CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Humanity is on the move as never before, and most of those seeking a better life leave home and head for a city. More than half of the world's population live in areas that are classified as urban (Brook and Davila, 2000). It is estimated that, in approximately twenty years, two out of every three West Africans will live in the urban centres (Drechsel and Quansah, 1998).

With the resultant rapid increase in urban population growth, there is the need for intensive urban and peri-urban farming to cater for the food requirement of urban dwellers. According to UNDP estimates as many as 800 million people are involved in urban and peri-urban agriculture worldwide (Smit *et al.*, 1996b). Of these, 200 million are market producers, employing 150 million people full-time. However, the scarcity of land, and soil fertility management in the face of impossible shifting cultivation have rendered soils in most urban and peri-urban areas exhausted, and only an immense fertilizer import and/or nutrient recycling will sustain food supply from the urban and peri-urban production areas.

Also of great importance is the issue of urban waste management. Besides the issue of food and soil nutrient requirements, environmental pollution has emerged as another serious consequence of the rapid surge in the urban population growth. In recent times, one method of nutrient recycling that has caught the attention of Municipal and Metropolitan Authorities in the urban centres is organic farming.

Though organic farming is yet gaining popularity among developing countries in Sub-Saharan Africa, it provides a formidable means of fulfilling the dreams of achieving food security for urban dwellers, via the provision of an economic and sustainable source of nutrient and soil conditioner for urban and peri-urban agriculture, while serving as a viable waste management option for urban governments.

Thus organic farming, a single concept can be relied upon to provide solution to two of the major problems currently facing the urban centres, namely food insecurity and improper waste management, with minimum trade-offs, if any at all.

1.2 TYPES OF URBAN AGRICULTURE

Different types of farming systems are found in the urban and peri-urban areas of Ghana. Prominent among these farming systems are the following:

1.2.1 Vegetable Growing Systems

These mainly occur along big drains and streams, the water from which is used for irrigation. In a few cases, pipe-borne water is used. Crops grown include; exotic vegetables such as lettuce, cabbage, carrot, sweet pepper and herbs which need intensive care. Also included are tomatoes, pepper, okra and other leafy vegetables.

1.2.2 Seasonal Farming

These rely entirely on rainfall. Mainly food crops are grown, most commonly maize but also cassava, millet, yam, rice and beans are common. Crops grown for sale include tomatoes, pepper, and in a few cases okra, groundnut and other specialized crops.

1.2.3 Backyard Gardening

These basically comprise the cultivation of crops for home consumption. It is carried out throughout the year and both rain and pipe-borne water are used. Intercropping of vegetables is very common; however, a few crops like maize and legumes are grown as sale crops during the rainy season.

1.2.4 Commercial Livestock

These differ from the keeping of small ruminants and poultry by virtue of its scale and market orientation. The main livestock kept for commercial purposes is cattle, poultry and pigs.

1.2.5 Small Ruminants and Poultry Farming Systems

These usually appear to be the largest farming category within most cities. Animals usually kept include goats, sheep, ducks and chicken.

1.3 PROBLEM STATEMENT

The concept of exploiting our resources and technology in producing enough to feed the ever-increasing human population would have been a laudable one but for the long-term negative effects of some of those technologies on the soil/environment.

Apart from its high cost, chemical fertilizer, when used for intensive crop production leaves the soil acidic and when washed away into water bodies, becomes a threat to aquatic life and human health.

In the light of the above argument, organic farming is gradually becoming popular in urban and peri-urban agriculture, especially with regard to irrigated urban vegetable production. However, the financial viability of organic urban vegetable production has not been assessed vis-à-vis that of chemical fertilizer.

1.4 OBJECTIVE OF THE STUDY

The main objective of this study is to assess the utilization of poultry manure as a sustainable and financially viable alternative to other modes of soil fertility management in cabbage production within the Kumasi Metropolis.

1.4.1 Specific Objectives

1. To identify and categorise urban cabbage production in the Kumasi Metropolis based on the modes of soil fertility management.
2. To identify inputs used, and estimate the total cost of production (GH¢/ha) for each mode of cabbage production.
3. To determine the benefit or returns (GH¢/ha) from each soil fertility management mode by valuing the economic yield (kg/ha) of cabbage from it.
4. To compute the cost-benefit ratio for each mode of cabbage production and use it as proxy for profitability.
5. To identify and compare the externalities associated with each mode of cabbage production.

1.4.2 Research Questions

Based on the above specific objectives the following research questions were developed:

1. What are the various modes of cabbage production in the Kumasi Metropolis with respect to soil fertility management?
2. Which type of inputs does each mode use, and what is the corresponding total cost (GH¢/ha) of production?
3. How much is the benefit or returns (GH¢/ha) from each mode of cabbage production with respect to economic yield (kg/ha)?
4. What is the cost-benefit ratio for each mode of cabbage production?
5. What are some of the externalities associated with each mode of cabbage production?

1.5 *A PRIORI* EXPECTATION

Urban vegetable production irrespective of the type cannot be sustained on continuous basis without immense fertilization due to the strong competition for the limited land area in the urban centres, between food production and infrastructural needs of the ever-increasing urban populace. However, the application of soil/nutrient amendments results in additional cost, which decreases profit, when the additional revenue does not happen to be greater. That notwithstanding, chemical or inorganic fertilizer is envisaged to be an economically viable alternative to organic fertilizer like poultry manure in the attainment of urban food security under efficient land management. This is because unlike poultry manure, mineral components of chemical fertilizer are readily made available for plant absorption. Also poultry manure may not be readily available to farmers, and if available, the quantity may be limited. In addition, poultry manure may be bulky in handling.

1.6 HYPOTHESES

1. The first Null hypothesis is that; there is ***no*** significant difference among the ***means of economic yield*** from the various production modes or treatments. In other words; the ***means of economic yield*** from the production modes are equal.

   Mathematically expressed as; $\mathbf{H_0: \mu^{\psi}_{PM} = \mu^{\psi}_{IF} = \mu^{\psi}_{PM+IF} = \mu^{\psi}_{CTRL}}$

   Where μ^{ψ} refers to the means of economic yield from the various production modes (treatments) And PM, IF, PM+IF, and CTRL represent Poultry Manure, Inorganic Fertilizer, Poultry Manure+Inorganic Fertilizer, and Control respectively.

   The Alternative hypothesis ($\mathbf{H_1:}$) is that; there is a significant difference among the ***means of economic yield*** from the various cabbage production modes (treatments).

   Mathematically expressed as; $\mathbf{H_1: \mu^{\psi}_{PM} \neq \mu^{\psi}_{IF} \neq \mu^{\psi}_{PM+IF} \neq \mu^{\psi}_{CTRL}}$

2. The second Null Hypothesis is that; there is ***no*** significant difference among the ***means of profitability*** from the various production modes (treatments). In other words; the ***means of profitability*** from the production modes are equal.

