FACTORS INFLUENCING THE ADOPTION OF ORGANIC FERTILIZERS IN VEGETABLE PRODUCTION IN ACCRA

BY

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DECLARATION

I, ROBERT KOFI LAVISON, the author of this thesis, titled; **"FACTORS INFLUENCING THE ADOPTION OF ORGANIC FERTILIZERS IN VEGETABLE PRODUCTION IN ACCRA"**, do hereby declare that with the exception of the relevant references duly cited, the entire research was carried out by me in the Department of Agricultural Economics and Agribusiness, College of Agriculture and Consumer Sciences, University of Ghana, Legon from August 2012 to July 2013. This thesis has never been presented either in whole or in part for any degree in this University or elsewhere.

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This thesis has been submitted for examination with our approval as supervisors

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(Major Supervisor) (Co-Supervisor)

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DATE DATE

DEDICATION

I dedicate this work to my parents (Mr. and Mrs. Cyril Kofi Lavison), my sisters (Aku, Caro, Abla and Adzoa) my brother (Koku). I also dedicate it especially to Yao Lavison and his mother.

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ABSTRACT

Continuous tillage of soils results in nutrient mining. It leaves the soils in very fragile conditions and therefore nutrient augmentation through the application of fertilizers has become imperative to maintain crop yields of to feed the ever growing population of Ghana. The use of organic fertilizers has its pros and cons. This study sought to determine the factors that influence the adoption of organic fertilizers, in vegetable production in Accra. Vegetable growing areas were purposively selected and the farmers were randomly selected. Both primary and secondary data collected were analyzed using cost functions, descriptive statistics, multinomial logistic regression, partial farm budgeting techniques and Kendall's coefficient of concordance. The software used for data entry and analysis were SPSS, STATA and Microsoft Office Excel. It was found that currently, 96% of the respondents are users of organic fertilizers, 45.3% can be classified as adopters. The significant factors influencing the adoption of organic fertilizers include gender, type of farmer, consumer preference for organically grown vegetables, income from using organic fertilizers, income from using inorganic fertilizers and the type of market that a farmer produces for. Income from using inorganic fertilizers, consumer preference and type of market influence the adoption of organic fertilizers negatively. Income from using organic fertilizers, type of farmer and gender influence the adoption of organic fertilizers positively. Farmers using organic fertilizers incur a high transaction costs. The most pressing constraint associated with the use of organic fertilizers was bulkiness and there was agreement among farmers in the ranking of constraints. It is recommended that the use of organic fertilizers should be properly supervised by the Environmental Protection Agency (EPA) to ensure that excessive levels are not applied, as this could result in environmental pollution. Vegetable production in the city should be promoted by city authorities and other stakeholders as because it is a profitable venture and a viable source of livelihood. Suitable areas of the city of Accra such as marine drive, La Korle-bu, GBC and Dzorwulu should be reserved mainly for vegetable cultivation and other forms of agriculture by city authorities because increasing development could lead to a reduction in land area available for urban agriculture. The Government should introduce a fertilizer subsidy policy that is geared towards the production of vegetables and also one that consists mainly of organic fertilizers. Scientists should devise ways of reducing the bulky nature of organic fertilizers. Entrepreneurs and investors should be given incentives such as tax rebates and credit to invest in setting up more composting sites and organic fertilizer manufacturing plants to satisfy the demand for the fertilizers.

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CGIAR	Consultative Group on International Agriculture
CYMMIT	International center for Maize and Wheat Improvement
DFID	Department for International Development
FAO	Food and Agriculture Organization
GBC	Ghana Broadcasting Corporation
GM	Gross Margins
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy research Institute
IIA	Independent Irrelevant Alternatives
IWMI	International Water Management Institute
MAFF	The UK's Ministry of Agriculture and Fisheries
MDGs	Millennium Development Goals
MoFA	Ministry of Food and Agriculture
NGOs	Non Governmental Organizations
NPK	Nitrogen, Phosphorus and Potassium
PH	Power of Hydrogen
RUAF	Resource Centers on Urban Agriculture and Food Security
SSA	Sub-Saharan Africa
TCs	Transaction Costs
UN	United Nations
UN-Habitat	United Nations Habitat Programme
UPA	Urban, Peri-urban Agriculture.

CHAPTER ONE

INTRODUCTION

1.1 Background

It is estimated that given an increasing growth in population, the urban population of Sub-Saharan Africa (SSA) will exceed its rural population by the year 2020, and demands a paradigm shift in agricultural research and development. Besides urban sanitation issues, food resources for the cities will also become a challenge. Urban and Peri-urban agriculture (UPA) provide a significant share of the food supplies of many cities in Sub-Saharan Africa because it supports urban food consumption habits and lifestyles, in particular, perishable vegetables, fresh milk and poultry products (Cofie and Drechsel, 2006). Urban and peri-urban agriculture also contribute to employment and livelihoods as well contribute to poverty alleviation in the long run. Urban and Peri-urban vegetable production are usually intensive and are done all year round. They depend largely on the availability of water for irrigation and production inputs such as fertilizers (Cofie and Drechsel, 2006).

In developing countries, there is acceleration in the rate of urbanization and from UN estimates, the urban population in developing countries is expected to nearly double in size between the years 2000 and 2030. Again according to this projection, between the years 2015 and 2020, the urban population in developing countries will exceed the rural population for the first time and this is expected to continue to increase sharply while rural numbers remain more or less constant (UN, 2002). This development eventually culminated in the declaration by the then General Secretary of the UN, Kofi Annan, that the new millennium will be the “Urban Millennium” (UN-Habitat, 2001).

Africa in particular is experiencing one of the fastest rates of urban growth. As population grows, so is the demand for employment, urban infrastructure and food. One of the consequences of urban growth is that the urban resources are put under great pressure.

In Ghana, the national population grows at an annual rate of about 4% (World Bank, 2010). Urbanisation in Ghana remains high. Every year, thousands of young Ghanaians migrate from their rural dwellings into urban and City centres in search of jobs. Accra alone at its peak periods records a nominal population of about 3.5 million (World Bank, 2010). Urban agriculture provides a very viable means of feeding this escalating population. Urban agriculture as defined by Smit *et al.* (1996) "is the growing of plants and trees and rearing of livestock within or on the fringes of cities (intra-urban and peri-urban agriculture, respectively), including related input provision, processing and marketing activities and services".

Urban vegetable cultivation is common in Accra. It is a phenomenon that has gained much popularity over the decades from the late fifties, sixties and even seventies, the practice gained much popularity as a means of supplementing household income (La Anyane 1963 cited in Asomani-Boateng 2002). According to La Anyane (1963) cited in Asomani-Boateng (2002) the cultivation of vegetable in the city of Accra was introduced by the British Colonial Administration and it was the only type of agriculture permitted within the city for some time. In the early seventies there was a National agricultural policy that encouraged urban agriculture under the "Operation Feed Yourself" policy of the National Redemption Council (Asomani-Boateng, 2001 and Obuobie *et al.*, 2006). The UPA most often involves high-value commodities such as green vegetables, mushrooms etc. that are suitable for limited spaces. It could be subsistence based or recreational at the individual level or could be semi-commercial to fully commercial large scale enterprises (De Zeeuw *et al.*, 2010).

According to Moustier and Danso (2006), UPA in most developing countries such as Ghana is mostly family farms which combine both production for subsistence purposes and market oriented production. Jacobi *et al*. (2000) cited in De Zeeuw *et al.* (2010), in most developing countries UPA is mostly undertaken by the poorer segment of society but is also common to find members of the middle and upper echelons of society as well as purely profit oriented entrepreneurs. According to Obuobie *et al*. (2006) there are two forms of urban and per-urban vegetable cultivation: the open space farming and backyard farming (which takes place in and around homes). Again according to Obuobie *et al*. (2006) the two terms, thus urban agriculture and peri-urban agriculture are synonymous. As at the year 2001, there were 1000 vegetable farmers in Accra (FAO, 2001). Vegetables such as carrots, cabbages, pepper, tomatoes, etc are mostly cultivated. Fertilizers are used in cultivating these vegetables.

FAO (2001) identified two types of fertilizers which can be applied either through the soil or through foliar application. They are organic and inorganic fertilizers. Inorganic fertilizers are composed of simple inorganic minerals from non-natural sources and are manufactured artificially, examples are: NPK, Sulphate of Ammonia and Murate of Potash. Organic fertilizers on the other hand are mostly carbonaceous and can either be naturally occurring or manufactured

Organic fertilizers contribute to humus thereby improving soil fertility and eventually influencing crop yield and farmers' income (FAO, 2001). Traditionally, farmers engage in composting to supply organic fertilizers at the subsistence level to their farms and such organic fertilizer commodity does not pass through the market exchange system. However, in recent years organic fertilizers are produced in commercial quantities by organic fertilizer manufacturing enterprises for farmers' use in crop production (Alimi *et al.*, 2006). According to FAO (2004), the application of organic materials in agriculture has contributed immensely in converting poor fragile lands of the world into stable productive ecological zones.

According to Doss (2006) a very important way of improving agricultural productivity in developing countries is through technology adoption. Adoption of technologies provides leverage in improving output and eventually improving the lives of farmers. Adoption of a technology according to Rogers (2003) connotes continuous use of the technology. Also that adoption infers a change from one state to another and is influenced by factors that may either inhibit or promote the adoption of the technology or group of technologies that may come in a package.

Doss (2006) implies that adoption of technologies is a change in behaviour that eventually culminates in the acceptance or rejection of that technology. Adoption of improved technologies or innovations is driven by the desire to change an existing situation.

1.2 Problem Statement

Sustainable agriculture connotes perpetuity and continuance in profitable production. It involves agricultural practices that can be repeated without the depletion of available vital resources that support agriculture. It also means agricultural practices that will not destroy the environment (DFID, 2002).

Over 8 million tonnes of nutrients are mined from soils in Sub-Saharan Africa every year. In Ghana, about 5 Kg of soil nutrients per hectare is taken out by crops

(Bumb *et al*., 1994 and Henao *et al*., 2006). Henao and Baanante (2006) indicated that if Africa is to be able to feed its poor and hungry people, the use of inorganic fertilizers should be promoted by Governments and stakeholders rather than organic fertilizers which have more benefits than the nutrients that they provide (DFID, 2002). Also current levels of usage should be increased. In Ghana the current level of inorganic fertilizer usage is about 8 Kg per hectare (MoFA, 2008). In its attempt to increase the use of inorganic fertilizers, the Government of Ghana introduced the fertilizer subsidy programme in 2008 (Yawson *et al*., 2010). However the subsidy policy is bedevilled with problems such as shortages and high transaction costs. Small scale farmers who form about 80% of the farmers in Ghana complained that even with the subsidy, the inorganic fertilizers were still expensive (Yawson *et al*., 2010).

There is a strong argument by Savci (2012) that inorganic fertilizers used are constrained by their high costs and uncertain returns under rain fed agriculture. This was also an assertion made much earlier by McGuiness (1993). Alimi *et al*. (2006), also stated that inorganic fertilizers do not improve soil physical properties such as moisture retention capacity and bulk density among others, which organic fertilizers are capable of doing. McGuiness (1993) and Alimi *et al.* (2006) indicated that the leaching of inorganic fertilizer minerals into greater depths, contaminate ground water and bring about conditions such as water hardiness. Alimi *et al.* (2006) added further that the minerals are leached beyond the reach of plant roots.

McGuiness (1993) and Heal (2004), have reported that for agriculture to be sustainable, inorganic fertilizers are not suitable because of environmental degradation caused by their usage. It can affect current production negatively as well as jeopardize the agricultural productivity levels and compromise future production which will result in poverty in the long term. Heal (2004), submits that inorganic fertilizer usage in agriculture contributes to biodiversity losses, however available literature on the quantitative estimates is scanty. Organic fertilizers on the other hand promote the living of the soil by providing conditions that are suitable for diverse living organisms to coexist in the soil environment (Heal, 2004).

Savci (2012) stated that chemical fertilizers are agricultural pollutants and that they can pose health problems such as cancer. These issues raise concern of urgently finding alternatives such as organic fertilizer. However, Barnard and Nix (1979) posit that farmers will replace an existing input only when the new input will yield an incremental positive net return or that the new costs (both direct and transaction costs) per unit associated with that input is much lower than the associated benefits. Delgado (1998) also indicated that if transaction costs associated with an input are perceived to be high, farmers may be discouraged from using that input resource, hence farmers are likely to choose one input over another when the cost implications as well as the benefits are more favourable compared to the alternative being discarded.

According to Doss (2006) there many different definitions of whom an adopter is, or who should be considered an adopter of a given technology. The definition differs based of context. This study will among other things set a clear working definition of who an adopter is. Also the literature on economics of vegetable production is silent on the cost-benefit analysis of organic and inorganic fertilizer use in Ghana. To contribute to the raging debate on which fertilizer type should be used by vegetable producers in urban areas such as Accra, this study attempts to contribute to finding the answer by addressing the following questions:

- What are the sources of organic fertilizer supply?

- What is the rate of organic fertilizer adoption in vegetable production in Accra?
- What factors influence the adoption of organic fertilizers in vegetable production in Accra?
- What transaction costs are associated with organic fertilizers usage among vegetable producers in Accra?
- What is the net gain from the use of organic fertilizers instead of inorganic fertilizers in vegetable production in Accra?
- What are the constraints associated with organic fertilizers used by vegetable farmers?

1.3 Objectives of the Study

The primary objective of the study is to assess the factors that influence the adoption of organic fertilizers in vegetable production.

The specific objectives are:

1. To identify sources of organic fertilizers supply in Accra
2. To determine the rate of organic fertilizer adoption in vegetable production
3. To determine factors that influence organic fertilizer adoption in vegetable production in Accra.
4. To estimate the transaction costs associated with organic fertilizers usage in vegetable production in Accra.
5. To estimate net gain of using organic fertilizers in vegetable production in Accra.
6. To identify and rank the constraints associated with organic fertilizers used by vegetable farmers.

1.4 Relevance of the Study

The study is relevant because the contribution of urban and peri-urban vegetable production to the socio-economic development of the Accra Metropolis cannot be over-emphasized. The study will provide evidence to confirm or deny existing arguments about the two types of fertilizers.

The study is necessary because it will identify the sources of organic fertilizers in vegetable production in Accra, to see if the sources present any cost implications to the farmers. This research is a very useful undertaking because it will among other things, determine the current rate of adoption of organic fertilizers among vegetable producers within the confines of the study area. The study has become relevant also due to the fact that it aims at determining the factors that influence the adoption of organic fertilizers in vegetable production in Accra.

The issue of estimating the transaction costs associated with the use of organic fertilizers will be addressed. This is relevant because the adoption of any technology also has cost implications for the adopter. The net gain, quantifiable in monetary terms will be estimated because of the assumption that technologies with positive net gains of adoption will attract more adopters in the long run, hence it is relevant for the study to estimate the net gain.

Finally, the study is justified because the constraints associated with use of organic fertilizers will be identified and ranked accordingly.

1.5 Organization of the Study

The study is organized into five chapters. Following Chapter one, Chapter two reviews related literature. Chapter three outlines the methodology employed to accomplish the objectives of the study. The results and discussions of the study are presented in Chapter Four. Finally, the summary, conclusions and recommendations are presented in Chapter Five. The references and appendices are also provided after Chapter Five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This Chapter presents the review of literature related to the study. The relevant themes that will put this study into the right perspective are addressed. Themes such as: urban Vegetable production, organic fertilizer use, nutrients in organic fertilizers in Ghana and their functions and fertilizer policy in Ghana.

This Chapter also deals with issues such as: sources of organic fertilizers, adoption of organic fertilizer, factors influencing the adoption of organic fertilizer technology, transaction costs in agriculture, net gains, and the constraints associated with organic fertilizers as well as a summary of the literature review.

2.2 Urban Vegetable Production

Urban agriculture is the type of agriculture that is commonly practised in the cities, urban areas as well as the peri-urban areas (Obuobie *et al,* 2006). Accra is the most urbanised city in Ghana, it is also known as the Accra Metropolis. It provides employment and income and food for farmers and households (Maxwell and Amar-Klemesu, 2000). There are two major types of urban agriculture in Accra. Backyard gardening takes place in and around homes, estimated to be about 50-70 hectares distributed over 80,000 backyards (IWMI-Ghana, 2003). Open space farming in Accra is estimated to take place on about 978 hectares for vegetables, and mixed cereal-vegetable systems. There were 1,000 vegetable farmers in Accra as at the year 2006 who produce cabbages, lettuce, spring onions, cucumber, green pepper, and cauliflower, or the more traditional vegetables such as tomatoes, okra, eggplant (aubergines) and hot pepper. Plot sizes range between 0.01-0.02 hectare per farmer and reach 20 hectares in the peri-urban areas (Obuobie *et al*, 2006). Like other parts of Ghana, the main farming system is the traditional system which is characterized by the use of the hoe and cutlass at the small scale level. Mixed cropping is also very common among farmers with mono-cropping being amongst the larger scale farmers (Maxwell and Amar-Klemesu, 2000).

According to Maxwell and Amar-Klemesu (2000) there are seven urban agricultural systems practiced in Accra. These are: *Seasonal crop farming* which is rain fed and seasonal agriculture, that relies on informal land access and the produce are mostly for home consumption. *Customary land rights systems* This is also rain fed agriculture with some dry-season irrigation, on La Stool land between Labadi and Teshie, mostly by La residents for both commercial and subsistence purposes. "Stool lands" are owned by the local communities and are entrusted to the chiefs. *Vegetable growing systems*, these are irrigated, mostly market-oriented production of vegetables, relying mostly on informal land access, usually along main drains and streams in Accra. *Small ruminants and poultry production*, this involves the rearing of small livestock in densely populated areas, sometimes with a market orientation, but more frequently as an investment or asset strategy. *Backyard gardening*, this is small-scale gardening on one’s own land or rented compound, usually for home consumption. *Commercial livestock*, usually poultry, with a few examples of monogastrics, raised on medium to large scale for sale to urban market. *Miscellaneous*, usually we have export crop production as well as micro-livestock or snail farming or bee-keeping and even large ruminants, etc.” Both exotic and local varieties of vegetables are cultivated in the city (Obuobie *et al*., 2006). These include: Cabbages, Carrots, Cauliflower, Lettuces, and Tomatoes etc.

2.3 Organic Fertilizer Use

Fertilizers are inorganic or organic plant food which may be liquid or solid used to amend the soil in order to improve the quality and/or quantity of crops produced. They are materials that are added to the soil to supply elements needed for plant growth (Sinnadurai, 1992). They raise soil fertility thus the ability of the soil to provide plant nutrients and resources that support growth, by increasing plant nutrients during the cycle of growth and decay. They have the ability to also reduce the cost of production since they can raise yield with marginal increases in total cost per hectare (Cooke, 1972).

There are two broad groups of fertilizers: 1) organic fertilizers, and 2) inorganic fertilizers. Inorganic fertilizers are from inorganic sources whiles organic fertilizers are mainly from natural organic sources or manufactured using mainly organic materials (Alimi *et al*, 2006). The term “organic” means carbonaceous material or material containing carbon. Organic fertilizers can improve the soil by lowering bulk density, and they can reduce soil erosion and improve soil fertility.

Organic matter encourages formation of crumb soil structure thus improving soil drainage, infiltration and aeration. The dark colours that form with increasing organic matter content improve soil temperature relations with an effect of boosting important microbial activities and root development. These fertilizers also care for the ‘living soil’, which entails maintaining microbiological life in the soil in balance with the whole ecosystem without altering soil pH (Cooke, 1972).

Organic fertilizers include manure and compost. Manure is mainly from farm animals and other livestock. They are the droppings of poultry, ruminants and other animals that are rich in nutrients (Bary *et al.*, 2004). For farmyard manure, its quality is dependent upon the quality of feed given to the animals. The droppings from herbivores are preferred as manure because of the richness of the nutrients they contain (Bary *et al.*, 2004). Poultry manure may contain the wood shavings and other material which invites microbes. These microbes are essential for the process of decomposition to release nutrients. Bat guano is also a good source of nutrients and can be used for vegetable cultivation. Guano from marine sources is also used to fertilize crops. Manure can be obtained from livestock keepers and poultry farmers, even from dumpsites. Vegetable farmers who also keep animals can use the manure from their own animals to fertilize the soil (Bary *et al.*, 2004).

Some kind of nutrient cycle exists in an instance where a farmer uses droppings from his animals to grow crops to feed those same animals. Some animal farmers sell their manure to crop farmers, others give the manure out for free as a means of disposal. There are instances where middlemen go to collect the manure and sell to crop farmers (Waithaka *et al*., 2006).

Compost is the end product of the composting process. Organic materials are decomposed in composting plants under controlled conditions to produce the end product which is used as a fertilizer. Compost can also dissolved into a solution, called compost tea and given to crops. The quality of the compost will depend on the quality of materials used in the process. Compost can be obtained from the market or self produced by farmers. There are available manuals that farmers can use to make their own compost. Composts are quite common and easy to obtain (Bary *et al.*, 2004).

According to Bary *et al.* (2004), organic fertilizers come with an uncertainty about the nutrients contained and also the right amount to apply, so increasing usage improves the nutrient pool available to plants. Compost has the following advantages and disadvantages; slow release form of nutrients and usually higher nutrient than uncomposted manure. compost is easier to spread**,** with a lower potential to degrade water quality, less likely to contain weed seeds but require higher investment of time and money, compost has reduced pathogen levels (such as; salmonella and *E. coli*) but more expensive to purchase , compost has fewer odours than uncomposted manure.

According to Bary *et al.* (2004), uncomposted manure is sometimes difficult to spread and has a higher potential to degrade water quality than compost. Manure is more likely to contain weed seeds but requires a lower investment of time and money, manure has the potential for higher pathogen levels but are less expensive to purchase or acquire compared to compost**,** odours sometimes pose a problem. Both compost and uncomposted manure improve the tilth of the soil.

