to assume that GH¢1.00 worth of organic fertiliser would have the same effect on vegetable output as GH¢1.00 worth of synthetic fertiliser. The estimated coefficient of manure/fertiliser was positive and significant for all the farming systems. The positive coefficient was as hypothesised, with a significant relationship with vegetable output at 10% level. The results revealed that a 1% increase in the expenditure on organic manure applied, significantly improved vegetable productivity by 0.17%. This suggests that increasing the amount of organic manure used would contribute to higher vegetable output in the area. Organic manure is a major land augmenting input that increases yield per acre by improving fertility and organic material of the soil. Our result also confirms the work of Benin *et al*. (2007) who found organic manure to have a positive and significant impact on output.

Similarly, in the conventional vegetable farms and the pooled sample, the estimated coefficient for manure/fertiliser was significant at 1% level and does conform to the a priori expectation. From the results, the positive sign indicates that an increase expenditure on fertilisers would result in 0.162% and 0.22% corresponding increase in vegetable output for conventional farms and the pooled sample, respectively. This estimate is consistent with Amoah *et al*. (2014) who found a positive relationship between fertiliser usage and the level of output in Ghana.

Labour is an important factor in providing the needed manpower for crop production. From the result, labour had a negative relationship with conventional vegetable production and the pooled sample. This implies that other things held constant, an increase in the quantity of labour leads to a decrease in vegetable output for conventional farms and the pooled sample. This result is in conformity with the work of Serra & Goodwin (2009) who reports that labour has a negative and significant effect on output. The coefficient of labour was however, insignificant for organic vegetable production.

Generally, unlike the cultivation of most staple and cash crops that are more labour intensive, labour requirement for conventional vegetable production is relatively low. Perhaps, this could be explained by the low farm size and adoption of improved technologies like fertilizer for vegetable production. Egyir *et al*. (2011) concluded that farm practices like fertilizer applications for increasing the productivity of non-staple crops are low among Ghanaian farmers, and hence, require less labour. From the survey, it was evident that most of the labour used by the farmers is unpaid labour. This suggests that the farmers employ more unproductive or inefficient kinds of labour. This is also because there is less supervision of workers; therefore, it is possible the work done by these workers (inactive household workers) are less effective.

The estimated relationship between farm size and vegetable output is positive for all the farming systems and significant at 5% and 1% level, except for conventional vegetable farms where it was not statistically significant. This result indicates that an increase in one acre cultivated area, holding all other input constant, would lead to 0.524% and 0.259% increase in vegetable output for organic farmers and the pooled samples respectively. This finding is in sync with the results established by Asante *et al*. (2014).

The estimated coefficient of quantity of seeds planted though positive it was not statistically significant even at the 10% levels of significance for all the farming systems. This implies that quantity of seeds planted will not lead to any significant increase in the gross revenue of vegetable producers in the area (Table 8.2).

The predicted probability of adoption variable was also included in the pooled technical efficiency model to assess the effect of adoption on the productivity of the farmers in vegetable production. The adoption (of organic farming) coefficient was positive and statistically significant at 1% level, indicating that the adoption of organic farming technology results in a significantly higher vegetable output frontier. In other words, organic vegetable farms are using a more productive technology, and this increases their output by 0.630% compared to conventional vegetable farms. This finding synchronises with recent work by Asante *et al*. (2014) and Abdul-Hanan, Ayamga, & Donkoh (2014) in which adoption of agricultural technology increased farmers' productivity.

From the production parameter estimates, the output structure was calculated for each farming method and pooled farming method as shown in Table 8.2. Since the Cobb–

Douglas models coefficients have an elasticity interpretation (representing output elasticities of the corresponding inputs), the value of the parameters for all the farming systems can be taken as a measure of partial elasticity. Regarding the area under cultivation, large differences exist between the conventional and organic vegetable farms. The elasticity estimates indicate that farm size contributed the most to vegetable production in organic vegetable farms (Table 8.2). This finding, therefore, implies that the acreage expansion is more important in the organic farms than in the conventional farms.

The production elasticity estimates show that organic manure is the second highest contributor to vegetable production in organic farms whilst fertilizer is the first highest contributor in conventional farms (Table 8.2). The elasticity is 0.17, 0.16 and 0.22 in organic, conventional and pooled sample farms respectively. This clearly indicates that the expenditure on organic manure or fertilizer contributed more to vegetable production in organic and conventional farms as well as the pooled samples.

Furthermore, the sum of the calculated elasticities of production with respect to all the variable inputs was less than one. This implies that the individual inputs were inelastic and thus, indicating decreasing returns of the various inputs. The sum of the elasticity of production reflects the nature of return to scale. This measures the response of the vegetable output to a 1% change in all the inputs. The sum amounted to about 0.425 for the pooled sample with organic vegetable farms having a higher value of 0.703 than the pooled sample; while the value of 0.159 for conventional farms is lower than the pooled sample. This implies that 1% increase in all the inputs would lead to a less than proportionate increase in the vegetable output. In other words, production of vegetables in the study area during the 2014/2015 production year was characterised by decreasing returns to scale.