   Mathematically expressed as; $\mathbf{H_0: \mu^{\pi}_{PM} = \mu^{\pi}_{IF} = \mu^{\pi}_{PM+IF} = \mu^{\pi}_{CTRL}}$

Where μ^{π} refers to the means of profitability from the various production modes (treatments) And PM, IF, PM+IF, and CTRL represent Poultry Manure, Inorganic Fertilizer, Poultry Manure+Inorganic Fertilizer, and Control respectively.

The Alternative Hypothesis ($\mathbf{H_1}$**:**) is that; there is significant difference among the ***means of profitability*** obtained from organic urban vegetable production and that of chemical fertilizer. In other words, the ***means of profitability*** from the different production modes are ***not*** equal.

Mathematically expressed as; $\mathbf{H_1: \mu^{\pi}_{PM} \neq \mu^{\pi}_{IF} \neq \mu^{\pi}_{PM+IF} \neq \mu^{\pi}_{CTRL}}$

1.7 JUSTIFICATION OF THE STUDY

In spite of the increasing amount of literature on urban and peri-urban farming systems, little seems to have been done about the financial viability of the different vegetable production modes that are identified in a locality. The insufficient information on the comparative analysis of these production modes makes it quite mind boggling for policy makers and the prospective urban and/or peri-urban vegetable farmer alike when it comes to advocating organic urban vegetable production and selecting mode of production respectively. Besides, the large amount of money spent on inorganic fertilizers, with the attendant environmental implications makes a case for exploration of alternatives with financial and environmental advantages.

This work provides the necessary information required to fill this existing gap in the literature on urban farming systems. Upon this information, a sound decision can be made by policy makers and the prospective urban vegetable farmer as to which among the alternative production modes to promote and adopt respectively.

1.8 DEFINITIONS OF CONCEPTS

1.8.1 Urban and Peri-Urban Farming Systems

Urban Agriculture is a term originally used to cover intra-urban agriculture (popularly referred to, and used here in this text as urban farming systems) and peri-urban agriculture.

Urban agriculture is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, city or metropolis, which grows or raises, processes and distributes a diversity of food and non-food products, (re)-using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area (Aldington, 1997).

Among the farming systems common in urban areas are; aquaculture, horticulture, livestock, poultry, agro forestry, mushroom farming, snail farming and apiculture (Smit *et al.*, 1996). The peri-urban areas abound with relatively large-scale productions of agronomic crops mostly in the form of truck farming and market gardening.

Although, it is widely acclaimed that, the above mentioned farming systems are the most commonly identified in the urban and peri-urban areas, this study will be based only on cabbage production modes identified in the Kumasi Metropolis with respect to soil fertility management.

Based upon this criterion, the following three (3) cabbage production modes have been identified in the study area; urban-Kumasi and its peri-urban areas. They are: Poultry Manure, Chemical (Inorganic) Fertilizer, and a combination of the two namely Poultry Manure+Inorganic Fertilizer production modes.

Detailed information on urban and peri-urban farming systems has been provided in chapter two.

1.8.2 Production Mode

This refers to the method of production. In other words, production mode in this context refers to the kind of soil fertility management adopted by the farmer. Experimentally, production mode as used in this context refers to the type of treatment.

1.8.3 Vegetable Production Systems

These mainly occur along big drains and streams, the water from which is used for irrigation. In a few cases, pipe-borne water is used. Crops grown include; exotic vegetables such as lettuce, cabbage, carrot, sweet pepper and herbs which need intensive care. Also included are tomatoes, pepper okra and other leafy vegetables.

1.8.4 Cost-Benefit Analysis

Cost-Benefit analysis is an assessment of the worthiness of an investment by comparing its associated costs with the benefits. For the prospective urban and/or peri-urban vegetable farmer, various criteria exist for him/her to use in coming out with the best vegetable production mode. One of such effective criteria for the above is the cost-benefit analysis.

Cost-benefit of urban and peri-urban farming systems is an economic and/or financial analysis of urban and peri-urban farming systems, carried out to determine which among the alternative farming systems have acceptable returns (income), by comparing their costs and benefits.

In coming out with the best (most cost-effective) urban and peri-urban farming system, the cost and the benefit of the different urban and peri-urban farming system must first be identified. However, in project analysis, the objectives provide the standard against which cost and benefit are defined (Gittinger, 1982).

King'ori (2004) outlined the following as some of the objectives in urban/peri-urban vegetable production:

a) Contribute to food security.

b) Increase value of agric produce in urban /peri-urban area.

c) Ensure the sustainable management of urban environment.

d) Create employment.

1.8.5 The One-Way ANOVA

In research works like this, where the effectiveness of various methods of individual treatments (usually more than two treatments) is studied, there are options available, regarding the analysis. Specifically, in terms of comparing the ***means*** of the treatments and making decision on their effectiveness.

One popular method of performing this analysis is by doing all possible ***t-tests***, called the ***multiple t-tests***. In the context of this particular study, the ***mean*** profitability of chemical fertilizer+poultry manure is first compared with that of chemical fertilizer, and then that of poultry manure. After which, the ***mean*** profitability of chemical fertilizer is also compared with that of poultry manure. Three separate ***tests*** would result from this procedure. Therein lies the difficulty with the ***multiple t-tests***.

Firstly, because the number of ***t-tests*** increases geometrically, as a function of the number of treatments, analysis becomes cognitively difficult. An analysis of variance, however, organises and directs the analysis, allowing easier interpretation of results.

Secondly, by performing a greater number of analyses, the ***experiment-wise error rate*** increases. That is to say; the probability of committing at least one ***type I error*** somewhere in the analysis greatly increases. Performing fewer number of hypothesis ***tests***, however, reduces the ***experiment-wise error rate***. Hence the ANOVA procedure is recommended.

1.8.6 Marginal Analysis

Marginal analysis as used within this context is a procedure for calculating Marginal Rates of Return (MRR) between technologies, proceeding in a stepwise manner from a lower-cost technology to the next higher-cost technology, and comparing marginal rates of return to minimum acceptable rates of return (Perrin *et al*., 1988). The procedure is useful for making recommendations to producers and for selecting alternative technologies. The economic principle underlying the analysis is that; it is worthwhile for a producer to continue investing up to the point where the return from each extra unit invested equals the cost of the extra unit. As applied to a situation in which the producer is confronted with a set of discrete alternative technologies, the producer should invest in the costlier technology as long as the Marginal Rate of Return (MRR) in switching from a lower-cost technology to a higher-cost technology is greater than the Minimum Acceptable Rate of Return (MARR). Hence, recommending technologies to producers is not based solely on the premise that a technology must be profitable but it must also satisfy the added criterion that the MRR must be above a given MARR (Evans, 2008).

1.9 LIMITATIONS OF DATA

The completion of every research work like this is usually associated with constraints in one way or the other. This study is of no exception. The major problem encountered in the study was with record keeping; there was no properly kept record on farm operations, expenses and sales. The responses of the farmers, which were made use of in this study, are thus approximations of what could have been the most accurate information.