Comparatively, an equal amount of organic fertilizer will have less concentrated nutrients than inorganic fertilizer but the organic fertilizer will have a greater number of nutrients (Waithaka *et al*., 2006). Both organic and inorganic fertilizers will mineralize before plants can absorb, however inorganic fertilizers are mineral already so plants can absorb faster than organic ones (Bary *et al.*, 2004). Organic fertilizers are relatively cheaper by weight than inorganic ones (Bary *et al.*, 2004). A fifty Kilogramme bag of organic fertilizer will be cheaper than the quantity of inorganic fertilizer but more organic fertilizer will be required per hectare to bring about the same effect as the fifty kilogramme bag of inorganic fertilizer will have (Bary *et al.*, 2004).

Manure provides the most benefits to soils with nutrient deficiency and even to those with adequate levels of nutrients (Bary *et al.*, 2004). Soils with high or excessive levels of nutrients are not a good choice for manure use, because the nutrients contained in manure are less likely to be of benefit to crops but are more likely to leach into underground water or contaminate surface water as surface run-off.

2.4 Nutrients in Organic Fertilizers in Ghana and their Functions

The nutrients in organic fertilizers can be grouped into two groups as suggested by (Bary *et al.*, 2004). These are: micronutrients and macronutrients. These nutrients promote growth.

Macronutrients

Nitrogen (N) encourages leaf and shoots growth. It is a component of chlorophyll, and gives plants their greenness. If there is too little nitrogen, plants become stunted and pale. If plants are overdosed with nitrogen, they will grow too fast and become soft and sappy – an invitation to pests. Phosphorus (P) or phosphate encourages healthy growth in every part of the plant including the roots. Only small quantities are needed. A deficiency in phosphate shows as stunted growth. Potassium (K) or potash is associated with the size and quality of fruit and flowers. It toughens up plants and protects them from pests and diseases and its deficiency shows as small flowers and fruits and yellowing or browning of the leaves. Magnesium (Mg) is another greening agent. A deficiency shows as chlorosis, which is a yellowing of the leaves starting between the veins. It is easily remedied by adding organic matter to the soil. Calcium (Ca) helps to manufacture protein. Sulphur (S) is part of plant protein and also helps to form chlorophyll. Lack of sulphur is unusual where the soil is rich in organic matter (Jokella *et al.*, 2004).

Micronutrients

Micronutrients are mostly needed in minute quantities. Manganese (Mn) helps make chlorophyll and protein. A deficiency in Mn shows as stunting and yellowing of new leaves. Iron **(**Fe) has similar roles to that played by magnesium. Only the tiniest quantities of iron are needed. Iron deficiencies are most likely happen on chalky soils. Symptoms of lack of iron are pale leaves with brown edges on the margins. Copper (Cu) and zinc (Zn) are needed to activate enzymes. Boron (B) is an important element for growing plant tissues. A lack of Boron could cause 'corkiness' in fruit and vegetables Molybdenum (Mb) helps to produce protein. Oxygen, carbon and hydrogen are taken up from sunlight, air and water (Jokella *et al.*, 2004).

A Model Depicting the Effect of Fertilizers on Crop Growth and Yield

Fertilizers supply crops with growth factors (Tisdale and Nelson, 1970). These growth factors are in the form of nutrient elements and other growth resources which together promote plant growth (Tisdale and Nelson, 1970). According to Tisdale and Nelson (1970) growth of plants is a function of growth factors such as nutrients from the soil as well as nutrients through augmentation with fertilizers e.g. Nitrogen, Phosphorus, and Potassium. Growth can be measured in metres. The effect of fertilizers on crop growth can be expressed mathematically through the Mitschelichs equation, given as: $dy/dx = (A-y)\,C$

where dy is yield resulting from an increment of growth factor dx; dx is an increment of growth factor X like nitrogen and phosphorus, A is the maximum possible yield obtained by supplying all growth factors in optimum amounts, y is the yield obtained after any given quantity of the factor X has been applied and C is a proportionality constant which depends on the nature of a growth factor (Tisdale and Nelson, 1970).

2.5 Fertilizer Policy in Ghana

There is a fertilizer subsidy policy instituted by the Government of Ghana after the Abuja declaration and in line with the Food and Agriculture Sector Development Policy (FASDEP I). The fertilizer subsidy policy was also instituted as a response to food security issues (Yawson *et al.*, 2010). The policy supports a nationwide programme that covered four types of inorganic fertilizers when it began in the middle of 2008 (Yawson *et al.*, 2010). This was aimed at increasing fertilizer use and eventually also increase the production of staple crops such as roots and tubers, grains and cereals, legumes and even tree crops such as Cocoa. The policy ensures that the prices of those fertilizers remain uniform throughout the country. This the Government hoped would eventually help in reducing poverty, hunger and malnutrition which is consistent with the millennium development goals (MDGs), (Yawson *et al.*, 2010). The four types of inorganic fertilizers covered under the programme are: Urea, Sulphate of ammonia, NPK 15:15:15 and NPK 23:10:15. In 2008 about 600,000 bags of inorganic fertilizer (i.e. 50Kg bags) was subsidized at a cost of 14,067,964 United States dollars and in 2007 37 million Ghana Cedis was allocated for the programme (Yawson *et al.*, 2010). Farmers bought these subsidized fertilizers with coupons from the Ministry of Food and Agriculture (MoFA) through their extension officers. Table 2.1 illustrates the level of the subsidy in 2008.

Table 2.1: Fertilizer Subsidy Elements on 50 kg bag of fertilizer in 2008 (Exchange rate: 1 US Dollar to GHS1.4)

Fertilizers	Market Price (GHS)	Subsidized Price (GHS)	Percent Subsidized (%)
Sulfate of Ammonia	31	18	41.9
Urea	49	26	46.9
NPK 15:15:15	48	26	45.8
NPK 23:10:15	45	24	46.7

Source: Yawson *et al.*, (2010)

The Government subsidized the fertilizers to the tune of about 45% on the average. It means that farmers were relieved of almost half the cost they incurred on the four types of fertilizers.

2.6 Sources of Organic Fertilizers

Commercial organic fertilizers are organic fertilizers that are market oriented (Alimi *et al*, 2006). Those available on the market include: Bone meal, blood/ fish/ bone, blood meal, dried manures, Epsom salts, fish meal, hoof and horn, rock phosphate, seaweed meal and wood ash (Bary *et al.*, 2004). Bone meal is quite rich in phosphate to promote root growth. It is usually good to sprinkle a little in the planting hole. Blood, fish and bone for instance, is a balanced all round fertilizer. Blood meal unlike dried manure is very high in nitrogen. It can be used as a quick tonic for tired plants in the dry season.

Dried manures have all the trace elements but quite are low on NPK so more of it is needed to provide adequate amounts for crops. Epsom salts are a soluble form of magnesium. Fish meal contains nitrogen and phosphate. Hoof and horn are rich in nitrogen. It works on slow release and must be applied a week before planting. Rock phosphate promotes rooting and is a good alternative to bone meal (Bary *et al.*,2004 and Jokella *et al.*, 2004).

Rock potassium is quite useful as a source of pure potash. It works as a slow release and is a good fertilizer for vegetables. Seaweed meal is also quite excellent, it is a slow releaser of nutrients, and an all round fertilizer. It contains cytokinins and hormones that promote photosynthesis and protein synthesis. Ash from wood is high in potassium and some phosphate – the quantities depend on the type of wood however (Bary *et al.*,2004 and Jokella *et al.*, 2004).

Aside organic fertilizers obtained from market overt, some farmers undertake their own composting for self usage and any excesses sold for cash or given to other farmers (Odhiambo and Magandini, 2008). A recent phenomenon in the Greater Accra Region is the establishment of a number of composting plants to produce organic composts for farmers' use. Most of these composting plants get raw materials from organic waste produced by the populace. Zoomlion Ghana Limited a waste management company in Ghana has established a high capacity plant at Medie in the Ga West Municipality to process waste materials into organic fertilizers. Alimi *et al.*, (2006) identified two major sources for obtaining organic fertilizers: those that go through the market exchange system i.e. commercial organic fertilizers and those that do not go through the market exchange system. Odhiambo and Magandini (2008) posits that manure for instance is obtained mainly from neighbouring farms or from farmers' own livestock thus for farmers who engaged in mixed farming.

2.7 Adoption of Organic Fertilizers

Enos and Park (1988) cited in Bonabana-Wabbi (2002) define technology as the knowledge or information that permits some tasks to be accomplished more easily, some service to be rendered or the manufacture of a product. Technology, therefore, is aimed at improving a given situation or changing the status quo to a more desirable level. It assists the applicant to do work easier than he would have in the absence of the technology. According to Bonabana-Wabbi (2002) technology helps save time and labour.

Bonabana-Wabbi (2002) defines adoption of a technology as the decision to accept that technology i.e. the decision of an end-user to accept an introduced or existing technology. Adoption of an agricultural technology according to Bonabana-

Wabbi (2002) has two dimensions, thus: adoption intensity and the rate of adoption. Adoption intensity deals with the level of adoption whiles the rate of adoption deals with the number of adopters over a given time period. The rate of adoption is the relative speed with which farmers adopt a technology. The technology could be an entirely new idea or an already existing one (Bonabana-Wabbi, 2002).

Adoption of a technology begins with awareness, and then goes through interest, evaluation, acceptance, trial and then finally adoption (Rogers, 1983). According to Nchinda *et al.* (2010) adoption of a technology is the continued use of the technology and the decision can be a dichotomous choice or polythomous. Again they posit that a farmer will adopt a technology when the marginal benefits from adopting are positive. According to Nkonya *et al.* (1997) both adoption and adoption intensity decisions are made at the same time by farmers in Northern Tanzania.

According to Philip *et al.* (2000), the first step towards determining the impact of a technology on a given group of farmers is to obtain some knowledge about the rate of diffusion or adoption of the technology and the factors that influence that. The rate of adoption or diffusion will provide feedback as to how the technology was received by the target group (Idisi, 1990 cited in Maiangwa *et al.*, 2007).

Maiangwa *et al.* (2007) posit that the rate of adoption could be estimated using the ratio of adopters of the technology in question to the total number of farmers in the sample, and multiplied by 100 this is also the approach used by Bonabana-Wabbi (2002). Philip *et al.*, (2000) cited in Maiangwa *et al.* (2007) posits that the adoption of a technology follows a logistic trend or curve and the rate of adoption could be ascertained along the curve over time. Another measure of adoption according to Akino and Hayami (1975), as far as crops are concerned is the rate of adoption which can be calculated by expressing land area under which the crop is cultivated with the application of that technology, as a ratio of the total land area under which the crop in question is cultivated and multiplying by 100.

Another means of calculating the rate of adoption of a technology found in literature is the one proposed by Herdt and Capule (1983) which can be used when a number of technologies are introduced. In this case it is done by expressing the number of technologies adopted by farmers to the total number introduced and multiplying by 100. An arbitrary scale could then be used to classify the value estimated as low, medium or high (Ramaswamy, 1975 cited in Maiangwa, 2007). For the purpose of this study, the rate will be calculated by expressing the number of adopters over the total number of respondents. This approach is simple and easy to explain.

2.8 Factors Influencing the Adoption of Organic Fertilizer Technology

Boateng (2000) observed that Ghanaian farmers choose inputs based on factors such as availability, accessibility, market price, income level of farmers, previous experience of farmers with a particular type of fertilizer as well as economic factors such as labour, capital and land. Also some factors run across farmers in different areas whiles others may change from place to place depending on prevailing conditions (Bonabana-Wabbi, 2002). There are a number of factors that determine whether a farmer would adopt a given technology or not. Bonabana-Wabbi (2002) posits that these factors include Government policies towards a technology, technological change, market forces, environmental factors such as nature of the soil and soil fertility, demographic factors such as age and education, institutional factors such as access to information and the mechanisms for delivering the technology.

However for a given technology, not all the factors may apply thus a regression analysis is a way of knowing which ones would apply in a particular scenario. These include: Market factors including availability of labour, resource requirements of the technology, size of the farm, expected benefits and the effort required to apply the technology. Social factors such as age of the farmer, social standing of the farmer, size of the farmer's household, educational level of the farmer, farming experience and the gender of the farmer, membership to farmer based organizations. Management factors like Access to credit and Institutional/ technology delivery mechanism such as the access to information and extension contacts and prior experience with using the technology, environmental health concerns (Bonabana-Wabbi, 2002).

Kebede *et al.* (1990) broadly categorized the factors that influence adoption of technologies into Social, Economic and physical categories. Makokha *et al.* (2001) listed factors such as extension contacts, membership in an organization, household size, hired labour for manure application, off farm income among others as being the significant factors influencing the use of inorganic fertilizer technology and manure in maize production in Kiambu district, Kenya. Waithaka *et al.*, (2006) gave factors such as farmer characteristics, farm characteristics among others as factors that determine the adoption of fertilizer and manure by smallholder farmers in the Vihiga district of Kenya using a pair of Tobit models. They defined adoption of the two technologies in terms their continued use in production over more than a season. Bonabana-Wabbi defines adoption in terms of acceptance of the technology by the target group and ascertained the factors that influence the adoption of integrated pest management in cowpea, sorghum and groundnut cultivation in the Kumi district of Uganda by using the Probit, Logit and Tobit regression models. She found that Low levels of adoption were associated with five of the technologies and also that three technologies had high levels of adoption. She also indicated that farmers' participation in on-farm trial demonstrations, accessing agricultural knowledge through researchers and farmers' prior participation in pest management training were all associated with increased adoption of most Integrated Pest Management practices.

Makhoka *et al.* (2001) identified the determinants of fertilizer and manure use for maize production in Kiambu District, Kenya by using the Logistic regression model. They defined adoption in terms of the use of the technology and found that extension and off-farm incomes were significant factors influencing the adoption of manure. The age of household head, extension, membership in an organization, and off-farm income significantly influenced the use of inorganic fertilizer. The use of both inorganic fertilizer and manure was significantly influenced by extension, membership in an organization, household size, hired labour for manure application, livestock ownership, and off-farm income.

Bonabana-Wabbi (2002) gave farm size as the most important factor affecting the adoption of agricultural technologies. This was because farm size affects other factors of adoption and is subsequently affected by other factors. Farm size affects costs of adoption, risk perceptions in production, labour costs, credit requirements, labour requirements, and land tenure arrangements among others (Bonabana-Wabbi 2002). With small farms, it has been suggested that higher fixed costs become a limitation to technology adoption (Abara and Singh, 1993 cited in Bonabana-Wabbi, 2002).

According to Ajewole (2010), factors such as number of years of formal education, size of farmer's household, and the frequency of extension visits during previous cultivation season positively influence the adoption decision of organic fertilizers. According to Rogers (1983) in general, socio-economic characteristics of households strongly influence adoption of a technology. Ajewole (2010) adds further that access to a technology is key to adoption decisions about that technology. Aikins *et al.*, (1975), posit that the economic constraints affect the distribution of resource inputs such as technologies which further affects the decision to adopt the use of such input resources. Ajewole's (2010) study was mainly about farmers' response to adoption of commercially available organic fertilizers in Oyo state, Nigeria. The study employed the use of the Tobit model to look at use intensity of the commercially available organic fertilizers and also relative use of this type of fertilizers amongst the farmers in Oyo states, Federal republic of Nigeria. Ajewole found that, the number of years spent in acquiring formal education, household size, and number of extension visit received during last cropping season positively influenced adoption decisions, on the other hand farming experience, farm size, and distance from source of supply of commercial organic fertilizer negatively influenced adoption decisions.

Hooks *et al.* (1983) argue that the perceptions of an end user for which a technology is meant also defines or determines whether or not they will adopt that technology. Ajewole (2010) states that, when it comes to adoption studies, inconsistencies exist with regards to the socio-economic factors that affect adoption decisions and also on the nature of the effect. Odhiambo and Magandini (2008) added that before fertilizers can be accessed, they must be available and affordable so availability and affordability of a technology are major factors that should be considered in an adoption studies.

It is very important that for an adoption study like this, the socio-economic characteristics of the respondents are considered as influencing variables. Also management and institutional factors should be included in the study as well as any other factors observed from or within the study area that could have a bearing on the adoption decision of the respondents, either directly or indirectly.

2.8.1 Empirical Evidence of the use of the Multinomial Logit Model in Choice Studies

Curtis *et al*. (2003) studied westernization in China using processed potatoes as a case study. With the use of the multinomial logit model, they found that factors such higher incomes and positive opinions about western food tastes influenced the consumption of French fries, mashed potatoes and potato chips positively. Additionally, the multinomial logit revealed that factors such as young age and gender also influenced the Chinese consumer's choice of French fries and potato chips.

Gagnon *et al*. (2009) researched the idea of whether migrant workers were worse off in the urban labour markets in China. They used the multinomial logit model to investigate whether migrant workers were discriminated against in terms their earnings and the sectors in which they are allowed to work. They first estimated a multinomial logit model to determine the factors determining the choice of employment sector by the migrants and then applied the results to a decomposition analysis to test for the existence of wage discrimination. The factors used in the study were age, education, gender and marital status. The three categories of workers used were the urban dwellers, rural migrants and urban migrants. The sectors were formal employment, self employment and no contract. They used formal employment as the base or pivot and found that the urban labour market treats urban residents and rural migrants with identical individual characteristics differently, at least with respect to their choice of sector.

Ashford and Bencheman (1987) used the multinomial logit to study the choice of airports by air travellers in Central England and found that factors such as access time and flight frequency are significant factors for all types of passengers, while fare is significant for all passengers except international business travellers. Harvey 1987 also studied the choice of airports by passengers in San Francisco by using a multinomial logit model and found factors such as grounds access time and frequency of direct service to chosen destination to be the most significant factors.

Thompson and Caves (1993) employed a multinomial logit analysis in their passenger choice study in the Northern part of England and found that, access time, flight frequency and the number of seats on the aircraft (reflecting size/ comfort) are found to be significant, with access time being most important for travellers living close to the airport and frequency being more important for travellers living further away from the airfields. In the study by Windle and Dresner in (1995) the multinomial logit was used to model the choice of airports by travellers in the state of Washington, and identified Airport access time and flight frequencies are the dominant factors influencing the choices made by the passengers.

Kassie *et al*. (2009) investigated the factors influencing the adoption of organic farming techniques in the semi-arid areas of Ethiopia by using the multinomial logistic regression approach. They found out that poverty and access to information, among other factors, significantly influenced the choice of farming practices by farmers. Again they found evidence to show that the impact of gender on technology adoption is specific to the technology in question, whiles the significance of the plot characteristics indicated that the decision to adopt particular technologies is also specific the farmers' location.

2.9 Transaction Costs in Agriculture

The transaction cost approach to the theory of the firm was created by Ronald Coase in 1937. Transaction cost also refers to the cost of providing for some good or service through market exchange rather than having it provided from within the firm. Coase (1960) argues that without accounting for transaction costs, it will be impossible to understand the working of an economic arrangement and have a plausible basis for drawing appropriate economic policies.

Yawson *et al.* (2010) posits that a major constraint of the current fertilizer subsidy policy in Ghana is the high transaction costs. According to Coase (1960), a transaction cost is a cost incurred when an economic exchange is affected between a buyer and a seller. A number of transaction costs exist. Search and information costs for instance are costs such as those incurred in determining that the required organic fertilizer is available on a given market at a given point in time, at the price that the farmer can afford. Then bargaining costs will be incurred for the farmer in this case the buyer to come to a desirable agreement with the other party who is the seller for the transaction to be completed (Williamson, 1985). Policing and enforcing the agreement also brings a new cost dimension. These are the costs of ensuring that both parties stick to the terms agreed on to facilitate the exchange. It enables one to take legal action when the agreement is breached (Williamson, 1985).

According to Jagwe (2011), search and information costs involves the gathering of information about sellers of inputs, offered prices, mode for delivering the good, terms of payment and the repeatability of the transaction. Bargaining costs involves building consensus over prices through haggling, quantity of the good, quality, terms of payment and means of delivery. Policing and enforcement costs involve ensuring that essentially, the product delivered is the product agreed upon. Again Jagwe (2011) posits that every step of a transaction involves a transaction cost which serves as a wedge between the selling price and buying price. According to Williamson (1981), a transaction cost occurs "when a good or a service is transferred across a technologically separable interface. Therefore, transaction costs arise every time a product or service is being transferred from one stage to another, where new sets of technological capabilities are needed to make the product or service".

Coase (1960) asserts that the total cost incurred by a farmer can be grouped mainly into two parts: transaction and production costs. Transaction costs could be viewed as coordination costs. Transaction cost theory in a way also suggests that the costs associated with market transactions sometimes favour hierarchies. A smallholder farmer could face potentially higher transaction costs than a large scale farmer based on the ability to bargain.

Based on the following results and arguments, it suffices to argue that different sources of organic fertilizers will face different transaction costs. According to Jagwe (2011) transaction costs may have a fixed element and a variable or scale dependent element. Jagwe (2011) adds further that transaction costs differ from farmer to farmer based on reasons such as the remoteness of a farmer from the point where the exchange takes place.

According to Jagwe (2011), factors such as household size, distance to markets and ownership of a means of transportation are directly proportional to transaction costs. Transaction costs are often described as hidden due to a clear cut definition and means of measurement (Jagwe, 2011). Many forms of transactions may not take place due to high transaction costs (Key *et al.*, 2000, Jagwe, 2011).

Transaction costs may be viewed as opportunity costs and whether they are observable or not they are associated with the exchange of goods and or services at any point in time (Coase, 1960). According to Coase (1960) and Delgado (1999) transaction costs could serve as barriers to smallholder farmers to participate in input and product markets. Transaction costs also include the costs associated with reorganizing production inputs and resources to produce surpluses that can be marketed (Jagwe, 2011).

Transaction costs can be incorporated into an agricultural household model in which a choice variable (for example, the decision to adopt organic fertilizers in vegetable production) can be specified to ascertain its effect on the consumption of resources and the production of goods (Jagwe, 2011). Jagwe (2011) posits that transaction costs could be measured directly or as an opportunity cost of the time spent on a particular transaction. Jagwe (2011) incorporated both fixed and proportional transaction costs in a non-separable household model which maximizes utility subject to some resource constraint.

Delgado (1999), Coase (1960) and Williamson (1981) posit that transaction costs are measured by tangibles, thus direct means or intangibles, thus indirectly quantifying the components of the transaction through the opportunity cost of time spent on each component activity of that transaction.