8.4 Determinants of Technical Inefficiencies in Vegetable Production

The study also investigated the factors influencing farm technical inefficiency. Technical efficiency is usually estimated through the inefficiency model and the results are presented in Table 8.3. The estimates of the variance parameters gamma (γ) and sigma-squared (σ^2) are shown in the lower part of Table 8.3. The gamma (γ) measures the overall technical inefficiency in the production model, the estimate γ is very high for all the farming systems and significant at 1% level. These results suggest that on average about 88.3%, 83.7% and 84.6% of the variation between observed and best-practice total value of output for conventional, organic vegetable farming, and pooled sampled respectively, are as a result of inefficiency in input use and other farm practices among farmers. These, therefore, suggest that 11.7%, 16.3%, and 15.4% of the variation in conventional, organic, and pooled sampled vegetable output respectively are due to random shocks outside farmers' control. Some of the random shocks could be unfavourable weather conditions, pest and disease infestation, among others.

The estimated value of sigma-squared (σ^2) was statistically significant at 1% level for all the farming technology and indicates that the assumption about the distribution of the error variances is correctly specified. Other studies, including Bakhsh *et al*. (2006) and Binam *et al*. (2008) reported similar results.

This study estimated technical efficiency by assessing the effects of farm and farmer characteristics and institutional factors on technical efficiency. The technical inefficiency effects examined were those relating to gender, household size, education, off-vegetable farm activities, farmers' ability and resource to cultivate all year, ability to make own inputs, farming experience, FBO, extension, formal training in vegetable farming, access to external credit support and adoption of organic vegetable farming. The estimated coefficients for the factors influencing technical inefficiencies are reported in Table 8.3. The results show that the farming systems were influenced by different factors and the coefficients of efficiency variables had different signs among farming systems. The negative and positive signs associated with each explanatory variable denote the effects on the level of inefficiency such that a negative sign implies a decrease in technical inefficiency and thus an improvement in technical efficiency.

Table 8.3: Maximum-likelihood Estimation results of the inefficiency Effects Model

		Conventional		Organic		Pooled	
Variable	**Parameter**	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**
Constant	δ_0	1.567	1.408	0.709	1.806	-2.152	1.717
Sex	δ_1	-2.908***	1.13	-2.097***	0.666	-2.325***	0.521
Household size	δ_2	-0.076	0.093	0.097*	0.056	0.039	0.039
Education	δ_3	-0.029	0.071	0.001	0.039	0.015	0.032
Off farm work	δ_4	-1.467*	0.785	-0.764*	0.43	-0.842***	0.327
ARCAY	δ_5	0.266	0.638	0.61	0.483	1.277**	0.435
AMOI	δ_6	-0.153	0.585	-0.242	1.338	2.185**	0.976
Landownership	δ_7	1.005	0.737	1.032**	0.513	0.982***	0.371
FBO	δ_8	0.096	0.306	0.345	0.283	0.249	0.202
Extension contact	δ_9	-0.198	0.193	0.02	0.069	0.035	0.062
Training	δ_{10}	-2.665*	1.5	-0.932*	0.482	-1.349***	0.443
AECS	δ_{11}	-1.748	2.339	-0.826**	0.473	-0.940**	0.446
Farming Experience	δ_{12}	0.061*	0.036	0.039	0.028	0.058***	0.021
Adoption scores	δ_{13}					-0.268**	0.13

Table 8.3: Maximum-likelihood Estimation results of the Inefficiency Effects Model (continued)

		Conventional		Organic		Pooled	
Variable	**Parameter**	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**
Sigma^2		*3.673****	*1.46*	*2.540****	*0.718*	*2.549****	*0.551*
Gamma		*0.883****	*0.055*	*0.837****	*0.064*	*0.846****	*0.042*
Sigma_u^2		*3.243*	*1.459*	*2.127*	*0.728*	*2.157*	*0.55*
Sigma_v^2		*0.429*	*0.115*	*0.413*	*0.11*	*0.393*	*0.075*
Lambda		*7.559****	*12.687*	*5.150****	*6.618*	*5.489****	*7.333*
Mean TE (%)		44.7		55.5		50.1	
Maximum TE (%)		84.6		91		91	
Minimum TE (%)		0.3		1.9		0.3	

Source: Computed from Field Survey, 2015; Note: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively, ARCAY, AMOI, FBO and AECS refer to ability and resources to cultivate all year, the ability to make own inputs, farmer base organisation, and access to external credit support respectively.

The coefficients of years of schooling, 'ability to make own input' (AMOI), contact with extension service and farmers' ability and resource to cultivate all year (ARCAY) had no significant influence on the two farming systems of vegetable production whereas years of schooling and contact with extension service had no significant influence on the pooled sample (see Table 8.3).

The estimated coefficient of the sex of the farmer is negative and in line with the *a priori* expectation. It is statistically significant at the 1% level for all farming systems. This implies that male farmers are more technically efficient than female farmers. This might be due to the fact that men have greater access to land, probably because of cultural bias. Again, male farmers may have easy access to funds considering the fact that they own most assets in the household which could be used as collateral to raise funds to purchase improved seeds and employ labour. Similarly, men are physically stronger than women and can labour for longer hours than women. Also, as noted by Assibey-Mensah (1998), the domestic roles played by women in Ghana means that their engagement with household chores lessen the time they can spend on their vegetable farms, thus, making them inefficient in farming. This finding is similar to the results established by Amoah *et al*. (2014), Binam *et al*. (2008) and Shamsudeen *et al*. (2013) among Ghanaian farmers.