Again, a single production cycle was assessed and hence the tendency of disparity of cost-benefit ratio for the production modes or treatments in different cycles. (i.e. seasonality effect could not be observed)

Lastly, there was a general reluctance on the part of farmers to give information about their farming operations, especially regarding farm income.

In spite of the shortcomings spelt out, all possible means were exploited in order to present more accurate information upon which sound decision can be made. Also, this work provides an essential baseline for future studies.

1.10 DELIMITATIONS

The first delimitation is that; only sixty (60) cabbage producing farmers in the Kumasi Metropolis were sampled for this study.

The second delimitation is related to the type of poultry manure. Poultry manure used in the study was obtained from layer birds.

CHAPTER TWO

2.0 REVIEW OF LITERATURE

2.1 URBAN AND PERI-URBAN FARMING SYSTEMS

Although there is an increasing amount of literature on this topic, studies of urban and peri-urban farming systems in West Africa are scattered and scanty (Smith, 1999).

A wide spectrum of production modes can be found ranging from household subsistence to large-scale commercial farming. In general, there is a tendency towards more intensive production modes that better satisfy the increasing urban demand, in the peri-urban than in rural areas. Often, larger urban centres have conspicuous inner and outer zones where cultivation of food crops and market gardening are being pursued vigorously (Adam, 1998; Smith, 1999).

In general, this confirms the model described by Von Thunen in 1826. He concluded that farm products would be grown in a series of concentric zones outward from a central market city. Perishable crops or those which are high yielding, would be grown nearest to the city because readily accessible farmland would be in great demand and, therefore, quite expensive. Livestock production, potatoes and cereals would be raised farther away. Since transport cost to the city increase with distances, there comes a point beyond which it is uneconomical to grow food for the urban centres (Smith, 1999).

2.1.1 Distinction between Urban (Intra-Urban and Peri-Urban) Agriculture and Rural Agriculture

In a rare comparison between rural and urban agriculture (farming systems) Moustier (1998) defines urban agriculture as; agriculture being carried out within or on the outskirts of a city where a non-agricultural use of local resources is a real option, rural agriculture is found in areas where its option is not an issue (Bakker *et al.*, 2000).

In the CIRAD - Agricongo Study of (open-space) market vegetable farming in Brazzaville, for instance, gardens within the city limit are labelled "intra urban" whereas those off-limit (though within a certain travel time band) are called peri-urban (Moustier, 99; Bakker *et al.*, 2000). By far, the element most common to reviewed definitions is location "in (within) and around" cities or urban areas (e.g. Smit *et al.*, 1996b; Bakker, 2000).

Most urban agriculture field studies have been carried out in large urban centres, national capitals or secondary cities. Thus few can be assumed to have largely dealt with agriculture located in rural areas "typical" of the respective countries. However, few actually differentiate between intra and peri-urban location. Those which do so have used as criteria, for intra-urban agriculture, population size, density of household, officiatory limits (Murray 1997; Bakker *et al.*, 2000), municipal boundaries of the city (Armar-Klemesu and Maxwell, 1998), agricultural use of land zoned for other use (Mbiba, 1994), and agriculture within legal and regulatory purview of urban authorities (Aldington, 1997).

2.1.2 Differences between Intra and Peri-Urban Agriculture

In contrast to intra-urban location well within the older and more settled urban fabric, peri-urban locations are in closer contact with rural areas and tend to undergo, over a given period of time, more dramatic agricultural changes than do locations in more central and built-up parts of the city.

Many authors recognize the need to differentiate peri-urban agriculture from intra-urban agriculture, but criteria used vary widely (Bakker *et al*., 2000).

The leading feature of urban agriculture which distinguishes it from rural agriculture is its integration into the urban economic and ecological system. It is not its urban location, which distinguishes urban agriculture from rural agriculture, but the fact that it is embedded in and intersecting with the urban ecosystem (Richter *et al.*, 1995; Bakker *et al.*, 2000).

In a diagram representing some farming systems for which the occurrence in the peri-urban appeared to be related to distance from the city centres, Brook and Davila (2000) classified major farming systems in the peri-urban into four (4) groups, namely; Tree crops, Intensified cereal crops, Commercial poultry farming and Green maize and Backyard farming.

In a similar work, researchers found that, there were two forms of urban cropping activity in Kumasi; backyard farming and agriculture "in the gaps" - crop production on vacant plots or low lying land between urban developed zones (Brook and Davila, 2000).

2.2 THE IMPORTANCE OF URBAN AND PERI-URBAN FARMING SYSTEMS

Urban and Peri-urban farming or agriculture is one source of supply in urban food systems and one of several food security options for households. Similarly, it is one of several tools for making productive use of urban open space, treating and/or recovering urban solid and liquid wastes, saving or generating income and employment, and managing fresh water resources more effectively. (Bakker *et al.*, 2000)

Smit *et al.*, (1996b) claim that an estimated 800 million people are engaged in urban Agriculture worldwide; of these, 200 million are market producers, employing 150 million people full-time.

Data on several production systems show dramatic growth in number of producers, production system at work, area used, production and yield in several cities. Both output and yield have increased, despite area reduction in market vegetable gardening in Dakar (Bakker *et al.*, 2000). Similar trends are observable in Kumasi (Abutiate, 1995).

2.3 MAIN DOUBTS AND RISK RAISED BY URBAN AGRICULTURE

Little could be found in the academic literature which would condemn urban Agriculture at large and advocate its ban under any form. The debate is likely to heat up as urban Agriculture practice and policy grow in scale and in complexity in the next decade, thus affecting interest in very different and tangible ways. Some have argued that greater public support to urban agriculture in large cities would fuel rural-urban migration because several surveys show that most migrants to large cities come from rural areas (Bakker *et al.*, 2000). The surveys further suggest that migrants arrive in the cities with the initial ambition to work in anything but agriculture and that a majority of urban producers are not recent arrivals. Others have contended that, public support to urban Agriculture could significantly reduce public investment in rural agriculture, while urban agriculture needs intersectional co-ordination of current financial flows much more than major new funding. There is a gathering perception that, in an increasingly urban world, development challenges, among which are poverty and hunger reduction will not be met unless holistic agricultural policies tap on urban and rural complementarities, rather than ignoring them (Bakker *et al.*, 2000). Other doubt and risk raised by urban Agriculture include the assertion that urban Agriculture hampers urban development and as such agriculture should be confined to rural areas as it can interfere with more productive use/rent of land by other economic activities.

Also there is the argument of urban Agriculture posing a threat to public health. Such concerns refer to contamination risk of producers, handlers, consumers and people in the vicinity of production areas caused by crop and husbandry input, products and by-products. Environmental health issues including visual untidiness, soil erosion, destruction of vegetation, siltation, depletion of water bodies, and pollution of resources (air, soil and water) are also part of the doubts and risks raised by urban Agriculture.

Lastly, others also perceive urban Agriculture not to be a profitable venture compared to rural Agriculture.