2.10 Net Gain

Farmers use organic fertilizer technology in vegetable production to increase the yield of their crops. Higher yields in crops mean a greater crop output, eventually culminating in increased income levels of farmers, especially in commercial vegetable production (Alimi, 2005). In the case of subsistence farmers, higher yields means higher surpluses after domestic household consumption is satisfied and farmers sell for money therefore generating income for farmers (Alimi *et al.*, 2006).

Organic fertilizer technology is therefore, profitable when used in vegetable crop production systems (Alimi *et al.*, 2006). In integrated livestock and vegetable production systems, the use of organic fertilizers help to reduce cost of production and farmers can also sell these organic fertilizers to make additional income (Bary *et al.*, 2004). The technology helps to make the farm enterprise more profitable for farmers (Alimi *et al.*, 2006). According to Asomaning-Boateng (2002) majority of vegetable cultivators in the city of Accra do so mainly for financial and economic benefits that accrue from such undertakings. The inputs used are aimed at maximizing the benefits. There is therefore an overt economic justification for using such inputs as organic fertilizers.

The net returns associated with the adoption of a particular technology could be obtained by subtracting all the costs that are specific to the technology from the benefits that are derived from adoption of the technology (CIMMYT, 1988). This could be used to ascertain the financial justification for choosing that technology among other alternatives. This could also be looked at from the economic assumption of rationality, that a farmer or consumer would want to maximize returns on an investment by choosing alternative inputs that give the highest positive returns (Koutsoyiannis, 2005).

2.11 Constraints Associated with organic fertilizers

In their work, Alimi *et al*. (2006) identified constraints such as: bulkiness, offensive odour, slow acting, difficulty to transport and doubtful efficacy to be associated with the use of organic fertilizer in crop production.

2.12 Summary of Literature Review

The work by Yawson *et al*. (2010), did not address alternatives types of fertilizers that could be introduced to the subsidy programme. Their work did not explore the possibility of viable and cheaper substitutes to the four types of fertilizers used, particularly the organic fertilizers. The study by Yawson *et al.* (2010), did not establish the economic impact if any, of the policy in quantitative terms. This study will establish the financial impact of organic fertilizers use, even without subsidy.

Even though Alimi *et al*. (2006), were able to establish an economic rationale for commercial organic fertilizers use, their work was mainly based on comparisons drawn between users of commercial organic fertilizers and non users of fertilizers alone, no consideration was made of the users of inorganic fertilizers which this study seeks to address. Also this study will go further to find out the proportion of adopters of organic fertilizers and also assess the significant factors that inform farmers' decision to adopt organic fertilizer technology. This study will add to existing literature on organic fertilizer adoption, particularly literature pertaining to Ghanaian farmers.

Boateng (2000) outlined some factors that influence farmers' choice of fertilizers he however did not go further to establish the exact nature of the relationship between the factors and the farmers' choice which this study seeks to do. Bonabana-Wabbi (2002) tested the effect of the determining factors on a number of technologies but this study will concentrate on organic fertilizers only. This study favours the Multinomial Logit model instead of the Probit model because the famers have in this instance is expected to be polythomous, also the multinomial logit assumes that the addition of an alternative choice to the two choices will not affect any of the two choices because they are independent irrelevant alternatives. This study is quite different from the study of Bonabana-Wabbi (2010) because Accra, Ghana is the study area not Uganda and it is expected that different observations could be made due to the different setting and different acculturation of the respondents.

Kebede, Gunjal and Coffin (1990), also sought to identify factors influencing of adoption of new technologies by farmers in Tegulet-Bulga District, Shoa Province of Ethiopia. This study was undertaken in a different era and setting, it is expected that 23 years down the line a lot of new developments would have taken place and farmer's attitudes and perceptions towards technology adoption may have changed hence this current study. Thus far all the literature on factors influencing adoption reviewed in this section on studies outside the chosen study area and also had different specific objectives emphasizing the need for this research.

With regards to the sources of organic fertilizers, the expectation is that different farmers may choose different sources which this study will identify. All the literature reviewed concerning transaction costs were done in different study areas. This study will be in Accra and the transaction costs are expected to differ.

Asomaning-Boateng (2002) did not estimate the net benefits for using inputs for vegetable production even though the work established an economic basis for vegetable cultivation in the city of Accra. His study was undertaken more than a decade ago, and it is expected that farmers' demographics and perceptions may have changed. Alimi *et al.* (2006) estimated the net returns for using commercial organic fertilizers use as compared to not using fertilizers only and not for organic fertilizers in general. Their work was skewed towards organic fertilizers that go through the market exchange system. Their work did not take into account the fact that some farmers may produce and use their own organic fertilizers and also did not rank constraints as this study seeks to do.

Ajewole (2010) focused on only farmer's response to organic fertilizer adoption in Oyo State, Federal Republic of Nigeria. In both studies by Alimi *et al.* (2006) and Ajewole (2010), the areas of study were outside Ghana. Even though Alimi *et al.* (2006) estimated mean net returns from using commercial organic fertilizers, the basis of comparison was the mean net returns from not using any fertilizers at all. This is a limitation of that study because, given the already established fact that fertilizers have the potential to increase yield, which could translate into higher net returns, ceteris paribus.

Alimi *et al.* (2006) also used the partial budgeting approach but did not include any transaction costs in the analysis.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The discussions in this Chapter borders on the conceptual framework for the study, the methods employed to achieve the objectives of this study. It involves all the tools for the synthesis of facts and ideas as well as those for the analyses of data to generate meaningful information. This chapter also addresses the pertinent themes in a way and manner as to put the relevant concepts to be tested in perspective. The themes addressed include the method of analyses for rate of adoption of organic fertilizers, identifying the sources of organic fertilizers, estimating the transaction costs equivalences among available organic fertilizers, determining the factors that influence the adoption of organic fertilizers as well as the estimation of net benefits for using organic fertilizers.

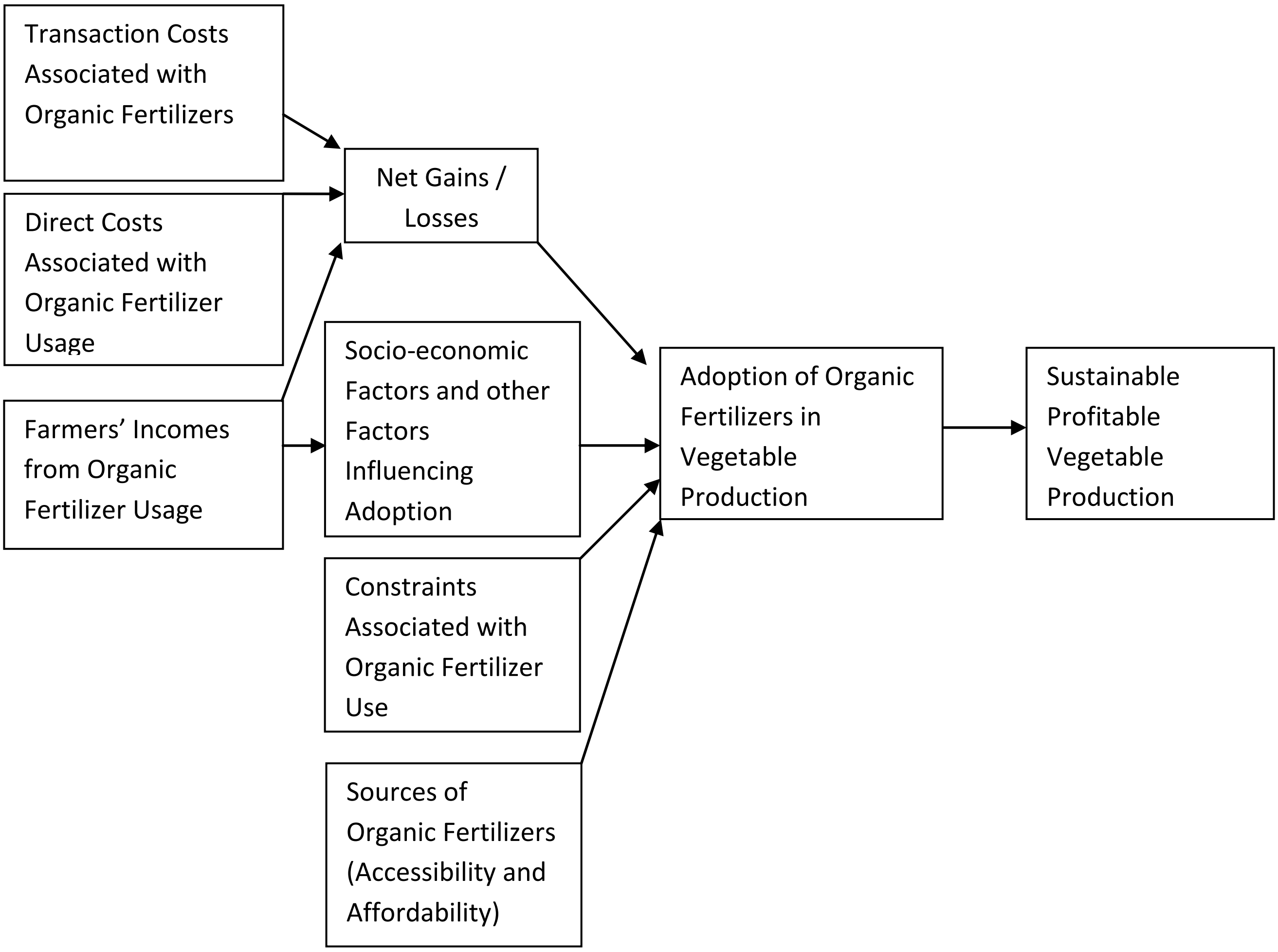
3.2 Conceptual Framework of the Study

Organic fertilizer use contributes to the enhancement of soil physical properties such as bulk density as well as water holding capacity (Alimi *et al*., 2006). Organic fertilizers contribute to soil organic matter which serves as a cementing agent in bringing together soil particles. The application of organic fertilizers eventually leads to sustainable production of crops. Organic fertilizer application brings about increased crop yields and contributes to farmers' incomes (Alimi *et al*., 2006). Farmers are likely to continue usage when they realize net financial gains after using. There is a net financial gain when the incomes realized are more than the costs incurred from usage (Barnard and Nix, 1979). This is supported by the cognitive theory of adoption which states that action is brought about through the uneasy stress which that emanates from an individual having conflicting thoughts in the mind concurrently, and therefore will only decide or choose through motivation (Ndah *et al*., 2010). A positive net gain will serve as a motivational factor. Also Ndah *et al*. (2010) explains that the decision or choice that a farmer makes from a given number of alternatives is influenced by the ability of the alternative to assist in problem solving.

Vegetable farmers in Accra are faced with the choice of organic fertilizers alone, inorganic fertilizers alone or a mix of the two types of fertilizers. These choices are influenced by a number of factors including socio-economic factors such as the age of a farmer, income earned from using the technology as well as off-farm income, educational level etc. (Bonabana-Wabbi, 2002). Farmers' past experiences with usage of the two types of fertilizers will most likely influence their choices. Their past experiences could encourage them to continue usage or discourage them. When a farmer continues using a particular type of fertilizer over a reasonable period of time, such as three or more years, only then can that farmer be considered an adopter. Adoption then is influenced by the farmer's own characteristics, the environmental characteristics as well as societal and institutional factors (Bonabana-Wabbi 2002 and Ajewole, 2010). This is supported by the behavioural theory of adoption (Ndah *et al*., 2010). The underlying idea is that learning from past experiences influences behaviour and hence the decision of a farmer to adopt. Also that behaviour is acquired through conditioning brought about through experiential learning.

Figure 3.1 illustrates the conceptualization of the research issues. Adoption of technologies by farmers is dependent upon factors that pertain to the type of technology, socio-economic characteristics of farmers, infrastructural and institutional factors affecting the farmers. The Application of technological knowledge in addition to farmers' own experiential knowledge will contribute eventually to equitable distribution of resources, opportunity to make financial gains, security of invested resources and output realized as well as the empowerment of farmers. Eventually the application of technological knowledge will contribute to the sustainability of natural resources (Heal, 2004).

Figure 3.1: Conceptual Framework for the Study



Source: Author's Own Conceptualization of the Study

The adoption of a given technology could be constrained by a number of factors. For organic fertilizers, constraints such as bulkiness, offensive odour, slow acting, and difficulty in transporting, as well as doubtful efficacy (Alimi *et al*., 2006).

These factors may differ from farmer to farmer or may even differ with regards to the sources of acquisition of the technology, particularly when there are different sources of obtaining the said technology. However if these constraints are eliminated, the technology becomes more appealing to farmers (Bonabana-Wabbi, 2002). For a given technology, the costs implications are important for adoption and should be taken into consideration (Bonabana-Wabbi, 2002). The costs associated would be direct costs such as acquisition cost and application costs, as well as indirect costs such as transaction and opportunity costs. The acquisition of a technology infers a transaction which in turns implies transaction costs (Jagwe, 2011).

Ajzen (1985 and 1991), indicates that the adoption of a given technology is a conscious action that is undertaken by farmers, hence it is a planned action influenced by important factors such as accessibility. According to Ndah *et al*. (2010), adoption theories are relevant in agricultural research because economic models alone are not sufficient due to their focus on interest and profit maximization. Also because of the limited capability of economic models to give proper explanation of the decisions made by farmers and also to capture the complex nature of farmers' viewpoints and their actions or behaviour. Again Ndah *et al*. (2010), stress that adoption theories are important because the economic models do not conceptualize the social aspects of knowledge, communication, information or even the rationality of farmers in decision making, in this case for profit maximization. Hence adoption theories are useful in plugging the gaps that exist in economic models.

As illustrated by Figure 3.1, the net gain (or loss when the total cost exceeds income gained). The direct costs, the transaction costs and the income from organic fertilizer usage will be used to estimate the net gain. The income from using organic fertilizers is also a socio-economic factor which can influence adoption of organic fertilizers directly. The net gain from organic fertilizer usage, the other socio-economic factors, and the constraints associated with organic fertilizers as well as the sources of obtaining organic fertilizers an all influence the adoption decision of vegetable farmers. The adoption of organic fertilizers will lead to a sustainable profitable vegetable production.

3.3 Methods of Analyses

3.3.1 Identifying the Sources of Organic Fertilizers

To achieve this objective, the sources were mentioned by the respondents as the places where they obtained the organic fertilizers from. Their responses were summarised using descriptive statistics, specifically frequency tables. According to Panneerselvam (2010), there are two main types of statistics thus, inferential statistics and descriptive statistics. Descriptive statistics are used to comment about a given set of information that has been collected.

Descriptive statistics are also used to convert large data into more meaningful forms for easier interpretation. Descriptive statistics help to summarize the data, for example, frequency, range, mean, mode, median etc. Descriptive statistics are usually presented in graphical or tabular form as well as summary statistics or single values (Panneerselvam, 2010).

Frequency tables show the distribution of data points and their corresponding frequencies or number of times that they are observed as well as percentages (Francis, 1998).

3.3.2 Determining the Rate of Organic Fertilizer Adoption

Theoretical Background

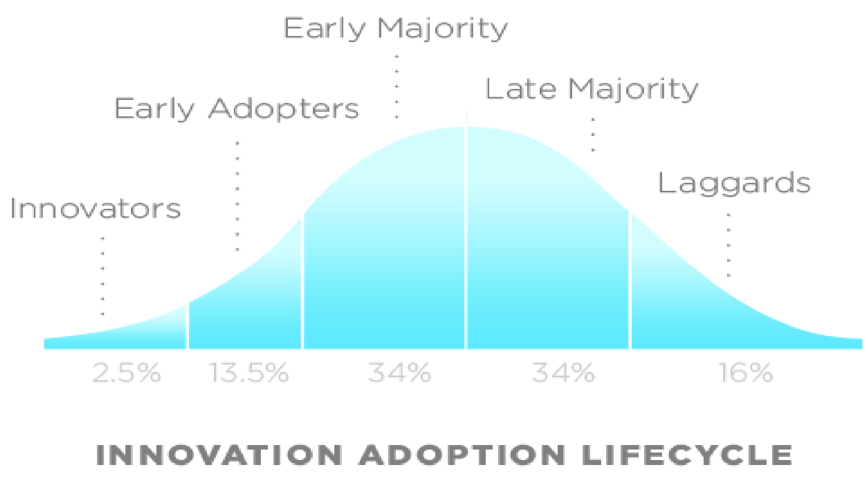
According to Rogers (1983) an individual's perceptions of the five main attributes of a technology can be used to predict the rate of its adoption. The rate of adoption of a technology, is the relative speed with which that technology is used continuously and extensively in production by members of a given society or social system. It is often measured in terms of the number of individuals who adopt the technology in a given period of time, for instance, a year. The rate of adoption could, therefore, be viewed as a numerical indication of how precipitous the adoption curve for an innovation or technology would be (Hoffman, 2005 and Ajzen, 1991).

However, Hoffman (2005) posit that the larger the number of people involved in making a decision or decisions about an innovation, the slower its rate of adoption would be. According to Rogers (1995) the perceived attributes of innovations accounts for about between 49% to 87% of the variance that exists in the rate of adoption of those innovations or technologies. The characteristics of an innovation that influence adoption of agricultural technology as listed by Rogers (2003) are: perceived attributes of innovations, type of innovation-decision, communication channel diffusing the innovation at various states in the innovation-decision process, nature of the social System and extent of change agent's promotion efforts. The variables that fall under the perception of respondents as being the attributes that determine the rate of adoption of a given technological innovation are: relative advantage, compatibility, complexity, trialability and observability.

Rogers (2003) posits that when persons perceive situations to be real, their consequences will also be real. One possible problem that could arise when measuring the five attributes of technological innovations is that they may not apply or be applicable in all cases due to the differences in characteristics for a particular set of respondents and also the type of innovation in question (Rogers, 2003). In the case of this study, the farmers have different characteristics and each farmer's response to organic fertilizers may differ so not all the attributes of any technological innovation concerning organic fertilizers may apply.

Again according to Hoffman (2005), the solution to this, would be, to elicit the main characteristics and attributes of innovations from the respondents in question as a prior step to measuring these attributes as predictors of the rate of adoption. Figure 3.2 illustrates the adoption lifecycle of an innovation, which Rogers (2003) posits. For every innovation there are early adopters and there are late adopters some adopters would come in later as the innovation is diffused to a larger audience. According to Robinson (2009) factors such as communication or information dissemination, the social system, efforts of promotion agents among others, all affect the rate of diffusion of an innovation.

Figure 3.2: Innovation Adoption Cycle



Source: Rogers (2003)

According to Robinson (2009), an innovation could just be a re-invention and re-introduction of an existing product or technology to better fit the needs of individuals or groups. He states further that re-invention is vital to the diffusion of technologies and that the eventual success of technological innovation depends largely on how well it has evolved to meet the needs of more people who demand it. These people are usually the risk averse in society. Robinson (2009), posits that a good way to make re-invention possible is to make users a part of it, in a continuous developmental process. Further, the importance of re-invention stems from the fact that it is a concept that shows or proves that no product or process should rest on it past achievements and that it must be continuously improving to ensure that it spreads to a wider audience.

Hoffman (2005), reiterates that re-invention of an already existing product is innovation and to introduce it to the target market creates the perception of an evolved product and that all the principles of innovation diffusion can be applied to it. Organic fertilizers are an existing products but any re-invention activity carried out on them means they can be considered an innovation and the principles can be applied to them. When you consider compost for instance, it is an innovation. Even with manure, when it is bagged or packaged or semi-processed, innovation could be said to have been created. The contents of manure and its quality depends largely on the quality of feed fed to the animals, an improvement in the feed or ration changes the quality of the manure and a different product could be said to have been created and the acceptance of it by vegetable farmers is considered adoption in the long run. Vegetable farmers may choose to acquire organic fertilizers from different sources largely because they search for best product that will maximize output in so doing they are choosing the best product.

Hoffman (2005), states that innovation includes methods and ideas that when applied to an existing product creates innovation. Also that an existing product which is introduced or recommended to an existing group who are not using it could also be thought of as innovation and that the principles of innovation can be applied to it. Getting people to adopt a given technology involves behaviour modification (Ndah *et al*., 2010).

Human behaviour is a result of a continuous ever changing interaction between human beings and their environment (Ndah *et al*., 2010). Hoffman (2005) reiterates that adoption is behaviour modified, and that it depends on both driving and inhibiting forces which exist in a state of equilibrium or disequilibrium. In other words, adoption is a planned behaviour driven by facilitating and impeding forces coupled with the expectation of others that will have a likely outcome of the desired behaviour.

The theory can help predict the deliberate actions of farmers. The theory makes an assumption that human behaviour can be guided by behavioural beliefs thus beliefs about the likely implications of adoption, by the normative expectations of other people and by controlled beliefs, thus beliefs concerning the presence of factors that may enhance or inhibit the performance of behaviour (adoption).

Empirical Model

In order to determine the rate of organic fertilizer adoption, the following relation was used as done by Bonabana-Wabbi (2002):

$$ROA = \frac{n}{N} * 100 \qquad (1)$$

Where ROA = rate of adoption, n = number of adopters and N= Total sample size. When ROA is <25% it implies a low rate of adoption and >75% implies a high rate of adoption (Bonabana-Wabbi, 2002). For the purpose of this study, adoption is defined as continuous usage for three (3) or more years.

3.3.3 Determining the Factors that Influence Organic Fertilizer Adoption

In order to identify the factors that influence the adoption organic fertilizers, the multinomial logit model was used. The multinomial logistic regression approach was used because the choices were more than two so a binary choice model such as the binomial logistic regression would not have been appropriate (McFadden 1987 and Gujarati, 2003). The multinomial logistic regression model is a regression model that generalizes the logistic regression model and allows for more than two discrete outcomes or choices. It also allows the prediction of the probabilities of categorically distributed dependent variables by a given set of independent or explanatory variables (Gujarati, 2003). The multinomial logistic regression approach has the assumption that each independent variable has a single value for each case thus, it assumes that the data are case specific.