The training on improved ways of cultivating organic vegetables and improving the soil nutrient was very vital as shown by the 5% significant level of the coefficient estimate, and negative expected signs. Other things held constant, farmers who received training on vegetable production were technically efficient compared to their counterparts who were not trained. This was because the training offered organic farmers the opportunity to search for and apply innovations in vegetable farming and increased their technical know-how in organic vegetable production. Similarly, the training programme offered to the conventional vegetable farmers was found to exert significant effect on technical efficiency. Overall, access to training on vegetable production improves farmers' efficiencies. This finding is in sync with a study by Kuwornu *et al*. (2013), who found a negative and significant effect of formal training in maize farming among maize producers in the Eastern Region of Ghana.

The results further demonstrate that enhancing farmers' access to external credit support is an important factor for improving farm production efficiency among vegetable farmers in general and organic farmers in particular. The coefficients of access to external credit support (AECS) in organic farm model and the pooled sample model were negative for all the farming system and are consistent with the *a priori* expectation. However, it was statistically significant at the 5% level for organic and the pooled vegetable farms. This suggests that organic vegetable farmers who had access to external credit support in their production process enhanced their technical efficiencies (Table 7.3). Ahmad *et al*. (2006), Kuwornu *et al*. (2013) and Waqar *et al*. (2008) also found that farmers with access to 'in-kind' input and institutional credit support in the form of seed and irrigation increase their productivity massively. Results presented in Table 6.2b show that most vegetable farmers received AECS in the form of cash, animals, seeds and equipment (such as donkey cart, wheelbarrows, shovels, and pick axe). From the perspective of farmers, AECS is a good opportunity to improve upon their production by overcoming liquidity constraints which affect their ability to perform timely operations and decision making.

Furthermore, the results reveal that off-vegetable farm activities were negative and significant for all the farming systems. This suggests that both conventional and organic farmers who diversified their income sources by engaging in off-vegetable farm activities tended to have lower technical inefficiencies. This could be attributed to the fact that farmers who earn more income from such activities, can reinvested into their vegetable farming activities (such as improved technologies like seeds). The finding confirms the discussions held with the farmers to the effect that most of them self–financed their farming activities from other income sources. The finding is consistent with other findings (Chirwa, 2007).

The coefficient of household size was positive and statistically significant in the organic vegetable farms model. This positive impact of the household size of organic farmers on technical inefficiency suggests that farmers with larger household size are technically inefficient. In other words, larger household sizes of farmers reduce technical efficiency. This is contrary to the research's expectation. This could be attributed to the fact that farmers with larger household sizes may allocate more resources and time to manage their households rather to manage their vegetable farms. The finding is also similar to the results established by Maganga (2012) in Malawi.

The land ownership variable had a positive and significant effect on technical inefficiency for organic and the overall farms; it shows that organic vegetable farmers operating their farming activities from rented land are technically more efficient than those farming on their own land. It is important to recall that land owner farmers had a high probability of engaging in organic vegetable production. Thus, although they may decide to go into organic vegetable production, their efficiency levels are lower. The high efficiency of farmers who used lands other than own lands can be as a result of their devotion of more attention to their farms in order to reap sufficient benefits due to the financial investment associated with organic farming, including the cost of rented land.

Farming experience was positively associated with technical inefficiency in organic farming but it was not significant. However, it was significantly positive for the conventional and pooled vegetable farms. The farming experience coefficient indicates that conventional vegetable farmers that are more experienced were less technically efficient in their production than the inexperienced ones or new farmers who are progressive and keen to implement new production methods. This finding stems from the fact that farmers with more years of experience tend to be relics and unwilling to adopt new practices, thus, leading to low efficiencies in production. This confirms the observation made from the field where the majority of the conventional farmers are unable to apply the required quantities of fertiliser due to increasing prices. In addition, incorrect timing of acquisition and application attenuate the effectiveness of the fertiliser, thereby increasing inefficiencies. This result confirms the findings of Esmaeili (2006), Kramol *et al*. (2013), and Onumah *et al.* (2010), but contrasts the findings of Amoah *et al*. (2014).

The education coefficient was not statistically significant but had the expected negative effect on inefficiency for all the farming system. The result is consistent with the findings by Amoah *et al*. (2014) who reported that education does not significantly affect the efficiency of vegetable farmers in the Peri- Urban Ghana. Similarly, the coefficients on extension contacts, ability to make own input' (AMOI), farmers' ability and resource to cultivate all year (ARCAY) and FBOs had no significant influence on the conventional and organic farming systems of vegetable production. However, AMOI and ARCAY variables had positive and statistically significant effect on vegetable farmer's inefficiencies in the pooled sampled (see Table 8.3). It was observed from the survey that, farmers who make their own inputs have less time for working on their vegetable farms, thereby, reducing their efficiencies. Similarly, farmers who have the ability to cultivate all year round hold the view that at every time of the year, they can have vegetables, therefore, are less concerned of producing efficiently.

Furthermore, (the predicted values of) adoption of organic farming technology was negative and statistically significant at five percent level. This suggests that vegetable farmers who adopted organic farming technology have lower technical inefficiencies in vegetable production compared to conversional vegetable farmers in the study area (see Table 8.2).