2.4 URBAN AGRICULTURE AND FERTILIZER USE

Fertilizer could be defined as a substance that provides plant nutrients when added to the soil. The term normally refers to inorganic chemicals containing one or more of the basic plant nutrients: nitrogen, phosphorus, or potash. It may also refer to compounds containing trace elements such as; boron, cobalt, copper, iron, manganese, molybdenum, zinc, and lime, which is used to correct acidity; or to a concentrated organic substance such as dried blood and bone meal. The term is also popularly used in a general sense to include organic materials, such as manure and compost. Fertilizers are added to the soil in granular, crystalline, powder, or liquid forms and may be injected directly into the ground or broadcast on the surface. Nitrogen usually comes in the form of nitrates or ammonium compounds, phosphorus in the form of phosphates, and potash in the form of potassium chloride or sulphate. Fertilizers can be organic (composed of organic matter) or inorganic. Fertilizers typically provide, in varying proportions, the three major plant nutrients (nitrogen, phosphorus, and potassium), the secondary plant nutrients (calcium, sulfur, magnesium), and sometimes trace elements (or micronutrients) with a role in plant nutrition: boron, chlorine, manganese, iron, zinc, copper and molybdenum (Cambridge Encyclopedia vol. 25).

2.4.1 Inorganic (Mineral) Fertilizers

Examples of naturally-occurring inorganic fertilizers include Chilean sodium nitrate, mined "rock phosphate" and limestone, a calcium source, which is mostly used to reduce soil acidity. Examples of manufactured or chemically-synthesized inorganic fertilizers include ammonium nitrate, potassium sulfate, and superphosphate, or triple superphosphate (Cambridge Encyclopedia vol. 25).

2.4.2 Organic Fertilizers

Examples of naturally occurring organic fertilizers include manure, slurry, worm castings, peat, seaweed and guano. Naturally occurring minerals such as mine rock phosphate, sulfate of potash and limestone are also considered organic fertilizers. Examples of manufactured organic fertilizers include compost, dried blood, bone meal and seaweed extracts (Cambridge Encyclopedia vol. 25).

Some ambiguity in the usage of the term 'organic' exists because some synthetic fertilizers, such as urea and urea formaldehyde, are fully organic in the sense of organic chemistry (Cambridge Encyclopedia vol. 25).

Although the density of nutrients in organic materials is comparatively modest, they have some advantages. Since the majority of nitrogen supplying organic fertilizers contain insoluble nitrogen and are slow-release fertilizers their effectiveness can be greater than conventional nitrogen fertilizers. They re-emphasize the role of humus and other organic components of soil, which are believed to play several important roles namely; mobilizing existing soil nutrients so that good growth is achieved with lower nutrient densities while wasting less releasing nutrients at a slower, more consistent rate; helping to avoid a boom-and-bust pattern; helping to retain soil moisture; reducing the stress due to temporary moisture stress; and improving the soil structure. Organic fertilizers also have the advantage of avoiding certain long-term problems associated with the regular heavy use of artificial fertilizers such as the possibility of "burning" plants with the concentrated chemicals (i.e. the necessity of reapplying artificial fertilizers regularly and perhaps in increasing quantities) to maintain soil fertility, the rising cost (substantial in recent years) and resulting lack of independence (Cambridge Encyclopedia vol. 25). Organic fertilizers also have their disadvantages though, in that, they are typically a dilute source of nutrients compared to inorganic fertilizers, and where significant amounts of nutrients are required for profitable yields, very large amounts of organic fertilizers must be applied. Again, the composition of organic fertilizers tends to be highly variable, thus accurate application of nutrients to match plant production is difficult. Hence, large-scale agriculture tends to rely on inorganic fertilizers while organic fertilizers are cost-effective on small-scale horticultural or domestic gardens (Cambridge Encyclopedia vol. 25).

In practice a compromise between the use of artificial and organic fertilizers is common; typically by using inorganic fertilizers supplemented with the application of organic materials that are readily available such as the use of crop residues or the application of manure (Cambridge Encyclopedia vol. 25).

2.4.3 Poultry Manure as an Organic Fertilizer

Animal manures have been used effectively as fertilizers for centuries. And poultry manure has long been recognized as perhaps the most desirable of these natural fertilizers because of its high nitrogen content. In addition, manures supply other essential plant nutrients and serve as a soil amendment by adding organic matter. Organic matter persistence will vary with temperature, drainage, rainfall, and other environmental factors. Because the presence of organic matter in the soil improves moisture and nutrient retention, the utilization of manure has become an integral part of sustainable agriculture (Sloan *et al*, 2003).

The increased in size and frequent clean-out of many poultry operations, make poultry manure available in sufficient quantities, and on a timely basis to meet most fertilization needs. Nonetheless, the most common procedure for determining the amount of manure to add per acre is to consider the manure's nitrogen content and the nitrogen needs of the crop. Some typical compositions for poultry manure are listed in the table below.

Table 2.1 Average Nutrient Composition of Chicken Manures

Average Nutrient Composition of Chicken Manures				
Manure Type	**Total N**	**Ammonium (NH_4-N)**	**Phosphorus (as P_2O_5)**	**Potassium (as K_2O)**
Broiler	lb/ton			
Fresh (no litter)	26	10	17	11
Broiler house litter	72	11	78	46
Breeder house litter	31	7	54	31
Stockpiled litter	36	8	80	34
Layer				
Fresh (no litter)	26	6	22	11
Under cage scraped	28	14	31	20
High-rise stored	38	18	56	30
	lb/1,000 gallons			
Liquid slurry	62	42	59	37
Anaerobic lagoon sludge	26	8	92	13
	lb/acre-inch			
Anaerobic lagoon liquid	180	155	45	265

Source: Biological and Agricultural Engineering Department, NCSU

2.4.4 Effects of Organic and Inorganic Fertilizers on Soil Fertility and Crop Quality

In 1958, Pettersson of the Nordic Research Circle for Biodynamic Farming in Järna, Sweden, began an agricultural field experiment that lasted until 1990, i.e. 32 years. The field experiment included eight different fertilizer treatments, each with a four-year crop rotation without repetitions: summer wheat, clover/grass mix, potatoes, and beets. The focus was primarily on aspects of crop quality, and the fertilizer application rates for the various treatments were adjusted to bring about comparable yields (Granstedt, 1992).

Two "daughter experiments" emerged from the main-experiment and were run in parallel with the mother project during 1971-1976 in Uppsala and 1971-1979 in Järna. In these experiments a comparison was made between two systems; biodynamic farming and conventional farming, in which both fertilizer regimes and crop rotations were studied (Dlouhy, 1981).

During the time between 1958 and 1990 the yield increased in all treatments in accordance with the overall trend in the Swedish agriculture, but the increase was highest in the organic treatments (65 % in the biodynamic in comparison with 50 % in the conventional). The effects of the different fertilizer treatments on product quality was in accordance with findings in the two "daughter experiments" which were based on the original main-experiment (Granstedt, 1992).