There is no need for the independent variables to be statistically independent from each other and colinearity is assumed to be low because it becomes difficult to differentiate between the impacts of several variables if they are highly correlated (Gujarati, 2003).

The multinomial logit relies on the assumption of independence of irrelevant alternatives (IIA). The assumption is that the odds of preferring one class over another do not depend on the presence or absence of other irrelevant alternatives. For example, the relative probabilities of taking Metro Mass or *Trotro* to the market place does not change if a motor cycle is added to the choices as an additional probability. This allows the choice of K alternatives to be modelled as K-1 independent binary choices because one alternative is chosen as a pivot or base against which K-1 alternatives are compared against at a time (McFadden, 1987; Gujarati, 2003; Moutinho and Hutcheson, 2007)

Mathematically, it can be represented as:

$$score(X_i, K) = \beta_K X_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where *Xi* is the vector of explanatory variables describing observation *i*, βk is a vector of weights (or regression coefficients) that corresponds to outcome *K* and score (*Xi, K)* of assigning observation *i,* to category *K.* In discrete choice theory, where observations represent people and outcomes represent choices, the score is considered the utility associated with person *i*, choosing outcome *K.* The predicted outcome is the one with the highest score (Gujarati, 2003). The basic setup for a multinomial logit is the same as in binary logistic regression, the only difference is that the dependent variables are categorical or polythomous rather than binary, i.e. there are *K* possible outcomes rather than just two outcomes. One fairly simple way to arrive at the multinomial logit model is to imagine, for *K* possible outcomes, running *K*-1 independent binary logistic regression models, in which one outcome is chosen as a "pivot" and then the other *K*-1 outcomes are independently regressed against the base or pivot outcome. This would proceed as follows, if outcome *K* (the ultimate outcome) is used as the pivot or base:

$$\ln \frac{\Pr(Y_i = K-1)}{\Pr(Y_i = K)} = \beta_{K-1}.X_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The probabilities can be solved for bearing in mind that the total probabilities must be equal to 1. The logarithms must be converted to exponential equations and this will give:

$$\Pr(Y_i = K-1) = \Pr(Y_i = K)e^{\beta_{k-1}.X_i} \text{.....................................(4)}$$

Introducing the total probability into the relations, we obtain the relation that can be used to predict the probabilities of other outcomes. This will give:

$$\Pr(Y_i = K) = \frac{1}{1+\sum_{K=1}^{K-1} e^{\beta'_K.X_i}} \text{.....................(5)}$$

The coefficients have the ability to show on the direction of the effect that an independent variable has on the dependent variable. The magnitude of the effect can be obtained from the marginal effects (McFadden, 1987). For the purpose of this study, the choices were three, thus the choice of adopting only organic fertilizers, the choice of inorganic fertilizers only and then choosing both. The Hausman test of independence was used to test for the independence of the alternatives.

The marginal effects or elasticities which indicate by how much the dependent variable will change if there is a corresponding change in the independent variable, can be calculated by taking the partial derivatives or differentiating the dependent variable with respect to the particular independent variable in question (McFadden, 1987). Then the marginal effect of the j^{th} predictor, X_j, on P_i can be expressed as; Given that i= 1, 2, 3……..k , for unordered responses.

$$\frac{\partial P_i}{\partial X_j} = P_i \left[\frac{\partial X'\beta_i}{\partial X_j} - \Sigma_K \left(P_k \frac{\partial X'\beta_K}{\partial X_j} \right) \right] \text{.....................................(6)}$$

3.3.3.1 Justification of Empirical Variables (Xs)

Farm size was chosen as a variable because it was expected that the larger the farm of a respondent, the larger the quantity of fertilizer needed and vice versa hence a positive sign is expected but it could also be negative. The farm size would therefore inform a farmer's decision to adopt or not taking into account the cost implications among other things (Bonabana-Wabbi, 2002).

The gender of farmer was introduced into the regression model as an independent variable because males and females perceive situations differently and as such it was expected that the gender of a vegetable farmer could influence the decision to adopt. This will be a dummy variable with the female gender as the base. (Ajewole, 2010).

It was expected that farmers who engage in organic farming would be more likely to adopt organic fertilizers, hence the introduction of that variable, the expected sign is positive (Alimi *et al.*, 2006). This variable is captured as "type of farmer" and the sign could either negative or positive. Farmers' perception of the fertility status of the soils on which they cultivate their vegetables can influence their decision to adopt organic fertilizers either positively or negatively. The education variable was thrown into the fray because it an axiom that education brings enlightenment, and also the more educated a farmer is, the better informed he or she would be, in order to make a more informed decision on whether or not to adopt organic fertilizers. (Ajewole, 2010 and Bonabana-Wabbi, 2002). The *a priori* expectation is a positive relationship with the dependent variable.

The irrigation variable was included because irrigation is a means of applying fertilizer because it helps to reduce the labour required for fertilizer application

(Odhiambo and Madangini, 2008). A farmer may prefer a fertilizer because it lends itself to be dissolved in water for easier application. So it was included as a variable to see the extent of its influence on the adoption of organic fertilizers. The expected sign of the coefficient is positive.

It was expected that a farmers' income would influence the choice of fertilizer. The income would influence ability to purchase organic fertilizers. With experience comes knowledge, a universally accepted truth. So experience can influence the decision to adopt organic fertilizers *ceteris paribus*. A farmer can only use fertilizers that are accessible. So accessibility would influence adoption of a given fertilizer (Bonabana-Wabbi, 2002).

Age has a bearing on experience. Also a certain age bracket may be more attracted a particular type of fertilizer. Even though the age of a farmer may not determine the length of time of exposure to a particular technology, it may give an indication of the number of technologies that a farmer has been exposed to over time. The older the farmer, higher the possibility of past trials of other related technologies.

Agriculture is a profit generating undertaking that is driven by demand by consumers. Even subsistence agriculture is driven by some kind of demand, so a farmer would be inclined to produce what consumers demand. So if the targeted consumers prefer organic vegetables, it would influence farmers' decision to adopt organic fertilizers. The Government's fertilizer subsidy policy is an important factor that could influence which type of fertilizer farmers choose. If a premium is placed on organically grown vegetables, it could potentially drive the adoption of organic fertilizers. So a variable is introduced to capture the effect of premiums on adoption of organic fertilizers.

Bonabana-Wabbi (2002) posits that factors such as Government policies, technological change, market forces, environmental factors, demographic factors, institutional factors and the mechanisms for delivering the technology could influence adoption of a given technology. However for a given technology, not all the factors may be appropriate. In this case factors such as the Size of the farm, the Age of the farmer, educational level of the farmer, farming experience and the gender of the farmer as well as access to information on technologies, extension contacts and prior experience with using the technology were presumed to be appropriate.

Odhiambo and Madangini (2008), added factors such as accessibility with regards to the technology in question and also affordability of the technology. According to Odhiambo and Madangini (2008), affordability may depend on the farmers' capital and the costs associated with the technology. Again the same authors posited that the fertility status of a given soil would inform the use of fertilizers. All these factors were considered in choosing the empirical variables.

3.3.3.2 Detailed Description of Empirical Variables (Xs)

The following is a detailed description of the empirical variables for the multinomial logistic regression. The variables were chosen after careful thought and are thus defined in the context of this study. They are thus defined as follows:

X_1 = Farm size (This are the farm sizes of respondents measured in Hectares)

X_2 = Gender, thus whether the farmer is a male or female. This was made a dummy variable with Male being 1 and Female being 0.

X_3 = Type of farmer whether a farmer is a fulltime farmer or part tie farmer. This was captured as a dummy variable with 1 being fulltime and 0 being part time. This variable was included to draw a distinction between the farmers, to see if that influenced their decision to adopt organic fertilizers.

X_4 = Fertility status of the soil. This was based on the perception of the farmers, thus whether they perceived the soil to be fertile or not. Even though perception is not reality, it was assumed that after tilling the soil continuously for a period the farmers would be able to form their perceptions about how fertile or otherwise that the soil was. This was also made a dummy variable: Fertile=1, Not fertile=0

X_5 = Education. The number of years of formal education had by respondents measured in years.

X_6 = Extension contacts. This variable ascertained whether the respondents had any contact with extension officers. This was captured as a dummy variable. Dummy: Yes (has contact) =1, No (No contact) =0)

X_7 = Irrigation was also captured as a dummy variable (Dummy: Yes (Irrigates=1, No (Does not irrigate) =0

X_8 = Organic Income (GHS). This was the income that a farmer gains from using organic fertilizers, measured in Ghana Cedis. This was estimated using the market value of the vegetables produced. Since farmers did not use standard units of measurement, the study used the value of vegetables on per bed basis. The value of the bed was then multiplied by the total number of beds that a farmer had applied organic fertilizers to, to get the total income from using organic fertilizers for a given farmer in Ghana Cedis. This was done for farmers who had problems recollecting the incomes that they had realized, however some farmers were able to recollect and give accurate values.

X_9 = Inorganic Income (GHS). This was the income that a farmer gains from using inorganic fertilizers, measured in Ghana Cedis. This was estimated just as X_8 thus using the market value of the vegetables produced. Since farmers did not use standard units of measurement, the study used the value of vegetables on per bed basis. The average value of the bed was then multiplied by the total number of beds that a farmer had applied inorganic fertilizers to, to get the total income from using organic fertilizers for a given farmer. Just as in the case of organic fertilizers this was done for farmers who had problems recollecting the incomes that they had realized, however some farmers were able to recollect and give accurate values.

X_{10} = No fertilizer Income (GHS). This was the income that a farmer gains from not using any of the two types of fertilizers, measured in Ghana Cedis. Just as was done in the case of X_8 and X_9 but in this case since no fertilizer was applied, it was the average value of the beds multiplied by the total number of beds, to get the total in Ghana Cedis

X_{11}= Experience of farmer (Years). This variable captured the number of years that a farmer has been in any vegetable production, measured in years.

X_{12}= Ease of access to organic fertilizers. This variable was aimed at capturing the ease with which respondents could access organic fertilizers to see if that had a bearing on the adoption of organic fertilizers. This also based on the perceptions formed by farmers based on their previous experience in trying to acquire organic fertilizers. It was made a dummy variable (Dummy: Easy access=1, otherwise=0)

X_{13} = Age of farmer (Years). This was the age of farmers measured in years.

X_{14} = Consumer Preference for organic products. This variable was aimed at ascertaining whether the respondents would consider consumer preference for organically produced vegetables particularly for those who produced mainly for export. This was also made a dummy variable (Dummy: Yes=1, No=0)

X_{15}= Government Fertilizer Policy This was to find out if the respondents considered the Government of Ghana fertilizer subsidy policy. This was also captured as a dummy variable. (Dummy: Yes=1, No=0).

X_{16}= Premium Payment for organic products. This was to ascertain from the farmers whether any premium placed by consumers on organically grown vegetables would influence their decision to adopt organic fertilizers. This was captured as a dummy variable with 1 being Yes and 0 being No.

All the variables used in the regression were identified from literature thus from studies conducted by other authors on technology adoption, from field observations made during the pilot survey for the study and also from the existing Government of Ghana fertilizer policy.

3.3.3.3 A priori expectation

The *a priori* expectations of the directions of the variables thus whether they change in the same direction as the dependent variable or not, was based partly on literature and then on the perceptions formed from field observations.

$B_0 >0$, $\beta_1 >0$, $\beta_2 >0/<0$, $\beta_3 >0/<0$, $\beta_4 >0/<0$, $\beta_5 >0$, $\beta_6 >0$, $\beta_7 >0$, $\beta_8 >0$, $\beta_9 >0$, $\beta_{10} >0$ $\beta_{11}>0/<0$, , $\beta_{12} >0/<0$, $\beta_{13} >0/<0$, $\beta_{14} >0$, $\beta_{15} >0$ and $\beta_{16} >0$

3.3.3.4 Testing of Hypotheses

All the variables to be used in the model are premised on facts and expectations and therefore for the right conclusions to be drawn, the requisite hypotheses will be tested.

The hypotheses tested are: H_o: Farm size has no influence on adoption organic fertilizers and H_a: Farm size has a positive influence on adoption of organic fertilizers.

This is repeated for all other variables. Where H_0 = the null hypothesis and H_a = the alternate hypothesis.

3.3.3.5 Hypotheses Validation

Following the generalized logistic regression approach, the Z-Statistic was used to measure the level of significance for each of the estimated coefficients: $Z = \beta j / S.e(\beta j)$; where βj is the coefficient of the variable X; S.e is the standard error. If Zcal > Zcrit, reject the null hypotheses. The goodness of fit statistic was estimated using the Mc-Fadden R-Squared. The likelihood ratio (LR) test is used to determine the joint significance of the independent variables in the model.

3.3.4 Estimating the Transaction Costs Associated with Organic Fertilizers

Theoretical Background

As the name suggests, any transaction will present a cost to the parties' involved in the transaction. Usually a buyer and a seller, each party may incur a different cost while some of the costs may be similar to both parties (Coase 1937 cited in Watkins 2011, Coase 1960 and Jagwe, 2011). Transaction costs could be invisible; they could also be opportunity costs etc. which have a bearing on a given transaction. For the buyer, activities such as search and information, bargaining and ensuring that the seller sticks to the agreement among others implies costs. A transaction cost just like any other type of cost has a fixed element as well as variable element (Williamson, 1985).

Therefore to estimate the total transaction cost, both the variable transaction costs and the fixed transaction cost elements will have to be considered and aggregated to arrive at the total transaction cost just as equation (2) seeks to do.

Transaction costs incorporation into an agricultural household model in which a choice variable (for example, the decision to adopt organic fertilizers in vegetable production) has been specified is possible. It enables the determination of its effect on the consumption of a given resource for the production of an agricultural output, which is vegetables in this case (Jagwe, 2011).

Empirical model

This objective was achieved using the relation:

$$TC_{ij} = \sum_{i=0}^{n} K_{ij} \qquad (7)$$

Where *TC*= total transaction cost of the *i*th farmer from the *j*th source. *K* is the transaction cost faced by the *i*th farmer from the *j*th source of supply. This formula is an aggregation of all transaction costs incurred by farmers in accessing and using the organic fertilizer technology. This formula stems from the transaction cost theory (Coase, 1937 cited in Watkins, 2011). All components were estimated using direct means and the opportunity cost of time spent on the transactional activities (Jagwe, 2011).

“K” is the sum of the search and information costs, bargaining costs and policing and enforcement costs incurred by a given farmer from a given source of organic fertilizer. “K” was measured in Ghana Cedis (GHS) per hectare. The results spreadsheet is presented in appendix 3.

3.3.5 Estimating the Net Gain from the Use of Organic Fertilizers

To achieve this objective, then the net benefit or gain of choosing organic fertilizers over inorganic fertilizers was estimated using the partial budgeting technique. According to CIMMYT (1988) cited in Alimi *et al.* (2006) the partial budgeting technique is a method of organising data on losses and gains of various alternatives to ascertain the net gains or losses. For this study the losses were considered to be the value of a forgone alternative and the costs associated with using organic fertilizers.

Net Gain (or Net Loss) = Total Gains – Total Losses …………………………. (8)

The partial budget can help a farmer to estimate the net change in income from an investment decision. A partial budget considers all incremental revenue and incremental expenses that would change when the farm business's operations are altered. According to CYMMIT (1988), the partial budgeting technique is a quick way of doing investment analysis of future investments and it shows the results of projected changes beforehand.

According to CYMMIT (1988), the partial budget can go beyond just putting figures together, to helping a farmer to define the reason or reasons for a change, give the alternative changes that can be made and eventually help the farmer to decide whether the proposed change will be worth it in the long run. Profitability in a partial budget is usually estimated by the average change in annual profits. A positive value indicates that the proposed change is profitable or a financially sound while a negative value indicates that the proposed change is not profitable (CYMMIT, 1988).

3.3.5.1 Estimation of Components of the Partial Budget

The components of the partial budget were estimated as follows:

Revenue

The revenues were estimated as the monetary value of vegetables cultivated from using each type of fertilizer, on per bed basis. The total revenue for a farmer was calculated by multiplying the average income per bed by the total number of beds. This was standardized to per hectare basis.

Labour Costs

The labour costs were estimated by using the time spent on each activity. The activities were: carting the fertilizers, measuring the fertilizers and application of the fertilizers. Room was made for other activities that are carried out by the farmers as far as fertilizer application was concerned. The time spent was multiplied by the rate paid for the work. The rate paid for the work was the estimated average cost of hiring labour per hour in the sector.

Cost of Fertilizer

The cost of fertilizer was estimated as the unit price multiplied by the quantity purchased. The transportation costs were also added. For organic fertilizers, particularly uncomposted manure, the drying costs were considered as well. The drying costs were estimated as the opportunity cost of time taken to dry. The packaging costs for inorganic fertilizers were estimated as the total cost of packaging material and the opportunity cost of the time spent on packaging.

Other Costs

Other costs such as storage costs were considered. The cost of any storage structure put up by the farmers for the purpose of storing fertilizers was considered. The storage structures were depreciated and the value added as a cost. For manure sometimes there were pest infestation during storage, any cost incurred by the farmers to control such pests, were duly noted.

Other fertilizer application equipment with long-term usage capability were depreciated by using the straight line depreciation method and the values added to the costs. It was realized that there were secondary markets for some of the equipment, so the salvage values of those equipment were subtracted from their original costs and divided over their useful life spans. The transaction costs estimated were also added.

3.3.5.2 Procedure for Preparing the Partial Budget

The gains are made up of the income from using organic fertilizers and the costs associated with the forgone alternative thus inorganic fertilizers. For the losses side, the income lost, is the revenue that a farmer would earn from using inorganic fertilizers. The farmers were not able to give value of per unit weight of vegetables sold, they did however give the monetary value of the vegetables on per bed basis. So the average value was multiplied was multiplied by the average number of beds to give the average total revenue from using inorganic fertilizers.

The new costs were estimated using the costs associated with organic fertilizers. The costs considered include; the cost of organic fertilizer, the transportation costs, storage costs, labour costs, packaging costs, cost of application equipment and drying costs for manure, these were added to the to the income lost as well as the transaction cost associated with organic fertilizers to arrive at the total loss.

For the gains side, the average revenue from using organic fertilizers was estimated using the same procedure used to estimate the average revenue from using inorganic fertilizers. The average revenue from using organic fertilizers was the new income since that was the alternative in question. The cost saved was then estimated as the costs associated with inorganic fertilizers, thus the cost of inorganic fertilizer, the transportation costs, storage costs, labour costs and cost of application equipment.

These were also aggregated to get the cost saved, which was then added to the new income as well as the transaction cost associated with inorganic fertilizers to arrive at the total gains. All values were estimated on per hectare basis by dividing through by the average farm size in hectares.

The net benefit/gain was calculated by subtracting the total losses from the total gains (Barnard and Nix, 1979; Kraybill *et al*., 2009; Malaiyandi *et al.*, 2010). Table 3.1 presents the format used.

Table 3.1: Partial Budget Analysis for Organic fertilizer in Vegetable Production

Losses	**Gains**
Income Lost	New income
New costs	Costs saved
Net Gain (If gains > losses)	Net Loss (If losses > gains)

3.3.6 Constraints Associated with Organic Fertilizers

In order to achieve this objective, the constraints were identified from literature and given to farmers to rank. The Kendall's coefficient of concordance was used to test for agreement among the rankers.

Theoretical framework

The Kendall's coefficient of concordance measures the strength of relation in a direct and easily understood way. The Kendall's coefficient has an intuitively simple interpretation and simpler than Spearman coefficient. It can even be computed from the actual observation without first converting them to ranks (Legendre 2005). The Kendall's coefficient of concordance (W) is the measure of the degree of agreement among 'm' (number of rankers) of 'n' (number of constraints) ranks. W is an index that measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of sum of ranks.

The idea behind this index is to find the sum of the ranks for each constraint being ranked and then to examine the variability of this sum. If the rankings are in perfect agreement, the variability among these sums will be a maximum (Legendre, 2005). The identified constraints/ problems are ranked from the least pressing to the most pressing using numerals; 1,2,3,4,……..n, in that order.

The rank scores computed are then used to calculate the coefficient of concordance (W), to obtain the degree of agreement in the rankings.

$$W = \frac{(\sum T^2 - (\sum T)^2 / n) / n}{m^2 (n^2 - 1) / 12} \quad \text{……………………………………….. (9)}$$

This is simplified as;

$$\frac{12 [\sum T^2 - (\sum T)^2 / n]}{nm^2 (n^2 - 1)} \quad \text{……………………………………………… (10)}$$

Where; T= sum of ranks for each constraint.

m= number of rankers (farmers).

n= the number of constraints being ranked.

Hypotheses and Significant Test for W: (F-Test)

Ho: There is no agreement among the rankings of the constraints by the farmers.

H_a: There is agreement among the rankings of the constraints by the farmers.

Where; Ho and H_a denote null and alternate hypotheses respectively.

The coefficient of concordance (W) may be tested for significance in terms of the F-distribution.

The F-ratio is given by: [(m-1) Wc]/ (1-Wc) ………………………………….. (11)

Wc is the calculated Kendall's Coefficient of Concordance (W) (Legendre, 2005).

3.4 Data Collection

The data collection was done within a period of about eight weeks using structured questionnaires. First of all, an approved sample questionnaire was use on a pilot survey using one third of the sample size (201 respondents). The questionnaires were revised and using the analyses generated from the test or pilot survey. Room was also made to accommodate any additional data outside the scope of the questionnaires but provided by the respondents during interview.

3.4.1 Types and Sources of Data

Primary data was collected from the study area and used for the study. The primary data included the socioeconomic characteristics of vegetable farmers, the type and quantities of organic fertilizers that the farmers use, farm sizes, access to credit, farmers' perceptions about soil fertility, the target market, where and how farmers obtain fertilizers, the types of vegetables they cultivate as well as the cycle of production among others. The farmers were asked about the constraints they face with regards to organic fertilizers and their level of importance by way of ranking.

Secondary data was also used. Secondary data about prices of fertilizers and the fertilizer consumption patterns of farmers was also obtained from fertilizer sales outlets within and close to the study area where the farmers indicated that the bought their fertilizers from. This secondary data was mainly used as a check to verify the responses that the farmers gave with regards to where they obtained their fertilizers and the costs they incurred.