8.5 Technical Efficiency Index among Vegetable Growers

The technical efficiency scores for vegetable farmers, corrected for selectivity bias, are presented in Figure 8.1. The figure also reports technical efficiency score obtained from the conventional and organic vegetable farmers in the Northern Region. The scores for technical efficiency were predicted after estimating the stochastic frontier production. The predicted technical efficiencies vary greatly among the conventional and organic vegetable farmers in the study area. For instance, it is evident in Figure 8.1 that 21% of conventional vegetable farms had technical efficiency levels less than 21% which is a larger proportion than 11.5% of organic vegetable farms. Furthermore, the results show that few of the conventional farms (14%) and organic farms (41%) operated from 71 to 100% efficiency levels. Additionally, the results indicate that majority of conventional (50.5%) and organic (36%) vegetable farmers are producing vegetables on a lower level of technical efficiency of 0 to 50%. This implies that larger proportion of vegetable farms (both conventional and organic vegetable farms) in the study area were not able to use their inputs effectively to achieve the highest output possible, based on their own technology sets.

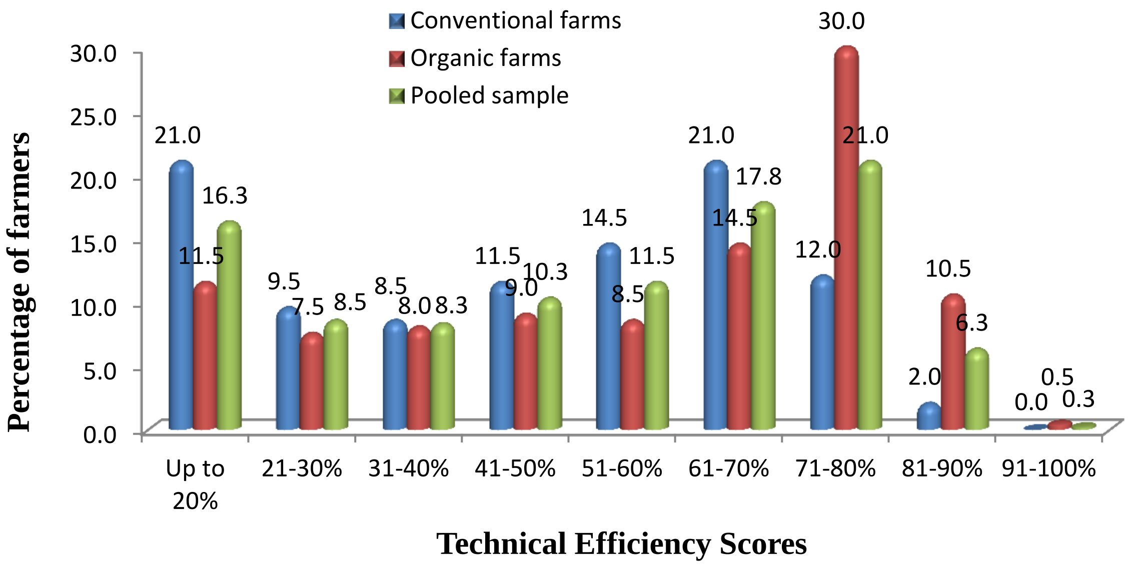

Fig. 8.1: Percentage distribution of technical efficiency scores for conventional organic and pooled sample farming systems in the Northern Region

The mean technical efficiency for the pooled sample corrected for selectivity bias is 50.1% with a minimum of 0.3% and a maximum of 91.0%. The average predicted technical efficiency score for conventional farms (44.7%) was lower than the pooled sample while the mean technical efficiency for organic vegetable farms (55.5%) was higher mean than the pooled sample. The most technically efficient farm among organic vegetable farms had a score of 91.0% compared with 84. 6% score for conventional vegetable farms. The least technically efficient organic vegetable farm recorded a score of 1.93% while the least score for conventional vegetable farms was 0.3%. These scores give evidence that there is a gap between the two divergent farms with regard to the technical efficiencies of both categories of farmers.

The results of a t-test (-4.5585; p-value<0.01) further show that the technical efficiency scores for organic vegetable farms was significantly higher than the mean technical efficiency for conventional farms at 1% level. This basically implies that on the average, organic farms operate closer to the production frontier compared to conventional farms.

However, it should be stressed that since organic and conventional vegetable farming represent different production technologies, organic vegetable farms face a different production frontier from conventional vegetable farms. Thus, the difference between the average technical efficiency score of conventional farms and that of organic farms does not imply that organic farms are more efficient than conventional farms in absolute terms. Nonetheless, such low efficiency levels are common in developing countries. Empirical studies on most major staple crops such as maize and rice found that efficiency levels of the farmers were higher (Anang, Backman & Sipilainen, 2016; Shamsudeen *et al*., 2013) than the estimated mean efficiency of vegetable farmers in this study and other studies on vegetable farming. For instance, Amoah *et al*. (2014) established that vegetable farmers in Kumasi had a mean technical efficiency of 24%. In Thailand, Kranol *et al*. (2013) found that vegetable growers of the various farming systems had a mean technical efficiency level ranging from 34% to 47%. Vegetable farmers also engage in the cultivation of these staple crops. In fact, staple crop production is often the main source of income and livelihoods, and this motivates farmers to invest more resources such as labour and capital into its cultivation than on vegetable farms. Because of small farm sizes of vegetable farms, most of the effective work hours of the farmers are spent on farms cultivated with staple crops and not on vegetable farms. Hence, it would be expected that vegetable farmers would have a lower efficiency when compared with major staple crops.