Compared with the conventional treatments, the crude protein content of potatoes and wheat was lower in the organic treatments, but protein quality was higher (i.e. relatively pure protein and essential amino acids, lower amount of free amino acids). Resistance to decomposition and store quality for potatoes were higher in the organic treatments, and starch quality seemed to be higher in wheat (Granstedt and Kjellenberg, 1997).

The organic treatments resulted in a higher soil fertility capacity and in crops; with higher quality protein, higher starch content, and a greater ability to tolerate stressful conditions and long-term storage in comparison with the inorganic treatments. Furthermore, the crops produced in the organic treatments developed a structure that could be studied through a picture formation method (Crystallization with CuCl2). This has also been described as a higher organizational level which is evident in terms of both soil and crop formation as a result of the long-term effects of organic manure compared with conventional NPK-fertilizer (Granstedt and Kjellenberg, 1997).

New experiments in Sweden and Finland have been started to study the effects of different organic treatments on farms. Preliminary results of these experiments confirm the described differences between organic and inorganic treatments, but indicate also that the effects of liquid organic manure on quality parameters are more similar to those of inorganic fertilizer (Granstedt and Kjellenberg, 1997).

Kisselle *et al.* (2003) carried out an experiment on the "Effects of Fertilizer Type (Chicken Litter Vs. Inorganic Fertilizer) and Cattle Grazing on the Soil Microbial Community." Results from the experiment indicated that Broiler litter plots had fewer fungi and slightly more bacteria and actinomycetes than plots receiving inorganic fertilizer.

2.4.5 Environmental Effects of Fertilizer Use

Since the Second World War the use of inorganic fertilizers has risen in response to the huge increases in grain production. Between 1945 and 1995 application levels of inorganic fertilizers have increased from 50 to 325 kg per hectare. But high levels of fertilizer application, especially of nitrogenous compounds, can cause pollution of watercourses and drinking water supplies. And in some countries, legal limitations are imposed on the total quantity of fertilizer which may be added to the land during each season. Little wonder then, that there is the public perception that inorganic fertilizers "poison the soil" and result in "low quality" produce in many countries. When used appropriately, however, inorganic fertilizers enhance plant growth, the accumulation of organic matter and the biological activity of the soil, while reducing the risk of water run-off, overgrazing and soil erosion. And the nutritional value of plants for human and animal consumption is typically improved when inorganic fertilizers are used appropriately (Cambridge Encyclopedia, vol. 25).

2.5 COST-BENEFIT ANALYSIS

2.5.1 Indicator of Worthiness

Cost-Benefit analysis is one of the tools for analyzing agricultural projects, by comparing costs with benefits and determining which among alternative projects have an acceptable return. A good indicator of worthiness should be comprehensive; thus, it should take into consideration/calculation of all the cost and benefit items involved in, and brought about by the project respectively. All these should be appropriately valued. If these two conditions are not met, the value of the indicator is in serious doubt (Panel, 1970).

The purpose of an indicator of worthiness is in two folds. These are; to make possible the acceptance or rejection of the project and to afford its ranking among alternative projects. Any indicator which does not satisfy these two requirements is defective and should not be used in measuring the worthiness of a project (Panel, 1970).

The indicators of worthiness can be either financial or economic. The difference between the two types of indicators stands from the composition of costs and benefits and their method of valuation. In the case of financial indicators, only the direct primary costs and benefits of the project are taken into account and they are valued at market prices (current or projected): discounting may or may not be attempted.

In the case of economic indicators both primary (indirect and direct) and secondary costs and benefits are taken into account and they are valued at shadow prices which reflect the opportunity cost of resources to the society. In the calculation of economic indicator, costs and benefits are usually discounted thus; they are adjusted to make allowance for the time preference scale of society. Generally, the financial indicators are used to measure the worthiness of a project to individual farmers and farm enterprises. Economic indicators on the other hand are used to assess the worthiness of a project to the society at large (Panel, 1970).

In project analysis, the objective of the analysis provides the standard against which costs and benefits are defined (Gittinger, 1982). Project analysis tries to identify and value the costs and benefits that will arise "with" the proposed project and to compare them with the situation as it would be "without" the project (Gittinger, 1982). However, this comparison is normally done for projects which last for more than a year.

2.5.2 Cost-Benefit Ratio and Working Definition

Adegeye and Dittoh (1985) defined cost-benefit ratio as the ratio of discounted costs to discounted revenue and is given by the formula: C/B = $\dfrac{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}$

Where C_t = Cost in each project year

B_t = Benefit in each project year

n = Number of years

r = Interest (discount) rate.

As an indicator of worthiness, this ratio is expressed in this study as the value of total cost of production divided by the value of total output from the production. When the ratio is less than unity the project is considered to be financially justified. That is to say the benefits outweigh the costs.

Mathematically: $$C/B = \frac{\sum[Inputs\ costs]}{\sum[Benefits(Revenue)]}$$

2.6 THE ONE-WAY ANOVA

As outlined in the Chapter One, the difficulty and time-consuming nature of the ***multiple t-tests***, coupled with the relatively high exposure to a ***type I error*** when the analysis involves more than two treatments underscores the preference for the One-Way ANOVA, which organises and directs analysis, allowing easier interpretation of results.

2.6.1 Some Applications of the One-Way ANOVA

Hall (1998) employed the use of the one-way ANOVA to study the effect of learning in groups of three and two against individual efforts on the performance of students. The study tested the hypothesis that; "learning in groups of three will be more effective than learning in pairs or individually," at a 5% α level and found that; "Those who studied individually scored significantly lower than those who studied in dyads or triads, while the latter two groups did not differ significantly from one another." In other words, the experiment indicated that studying in a group is more effective than studying individually, but the size of the group (two vs. three members) is not important.

According to Lowry (2007), while working on developing a cure for patients with Alzheimer's disease in 2002, a team of investigators from the Vassar College, Poughkeepsie, NY- USA used One-Way ANOVA in testing the effect of their experimental medication on four (4) groups of trained rats, and found that there was significant difference among the means of the various groups at 1% α level.

Stockburger (1996) studied the effectiveness of various methods of individual therapy on changes in self-concept of patients. The purpose of the study was to determine if one method was more effective than the other methods. Analysis of the study was done with the one-way ANOVA, and indicated a significant difference among the means (effectiveness) of the various methods of individual therapy at 1% α level.

2.7 MARGINAL ANALYSIS AS AN ECONOMIC PROCEDURE FOR SELECTING ALTERNATIVE TECHNOLOGIES/PRACTICES

Many agricultural researchers/extension agents today incorporate some level of economic analysis in decisions concerning the alternative technologies or practices they recommend to agricultural producers for improving income. This is in sharp contrast to the earlier periods when little or no economics were included in the decision-making process. At that time, researchers' recommendations were based solely on increasing yields because they thought producers were only interested in net returns. In recent times, however, researchers and those who recommend improved practices to the agricultural community, consider how proposed technologies and their associated risks may impact profitability, by undertaking marginal analysis, and therefore have become involved in the early stages of research planning and analysis. (Perrin, *et al*., 1988)

Marginal Analysis, like other economic principles, can aid researchers/extension agents in recommending or selecting technologies/practices that are the most profitable and have the best chance of being adopted by producers. Unlike other tools for analyzing agricultural projects, which compare costs with benefits and determine which among alternative projects have an acceptable return, Marginal Analysis does not always recommend the technology with the highest Yield, Net Benefit, Average Return, or Marginal Rate of Return (MRR) as the best. (Perrin, *et al*., 1988)

2.8 PRICING PROJECT - COSTS AND BENEFITS

Identified costs and benefits must be valued if they are to be compared. Since the only practical way to compare differing goods and services directly is to give each a money value, we must find the proper prices for the cost and benefits in our analysis.