3.4.2 Sample Size and Sampling Technique

The total number of respondents used for the study was 201. This number was arrived at, by considering a number of relevant factors such as the time required to administer a questionnaire and the willingness of the farmers to participate in the survey. The purposive sampling technique was used to select the communities within the city and the respondents were subsequently selected at random. Areas such as La, Osu, Marine Drive, Airport, GBC, Korle-bu, Dzorwulu were purposively sampled from the 11 Sub-Metros within the jurisdiction of the Accra Metropolitan Assembly because of the presence of vegetable farmers.

From these areas, the respondents were picked at random and those who were willing to participate in the survey after being selected went ahead to give data. However, care was taken so that no farmer was selected twice because it was realized that some farmers had farms in more than one location. It was random sampling without replacement, thus the first respondent had a probability of 1/N, the second respondent had a probability of 1/N-1 until the 201st respondent with a probability of 1/N-201. Where 'N' is the population of vegetable farmers in the study area.

Obuobie *et al.* (2006) indicated that there were a maximum of 1000 farmers engaged in vegetable production within the jurisdiction of the Accra Metropolitan Assembly. Also from enquiries made from MoFA and the vegetable growers association, the 2012 population of vegetable producers was about the same. This formed the basis of the population from which the sample of 201 respondents was obtained.

3.4.3 Survey Instrument

Structured questionnaires consisting of both close ended and open ended questions were used to elicit responses from the respondents. Also data from direct field observations and personal interviews were used in the study. The questionnaire was edited and finalized after the testing phase or the pilot phase of the data collection process.

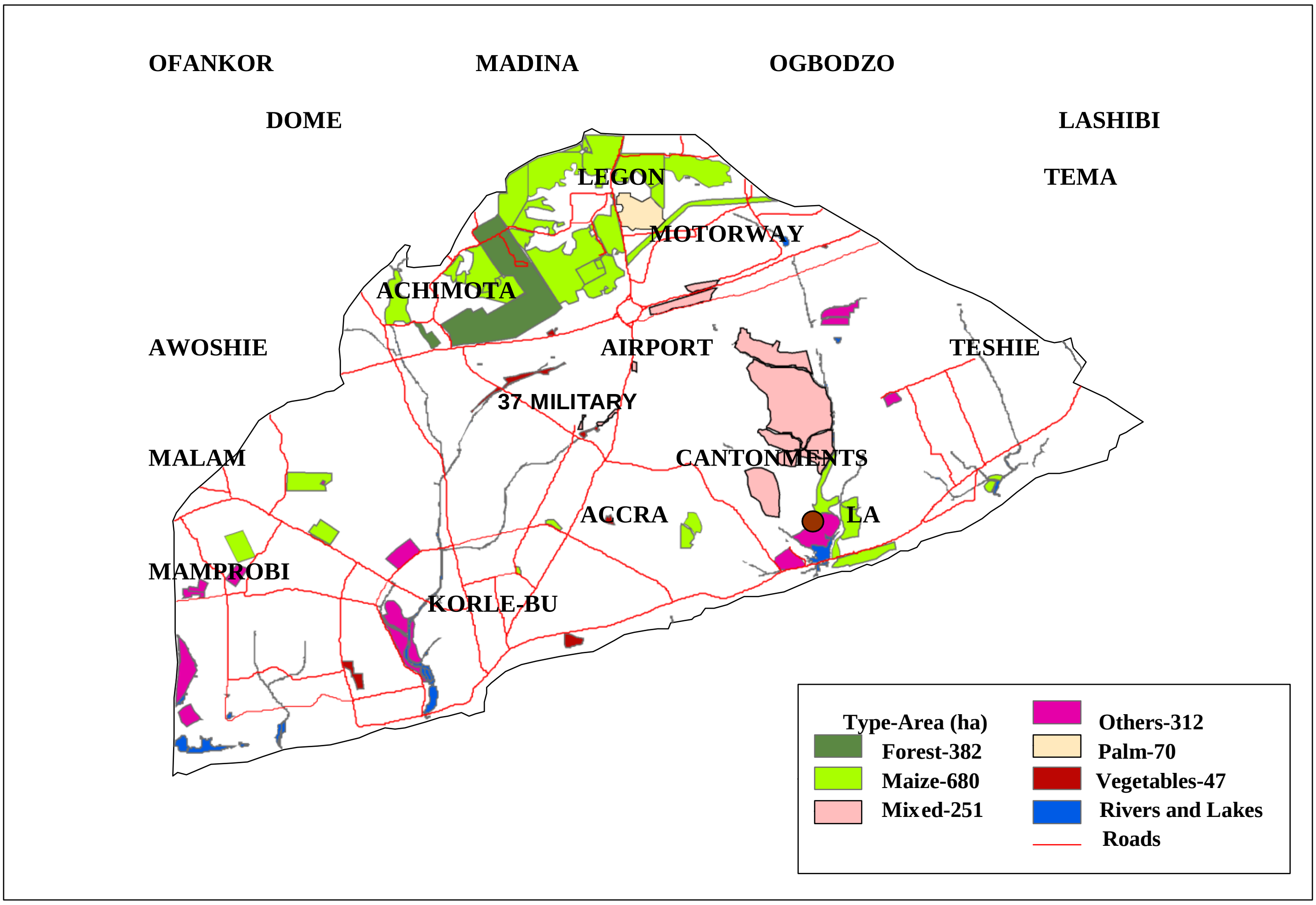
3.5 Study Area

Accra is the largest and most urbanized City in Ghana with a total land area of 240 square kilometres. The population of the city consists of both residents and migrants and at its peak it is 3.5 million people in the day. The total population grows at an annual rate of 4.4% (World Bank, 2010). The City is under the jurisdiction of the Accra Metropolitan Assembly. For the reason of administration and the decentralization drive of the government of Ghana, the metropolis is further sub-divided into sub-metropolitan areas or sub-metros. In all there are eleven (11) sub-metros (World Bank, 2010). These are Ablekuma North, Central and South, Ashiedu keteke, Ayawaso East, West and Central, La, Osu klottey and Okaikoi South (World Bank, 2010). The city has four distinct residential areas based on the average income per capita per annum, housing and environmental characteristics. There are first, second, third and fourth classes (World Bank, 2010). About 47% of the households earn an average monthly salary of 1000 Ghana Cedis, about 5% earn above 2000 Cedis, 16% earn 1000 Ghana Cedis and over whiles 21% earn below 1000 Ghana Cedis and only about 1% of the city’s populace earn an average monthly income of between 5,001 and 10,000 Ghana Cedis (World Bank, 2010). Accra lies within the coastal-savannah zone and has a low average annual rainfall of about 810 mm, this falls over an 80 day period.

The rainfall pattern of the city is bimodal, thus the major and minor rainy seasons. The major season occurs mainly between March and June, and a minor rainy season which occurs around October. Average temperatures vary from 24 ºC in August to 28 ºC in March. Drainage systems in the city are both natural and artificial with the artificial ones flowing into the natural systems (World Bank, 2010; Obuobie *et al.,* 2006). Natural drainage systems in Accra include streams, ponds and lagoons (For example in Songo, Korle and Kpeshie) making it suitable for agriculture in general and vegetable production in particular (Obuobie *et al.,* 2006). This makes irrigation of cultivated lands possible. Agriculture is very important in the city and it provides about 37.8% of the household income of the populace. It provides employment on both part time and full time basis (World Bank, 2010).

Vegetable production in Accra supplies about 90% of the fresh vegetable supply in the city with about 800 to 1000 producers (Obuobie *et al*., 2006). About 47 ha of the available agricultural land is cultivated to vegetables only and a further 251 ha is cultivated to mixed vegetable and cereal systems (Obuobie *et al.,* 2006). Both exotic and local varieties of vegetables are cultivated within the City. In Accra, there are about 800-1000 vegetable farmers out of which about 60% produce exotic vegetables and 40% of the farmers cultivate indigenous or local or traditional varieties of vegetables (Obuobie *et al.*, 2006). Some of the modern or exotic varieties of vegetables cultivated in the city of Accra are: cabbage, lettuce, spring onions, and cauliflower while the more traditional crops are tomatoes, okra, garden eggs, egg plant (aubergines) and chilli pepper (MoFA, 2008). Some of the major vegetable cultivating areas within the city are Korle Bu, Dzorwulu, La, Marine drive, Airport residential area, Ghana Broadcasting Corporation, Centre for Scientific and Industrial Research offices among others (Obuobie *et al*., 2006).

Figure 3.3: Map showing open spaces and (farming) activities on them in Accra



Source: Kufogbe *et al.*, 2005.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This Chapter presents the results obtained from the analyses of the data collected and also discusses the results as thoroughly as possible. The main thematic areas covered include the socio-economic characteristics of the respondents, the rate of adoption of organic fertilizers, the factors influencing the adoption of organic fertilizers, the transaction costs associated with organic fertilizers use, the net gains from choosing organic fertilizers and the constraints associated with organic fertilizers. Other results obtained are also discussed in their proper contexts.

4.2 The Socio-economic Characteristics of the Respondents

The socio-economic characteristics of the respondents are presented on Table 4.1. The overwhelming majority of respondents were males (97.5%). From direct field observations, it was clear that females preferred selling or marketing the produce and only about 2.5% were females cultivating out of which 1% were adopters. Some respondents (about 10%) also revealed during interviews that they had existing agreements with female marketers, who financed the production and sold the produce. Some also shared the profits with these marketers in which case the financing was treated as equity. The male organic fertilizer adopters and non-adopters were 44.5% and 53% respectively.

No respondent below the age of 18 years adopted organic fertilizers. Respondents who fell in the range of 19 to 50 years of age were the majority. Out of which 36% adopted organic fertilizers and 45% were non-adopters. For respondents who were above 50 years, 9.5% were adopters while 7.5% were non-adopters of organic fertilizers.

From the age distribution, 80.5% of the respondents were between 19 years and 50 years, which is the most productive stages of their lives, all things being equal, in terms of their capacity and ability to work. Those who fell below 18 years of age were all above 15 years, some explained that they needed the extra revenue to supplement whatever resources they received from their parents or guardians. One respondent indicated that he used the income to take care of his siblings and also to educate himself.

Regarding the marital status of farmers, the majority of farmers were married, (64%). About 33% of the respondents were married adopters of organic fertilizers while 31% were married non-adopters. Respondents who are household heads as a result of being married are more likely to adopt innovations for the simple reason that they want to improve output (quantity and quality) at the minimal possible cost because of limited resources and competing uses of those resources (Bonabana-Wabbi, 2002). About 32% of the population were single. Of the Single respondents, 8.5% of the population adopted organic fertilizers and 23.5% did not adopt. Nearly 2.5% of the respondents were divorcees and adopters of organic fertilizers while 0.5% were divorcees and non-adopters. About 1% of the respondents had deceased spouses and adopted organic fertilizers.

Table 4.1: Summary of Socio-economic characteristics of respondents

	Adopters		Non-Adopters		Total	
Category	Freq.	Perc. (%)	Freq.	Perc. (%)	Freq.	Perc. (%)
Gender:						
Male	89	44.5	107	53	196	97.5
Female	2	1	3	1.5	5	2.5
Age:	0	0	5	2.5	5	2.5
Less than 18	72	36	90	45	162	80.5
19-50	19	9.5	15	7.5	34	17
Above 50						
Marital Status:						
Single	17	8.5	47	23.5	64	32
Married	67	33.5	62	31	129	64
Divorced	5	2.5	1	0.5	6	3
Widowed	2	1	0	0	2	1
Household Size:						
1-5	70	34.8	90	44.8	160	79.6
6-10	21	10.4	19	9.5	40	19.9
Above 10	0	0	1	0.5	1	0.5
Education:						
None	27	13.4	49	24.3	76	37.8
Basic	50	24.8	49	24.3	99	49.3
Secondary	11	5.5	12	6	23	11.4
Tertiary	3	1.5	0	0	3	1.5
Residential Status:						
Native	30	15	22	11	52	25.9
Migrant	61	30.3	88	43.8	149	74.1
Category of Farmer :						
Full time	57	28.3	83	41.3	140	69.7
Part time	34	16.9	27	13.4	61	30.3
Type of crop:						
Vegetables	91	45.5	110	54.5	201	100
Others	18	9	15	7.5	33	16.5
Vegetables Grown:						
Local only	5	2.5	14	7	19	9.5
Exotic only	68	34	61	30	129	64
Both	18	9	35	17	53	26.5
Fallow:						
Included	48	23.8	69	34.3	117	58.2
Not Included	43	21.4	41	20.4	84	41.8
Channel of Sale:						
Middlemen	54	26.9	74	36.8	128	63.6
Other means	37	18.4	36	17.9	73	36.3
FBO:						
Ye	61	30.3	66	32.8	127	63.2
No	30	14.9	44	21.9	74	36.8
Under Contract:						
Yes	14	7	13	6.5	27	13.5
No	77	38.3	97	48.3	174	86.5
Land Ownership:						
Land Owner	1	0.5	3	1.5	4	1.99
Tenant	5	2.5	12	6	17	8.5
Squatter	85	42.3	95	47.3	180	89.6
Years cultivating Vegetables:						
Less than 3	0	0	32	16	32	16
3-10	39	20	44	21	83	41
More than 10	48	25	38	18	86	43

Source: Author's own computation

Cross-tabulating household size with adoption of organic fertilizers, revealed that, 34% respondents with household sizes ranging from 1 to 5 adopted organic fertilizers while 45% of the sample population, in the same household size range did not adopt organic fertilizers. Of the respondents with household sizes ranging from 6 to 10, 10.4% adopted organic fertilizers and 9.4% did not adopt. No respondent with a household size above 10, adopted organic fertilizers. In terms of education, 13.4% of the respondents had no education and adopted organic fertilizers and 24.4% uneducated respondents were non-adopters. In terms of education, the assessment was based on formal schooling and the highest level reached by a respondent is what is presented in Table 4.1. In all nearly 38% of the respondents indicated that they had no formal education. Some members of this group did indicate, however, that they had been taught to recite the *Qur'an* in Arabic. They claimed that they could only read and write the Arabic texts. The majority of this group originated from the Northern part of Ghana.

It suffices then to say that 62.2% of the population had had formal education to varying levels. Out of the 62.2%, 49% had basic education. Out of those with only basic education, 24.8% were adopters and 24.2% were non-adopters. An estimated 11.4% received Secondary education out of which 5.5% were adopters and 6% were non-adopters. About 1.5% of the respondents had tertiary education of which all were adopters. About 74.1% of the farmers were migrants and 25.9% of the respondents were natives. 15% were natives who adopted organic fertilizers and 11% were also natives who did not adopt organic fertilizers. 30.3% of the respondents were migrants who adopted organic fertilizers and 43.8% were migrant non-adopters.

Farmers were asked whether they cultivated vegetables as a full time occupation. The results indicate that about 69.7% of the farmers were full time farmers out of which 28.3 % were adopters of organic fertilizers, and 30.3% of the farmers were part time farmers out of which 17% adopted. All the respondents were vegetable farmers. About 9% cultivated other crops in addition to vegetables and adopted organic fertilizers. Other crops grown included roots and tubers, grains and cereals and tree crops.

In terms of vegetables cultivated 2.5% of the respondents cultivated local varieties only and adopted organic fertilizers 34% of the respondents cultivated exotic varieties only and adopted organic fertilizers. About 9% of the respondents cultivated both exotic varieties and local varieties and adopted organic fertilizers. Lettuces were the most cultivated vegetables with some 74.1% of the respondents cultivating it. Other vegetables cultivated include tomatoes, cabbages, carrots, cauliflower, sweet pepper, onions, aubergines, water leaf etc. First of all, the exotic vegetables were preferred because they have higher value as compared to the local varieties. Lettuces are the most cultivated because they mature quicker than the other varieties and also have a low cost of production, so the respondents save a lot of time, energy and money while making a bigger profit margin.

Out of the total number of respondents, 58.2% incorporated fallow periods in their operations, of which 23.9% were adopters of organic fertilizers and about 42% of the respondents did not include fallow periods in their operations, out of which 24.4% were adopters. A majority (58.2%) of the farmers appreciate the value of incorporating fallow periods even though they have to produce to meet constant demand, they know that the soil resources are not infinite and it is important to allow the soil to regain lost nutrients which help to cut down the cost of nutrient augmentation in the long run. In total, 63.1% of the respondents sold their produce through middlemen, of which 26.8% were adopters of organic fertilizers and 36.3%

respondents did not sell their produce through middlemen, out of which 18.4% were adopters of organic fertilizers. The majority sold their produce through middlemen probably because that reduces the cost of marketing while also guaranteeing a readily available outlet.

About 63.2% were members of farmer based organizations of which 30.3% were adopters of organic fertilizers and 41.8% did not belong to any farmer based organization. From the population, 13.4% of farmers were under contract to produce vegetables out of which 7% were adopters. About 86.6% of the farmers were not under any contract to produce, of which 38.3% were adopters. About 4% of the farmers owned their land of which 0.5% was an adopter and. about 8.5% of the farmers were tenants who paid some form of rent to the land owners of which 2.5% were adopters of organic fertilizers. About 89.6% of the farmers were squatters out of which 42.2% were squatters and adopters and 47.3% were non-adopters and squatters (Table 4.1). About 20% of the respondents had between 3 and 10 years experience in vegetable cultivation and were adopters of organic fertilizers while 21% had between 3 and 10 years experience in vegetable cultivation and were not adopters of organic fertilizers. Farmers who had engaged in vegetable cultivation for more than 10 years formed 43% of the sampled population out of which 25% were adopters and 18% were non-adopters of organic fertilizers. About 16% of the respondents were farmers who have been engaged in vegetable production for less than 3 years.

The Number of Times a Vegetable is Cultivated in a Year

The summary on Table 4.2 is the average number of times that a particular vegetable is cultivated in a given calendar year thus 12 months. In this regard, Lettuce is the most cultivated vegetable with an average of 4.44 cultivations in a given year. This may be due to the fact that the vegetable needs about 2 months before it is ready for harvesting. It is also very lucrative in terms of its market value. Lettuce is followed by the Ayoyo, Aleefu and Suule group. Then the Other vegetables group follows as the third most cultivated in a given year. Water leaf is the fourth most cultivated in a given year. Following Water leaf is Cauliflower, Spring onion and Cucumber, Spring onion, Sweet pepper, Cabbage, Okra and carrot came in last.

Table 4.2: The Number of Times a Vegetable is Cultivated in a Year

Vegetable	Average number of cultivations in a year
Cabbage	2.60
Carrot	2.33
Cauliflower	2.85
Lettuce	4.44
Okra	2.50
Sweet pepper	2.74
Ayoyo/Aleefu/Suule	3.69
Water leaf	3.15
Spring onion	2.80
Cucumber	2.80
Others	3.20

Source: Author's own computation

4.3 Sources of Organic Fertilizers

This section presents results on sources of organic fertilizers that are used by the respondents. The organic fertilizers used by the farmers can be categorized as manure and compost. For manure, a majority (73.6%) of the sampled population reported they got their manure from poultry farmers who are mostly located in areas close to the farmers, again the issue of proximity and easy access is important for to adoption of a technology (Odhiambo and Madangini, 2008; Ntege-Nanyeenya *et al.*, 1997). About 0.5% produced their own manure; those who reared animals in addition to producing vegetables. About 21.4% of the respondents indicated that they got their manure from other sources beside poultry farmers and in addition to producing on their own. The other sources included dumpsites, other animal farmers, collecting from Bat infested areas among others (Table 4.3). The sources chosen by the farmers were influenced by cost involved. Both direct costs (such as purchasing and transportation costs) were considered by the farmers as well as indirect costs (such as time spent in acquiring the fertilizers). The conclusion can be drawn that farmers prefer sources with little cost implications.

Table 4.3: Sources of manure

Category	Frequency	Percent
NA	9	4.5
Own production	1	0.5
Poultry farmers	148	73.6
Others (Dumpsites, NGOs etc.)	43	21.4
Total	201	100.0

Source: Author’s computation

For compost, 172 respondents indicated that they did not use them, representing 85.6% of the respondents. About 14.4% of the respondents indicated they used them. Of those who use compost 6 (3%) indicated they bought them from the open market. About 2% percent indicated that they got compost from suppliers who brought the compost for free. 1.5% indicated that they bought compost through Ministry of Food and Agriculture (MoFA) outlets. Some (3.5%) respondents reported that they had been trained to produce their own compost, so they did that. The low use of compost could be due to that those sold on the market are more expensive than poultry manure for instance. The remaining 9 (4.5%) respondents reported that they either bought or received free compost from other avenues apart from the Open market, Suppliers, MoFA or producing on their own. Those other sources included neighbours and friends, NGOs, among others (Table 4.4). The respondents indicated that some NGOs brought them free inputs from time to time.

Table 4.4: Sources of Compost

Category	Frequency	Percent
NA	172	85.6
Open market	6	3.0
Suppliers	4	2.0
MoFA	3	1.5
Own production	7	3.5
Others	9	4.5
Total	201	100.0

Source: Author's own computation

When farmers were asked which avenue they considered the most reliable supply of organic fertilizers (manure and compost), nearly 10% of the respondents could not pick one single source, but about 73.6% mentioned poultry farmers. About 11.44% respondents mentioned other sources. One person (0.5%) mentioned MoFA, 2 (1%) reported that they produced their own organic fertilizers and felt it was the most reliable way to obtain it, 2% of the respondents mentioned other animal farmers and finally 1.5% of respondents reported that the most reliable source to obtain organic fertilizers was from the Open market (Table 4.5). The results are consistent with Jokella *et al*. (2004), that the poultry industry is a major source of manure for farmers.