CHAPTER NINE

SUMMARY, CONCLUSIONS, AND POLICY RECOMMENDATIONS

9.1 Introduction

This chapter summarises the findings, presents conclusions, and provides policy recommendations based on the conclusions.

9.2 Summary

The potential for improving food security and farmers' income through the adoption of agricultural technology is substantial. This study explored the determinants and effects of organic vegetable farming on output, technical efficiency and welfare of farmers in the Northern Region of Ghana. From the results it can be deduced that that organic vegetable farming is more appealing to the educated and experienced farmers. Institutional factors that positively influenced the adoption of organic vegetable farming included farmers' contacts with extension staff, access to external credit support and farmers' FBO membership. Also, farmer's ability to make their own inputs (AMOI) had a positive influence on adoption while at the same time; it helped to reduce the costs of organic production. Furthermore, farmers' ability and ownership of resources to cultivate throughout the year (ARCAY) and sole ownership of farmland influenced their adoption of organic farming. Most of these factors also enhanced farmers' technical efficiency and welfare.

The findings of the study also confirm the potential role of organic farming in improving farmers' output and technical efficiency and welfare.

9.4 Policy Recommendations

The results of the study have important implications for policy formulation. Farmers must be sensitized and supported to adopt organic vegetable farming, given the benefits of organic produce. MoFA in particular should take the lead role in sensitising farmers on the importance of adopting organic farming technologies to enhance retention of soil fertility and other environmental factors. Government and NGO's (such as GOAN, MIDA, MADE, Care International, ADVANCE) should also play a lead role in providing accessible educational training programmes to farmers; At least, non-formal education can be helpful in providing literacy to farmers for whom it is too late to access formal education. There is also the need for government (through MoFA) to network with agricultural research institutions (such as UDS, SARI) for capacity building and technology development to improve quality and access to extension services. This can be done through the design of innovative tools such as videos and mobile phone technology to improve access to extension services.

The study also recommends that MoFA, SARI and other development partners (GOAN and CAOF) should support organic farmers with training programmes that can make them knowledgeable and effective in preparing their own inputs such as on-farm compost or organic manure from agricultural waste. In line with this, households may also be trained to separate agricultural waste from general waste so that the former can be further used to prepare compost for the farmers. Waste companies may be viable organisations to collaborate with in this exercise.

One other important way by which government and NGO's (such as GOAN, MADE, Care International, AVANCE, etc.) can support organic vegetable production is by establishing a clear legal framework aimed at the institution of certification processes which would promote premium prices. Certification would give prospective patrons the guarantee that the vegetable they are buying is organic and of better quality. Similarly, government can establish special award scheme in the Farmers' Day Celebration for organic vegetable. Finally, there is the need for government to encourage credit institutions to restructure their credit policies to favour vegetable producers which will go a long way to encourage the adoption of and raise the technical efficiency in organic vegetable production.

9.5 Final Conclusion and Recommendations for Further Studies

Per the findings of this study, organic vegetable production in the Northern Region of Ghana is economically worthwhile compared to conventional vegetable production. Accordingly, organic farming must be encouraged by all stakeholders to ensure supply and consumption of organic vegetable as a means of attaining sustainable agricultural development in Ghana.

Since organic vegetable production system varies from that of conventional vegetable production, it is suggested that future studies should employ the metafrontier production approach. Also Greene's (2010) methods for correcting for selectivity bias as applied to stochastic frontier may be adopted. In this study an attempt was made to employ the latter but the data was unsupportive and so the full results were not obtained (see appendix B I and B II).

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APPENDICES

APPENDIX A: A SAMPLE QUESTIONNAIRE FOR THE SURVEY

ORGANIC VEGETABLE PRODUCTION AND ITS EFFECTS ON FARMERS' WELFARE IN THE NORTHERN REGION OF GHANA

QUESTIONNAIRE FOR PRODUCERS

Name of community……………… Questionnaire no………………

Date of interview………………….. Contact number ……………….

SECTION A: Socio-Economic Characteristics

1.0 PROFILE OF RESPONDENT

1.1 Sex of respondent Male [ ] Female [ ] 1.2 Age (in years): [ ]

1.3 Household size (specify number) …………………………..

1.6 Please select the highest level of education you have completed. (Please tick one)

[ ] Primary education
[ ]JHS/middle
[ ] Senior high education
[ ] Teacher training/Nursing training school
[ ] Vocational/Technical education
[ ] Tertiary
[ ] No formal education
[ ] Others (specify)…………

1.7 Which of the following best describes your current marital status? (Please tick one)

[ ] Married
[ ] Single
[ ] Others (specify)………
[ ] Divorced/ Separated
[ ] Widowed

1.8. Major occupation of respondent …………………

1.9 Other occupation…………………………………

1.10 Does your family have any other sources of income besides vegetable farming?

[ ] Yes [ ] No

1.11 What percentage of your total household income comes from sources other than the vegetable farm? ....

2.0 Average expenditure of the farming household……….

Items	Qty/no of persons	Price/cost per unit	Weekly Expense	Monthly Expense	Average annually expenditure (GH¢)
Medical care NHIS Cash Medicine					
Food expenditure Food crop: Maize Millet/sorghum Rice Yam/potatoes Cowpea Soy beans Others (specify)…					
Ingredient Meat Fish Cooking oil Vegetables Fruits Salts/Maggi/ Others (specify)…					
Education expenditure Nursery Kindergarten Primary JHS SHS/VS Tertiary Book/pens/ pencil/erasers					
Transportation/ fuel Car Motor bike Bicycle Others (specify)...					
Maintenance Car Motor bike Bicycle Others (specify)...					