2.8.1 Prices Reflect Value

Underlying all financial and economic analysis is an assumption that prices reflect value or can be adjusted to be so. (Gittinger, 1982) From a single farmer to the economy as a whole, the same principles apply. In a "perfect" market, every economic commodity would be priced at its marginal value product. This is the price at which every good and service would exactly equal the value that the last unit utilized contributes to production or the value in use of the item for consumption would exactly balance the value it could contribute to additional production.

2.9 POINT OF FIRST SALE AND FARM GATE PRICE

In project analysis, a good rule for determining a market price for agricultural commodities produced in the project is to seek the price at the "point of first sale". According to Adegeye and Dittoh (1985), market exists wherever buyers and sellers can be in touch with one another. However, for many agricultural projects in which the objective is to increase production of a commodity, the best point of first sale to use is generally the boundary of the farm. We are after what the farmer receives when he sells his product at the "farm gate price". Usually the price at point of first sale can be accepted as the farm gate price, even if this point is in a nearby village market, the farmer sells his output there and thus earns for himself any fee that might be involved in transporting the commodity from the farm to the point of first sale.

But if any new equipment is necessary to enable the farmer to do this, say a new bullock cart or a new truck, then, that new equipment must be shown as a cost incurred to realize the marketing benefits in the project.

2.10 LIMITATIONS OF OTHER WORKS

Most works involving financial analysis of agricultural project do not cost family labour. However, this study costs family labour at the value of hired labour prevailing in the location of the enterprise. In this way, the total cost actually incurred on the project is presented to the prospective farmer for the preparation of more efficient or balanced budget. Apart from increasing the accuracy of budgeting for the prospective farmer, it also sensitizes the present farmer on the exact contribution he makes in his production.

Anderson (1988) worked on the economics of afforestation in Africa, as a case study. Even though his study included cost-benefit analysis, it focused more on the "with" and "without" the project impact of afforestation on the welfare of the farmer and the community as a whole. Thus cost benefit analysis was carried out solely on afforestation as a single farming system. However, this study seeks to compare the cost-benefit of different cabbage production modes in urban Kumasi and its peri-urban areas.

Balma and Sule (1999) considered cost-benefit analysis while working on the Economics of guinea fowl production and its contributions to household food security. Again the analysis was narrowed to a single production mode.

Working on the occurrence of different farming systems in the peri-urban areas, with respect to relative distance to the city centres, Bakker *et al*. (1997) classified major farming systems in the peri-urban areas of Kumasi into four (4) groups but failed to talk about the profitability of these farming systems. This study however, identifies cabbage production modes in urban Kumasi and its peri-urban areas and provides vital information on their profitability.

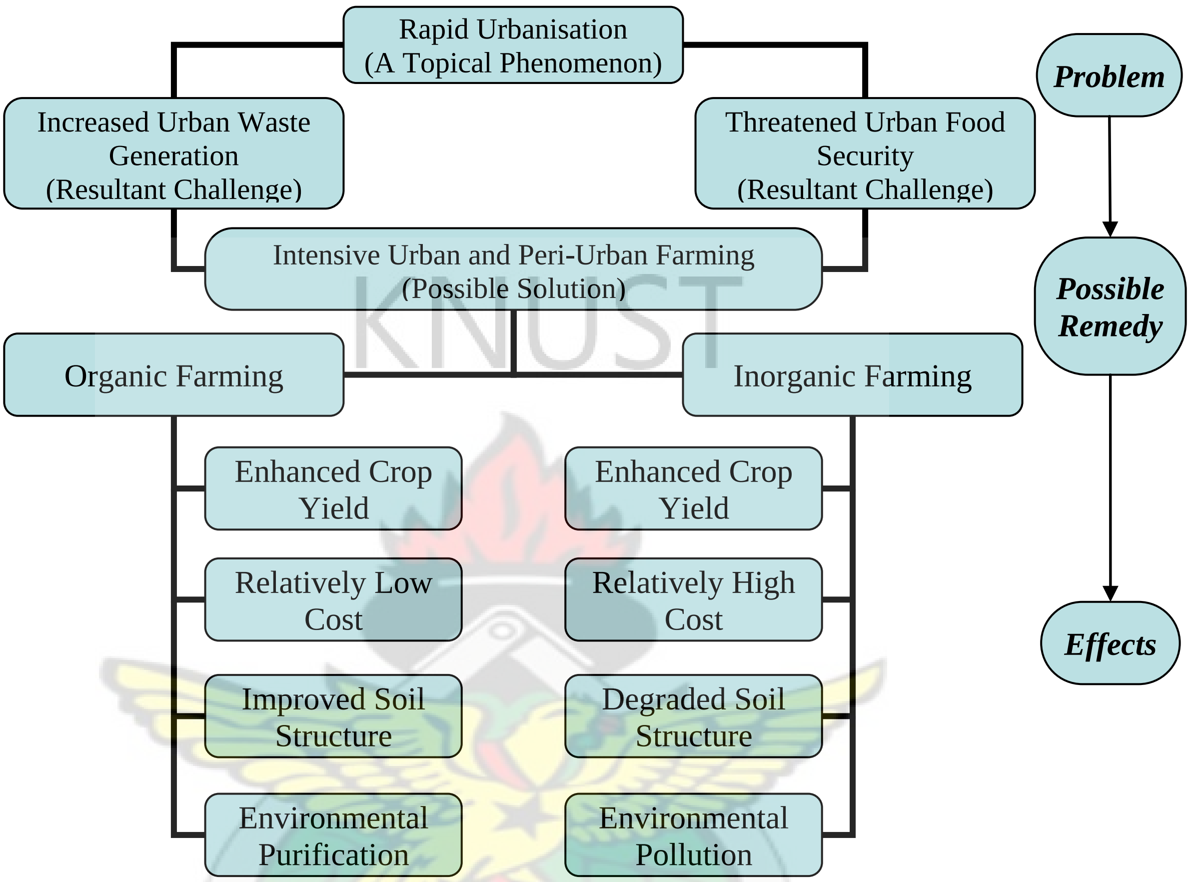
In a report to IDRC and Noguchi Memorial Institute of Medical Research (NMIMR), Legon, Armar-Klemesu and Maxwell (1998) presented work on urban Agriculture in the greater Accra Metropolitan Area. The report entailed much detail of the different identified farming systems in the study area, including their contribution to the household economy but failed to compare their profitability.