Table 4.5: Most Reliable Source of Organic Fertilizer Supply

Category	Frequency	Percent
Multiple Sources	20	10.0
Open market	3	1.5
Other animal farmers (Sheep, Goats, Cattle etc.)	4	2.0
MoFA	1	.5
Own production	2	1.0
Poultry farmers	148	73.6
Other sources	23	12.4
Total	201	100.0

Source: Author's own computation

4.4 Rate of Adoption of Organic Fertilizer

First of all farmers' knowledge of what constitutes organic fertilizers was ascertained. The overwhelming majority (99.5%) of the respondents indicated they had knowledge of organic fertilizers that organic fertilizers were from organic sources that they are obtained from plants and animals. Also they indicated that that organic fertilizers stay in the soil long after application and that some require further decomposition before they can be applied so that they heat from decomposition does not scorch the plants. Organic fertilizers are quite popular among vegetable producers (Alimi *et al.*, 2006). From the population, 8 (4%) respondents were non-users of organic fertilizers while 193 (96%) were users of organic fertilizers. When asked which organic fertilizer that they preferred, the respondents chose manure (85%) over compost (1%). About 4% of the sampled population indicated that they did not use organic fertilizers (Ajewole, 2010).

The manure most patronized was poultry manure with 184 (96.3%) persons attesting to this fact followed by cow dung and lastly Sheep/Goat droppings. Their percentages were 96.3, 3 and 1 respectively. Poultry manure is the most patronised probably due to the proximity of poultry farms to the farmers. It is consistent with the assertion made by Ajewole (2010) that proximity of the source of manure plays a role in farmers' choice.

Out of 201 respondents, 95.5% use manure. An estimated 16.4% of the respondents have used organic fertilizers for less than three years, 64.7% have used organic fertilizers for periods between three and 10 years and 18.9% have used organic fertilizers for more than ten years. About 55.2% of the sampled population use organic fertilizers only, about 4% of the respondents use inorganic fertilizers only with about 40.8% of the respondents using a mixture of the two types of fertilizers.

Organic fertilizers can be used alone in vegetable production to provide the nutrients needed by the crops (Alimi *et al.,* 2006). An estimated 62.7% of the respondents indicated they used not less than 2 Kg of the fertilizer per metre squared. 23.4% or 47 respondents indicated they used 4 Kg per metre squared and about 10% of the respondents indicated that they applied 8 Kg of organic fertilizer per metre squared. The bed sizes were standardized by using the average bed size of about 11.85 meters squared and the average number of cycles of production per was three (3).

Table 4.6: Summary of Rate of Adoption of Organic Fertilizers

Category	Frequency	Percent (%)
Knowledge of organic fertilizers:		
Yes	200	99.5
No	1	0.5
Usage of organic Fertilizers:		
Users	193	96
Non-users	8	4
Most Preferred Organic Fertilizer:		
None	8	4
Manure (Animal)	191	95
Compost (Organic materials put together and processed /composting process)	2	1
Most Patronized Manure:		
Poultry	184	91.5
Cow Dung	6	3
Sheep/Goats Droppings	1	1
Duration of Usage of Organic Fertilizers:		
Less than 3 years	33	16.4
3-10 years	130	64.7
More than 10 years	30	18.9
Number of Users of Fertilizers:		
Organic Fertilizers Alone	111	55.2
Inorganic Fertilizers Alone	8	4
Organic and Inorganic Fertilizer Mix	82	40.8
Quantity of Organic Fertilizer Applied Per Square Metre		
2 Kg	126	62.7
4 Kg	47	23.4
8K g	20	10
Organic Fertilizer Adopter:		
Adopters	91	45.3
Non-adopters	110	54.7

Source: Author's computation

Eventually the proportion of adopters was determined to be 0.453 or 45.3% of the respondents. 54.7% or 110 of the respondents were non-adopters (never used or have used for less than 3 years). According to Bonabana-Wabbi (2002), if the proportion is greater than 25%, then it could be said to be moderately high, in this case it was a little below the half mark thus less than half of the respondents can be classified as adopters. A summary of this section is presented on Table 4.6.

4.5 Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra (AMA)

This section deals with the variables that influence the adoption of organic fertilizers in vegetable production. Using the selected variables discussed in chapter three, a statistical test of a relationship between the dependent variable and combination of independent variables was carried out. The null hypothesis that there was no difference between the model without independent variables and the model with independent variables was tested. From the test results, the probability of the model chi-square (3607.125) was found to be 0.000, this infers a level of significance of 1%. The null hypothesis that there was no difference between the model without independent variables and the model with independent variables was rejected. The existence of a relationship between the independent variables and the dependent variable was confirmed. The marginal effects of factors influencing the adoption of organic fertilizers are presented in section 4.5.1. Descriptive statistics (cross-tabulations) of some of the explanatory variables are presented as an appendix.

By the definition given to adoption in this study, it was identified that there existed three types of fertilizer adopters within the study area. The farmers face three distinct choices. The three categories of adopters were: organic fertilizer adopters, inorganic fertilizer adopters and adopters of both types of fertilizers. For the multinomial regression, one category was used as the base category, which was the inorganic fertilizer adopters, because they were the fewest. This was done to satisfy the condition of the multinomial logistic regression approach.

4.5.1 The Marginal Effects of Factors Influencing the of Adoption of Organic Fertilizers

Table 4.7 shows the effects that significant factors have on the adoption of fertilizers. As discussed earlier in chapter three, the coefficients of the multinomial logistic regression only show the direction of the effects that an explanatory variable has on the dependent variable. Therefore, the marginal effects which show the magnitude of the changes that occur in the dependent variable when there are corresponding changes in the independent variables were estimated. The three choices were the adoption of organic fertilizers, inorganic fertilizers and the adoption of both. The base was the choice of inorganic fertilizers. The Hausman test for independence of irrelevant alternatives (IIA) assumption was conducted to establish the validity of the model. The test indicated that the choice of one alternative was independent of others, hence the test failed to reject the null hypothesis that the alternatives are independent of each other, therefore the multinomial logit model fits the data.

From Table 4.7, factors such as income from organic fertilizer usage, income from inorganic fertilizer usage, access to credit and type of market significantly influence the choice of more than one alternative with respect to the base alternative. Farm size influences the adoption of both types of fertilizers. As pointed out by Bonabana-Wabbi (2002), farm size is a significant determinant of the adoption of farming technologies. As shown from Table 4.7 the larger the farm size, the more likely a farmer is, to adopt both fertilizers, this re-affirms the assertion made by Bonabana-Wabbi (2002).

Table 4.7: The Marginal effects of factors influencing the of adoption of organic fertilizers

Variable	All fertilizers		Organic Fertilizer	
Gender	0.0044	(0.8010)	0.036341 ***	(0.000)
Age	0.04354***	(0.000)	-.0006421	(0.6210)
Organic Income	0.0314***	(0.000)	0.00213 **	(0.0432)
Inorganic Income	0.000259***	(0.000)	-0.000226 ***	(0.004)
Farm Size	0.00339***	(0.000)	-0.99958	(0.5636)
FBO Membership	-0.0029***	(0.000)	-0.69285	(0.7347)
Consumer Preference	-0.00433	(0.881)	-0.066215***	(0.000)
Access to credit	0.00134*	(0.032)	-0.066564*	(0.0491)
Type of Farmer	-5.894e-5	(0.3478)	0.0488659***	(0.000)
Fertility Status	-1.239e-4***	(0.000)	0.12686	(0.4254)
Government Fertilizer Subsidy	-3.446e-4**	(0.021)	-0.00056	(0.984)
Type of Market	-0.00523***	(0.0025)	-0.08869 ***	(0.000)
No Fertilizer Income	0.0060 ***	(0.000)	0.0008369	(0.9150)
Observations (N)	201			
Wald $Chi^2(42)$	3607.125			
Prob $>Chi^2$	0.0000			
Pseudo R^2	0.3662			

Note: P values in brackets and *significant at 10%, ** significant at 5% and *** significant at 1%.

Source: Author's own computation from field data

From the regression results (Table 4.7), the age of respondents also influences the adoption of organic of fertilizers significantly. It can be deduced from results that the older the farmer, the more likely that he/she will adopt organic fertilizers in comparison to adopting inorganic fertilizers alone. This could be due to the fact that older farmers are likely to be more experienced in vegetable production so they may have used both fertilizers in the past and know the benefits that each type of fertilizer would likely bring, as well as the benefits of combining the two types. In doing so, they stand to reap the combined benefits that will accrue from using both.

The membership of a farmer to a farmer based organisation (FBO), negatively influences the adoption of both types of fertilizers with respect to the base alternative. The results show that farmers who belong to an FBO are less likely to adopt both fertilizers as compared to adopting inorganic fertilizers alone. This is because farmer based organisations offer platforms for the farmers to learn and they are more likely to learn about the potential benefits of using both types of fertilizers together.

The fertility status of the soil negatively influences the adoption of both types of fertilizers, hence the more fertile the soil is perceived by the farmer, the less likely he/she will adopt both fertilizers as compared to adopting inorganic fertilizers alone. The income that a farmer gains during the periods when he/she is does not apply any fertilizer (No fertilizer income), positively influences his/ her decision to adopt a mixture of both fertilizers as compared to adopting inorganic fertilizers. This is supported by Bonabana-Wabbi (2002) who reported that income of a farmer was key in choosing technologies to adopt.

Government subsidy on inorganic fertilizers negatively influenced the adoption of both fertilizers as compared to the adoption of inorganic fertilizers. The result suggests that the higher the subsidy on inorganic fertilizers the less likely the vegetable farmers in Accra (AMA) are, to adopting a mixture of both types of fertilizers. Perhaps this goes to re-enforce the assertions made by Yawson *et al.* (2010), that the Government's fertilizer policy is fraught with problems such as shortages and high transaction costs, which make the subsidized fertilizers less attractive.

With regards to the gender of vegetable farmers in the study area, male farmers are more likely to adopt organic fertilizers than female farmers, hence a positive relationship. The Gender variable was a dummy variable with Females as the base because they are the source of life that is, being mothers and all.

The Consumer preference for organically grown vegetables negatively influences the adoption of organic fertilizers with respect to the adoption of inorganic fertilizers. This could be due to the fact that majority of farmers reported they were not influenced by the preference of consumers for organically grown vegetables when it comes to choosing which type of fertilizer to patronize. This did not conform to a prior expectation, but then again, it could have been because of the fact that Ghanaian consumers are not demanding organically grown vegetables.

With regards to the variable “Type of farmer”, thus whether a farmer is a full time farmer or a part time, it can be deduced from the positive sign that a full time vegetable producer will be more likely to adopt organic fertilizers with reference to inorganic fertilizers. This is shown by the variable Type of farmer (Table 4.7). A positive change in this variable results in a corresponding positive change in the adoption of organic fertilizers.

4.6 Transaction costs associated with organic fertilizers

This section deals with the transaction costs associated with organic fertilizers. The costs considered were searching and information costs, bargaining costs, policing and enforcement costs, quality ensuring costs like ascertaining the quality of the organic fertilizer. The time taken to complete each activity before a transaction is completed was noted and the opportunity cost of the time spent was calculated as the value of the best alternative.

The time spent was valued at the prevailing average hourly rate paid to hired labour in the study area as at the period that the data was being collected, which was an average of GHS 10. The values were standardized using the average farm size of the population, which was estimated to be 0.066 hectares, to obtain the average transaction cost per hectare for the two groups. Following the methodology discussed in section 3.3.4, the results are presented as follows:

Table 4.8, shows the results of transaction costs incurred by both users of organic and inorganic fertilizers. The student t-test was used to test the significance of the difference between the two means at 5%. The P-value was found to be 0.001 hence the difference between the two means is significant at 5%. The mean difference was found to be GHS 1568.75 per hectare.

Table 4.8: Comparing the Transaction Costs Incurred by Fertilizer Users

Fertilizer Users	Average transaction Cost (GHS) Per Hectare
Organic fertilizer users	3,846.67
Inorganic fertilizer users	2,277.92

Source: Author's computation

It means then that, if a farmer chooses organic fertilizers over inorganic ones, he or she is likely to incur a higher transaction cost than what he or she would have incurred had they chosen inorganic fertilizers instead. The high transaction costs associated with organic fertilizers was due to the long searching periods and transportation costs.

With inorganic fertilizers, users of the Government subsidy coupons need to wait for long periods to get their fertilizers due to shortages. In many instances, farmers waited for several months in order to complete their transactions. Even though the subsidy reduces the direct purchasing costs, the transaction costs are increased by the long searching and waiting periods. Perhaps if all the inorganic fertilizers were purchased on the open market with no coupons, the transaction costs could be lowered. The spread sheet is provided as an appendix.

4.7 Net Gains from using organic fertilizers

This section deals with the net gains that accrue from the use of organic fertilizers. The section uses the partial budget approach to ascertain the net gains or possible loss when three different choices are made thus; when a farmer chooses to use organic fertilizers over not using fertilizers, when a farmer chooses to use inorganic fertilizers over not using fertilizers and when a farmer chooses organic fertilizers over inorganic fertilizers.

4.7.1 Partial Budget

The budgets show the eventual consequence or rewards that a farmer stands to suffer or benefit for choosing one alternative over another. The partial budgets were prepared using the format and procedures discussed in section 3.3.5. When a farmer chooses to use organic fertilizers rather than inorganic fertilizers, that farmer would make a net gain of GHS 819.8 per hectare. It means then that given the two alternatives, organic fertilizers would make more financial sense than inorganic fertilizers.

Organic fertilizers are the best alternative for vegetables as shown by the results in Table 4.9. Since most of the farmers cultivate lettuce, it suffices to say then that organic fertilizers are able to meet the entire nutrients required of the crop for optimal growth which translates into higher net gains for the farmers in the long run.

Table 4.9: Partial budget of choosing organic fertilizers over inorganic fertilizers

Losses	GHS	Gains	GHS
Income lost:		**Income gained**:	
Inorganic fertilizer income	10013.51	Organic fertilizer income	20709.50
New costs:		**Cost saved**:	
Organic labour cost	1875.75	Inorganic labour cost	550.26
Direct organic fertilizer cost	7647.74	Direct inorganic fertilizer cost	665.79
Organic fertilizer transaction cost	3846.67	Inorganic fertilizer transaction cost	2277.92
Total loss:	23,383.67	**Total gain:**	24,203.47
Net gain:	819.8		

Source: Author’s computation

The partial budgets considered the revenues from using organic fertilizers, the revenue from using inorganic fertilizers, the direct costs, packaging and drying costs of organic fertilizers as well as the transaction costs associated with organic fertilizers and inorganic fertilizers. All are standardized to per hectare basis.

4.8 Ranking of Constraints Associated with Organic Fertilizer Use

The constraints were ranked in order from 1 to 5 in an increasing order of importance. The constraints ranked included bulkiness, difficulty in transporting, doubtful efficacy, offensive odour, slow acting and requirement of large storage space, need for drying, health risks posed by organic fertilizers among others (Alimi *et al.,* 2006). From Table 4.10 it is clear that, bulkiness ranked highest since it recorded the highest mean rank. This was actually observed on the field as heaps of the fertilizers were stored by the farmers. The result is therefore very consistent with field observations. The second highest average factor was ranked as difficulty to transport organic fertilizers, the difficulty to transport stems from the bulky nature as more labour is required to load and unload the fertilizers from trucks. Then offensive odour which was the net ranking constraint also makes transportation and handling very difficult. This also conformed to literature (Ajewole, 2010; Odhiambo and Madangini, 2008; Alimi *et al*., 2006).

Slow acting was the fourth highest ranking constraint. This attribute of organic fertilizers could be viewed as both an advantage and a disadvantage because while the slowness may decrease current output (short term), the longer lasting (long term) effect of organic fertilizers due to the slow release of minerals may help decrease future costs of production as well as increase future output (Alimi *et al.,* 2006). The slow release of nutrients is probably due to the organic attribute of the fertilizers meaning that microbes are required to decompose the fertilizer before the nutrients can be released. So while the fertilizer stays in the soil it serves as a cementing agent for other soil components therefore contributing to soil physical properties (structure, bulk density, microbial activity, porosity and humus etc.), the soil physical properties subsequently also facilitate the release of nutrient elements into for plant use. Doubtful efficacy was fifth highest ranking constraint, because it is difficult to ascertain the actual nutrient composition of organic fertilizers, it becomes difficult a bit difficult to know the right amount to apply (Jokella *et al*., 2004). This constraint is however, offset by the large number of different nutrients that organic fertilizers contain. Also now formulae are available that enable farmers calculate how much of raw manure to apply and also which amounts of the different components to use in a composting process (Jokella *et al.*, 2004). Others, refers to those constraints that were observed, aside those presented to the respondents to rank. These include, inadequate storage space, need for drying, proper decomposition, health risks etc. A very important other constraint is the health risks posed by organic fertilizers. Some of the risks include nausea and blocked sinuses as a result of the offensive odour this makes handling quite difficult.

Table 4.10: Ranked constraints

Constraints	Mean Rank (In decreasing order)
Bulkiness	4.50
Difficulty in transporting	4.48
Offensive Odour	4.21
Slow acting	3.50
Doubtful efficacy	2.34
Others (Inadequate storage space, need for drying, health risks etc.)	1.97

Source: Author’s computation. N (Population): 201, Kendall’s W: 0.372, df: 5, Asymptotic. Sig. 0.000 , Some farmers restricted themselves to only the constraints presented to them whiles other gave other constraints which they encounter whiles using organic fertilizers. The results (Table 4.10) show that there is agreement among the ranking and it is fairly high, since the Kendall's coefficient is 0.372 or 37.2%. This was also asymptotically significant at 1% and had a Chi-Square value of 374.216. Hence we reject the null hypothesis, which states that there is no agreement amongst the rankings as discussed in section 3.3.6

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This concluding chapter summarises the findings made during the course of the study, the conclusions drawn, as well as the recommendations made.

5.2 Summary

The study sought to identify the sources of organic fertilizer supply by using descriptive statistics, to find out the rate of adoption of organic fertilizers in vegetable production using a rate model, to identify the factors that influence the adoption of organic fertilizers using the multinomial logistic regression approach, to estimate the transaction costs associated with organic fertilizer use which was done both directly and indirectly through the measure of opportunity cost of time spent on the transaction. Other objectives were to estimate the net income gain(s) from choosing organic fertilizers by using a partial budget analysis and finally to identify the constraints associated with organic fertilizer use by farmers using the Kendall's coefficient of concordance.

Organic fertilizers are preferred by many farmers (55.2% of vegetable farmers in the Accra Metropolitan area) as the main fertilizer or used in combination with inorganic fertilizers (40.8% of vegetable farmers in Accra). There is a perception among vegetable farmers (55.2% of the farmers) that organic fertilizers have lasting positive effects on the soil and they may have positive environmental consequences after use. Also those organic fertilizers are unlimited in nutrients content. Organic fertilizers are considered to be less expensive for small scale vegetable farmers for the same equivalence of inorganic fertilizers. However inorganic fertilizers are still the fertilizers being promoted by Government through subsidization. Organic fertilizers are perceived by about 96% of the vegetable farmers to promote the life in soils by providing suitable conditions and materials for microbes and other living organisms. Organic fertilizers are also perceived by 96% of the vegetable farmers to be able to improve soil physical properties such as bulk density and porosity. Organic fertilizers provide a source of soil organic matter which serves as cementing agents that bind soil particles together.

After data was collected and analysed the following findings were thus made. There is a reasonably high rate of adoption of organic fertilizers among vegetable farmers in Accra which was estimated to be about 45.3%. Farmers obtain their organic fertilizers from diverse sources such as poultry farmers, suppliers and the open market. The majority of organic fertilizer users prefer manure, particularly poultry manure which they obtain from poultry farmers in and around Accra. About 55.2% of the farmers prefer to use organic fertilizers alone.

The use of organic fertilizers has a higher associated transaction cost in Ghana Cedis per hectare than the use of inorganic fertilizers. It was estimated to be GHS 3,846.67 per hectare compared with that for inorganic fertilizers of GHS 2,277.92 per hectare.

There is a net gain in income from choosing to use organic fertilizers rather than inorganic fertilizers. The net gain in income was GHS 819.8 per hectare producing mostly lettuces. The factors that influence the adoption of organic fertilizers significantly include; gender, type of farmer, consumer preference for organically grown vegetables, organic income, inorganic income, type of farmer and the type of market that a farmer produces for. Inorganic income, consumer preference and type of market served, influence the adoption of organic fertilizers negatively. Organic income, type of farmer and gender influence the adoption of organic fertilizers positively.

The most pressing constraint associated with the use of organic fertilizers is the bulky nature of the fertilizer, followed by difficulty in transportation, offensive odour, slow acting, and doubtful efficacy. The other constraints included; the need for more storage space due to the bulky nature of organic fertilizers, need for drying, health risks such as blocked sinuses and headaches brought on by the offensive smell, among others.

5.3 Conclusions

Farmers obtain their organic fertilizers mostly from poultry farmers in and around Accra from areas such as Labadi and Madina, therefore the supply of organic fertilizers depends directly on the presence of the poultry sector in Accra. There is a reasonable rate (45.3%) of organic fertilizer adoption among vegetable farmers in Accra, meaning that quite a large number of the vegetable farmers have used organic fertilizers continuously for three or more years. Vegetable farmers in Accra prefer organic fertilizers (55.2%) to inorganic, though only 45.3% fit the definition of adopters of this study. All the farmers apply 2Kg or more of organic fertilizer per square meter per year.

The gender of a farmer influences the adoption of organic fertilizers positively, implying that as more males produce vegetables adoption rate of organic fertilizers will increase and vice versa, this so because the males dominate in the production of vegetables in Accra. The type of farmer influences adoption of organic fertilizers positively, full time farmers are more likely to adopt organic fertilizers than part-time farmers. Income from using organic fertilizers also influences the adoption of organic fertilizers positively, implying that the more income a farmer got from previous use of organic fertilizers, the greater the likelihood of adoption of organic fertilizers.

Whether or not consumer preference for organically grown vegetables influences the farmer's decision to adopt organic fertilizers, the overwhelming majority replied in the negative. This disposition of the vegetable farmers may stem from the fact that there is no market segment for organically grown vegetables in the study area. Therefore the farmers make the decision to adopt mainly based on their convenience. The type of market that a farmer produces for also influences the adoption of organic fertilizers significantly. This shows that majority of the farmers covered in the study produce for the domestic market where no premium is paid for organic vegetables.