Items	**Qty/no of persons**	**Price/cost per unit**	**Weekly Expense**	**Monthly Expense**	**Average annually expenditure (GH¢)**
House rents					
Gas Charcoal Firewood					
Social contribution Outdooring Funerals Marriage					
Others (specify)…					

3.0 PRODUCTION AND LABOUR ACTIVITY

3.1 Are you a vegetable farmer? [ ] Yes [ ] No

If yes, what farming methods are you using for your vegetable production?

[ ] Producing vegetables naturally or organic farming (that is not using any synthetic Chemicals)

[ ] producing vegetables conventionally or with the use of synthetic chemicals

3.2 How many vegetables do you cultivate? …………………………………

3.3 Please name the crops you normally cultivate….…………………………

……………………………………………………………………………

(For inorganic farmers please skip to questions 2.8-2.9)

3.4 Please indicate the extent to which the following has assisted you in making up your mind to start farming organically?

Statement	**Most Helpful (1)**	**Helpful (2)**	**Not Helpful (3)**
a. Talks and seminars	1	2	3
b. Articles or books on organic farming	1	2	3
c. Radio or television programs	1	2	3
d. Internet	1	2	3
e. Discussions with your MoFA and NGOs advisor	1	2	3
f. Discussions with research personnel	1	2	3
g. Discussions with friends and neighbours	1	2	3
h. Profit incentive,	1	2	3

i. Other (Please specify)............	1	2	3

3.5. What or who was the single most influential element in persuading you to start organic farming?…………………………………………………………………… ……………………………………………………………………………………

3.6 What initially attracted you to become involved inorganic Farming?
……………………………………………………………………………………
……………………………………………………………………………………

3.7 Do you think the public is aware of organic products? Yes [ ] No [ ]

3.8 Which time of the year do you cultivate the land?
[ ] During the rainy season [ ] During the dry seasons [ ] Both seasons
[ ] All year round

3.9 Do you have you have the resource to cultivate throughout the year?
Yes [ ] No [ ]
If yes, give reasons for your answer in question above:
……………………………………………………………………………………
………………………………………………………………………………………
…………………………………………………………………………………

3.10 What are the reasons for cultivating organic vegetables? (You can tick more than one)

Reasons	**Remarks**	**Rank**
(a) Increasing cost of inorganic chemicals	Yes [ ] No [ ]	[ ]
(b) Increasing return from organic vegetables	Yes [ ] No [ ]	[ ]
(c) Soil health oriented motives	Yes [ ] No [ ]	[ ]
(d) Motivation by neighboring organic farmers	Yes [ ] No [ ]	[ ]
(e) Sustainable and environment-friendly farming	Yes [ ] No [ ]	[ ]
(f) Producing high quality and healthy organic vegetables product	Yes [ ] No [ ]	[ ]
(g) Organic farming is the best method of ensuring a sustainable future for farming	Yes [ ] No [ ]	[ ]
(h) Reliable and stable income	Yes [ ] No [ ]	[ ]
(i) Maximise profit	Yes [ ] No [ ]	[ ]
(j) Organic farmers receive too much public support	Yes [ ] No [ ]	[ ]
(k) Availability of ready market	Yes [ ] No [ ]	[ ]
(l) Ill-health associated with the use of chemical	Yes [ ] No [ ]	[ ]
Others (Please specify)	Yes [ ] No [ ]	[ ]

(Skip question 2.10 if the farmer is an inorganic producer to 2.11-2.24)

3.11 In the table below, please indicate the size of plot/land cultivated to each crop in the 2014 growing season, and the corresponding percentage of sales revenue generated

		Organic				**Conventional**		
Vegetables	**Farm size (Acres)**	**Freq of prod**	**Price / unit**	**Total quantity sold out**	**Farm size (Acres)**	**Freq of prod**	**Price/ unit**	**Total quantity sold out**
1. Pepper								
2. Tomatoes								
3. Cabbage								
4. Lettuce								
5. Carrot								
6. Spring onion								
7. Green/Sweet pepper								
8. Cucumber								
9. Green beans								
10. Cauliflower								
11. Alefu								
Others (please state) ………..								

3.12 What is the nature of ownership of farmland under your production?

[ ] Sole owner [ ] Rent [ ] others (Please specify)………
[ ] Leased [ ] Partnership

3.13 Does the type of ownership affect the way you farm? Yes [ ] No [ ]

If yes, Please explain……………………………………………………………
……………………………………………………………………………………

3.14 What determines the price of the vegetable you sell?

	Organic Vegetables		**Conventional Vegetables**	
Price Determinant	**Response Yes/No**	**Rank**	**Response Yes/No**	**Rank**
i. Set own prices				
ii. Buyer negotiation				
ii. Prevailing domestic market price				
v. Contact others farmers before you price				
v. Use cost of production				
vi. Others (please specify) a.				
b.				