Obuobie *et al.* (2006) conducted a research on irrigated urban vegetable production in Ghana: Characteristics, Benefits and Risks and presented interesting and revealing findings. Although the study touched on the financial benefits and trade-offs of different urban and peri-urban farming systems, highlighting different soil/nutrient amendment methods, it was silent on the profitability of these different soil/nutrient amendment methods.

To help the prospective urban and/or peri-urban cabbage farmer to make a choice out of the different production modes (soil fertility management methods), however, it is very important to make a comparison among the different production modes, with respect to their profitability. This is the vacuum intended to be filled by this work.

2.11 CONCEPTUAL FRAMEWORK

Organic Farming as Remedy for Urban Waste and Food Security problems in the Face of Rapid Urbanisation



Source: *Developed by the researcher, 2005.*

Moving downward from the top of the above diagram, it is observed that rapid urbanisation has become a topical issue in recent times, resulting in increased urban waste generation and threatened urban food security as challenges. To help address these two challenges is; intensive urban and peri-urban farming, which could be pursued either in the form of organic or inorganic farming, considering their respective effects on crop yield, production cost, soil structure, and the environment

CHAPTER THREE

3.0 METHODOLOGY

3.1 SOURCE OF DATA

The survey for the study was done between February and June 2005, and covered the Kumasi Metropolis. Primary data (both quantitative and qualitative) were collected by means of semi-structured questionnaires, which were administered to the sampled farmers alongside informal interviews, discussions and first-hand observation. With regard to secondary data, these were obtained mainly from publications available at the website of the Resource Centre on Urban Agriculture and Food Security (RUAF) as well as other related earlier studies on vegetable production in Kumasi.

3.2 SAMPLING PROCEDURE

A total of sixty (60) farmers were sampled for the study by means of the stratified random sampling method. The reason for the stratified random sampling was to ensure that the different major cabbage production sites identified in the Kumasi metropolis were fairly and adequately represented.

A census by this study revealed that the population of commercial vegetable farmers in the Kumasi metropolis is about 123 persons. Nineteen (19) out of this, however, do not produce cabbage on regular basis (producing cabbage at most once in every two years). Thus employing the formula below, the sample size of 60 farmers for the study was determined.

3.2.1 A Simplified Formula for Determining Sample Size

Yamane (1967) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size for the study and is shown below. A 95% confidence level, a degree of variability, p = 0.5, and a level of precision or sampling error, e = ±10% are assumed.

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the level of precision. When this formula is applied to the above sample, we get the equation below;

$$n = \frac{123}{1 + 123(0.1)^2} \equiv \frac{123}{1 + 123(0.01)} \equiv \frac{123}{1 + 1.23} \equiv \frac{123}{2.23} \equiv 55.16 \cong 56$$

This implies that for the purpose of this study the recommended sample size should not be below 56. Better still; a sample size of 60 was used.

3.3 THE STUDY AREA

The study area comprises the Kumasi Metropolis. Lying roughly in the middle belt of Ghana, Kumasi is the capital town of Ashanti Region and the second largest city in Ghana with a population of 1.0 million and an annual growth rate of 5.9% (Ghana Statistical Service, 2002). Daytime population – attracted by Kumasi's large central market - is estimated at 1.5 to 2 million people. Kumasi itself has a total area of 225 km² with about 40% being open land. Kumasi has a semi-humid tropical climate and lies in the tropical forest zone. It has an annual average rainfall of 1420 mm. The rainfall pattern of the city is bimodal with the major season falling between March and July and a minor rainy season around September and October. The mean monthly temperature of the area ranges from 24°C to 27°C. Important streams and rivers include the Owabi River, which flows through the suburb of Anloga; Subin River, which passes through Kaasi and Ahensan; and Wiwi River, which runs through the KNUST campus. Due to the hilly landscape of Kumasi, most streams run through inland valleys unsuitable for construction and of high value for urban vegetable production.

The population of Kumasi comprises mainly Ashanti and other ethnic groups, with about 20% being Moslems. At least two out of every three households have some kind of backyard farming. A much higher percentage has at least a few plantain crops or chickens (IWMI, unpublished). This corresponds with the estimates of KNRMP (1999).

The peri-urban area of Kumasi has a radius of approximately 40 km from the city centre (Adam, 2001).

It is characterized, among other things, by a concentration of large poultry farms. Lying in the "tuber belt" of West Africa, cassava, plantain, maize and other traditional staple food crops are dominant on upland sites, often accompanied by dry-season vegetable farming especially along streams.