Farmers who choose organic fertilizers are likely to enjoy a positive net income. The bulky nature of organic fertilizers was found to be the most pressing constraint among other constraints associated with organic fertilizer use. This may explain the limited use by females since it requires more labour for handling. Most of the respondents (69.3%) are full time farmers who cultivate vegetables as their main source of livelihood while 30.7% produce vegetables to supplement their income. The average gross income estimate of about GHS 20,709.50 per hectare per year, with an average farm size of 0.066 hectares, it can be concluded that though urban vegetable production is a very lucrative (1,725.79 per hectare per month) undertaking, may not be able to support the average Ghanaian family.

5.4 Recommendations

There is a high level of usage of organic fertilizers among respondents within the study area and the organic fertilizers have been observed to be slow acting therefore it takes the soils a longer period to fully break them down, so there is the risk of over application. All the respondents apply 2Kg or more per square meter of organic fertilizers for an average of three cycles of production in a year. Therefore the use of organic fertilizers should be supervised by the Environmental Protection Agency (EPA) and other Government Agencies to make sure that excessive levels are not applied, as this could result in environmental pollution in the long run if left unsupervised.

Due to the fact that urban vegetable production in the city is financially rewarding as shown by the partial budget and it contributes to the economic life of the city, certain areas of the city of Accra could be reserved mainly for vegetable cultivation and other forms of agriculture by city authorities because increasing development could lead to a reduction in land area available for urban agriculture.

Even though urban vegetable production in the city is financially rewarding (1,725.79 per hectare per month) it should be promoted mainly as a supplement to income from other sources because the monetary rewards from vegetable production alone may not be enough to cater for the average Ghanaian family.

There is the need for consumer sensitization by nutritionists on the potential benefits of patronizing organically grown vegetables. This could expand the demand for organically grown vegetables and the willingness of consumers to pay premium price and hence stimulate organic production by farmers.

Entrepreneurs and investors should be incentivised by Government through tax exemptions and subsidies among others things to invest in setting up more composting sites as composting helps remove some of the constraints associated with raw manure such as the need for drying which consumes time and increases opportunity cost

Scientists should devise ways of reducing the bulky nature as well as the offensive odour associated with organic fertilizers.

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APPENDIX 1: SAMPLE QUESTIONNAIRE

FACTORS INFLUENCING THE ADOPTION OF ORGANIC FERTILIZERS IN VEGETABLE PRODUCTION IN ACCRA.

Department of Agricultural Economics and Agribusiness, University of Ghana, Legon

Contact……………………………
Sub-Metro…………………………
Town………………………………
Enumerator………………………..
Start of interview………………….. Am/Pm

Questionnaire Number

Section 1: Socioeconomic Characteristics of Vegetable Farmers

1. Name of respondent: ……………………………………………..…
2. Gender: Male………………. Female……………………….
3. Age of respondent (Years): …………………………………
4. Marital Status: Single……………………… Married…………… Divorced………… Widowed…………….. Never Married……………….
5. Household Size: ……………………
6. Highest level of Education reached: No Education………………… Primary …………….. JHS…………… SHS……………… Vocational………… Tertiary……………..
7. Residential Status: Native………………… Migrant…………………
8. Are you a full time farmer? Yes ……….. No …………….
9. What other activity do you undertake besides farming?
   ....
10. Land Ownership: Land Owner…………… Tenant………………… Squatter...……...
11. How many years have you been growing vegetables on current land? …………...……
12. Which vegetables do you produce?
   ……………………………………………………………………………
   ……………..……
13. Do you grow vegetables only? Yes………….. No……….......………..
14. If "No" what else do you cultivate?………………………………………

15. When do you sell? After harvest………….. At customers'' request……….. Other times ………......…….

16. How much of your yield do you sell? Less than a quarter………… Quarter................. Half………… Everything…………………

17. How long does it take to produce and sell?

Crop	Length of time

18. How many times do you produce in a given year?

Crop	No. of times cultivated in a year

19. Do you incorporate a fallow period in your production cycle? Yes……….. No………

20. If "Yes" why the fallow period? To prevent pest build up …………. To allow the soil to regain lost nutrients……….... To serve as a rest period ……….. Other reason(s), specify... ……………………………………………………………………………… ………………………………………………………………………………

21. Do you sell directly on the market? Yes………. No….............………

22. Do you sell through middlemen? Yes………… No……………………..

23. If "No" who do you sell through? ……………………………………

24. Are you a member of any farmer based organization? Yes…………….. No…………

25. Are you under any contract or agreement to produce? Yes……No …………

26. If "Yes", with whom do you have such an agreement?

Individual(s) ………………… Restaurant/Hotel………………..

School/Institution…………….. Other(s)…………...

Section 2: Rate of Adoption of Organic Fertilizers

27. Do you know what organic fertilizers are? Yes ……….. No………………
28. Do you use organic fertilizers? Yes ……….. No………………
29. Which one do you patronize the most? Manure……… Compost………..Other…...
30. If manure, which of the following do you patronize the most? Poultry………………. Sheep/Goat droppings…………… Cow dung……………… Other(s) Specify ………………………………
31. For how long have you been using organic fertilizers? ....
32. Do you use organic fertilizers alone? Yes………….. No…………
33. What is the quantity of organic fertilizer that you apply per bed per growing period? 25Kg/bed .... 50 Kg/bed ………… 100 kg/bed …………
34. What kind of organic fertilizer do you use? Manure……………… Compost……….. Other………………

Section 3: Factors Influencing the Adoption of Organic Fertilizers

35. Farm Size: Average bed Length…................ m Average bed Width ……………….m Total number of beds ……………………….
    Total Farm Size (Bed length*Bed Width* No. of beds) = …………………..m^2
36. Access to credit: Have access…..……. No access………………
37. What type of credit? Cash…………….. Kind…………… Both………………
38. What type of vegetable producer are you? Organic producer ……………. Non organic ………..
39. Do you have contact with extension agents? Yes……. No………
40. Do you irrigate? Yes……. No………..
41. What is the level of access that you have to Organic Fertilizers? No Access……… Very Limited Access………. Limited Access …………….. Unlimited Access……..
42. What is your perception about the fertility status of the soil: Very Fertile…………… Fairly Fertile……………………..… Fertile……………….Not fertile ………………
43. Does consumer preference for organically grown vegetables affect your decision to adopt organic fertilizers? Yes ……………. No……………

44. Does consumers' willingness to pay premium for organically grown vegetables influence your decision to adopt organic fertilizers? Yes ……… No ……………
45. Does the Government Fertilizer subsidy programme influence your decision to adopt organic fertilizers? Yes ………… No ………………..
46. Which market do you produce for? Export………… Local………… Both………

Section 4: Sources of Organic Fertilizers

47. Where do you get organic fertilizers from?

Organic Fertilizers	Source
Manure	
Compost	
Other	

48. Which source would you say is the most reliable? ……………………………………
49. How do you determine the quality or efficacy of the organic fertilizer? By visual appraisal ……………... Yield of produce ………….. Laboratory testing ………….. Other means ……………..
50. Are the organic fertilizers that you get from these sources subsidized by government? Yes………… No……………

Section 5: Transaction Costs Associated with Organic Fertilizers

51. Do you produce your own organic fertilizers? Yes……… No…………
52. If "Yes" what do you produce? Manure………… Compost …………… Other………
53. If "No", where do you get your organic fertilizers from? Open market ……….. Suppliers……….. MoFA…………. Producers…………… Poultry farmers……… Other sources …………..
54. How far is the source from your farm? ……………..
55. How long does it take to identify the source?...........................
56. When searching for a suitable source how much cost (in GH¢) do you incur in terms of: Transportation……………..
57. When searching, do you make phone calls? Yes………… No…………...

58. If “Yes” how often do you make the calls?.....…………

59. If “Yes” how long does a call usually take?.......................

60. When searching, do you use the SMS service? Yes………….. No…………

61. If “Yes”, how often do you use the SMS service?....................

62. When searching, do you use the Internet? Yes……….. No………..

63. If “Yes” how often?............................

64. How long does a session usually take?.......................

65. Which source would you say has the highest searching costs? ....

66. What is the time lapse between search and acquisition?……..……………………..

67. List some of the activities you perform between search and acquisition and their duration?

Activity	Duration

68. List some of the activities you perform between acquisition and application and their duration?

Activity	Duration

69. Where do you get information about the organic fertilizers? From Suppliers……….. Friends…………… Neighbouring farms…………… Producers……………….. Other sources…………

70. Do you pay for this information? Yes…………… No……………

71. If “Yes”, how much do you pay on the average? GH¢……………………..

72. How long does it take to get information?...................

73. Which source of organic fertilizers in your opinion do you incur the highest information costs? ………………………

74. Do you bargain when trying to acquire the organic fertilizers? Yes……. No…………

75. How long does it take to bargain?................…………………………………..

76. After you have sought for information and identified the source of organic fertilizer that you want, how long does it take you to decide on whether to acquire or not? …………….…………………………………………………

77. After you have made the decision to acquire the fertilizers what measures do you take to ensure that the agreement with the supplier is enforced? …………………………….
78. How long does it take in doing so? ....
79. Which other costs do you incur when trying to acquire the organic fertilizers (Please list them)?……………………………………………………….
80. Which one amongst the costs that you have enumerated would you say is most prevalent? ....
81. Do you incur costs in ensuring the quality of the organic fertilizer? Yes …….. No….
82. How much do you incur? GH¢ …………
83. What measure (s) do you take to minimize these costs that you have enumerated? Acquire from trusted sources………… Acquire from sources close to farm………… Acquire only when needed…………Establish cordial relations with the source…………… Other measure(s) Specify……………
84. In trying to access organic fertilizers do you forgo any benefit? Yes………… No………
85. Which benefits in your view do you forgo? Benefits of using inorganic fertilizers …………Benefits of not using fertilizers………Other Benefits……….
86. Do you use inorganic fertilizers like NPK, Sulphate of Ammonia, Urea, Murate of Potash etc.? Yes………….. No…………..
87. Do you use them alone? Yes……… No…………
88. Do you prefer the use of organic fertilizers to inorganic fertilizers? Yes……… No……
89. If "Yes" why? They are cheaper............. They protect the soil.......... They improve the living of the soil.......... They are easier to obtain........... Customers Demand…....Other reasons................
90. If "No" why? They are more expensive............. They don't protect the soil............ They don't improve the living of the soil ………… They are not easy to obtain........... Customer Demand…………Other reasons.....................
91. What is your cycle of organic fertilizer application? With every planting……… With every other planting………… Every third planting………… Every fourth……….. Other (Specify)……………………..

Section 5: Transaction Costs Associated with Inorganic Fertilizers

92. Where do you get your inorganic fertilizers from? Open Market …………… MoFA …………. Other sources ……………..
93. How did you identify the source?...
94. What is the distance between your farm and the source?....................................

95. How long does it take to identify the source?..
96. When searching for a suitable source how much cost (in GH¢) do you incur in terms of: Transportation……………..
97. When searching, do you make phone calls? Yes………… No…………...
98. If "Yes" how often do you make the calls?......…………
99. If "Yes" how long does a call usually take?.......................
100. When searching, do you use the SMS service? Yes………….. No…………
101. If "Yes", how often do you use the SMS service?.....................
102. When searching, do you use the Internet? Yes……….. No…………
103. If "Yes" how often?............................
104. How long does a session usually take?.......................
105. Where do you get information about the inorganic fertilizers? MoFA………… Friends……… Neighbours………… Other Sources………
106. Do you pay for this information? Yes…………… No……………
107. If "Yes", how much do you pay on the average? GH¢……………………..
108. How long does it take to get this information?………………………………………...
109. Which source of inorganic fertilizers in your opinion do you incur the highest search and information cost? Open Market……………… MoFA……… Other sources…….
110. How do you acquire the fertilizers? Cash Payment ………… Credit…….Government Coupon……….Others……..
111. Do you bargain when trying to acquire the inorganic fertilizers? Yes……. No…………
112. If "Yes" how long does it take to bargain?..
113. After you have sought for information and identified the source of organic fertilizer that you want, how long does it take you to decide on whether to acquire or not?
 Less than an hour……….. Hours………….. Days ………….. Weeks…….. Month………. More……………..
114. After you have made the decision to acquire, what measures do you take to ensure that the agreement with the supplier is enforced?………………………………………………
115. How long does it take in doing so? ....……….……………
116. Do you always get what you want? Yes…….. No……….
117. How long do you usually wait to get the fertilizer after placing an order? ……………………………………..………

118. Which other costs do you incur when trying to acquire the inorganic fertilizers (Please list them)?

…………………………………..………………………………………..

…………………………………..………………………………………

119. Which one amongst the costs that you have enumerated would you say is most prevalent? ....

120. What measure (s) do you take to minimize these costs that you have enumerated? Acquire from trusted sources………… Acquire from sources close to farm………… Acquire only when needed…………Establish cordial relations with the source…………… Other measure(s) Specify………………………………………………………………………………

121. In trying access inorganic fertilizers do you forgo any benefit?

Yes………No………

122. Which of these benefits in your view do you forgo? The benefits of not using fertilizers ……… The benefits of using organic fertilizers……… Other benefits………

123. What is your cycle of inorganic fertilizer application? With every planting……… With every other planting………… Every third planting………… Every fourth……….. Other (Specify)……………………………………………………….

Section 6: Benefits from using Organic Fertilizers

124. When you use organic fertilizers what is the level of income that you realize? GH¢/bed…………......

125. When you don't use either organic or inorganic fertilizers, what is your income? GH¢/bed ………………….

126. When you use inorganic fertilizers what is the level of income that you realize from production? GH¢/bed..........................

127. *(please provide information for the following tables)*

Cost introduced (Organic fertilizer application)

Item	**Quantity**	**Price (GH¢)**	**Total Cost (GH¢)**
Application equipment			
Organic fertilizer			
Transportation			
Storage			

Labour

Activity	**Adult Male**		**Adult Female**		**Children**	
	No.	Hrs.	No.	Hrs.	No.	Hrs.
Carting the Fertilizer						
Measuring Fertilizer						
Application of fertilizer						
Other Activity (Specify)						
Total						

Application Equipment	**Unit Cost (GH¢)**	**Age**
Storage Structure	**Cost of Building**	**Age**

128. Do you bag/package the organic fertilizer yourself? Yes…………… No………….

129. If "Yes" what is the cost of a bag/packaging material (in GH¢)?............................

130. If "Yes" how much does it cost bag (in GH¢)?…………………...

131. If "Yes" how long does it take to bag?...

Cost Forgone (Inorganic fertilizer application)

Item	Quantity	Price (GH¢)	Total Cost (GH¢)
Application equipment			
Organic fertilizer			
Transportation			
Storage			

Labour							
Activity	**Adult Male**		**Adult Female**		**Children**		
	No.	Hrs.	No.	Hrs.	No.	rs.	
Carting the Fertilizer							
Measuring Fertilizer							
Application of fertilizer							
Other Activity (Specify)							
Total							

Application Equipment	Unit Cost (GH¢)	Age

Storage Structure	Cost of Building	Age

Section 7: Ranking of constraints

132. On a scale of 1 to 5, with 5 being the highest, how would you rank the following constraints:

A. Bulkiness ……………………… B. Offensive odour ……………..…

C. Doubtful efficacy ……………… D. Difficult to transport………………

E. Slow acting ……………………

F. Are there any other constraints that you would like to mention, and how would you rank them compared to those above?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

End of interview…………………… Am/Pm

APPENDIX 2:

DESCRIPTIVE STATISTICS OF EXPLANATORY VARIABLES WITH RESPECT TO THE DEPENDENT VARIABLE

Crosstab

Count		Ease of Access to Organic Fertilizers				Total
		0	1	3	11	
Dependent Variable	Inorganic alone	5	3	0	0	8
	Organic alone	28	77	5	1	111
	Both	32	43	7	0	82
Total		65	123	12	1	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.687	6	.099
Likelihood Ratio	11.177	6	.083
Linear-by-Linear Association	.039	1	.844
N of Valid Cases	201		

Crosstab

Count		Extension Contacts		*Total*
		0	1	
Dependent Variable	Inorganic alone	3	5	*8*
	Organic alone	24	87	*111*
	Both	21	61	*82*
Total		48	153	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.263[a]	2	.532
Likelihood Ratio	1.188	2	.552
Linear-by-Linear Association	.009	1	.923
N of Valid Cases	201		

Crosstab

Count

		Fertility status				Total
		0	1	2	3	
Dependent Variable	Inorganic alone	2	6	0	0	8
	Organic alone	35	68	2	6	111
	Both	29	47	2	4	82
Total		66	121	4	10	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.495	6	.960
Likelihood Ratio	2.037	6	.916
Linear-by-Linear Association	.074	1	.785
N of Valid Cases	201		

Crosstab

Count

		Gender		Total
		0	1	
Dependent Variable	Inorganic alone	3	5	8
	Organic alone	52	59	111
	Both	41	41	82
Total		96	105	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.540[a]	2	.764
Likelihood Ratio	.544	2	.762
Linear-by-Linear Association	.449	1	.503
N of Valid Cases	201		

Crosstab

Count

		Irrigation		Total
		0	1	
Dependent Variable	Inorganic alone	2	6	8
	Organic alone	34	77	111
	Both	35	47	82
Total		71	130	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.387	2	.184
Likelihood Ratio	3.381	2	.184
Linear-by-Linear Association	3.267	1	.071
N of Valid Cases	201		

Crosstab

Count

		Type of Farmer			Total
		0	1	2	
Dependent Variable	Inorganic alone	7	1	0	8
	Organic alone	2	108	1	111
	Both	9	23	50	82
Total		18	132	51	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.690E2[a]	4	.000
Likelihood Ratio	152.621	4	.000
Linear-by-Linear Association	64.422	1	.000
N of Valid Cases	201		

Crosstab

Count		Type of market			Total
		0	1	2	
Dependent Variable	Inorganic alone	5	2	1	8
	Organic alone	66	31	14	111
	Both	50	22	10	82
Total		121	55	25	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.070[a]	4	.999
Likelihood Ratio	.070	4	.999
Linear-by-Linear Association	.014	1	.907
N of Valid Cases	201		

Crosstab

Count		Willingness		Total
		0	1	
Dependent Variable	Inorganic alone	8	0	8
	Organic alone	79	32	111
	Both	46	36	82
Total		133	68	201

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.047	2	.011
Likelihood Ratio	11.453	2	.003
Linear-by-Linear Association	8.516	1	.004
N of Valid Cases	201		

APPENDIX 3
SPREADSHEET OF REVENUE AND COST ESTIMATIONS

Res.	Farm Size (Ha)	Org. Rev. (GHS)	Inorg. Rev. (GHS)	No fert Rev. (GHS)	Dir. Org. Cost (GHS)	Org. Lab. Cost (GHS)	Dir. Inorg. Cost (GHS)	Inorg. Labour Cost (GHS)	Org. Trans. Costs (GHS)	Inorg. Trans. Cost (GHS)	Total Org. Cost (GHS)	Total Inorg.
1	0.00700	800.0	800.0	800.0	0.000	47.500	40.000	20.000	120.000	91.100	167.500	151.100
2	0.00595	680.0	680.0	680.0	0.000	80.000	40.000	60.000	3.400	92.500	83.400	192.500
3	0.00700	600.0	0.000	0.00	0.000	80.000	0.000	0.000	3.400	0.000	83.400	0.000
4	0.02100	1500	0.000	0.00	145.000	103.200	0.000	0.000	170.000	0.000	418.200	0.000
5	0.00700	800.0	0.000	800.0	91.700	6.320	40.000	6.600	60.000	106.685	158.020	153.285
6	0.00700	400.0	0.000	400.0	50.000	105.000	70.000	90.000	66.700	102.400	221.700	262.400
7	0.00525	750.0	0.000	0.00	70.000	80.000	0.000	0.000	55.100	0.000	205.100	0.000
8	0.01015	1450	0.000	0.00	125.000	61.000	0.000	0.000	43.400	0.000	229.400	0.000
9	0.01050	1500	0.000	0.00	80.000	100.000	0.000	0.000	53.570	0.000	233.570	0.000
10	0.01400	800.0	0.000	0.00	95.000	60.000	0.000	0.000	55.170	0.000	210.170	0.000
11	0.02800	4000	0.000	0.00	65.000	120.000	0.000	0.000	38.570	94.925	223.570	94.925
12	0.00700	800.0	0.000	0.00	52.500	90.000	0.000	0.000	46.870	0.000	189.370	0.000
13	0.01400	800.0	0.000	0.00	119.000	90.000	0.000	0.000	12.750	92.725	221.750	92.725
14	0.01400	2000	0.000	0.00	45.000	90.000	0.000	0.000	6.625	0.000	141.625	0.000
15	0.04200	13650	0.000	0..00	75.000	60.000	0.000	0.000	9.425	0.000	144.425	0.000
16	0.02205	1890	0.000	0.00	27.000	80.000	0.000	0.000	9.425	0.000	116.425	0.000
17	0.01890	2430	0.000	0.00	70.000	80.000	0.000	0.000	13.225	0.000	163.225	0.000
18	0.01755	1750	0.000	0.00	75.000	120.000	0.000	0.000	12.725	0.000	207.725	0.000
19	0.01050	900.0	0.000	0.00	50.000	80.000	0.000	0.000	12.725	0.000	142.725	0.000
20	0.01575	1350	0.000	0.00	65.000	120.000	0.000	0.000	8.925	0.000	193.925	0.000
21	0.00700	800.0	0.000	0.00	45.000	80.000	0.000	0.000	8.925	0.000	133.925	0.000
22	0.00875	1250	0.000	0.00	45.000	80.000	0.000	0.000	12.725	89.950	137.725	89.950
23	0.01155	1155	0.000	0.00	55.000	43.400	0.000	80.000	12.725	0.000	111.125	80.000