3.15 Are you able to differentiate between conventional vegetables from organic vegetables? Yes [ ] No [ ]

If yes, how do you differentiate conventional vegetables from organic vegetables?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

3.16 Are prices for organic vegetables different from the conventional ones?

Yes [ ] No [ ]

If yes, what are the factors responsible for the price differences?

Factors		**Response Yes/No**	**Rank**
i.	Organic vegetables are of better quality		
ii.	Organic vegetables are of better taste		
iii.	Organic vegetables have longer shelf life		
iv.	Organic vegetables are neat		
v.	Organic vegetables are firm		
vi.	Organic vegetables are readily available		
vii.	Others (please specify)		
a.			
b.			
c.			

3.17 How does organic farming differ from other farming operations with regard to the effects on the environment?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

3.18 How many people did you employ in your farm's vegetable operation, full-time, part-time, or occasionally? Number of farm labours (include yourself and any family/household members).

	Organic Farms		**Inorganic Farms**	
	Family Labour	Hired Labour	Family Labour	Hired Labour
Full-time, year-round	[ ]	[ ]	[ ]	[ ]
Full-time, seasonally	[ ]	[ ]	[ ]	[ ]
Part-time, year round	[ ]	[ ]	[ ]	[ ]
Part-time, seasonally	[ ]	[ ]	[ ]	[ ]

3.19 How do you maintain the soil quality to sustain your vegetable production?

…………………………………………………………………………………

…………………………………………………………………………………

3.20 How do you control weeds problems?
……………………………………………………………………………………………
……………………………………………………………………………………………

3.21 How do you control pests problems?
…………………………………………………………………………………..

3.22 Asset Position of the farm

Types of assets	Quantity	Year of purchase	Purchase Value(GH)	Expected life span
Hoe				
Cutlass				
Pumping machine				
Irrigation equipment				
Watering can/bucket				
Knapsack sprayer				
Donkey cart				
Rake				
Wheelbarrow				
shovel				
Pan				
Motor king				
Others (please state)				

3.23 Inputs used in vegetable production

	Organic farming		**Inorganic farming**		
Type of input	**Price/bag/ unit**	**Qty used (bag/acre)**	**Type of input**	**Price/bag/ unit**	**Qty used (bag/unit/ acre)**
Seeds			Seeds		
Bio-fertilizer(Deco organic manure)			Fertilizer		
compost					
Farm yard manure					
Animals dung					
Green manure			Pesticides		
Others (please specify			a.		
			b.		
Bio-pesticides			c.		

(organic pesticides)					
Neem extract					
Wood ash					
Others(specify)					
	Organic farming		**Conventional farming**		
Type of input	**Price/bag/ unit**	**Qty used (bag/acre)**	**Type of input**	**Price/bag/ unit**	**Qty used (bag/unit/ acre)**
Irrigation charges/ water used					
Others (please specify					

3.24 Labour/implement use in different farm operations and cost (Ghana cedis).

Name of the operation	**No of time**	**Family labour**		**Hired labour**		**Machine hired**	**Animal plough**
		Women	**Men**	**Women**	**Men**		
Land preparation							
Transportation of organic manure							
Harrowing							
Spreading of organic manure							
Sowing							
Hand weeding							
Pesticides /Bio-pesticides application							
Harvesting							
Others (please specify) 1.							
2							

4.0 FARM EXPERIENCE

4.1 How long have you known about organic farming methods? ……………
4.2 How did you first hear about organic farming? ……………………………
4.3 In what year did you first start your organic production ……………………
4.4 How many years have you been farming? …………………………………
4.5 How many years have you been farming organically?……………………..

4.6 Have you increased the size of land under your cultivation since you started the organic vegetable? [ ] Yes [ ] No
If yes, how many acres did you start with?…………………………………
4.7 How many acres are you cultivating now…………………………………..
4.8 Type of farming: [ ] Full time [ ] Part time

5.0 PERFORMANCE

5.1 Where do you sell your vegetables and why do you sell at these points?

	Organic farming			Inorganic farming		
Sale outlet	**Response Yes =1 No = 0**	**Reason**	**Rank**	**Response Yes =1 No = 0**	**Reason**	**Rank**
Direct sales to customers						
Households						
Local market						
Restaurants and chop bars						
Open markets						
Hotels						
Buyers come to buy from the farm gate						
Schools / Hospitals						
Others (please state)…						
2.						
3.						

5.2. Who buys your vegetables and why do you sell to this person? From the following categories, indicate what percentages of your volume were delivered to the following marketing channels.

	Organic farming			**Inorganic farming**		
Buyer	**Response Yes =1 No = 0**	**Reason**	**% volume sold out**	**Response Yes =1 No = 0**	**Reason**	**% volume sold out**
Wholesaler						
Retailer						
Processor						
consumers						
Others(please state)						
a.						

5.3 Taking everything into consideration how satisfied are you with the results from farming thus far?

	Completely satisfied	**Moderately satisfied**	**Not at all satisfied**
Organic farming			
Inorganic farming			

5.4 List in order of importance the main advantage(s) of organic farming.

…………………………………………………………………………………

……………………………………………………………………………...........