24	0.01400	1600	0.000	0.00	50.000	80.000	0.000	0.000	9.425	0.000	139.425	0.000
25	0.01925	2750	2200	0.00	90.000	80.000	0.000	0.000	9.425	84.450	179.425	84.450
26	0.01225	1400	0.000	0.00	50.000	80.000	0.000	0.000	9.425	0.000	139.425	0.000
27	0.01050	900.0	0.000	0.00	50.000	0.000	0.000	0.000	11.025	0.000	61.025	0.000
28	0.01050	1050	0.000	0.00	40.000	80.000	0.000	0.000	9.725	0.000	129.725	0.000
29	0.00980	980.0	0.000	0.00	37.500	80.000	0.000	0.000	8.925	0.000	126.425	0.000
30	0.00875	1000	0.000	0.00	50.000	80.000	0.000	0.000	9.425	0.000	139.425	0.000
31	0.02100	3000	0.000	0.00	110.000	100.000	0.000	0.000	8.925	89.450	218.925	89.450
32	0.01400	1600	0.000	0.00	47.500	80.000	0.000	0.000	10.550	89.450	138.050	89.450
33	0.01225	1400	0.000	0.00	42.500	80.000	0.000	0.000	8.925	0.000	131.425	0.000
34	0.01050	2200	0.000	0.00	77.500	80.000	0.000	0.000	9.425	89.250	166.925	89.250
35	0.01400	1400	800.0	0.00	0.000	0.000	0.000	0.000	8.925	89.450	8.925	89.450
36	0.01750	2250	0.000	0.00	100.000	80.000	0.000	0.000	8.925	0.000	188.925	0.000
37	0.02275	2600	0.000	0.00	150.000	80.000	0.000	0.000	9.425	89.450	239.425	89.450
38	0.01225	1400	0.000	0.00	50.000	60.000	0.000	0.000	8.925	0.000	118.925	0.000
39	0.00875	1125	0.000	0.00	50.000	80.000	0.000	0.000	9.425	89.250	139.425	89.250
40	0.00700	800.0	500.0	0.00	0.000	0.000	0.000	0.000	9.425	89.250	9.425	89.250
41	0.01750	1750	0.000	0.00	170.000	160.000	0.000	0.000	8.925	0.000	338.925	0.000
42	0.01680	1920	0.000	0.00	130.000	160.000	0.000	0.000	9.425	0.000	299.425	0.000
43	0.0098	1120	980.0	0.00	40.000	20.000	0.000	0.000	14.425	89.450	74.425	89.450
44	0.01645	1880	1410	0.00	80.000	80.000	0.000	0.000	9.425	88.950	169.425	88.950
45	0.01050	1575	0.000	0.00	75.000	80.000	0.000	0.000	9.425	0.000	164.425	0.000
46	0.01400	1400	0.000	0.00	55.000	80.000	0.000	0.000	9.425	0.000	144.425	0.000
47	0.01225	1225	875.0	0.00	50.000	120.000	0.000	0.000	9.225	89.950	179.225	89.950
48	0.01155	1485	1155	0.00	60.000	100.000	0.000	0.000	9.225	89.450	169.225	89.450
49	0.01085	1550	0.000	0.00	50.000	80.000	0.000	0.000	8.925	0.000	138.925	0.000
50	0.01330	1710	0.000	0.00	115.000	80.000	0.000	0.000	10.025	0.000	205.025	0.000
51	0.51750	875.0	875.0	350.0	715.000	120.000	365.000	46.600	403.000	111.750	1238.000	523.350
52	0.04500	600.0	0.000	200.0	720.000	375.000	0.000	0.000	36.700	0.000	1131.700	0.000

53	0.02000	1200	0.000	400.0	1280.000	69.900	0.000	0.000	20.000	0.000	1369.900	0.000
54	0.01200	400.0	0.000	200.0	490.000	135.000	0.000	0.000	86.700	0.000	711.700	0.000
55	0.01250	625.0	0.000	125.0	585.500	180.000	0.000	0.000	108.000	0.000	873.500	0.000
56	0.07500	1500	0.000	250.0	130.000	169.800	0.000	0.000	89.700	0.000	389.500	0.000
57	0.01500	600.0	0.000	300.0	600.000	88.000	0.000	0.000	114.000	0.000	802.000	0.000
58	0.01800	1350	875.0	450.0	40.000	90.000	150.000	43.400	173.000	884.725	303.000	1078.125
59	0.01000	300.0	0.000	200.0	665.000	210.000	0.000	0.000	81.600	0.000	956.600	0.000
60	0.01050	900.0	0.000	300.0	590.000	150.000	0.000	177.000	274.840	0.000	1014.840	177.000
61	0.09800	700.0	700.0	210.0	785.000	220.200	220.000	86.800	162.000	259.050	1167.200	565.850
62	0.02400	1200	0.000	0.00	150.000	190.000	0.000	0.000	480.000	0.000	820.000	0.000
63	0.01160	1450	0.000	580.0	1294.000	120.000	0.000	0.000	145.040	0.000	1559.040	0.000
64	0.03000	900.0	900.0	300.0	975.000	300.000	0.000	43.400	67.000	101.750	1342.000	145.150
65	0.11250	2500	0.000	750.0	1195.000	375.000	155.000	46.600	12.000	96.050	1582.000	297.650
66	0.01250	375.0	0.000	125.0	1150.000	155.000	0.000	0.000	120.000	0.000	1425.000	0.000
67	0.03500	1050	0.000	700.0	1248.000	210.000	0.000	0.000	10.040	0.000	1468.040	0.000
68	0.05000	250.0	0.000	100.0	1210.000	28.330	0.000	0.000	0.000	0.000	1238.330	0.000
69	0.01500	450.0	0.000	150.0	685.000	190.000	0.000	0.000	26.700	0.000	901.700	0.000
70	0.01840	920.0	0.000	0.00	2430.000	0.000	0.000	0.000	244.700	0.000	2674.700	0.000
71	0.02500	100.0	0.000	0.00	664.000	280.000	0.000	0.000	83.700	0.000	1027.700	0.000
72	0.01200	450.0	0.000	0.00	425.000	13.500	0.000	90.000	32.000	0.000	470.500	90.000
73	0.02000	600.0	600.0	200.0	445.000	13.500	85.000	95.100	83.540	90.450	542.040	270.550
74	0.02000	600.0	0.000	200.0	696.600	13.500	0.000	0.000	169.000	0.000	879.100	0.000
75	0.05500	330.0	330.0	0.00	880.000	150.000	90.000	139.800	93.000	330.000	1123.000	559.800
76	0.06000	1200	900.0	500.0	710.000	270.000	90.000	139.800	642.200	745.000	1622.200	974.800
77	0.02000	1200	800.0	800.0	690.830	300.000	0.000	0.000	642.000	0.000	1632.830	0.000
78	0.04500	1200	0.000	0.00	1215.830	270.000	0.000	0.000	645.000	0.000	2130.830	0.000
79	0.02000	500.0	0.000	400.0	1180.000	90.000	0.000	0.000	645.000	0.000	1915.000	0.000
80	0.05000	2000	0.000	1000	1270.000	30.000	0.000	0.000	160.000	0.000	1460.000	0.000
81	0.03000	1200	0.000	900.0	867.000	240.000	0.000	0.000	2482.000	0.000	3589.000	0.000

82	0.01400	875.0	0.000	0.00	620.000	105.000	0.000	60.000	2245.000	0.000	2970.000	60.000
83	0.00750	250.0	250.0	250.0	575.000	39.900	90.000	60.000	1282.000	95.600	1896.900	245.600
84	0.12000	8400	8400	6000	885.000	300.000	150.000	259.800	640.000	256.400	1825.000	666.200
85	0.01000	500.0	0.000	300.0	500.000	150.000	0.000	0.000	162.300	861.700	812.300	861.700
86	0.08400	2100	2100	900.0	860.000	330.000	118.500	43.400	720.000	94.500	1910.000	256.400
87	0.01200	600.0	600.0	300.0	60.000	120.000	145.000	43.400	0.000	94.200	180.000	282.600
88	0.10000	0.000	2500	0.00	450.000	0.000	75.000	243.400	85.000	180.000	535.000	498.400
89	0.07500	750.0	750.0	0.00	830.000	380.000	121.000	250.000	25.000	180.830	1235.000	551.830
90	0.13500	1500	0.000	0.00	990.000	255.000	0.000	0.000	91.700	0.000	1336.700	0.000
91	0.77000	800.0	800.0	400.0	75.000	200.000	80.000	20.000	0.000	121.700	275.000	221.700
92	0.40000	0.000	2500	0.00	560.000	0.000	75.000	99.900	13.000	175.700	573.000	350.600
93	0.01360	510.0	0.000	170.0	625.000	150.000	0.000	0.000	90.800	0.000	865.800	0.000
94	0.00500	150.0	0.000	50.00	1135.000	69.900	0.000	0.000	22.000	0.000	1226.900	0.000
95	0.03000	800.0	600.0	200.0	655.000	159.200	157.000	67.500	92.000	98.400	906.200	322.900
96	0.01800	900.0	0.000	600.0	475.000	147.500	0.000	0.000	17.740	0.000	640.240	0.000
97	0.00790	570.0	0.000	0.00	619.000	120.000	0.000	0.000	30.000	0.000	769.000	0.000
98	0.00500	200.0	0.000	150.0	521.200	90.000	0.000	0.000	85.000	0.000	696.200	0.000
99	0.13880	1380	1380	1150	530.000	300.000	162.000	150.000	80.000	121.725	910.000	433.725
100	0.12000	300.0	300.0	0.00	99.000	90.000	130.000	0.000	167.700	97.800	356.700	227.800
101	0.01200	450.0	0.000	0.00	123.000	135.000	0.000	0.000	90.700	0.000	348.700	0.000
102	0.02000	2000	0.000	750.0	650.100	105.000	0.000	0.000	85.000	0.000	840.100	0.000
103	0.03850	1100	0.000	550.0	605.000	270.000	0.000	0.000	0.000	0.000	875.000	0.000
104	0.02000	1250	0.000	500.0	590.000	81.000	0.000	0.000	91.700	0.000	762.700	0.000
105	0.01500	600.0	0.000	210.0	635.000	180.000	0.000	0.000	101.500	0.000	916.500	0.000
106	0.01500	450.0	450.0	0.00	605.000	81.000	230.000	80.100	80.000	310.000	766.000	620.100
107	0.00660	220.0	0.000	0.00	63.500	50.000	0.000	0.000	20.000	0.000	133.500	0.000
108	0.02750	1375	0.000	550.0	1170.000	120.000	0.000	0.000	1120.000	0.000	2410.000	0.000
109	0.02400	3600	0.000	0.00	675.000	105.000	0.000	0.000	6.700	0.000	786.700	0.000
110	0.19600	3430	3430	490.0	510.000	180.000	85.000	63.400	110.800	310.000	800.800	458.400

111	0.01500	1200	0.000	600.0	635.000	167.000	0.000	0.000	5.000	0.000	807.000	0.000
112	0.03000	1200	0.000	300.0	460.000	280.000	0.000	0.000	100.000	0.000	840.000	0.000
113	0.02000	800.0	0.000	600.0	610.000	90.000	0.000	0.000	13.400	0.000	713.400	0.000
114	0.01000	250.0	0.000	1250	1190.000	49.800	0.000	0.000	2485.000	0.000	3724.800	0.000
115	0.15000	2500	0.000	500.0	200.000	330.000	0.000	0.000	0.000	0.000	530.000	0.000
116	0.01700	700.0	0.000	0.00	620.000	108.200	0.000	0.000	161.000	0.000	889.200	0.000
117	0.01800	180.0	180.0	0.00	580.000	174.900	86.000	109.900	93.000	103.400	847.900	299.300
118	0.15000	2000	2000	0.00	1350.000	420.000	380.000	120.000	106.700	141.500	1876.700	641.500
119	0.03000	300.0	300.0	0.00	740.000	195.000	86.000	279.600	19.330	183.400	954.330	549.000
120	0.13000	4550	3900	2600	760.000	360.000	210.000	105.000	1362.000	188.400	2482.000	503.400
121	0.06000	1200	0.000	900.0	590.000	75.000	0.000	0.000	80.000	0.000	745.000	0.000
122	0.01050	750.0	750.0	0.00	595.000	69.900	84.000	100.000	242.000	176.400	906.900	360.400
123	0.02800	2100	0.000	700.0	535.000	169.800	0.000	0.000	90.000	0.000	794.800	0.000
124	0.03000	450.0	0.000	0.00	450.000	150.000	0.000	0.000	92.550	0.000	692.550	0.000
125	1.00000	4000	4000	1000	300.000	300.000	210.000	105.000	0.000	178.400	600.000	493.400
126	0.50000	0.000	4000	0.00	360.000	0.000	75.000	0.000	92.300	183.400	452.300	258.400
127	0.02000	750.0	200.0	0.00	605.000	120.000	43.000	69.900	163.000	178.400	888.000	291.300
128	0.03520	1700	0.000	0.00	755.000	80.000	0.000	0.000	85.850	0.000	920.850	0.000
129	0.67500	7500	6000	3000	920.000	120.000	162.000	65.100	160.000	138.400	1200.000	365.500
130	0.06400	300.0	300.0	0.00	710.000	50.000	162.000	0.000	167.000	117.400	927.000	279.400
131	0.02800	1200	0.000	600.0	630.000	15.000	0.000	0.000	11.700	0.000	656.700	0.000
132	0.12500	2500	2500	1000	650.000	180.000	290.000	140.000	242.000	116.400	1072.000	546.400
133	0.03500	1750	0.000	700.0	628.000	60.000	0.000	0.000	100.000	0.000	788.000	0.000
134	0.06800	1700	1700	0.00	660.000	150.000	78.000	124.900	80.000	99.200	890.000	302.100
135	0.01250	625.0	0.000	250.0	590.000	305.000	0.000	0.000	92.000	0.000	987.000	0.000
136	0.06000	7200	7200	1200	666.000	90.000	84.000	93.200	35.000	777.900	791.000	955.100
137	0.00800	300.0	0.000	100.0	420.000	109.800	0.000	0.000	83.000	0.000	612.800	0.000
138	0.01440	540.0	540.0	270.0	22.500	150.000	72.000	95.100	486.700	100.400	659.200	267.500
139	0.01000	400.0	300.0	200.0	570.000	50.000	75.000	150.000	482.000	374.530	1102.000	599.530

140	0.05400	1440	2160	720.0	615.000	219.600	85.000	150.000	1442.000	237.530	2276.600	472.530
141	0.06000	1500	900.0	600.0	1145.000	124.800	0.000	0.000	483.040	0.000	1752.840	0.000
142	0.02000	650.0	0.000	250.0	567.000	124.800	0.000	0.000	404.040	0.000	1095.840	0.000
143	0.00900	450.0	450.0	150.0	590.000	270.000	43.000	43.400	182.890	106.400	1042.890	192.800
144	0.00800	500.0	0.000	175.0	675.000	210.000	0.000	0.000	1442.000	0.000	2327.000	0.000
145	0.01000	500.0	500.0	250.0	60.000	129.900	75.000	180.000	0.000	455.400	189.900	710.400
146	0.50000	0.000	3000	200.0	710.000	0.000	74.000	180.000	1845.000	375.400	2555.000	629.400
147	0.05000	1500	0.000	1000	560.000	90.000	0.000	0.000	1362.000	0.000	2012.000	0.000
148	0.01400	1200	1500	600.0	570.500	90.000	75.000	210.000	160.000	295.400	820.500	580.400
149	0.01250	500.0	500.0	250.0	25.000	90.000	80.000	60.000	0.000	100.400	115.000	240.400
150	0.50000	0.000	1000	0.00	1120.000	0.000	72.000	80.100	2240.000	263.400	3360.000	415.500
151	0.00800	300.0	0.000	200.0	580.000	90.000	0.000	0.000	2242.000	0.000	2912.000	0.000
152	0.01000	300.0	0.000	200.0	5.000	120.000	0.000	0.000	0.000	0.000	125.000	0.000
153	1.00000	0.000	800.0	100.0	1120.000	0.000	75.000	75.000	2326.000	221.400	3446.000	371.400
154	0.01400	1750	0.000	1050	15.000	60.000	0.000	0.000	0.000	0.000	75.000	0.000
155	0.01600	0.000	1200	160.0	601.700	0.000	75.000	120.000	1443.000	375.400	2044.700	570.400
156	0.05000	2500	2600	1000	625.000	9.510	85.000	43.400	1442.000	4916.700	2076.510	5045.100
157	0.02000	400.0	400.0	200.0	575.000	11.100	75.000	90.000	482.000	271.700	1068.100	436.700
158	0.02000	800.0	800.0	600.0	570.000	46.600	75.000	43.400	1442.000	113.400	2058.600	231.800
159	0.03000	1200	0.000	600.0	620.000	99.900	0.000	0.000	402.000	0.000	1121.900	0.000
160	0.01000	500.0	0.000	500.0	580.000	60.000	0.000	0.000	482.000	0.000	1122.000	0.000
161	0.02000	600.0	600.0	400.0	665.000	60.000	74.000	54.900	25.550	1047.200	750.550	1176.100
162	0.04500	1500	1500	150.0	655.000	180.000	145.000	180.000	0.000	101.700	835.000	426.700
163	0.01800	900.0	0.000	450.0	1182.300	54.900	0.000	0.000	0.890	0.000	1238.090	0.000
164	0.00800	600.0	0.000	160.0	620.000	139.800	0.000	0.000	83.940	0.000	843.740	0.000
165	0.02000	1000	0.000	250.0	620.000	199.800	0.000	0.000	7.000	0.000	826.800	0.000
166	0.03000	1800	0.000	600.0	620.000	139.800	0.000	0.000	80.000	0.000	839.800	0.000
167	0.02800	1200	0.000	400.0	605.000	90.000	0.000	0.000	16.700	0.000	711.700	0.000
168	0.02000	1000	0.000	250.0	635.000	109.800	0.000	0.000	243.725	0.000	988.525	0.000

169	0.01000	375.0	375.0	125.0	640.000	105.000	155.000	41.600	45.000	113.400	790.000	310.000
170	0.00150	600.0	600.0	240.0	60.000	75.000	165.000	46.600	72.000	95.900	207.000	307.500
171	0.01120	840.0	0.000	420.0	635.000	345.000	0.000	0.000	95.275	0.000	1075.275	0.000
172	0.00720	840.0	0.000	240.0	1165.000	90.000	0.000	0.000	174.000	0.000	1429.000	0.000
173	0.01700	1360	0.000	510.0	35.000	105.000	0.000	0.000	0.000	0.000	140.000	0.000
174	0.01500	0.000	1500	0.00	560.000	0.000	148.000	84.900	181.700	455.400	741.700	688.300
175	0.03000	2000	0.000	700.0	900.000	169.800	0.000	0.000	169.000	0.000	1238.800	0.000
176	0.52500	7500	7500	3000	720.000	580.000	200.000	146.800	190.900	119.400	1490.900	466.200
177	0.02000	900.0	0.000	400.0	1330.000	120.000	0.000	0.000	16.700	0.000	1466.700	0.000
178	0.60000	4500	4500	0.00	670.000	135.000	105.000	233.000	25.000	93.400	830.000	431.400
179	0.12500	3000	3000	0.00	1220.000	90.000	85.000	65.100	410.000	128.400	1720.000	278.500
180	0.03000	2400	1800	600.0	45.000	54.900	38.000	46.600	20.000	91.800	119.900	176.400
181	0.02500	2000	2000	750.0	620.000	75.000	75.000	50.000	31.000	251.700	726.000	376.700
182	0.02800	1400	2100	700.0	130.000	105.000	70.000	46.600	51.000	116.700	286.000	233.300
183	0.02000	800.0	800.0	160.0	830.000	69.900	140.000	50.100	427.500	226.000	1327.400	416.100
184	0.00750	500.0	725.0	250.0	40.000	105.000	80.000	69.900	21.000	410.400	166.000	560.300
185	0.02000	2000	2000	500.0	60.000	120.000	170.000	50.000	575.000	98.400	755.000	318.400
186	0.07500	4500	4500	1500	633.000	230.000	170.000	66.600	17.700	97.100	880.700	333.700
187	0.01200	900.0	0.000	0.00	720.000	115.000	0.000	0.000	197.300	0.000	1032.300	0.000
188	0.40000	4000	4000	800.0	760.000	300.000	210.000	165.000	99.000	7315.700	1159.000	7690.700
189	0.01800	1350	1350	450.0	829.500	75.000	160.000	43.400	60.000	786.700	964.500	990.100
190	0.01000	400.0	0.000	140.0	1126.000	0.000	0.000	0.000	190.000	0.000	1316.000	0.000
191	0.01730	645.0	0.000	430.0	50.000	90.000	0.000	0.000	540.000	0.000	680.000	0.000
192	0.01250	500.0	500.0	250.0	1150.000	120.000	155.000	120.000	300.000	168.400	1570.000	443.400
193	0.00700	450.0	0.000	150.0	61.700	164.700	0.000	0.000	325.000	0.000	551.400	0.000
194	0.28000	800.0	800.0	300.0	40.000	0.000	75.000	43.400	190.000	103.400	230.000	221.800
195	0.03750	1000	0.000	500.0	597.500	39.900	0.000	0.000	722.000	0.000	1359.400	0.000
196	0.07000	1400	1400	0.000	710.000	120.000	150.000	20.000	722.000	0.000	1552.000	170.000
197	0.06000	900.0	0.000	600.0	620.000	84.900	0.000	0.000	20.000	0.000	724.900	0.000

198	0.03000	750.0	600.0	0.00	1295.000	46.600	75.000	50.000	26.700	14.400	1368.300	139.400
199	0.07500	1000	1000	0.00	766.700	150.000	200.000	155.000	387.700	108.400	1304.400	463.400
200	0.02000	1500	0.000	750.0	635.000	120.000	0.000	0.000	105.325	0.000	860.325	0.000
201	0.03500	1500	0.000	500.0	95.000	240.000	0.000	0.000	10.000	0.000	345.000	0.000
Total	13.209155	273555	132270	68090	101020.160	24777.060	8794.500	7268.500	50811.285	30089.375	176608.505	46152.375
Average	0.065717189	1360.97	658.0597015	338.7562189	502.588	123.269	43.754	36.162	252.792	149.698	878.649	229.614
Per ha		20709.50	10013.50957	5154.758196	7647.738	1875.749	665.788	550.262	3846.672	2277.918	13370.159	3493.969