…………………………………………………………………………………

…………………………………………………………………………………

5.5 Do you believe farmers are interested in organic farming? [ ] Yes [ ] No
If yes, why are there presently very few farmers farming organically?
……………………………………………………………………………………………
…………………………………………………………………………………

5.6 What changes could be made to encourage the future of organic farming in Ghana?……………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………………………

5.7 Do you consider organic farming as a sustainable enterprise? [ ] Yes [ ] No
If yes, Please explain…………………………………………………………
…………………………………………………………………………………………

5.8 Have you personally taken any steps to promote organic farming in your area?
Yes [ ] No [ ]
Please comment………………………………………………………………

……………………………………………………………………………………………

5.9 Could you identify the most common challenges/constraints associated with the success of your operation?

Barriers	**Response (Yes or No)**	**Rank**
A. Production related issues		
i. Non-availability of planting material		
ii. Limited availability bio-pesticides		
iii. Non-availability Manure/organic waste		
iv. Non- availability of information on organic farming		
v. Lack of extension advice		
vi. Lack of technical know-how		
vii. Aggressive marketing strategies of conventional input dealers		
viii. Others (please state)		
a.		
b.		
c.		
B. Marketing issues		
i. Non-availability of market related information		
ii. Non- availability of exclusive market for organic produce		
iii. Absence of premium price in the local market		
i. Lack of certification for organic produce		
ii. Others (please state)		
a.		
b.		
c.		

6.0 INSTITUTIONS

6.1 Are you member of any farming group or professional associations within the farming industry? Yes [ ] No [ ]

If yes, please specify………………………………………………………..

6.2 Are there institutions / organizations that address the interests of vegetable producers? Yes [ ] No [ ]

If yes, please mention the institutions / organizations?...............................

6.3 Have you received any extension services? Yes [ ] No [ ]

If yes, please mention the services you receive?

……………………………………………………………………………………………

……………………………………………………………………………………………

6.4 Within one farming season, how many visits did you receive from the extension agent? ………………………

6.5 Have you had any training in vegetable farming? Yes [ ] No [ ]

If yes, what training have you received……………………………………..

……………………………………………………………………………………..

6.6 Which organizations/institutions provided the training?

………………………………………………………………………………………

6.7 Do you obtain enough support from government agencies, local authorities, industry, associations or any other relevant stakeholders? Yes [ ] No [ ]

If yes, what support do you receive from government agencies?

………………………………………………………………………………………

………………………………………………………………………………………

6.8 What support do you obtain from the local authorities, industry, associations or any other relevant stakeholders or NGOs?

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

7.0 FINANCE AND MARKETING

7.1Do you have access to external credit support for your farming activities?

Yes [ ] No [ ]

If yes, what form did the credit support take? …………………………………..

7.2What has traditionally been your main source of credit?

……………………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………………

7.3 Do you get ready market for your organic produce? Yes [ ]No [ ]

Explain

……………………………………………………………………………………

……………………………………………………………………………………

7.4 How much income do you earn on average from the sale of your vegetable produce?

…………………………………………………………………………………….

……………………………………………………………………………………..

…………………………………………………………………………………….

7.5 Is your produce recognized as organic? Yes [ ] No [ ]

Give reasons for your answer to above question
………………………………………………………………………………………………
……………………………………..………………………………………………..

7.6 Approximately what percentage of your household gross farm income comes from organic vegetable farming: (Please tick one)

0-25% [ ] 26-50% [ ] 51-75% [ ] 76-100% [ ]

7.7 Compared to other similar sized vegetables farmers, do you consider your financial performance to be?

(a) [ ] Above average (b) [ ] About average (c)[ ] Below average

APPENDIX B

APPENDIX B I: Parameter estimates of the probit variety selection equation

Variables	Coefficient	Standard Error
Constant	-1.3661***	0.1327
Age	-0.0363***	0.0082
Household size	-0.0734**	0.0230
Education	0.0129	0.0171
Off-vegetable farm activity	-0.1121	0.1686
Farming Experience	0.0003	0.0102
Farm size	-0.2181*	0.1077
ARCAY	0.8705***	0.1686
FBO	0.4093*	0.1920
Extension	0.0788	0.0403
AECS	-0.3300	0.4435
AMOI	1.7542***	0.2332
Training	1.3776***	0.2284
Land ownership	0.0589	0.1706
Log-likelihood function	-151.6217	
Chi-squared test statistic	251.2744***	
Number of observations	400	

Source: Field Survey, 2015. Note: *** significant at <=1% level, ** significant at >1&<=5% level, * significant at >5&<=10% level. ARCAY, AMOI, FBO and AECS refer to ability and resources to cultivate all year, ability to make own inputs, farmer base organization, and access to external credit support respectively

Appendix II: Parameter Estimates of the Stochastic Production Frontier Models for Vegetable (jointly estimated with the probit selection equation)

Variable	Coefficient	Standard error
Constant	10.6170***	0.4321
Ln Farm size	0.7123*	0.3234
Ln labour	0.1236*	0.6309
Ln seeds	0.3622	0.2494
Ln manure	0.2898**	0.1124
Model diagnostics		
Log likelihood	-2044.843	
σ_u	0.0148	0.01035
σ_v	-0.1011	0.0257***
Selectivity bias (ρ w,v)	-0.2544	0.0570***
Number of observations	400	

Note: *** significant at <=1% level, ** significant at >1&<=5% level, * significant at >5&<=10% level.