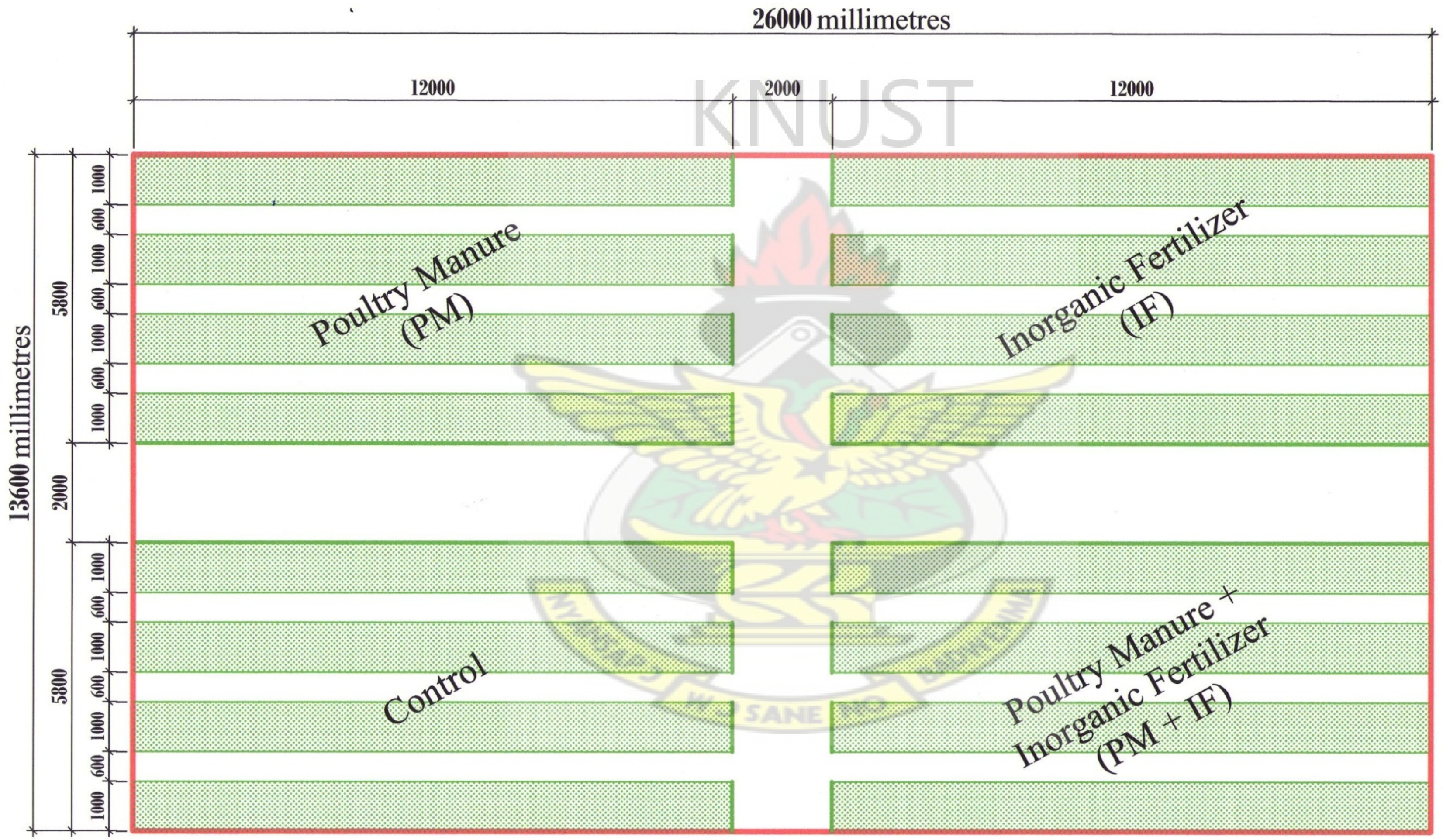
3.4 STUDY DESIGN

The study, conceived in the Randomised Complete Block Design (RCBD), was implemented in the form of an on-farm trial of different treatments, and in this instance, modes of cabbage production with respect to soil fertility management, with the 60 farmers serving as replicates, and their fields serving as the testing sites.

Each of the 60 sampled farmers was animated and assisted in terms of skills to produce cabbage by means of each of the three identified soil fertility management methods, separately on identical plots of land on his/her field using the usual or conventional cultural practices known to him/her. A control plot was recommended so as to be able to measure the effects of the various soil fertility methods. The control plot thus received no application of fertility management substance as its treatment. The primary indicators of comparison were economic yield and profitability.

The experimental plot measured $13.60m \times 26m = 353.60m^2 \cong 354m^2$, out of which four identical plots of $69.60m^2$ were demarcated for the four treatments namely Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fetilizer, and the Control (no application of fertility management substance). Below is a model of the experimental design implemented on the fields of the sampled farmers:

MODEL OF THE EXPERIMENTAL PLOT



3.5 METHOD OF DATA COLLECTION

Data were gathered from each of the sampled farmers through the administration of a semi-structured questionnaire designed for pre-implementation and post-implementation phases of the field trial, alongside informal interviews, discussions, and field observations.

Questionnaire was structured in such a way that it captured the following data:

- Total cost per production mode
- Economic yield of cabbage per production mode (kg/ha of saleable portion)
- Revenue from each of the production modes
- Indirect cost elements in each of the production modes
- Indirect benefits from each of the production modes

3.6 METHOD OF DATA ANALYSIS

Descriptive Analysis of data was done with frequency tables, graphs, and simple descriptive statistics like the means, modes and percentages.

Inferential Analysis of data was done with the Cost-Benefit ratio, the One-way ANOVA (using the SPSS software version 15), and Marginal Analysis.

The working definition for Cost-Benefit ratio in this study, as expressed earlier in chapter two is presented as:

$$C/_{B} = \frac{\sum[Inputs \cos ts]}{\sum[Benefits(\mathrm{Re}\,venue)]}$$

Where ***C***=cost, and ***B***=benefit

3.6.1 Components of Costs and Benefits

Given the difficulties involved in the measurement of costs and benefit in particular, the approach here was to determine the kinds of indicators that could be approximate estimates of costs and benefit of the different production modes. Components of costs include the value of all the variable inputs, and the depreciation of all the fixed inputs used in a production mode by the farmer. Among these inputs are; land, fertilizer, labour, seeds, watering cans, hoes, cutlasses, water hose, water, knife, buckets, agro chemicals, spraying equipment, and transportation service.

The Variable Cost was estimated by multiplying the quantity of input used by their prices as paid for by the farmer. Fixed Cost on the other hand was estimated by depreciating the original value of the fixed asset by the straight line method and obtaining a yearly value, which is then distributed over the cropping times per year. Appendix-1 illustrates the details of cost computation.

Benefit here, basically refers to the value of all the produce from the production, estimated in the usual way by multiplying the volumes produced by the prices of the produce as received by the farmer concerned at the first point of sale. Economic yield from each production mode was thus valued at the price at the first point of sale as received by the farmer, and used for analysis. Appendix-2 provides details of revenue.

3.6.2 Conceptual Introduction to the Analysis of Variance

The interest of this study is to assess the relative effects of three types of soil fertility management (production modes) namely Poultry Manure, Inorganic Fertilizer, and Poultry Manure+Inorganic Fertilizer on profitability. As shown abstractly in the table below, three independent samples of measures, ***A***, ***B***, and ***C*** are obtained. If the three production modes have different effects on profitability, it would be expected that significant differences among the ***means*** of the three samples is established.

A	***B***	***C***
X_{a1} X_{a2} X_{a3} ***etc.***	X_{b1} X_{b2} X_{b3} ***etc.***	X_{c1} X_{c2} X_{c3} ***etc.***
M_a	M_b	M_c

Let ***A***= Poultry manure; ***B***= Inorganic Fertilizer and ***C***= Poultry Manure+Inorganic Fertilizer. And let ***X***=Cost-Benefit ratio, proxy for profitability of individual farmers. Then, ***M***=Mean profitability of each production mode.

At first glance, it might appear possible to determine whether ***means*** of the three groups significantly differ from one another by performing a separate ***independent-samples t-test*** for each possible pair of ***means***: that is,

- one test for M_a versus M_b
- another for M_a versus M_c
- and yet another for M_b versus M_c

A moment's reflection, however, will show why this simple strategy would not be advisable. Essentially it is an exercise in disjunctive probabilities, along with a reminder of what it means to say that some particular result is "significant." If an observed result is found to be significant at the basic 0.05 level, it means that there is only a 5% chance of its having occurred through mere chance. For any particular one of the three pair-wise ***t-test*** comparisons listed above, there would be a 5% probability by mere chance, even if the null hypothesis were true, of ending up with a difference that is "significant" at the 0.05 level. Thus if all possible pair-wise comparisons are performed for all three samples as listed above, the disjunctive probability that one or another of the comparisons might end up "significant" at the 0.05 level by mere chance, even if the null hypothesis were true for the three production modes, would be in the order of 0.05+0.05+0.05=0.15. This emphasizes the fact that, if ***t-tests*** on multiple pairs of sample ***means*** are performed, the probability that one or another of the comparisons might end up "significant" at the 0.05 level, by the merest chance, is substantially greater than 0.05.

The analysis of variance, commonly referred to by the acronym ANOVA, was accordingly developed as a strategy for dealing with this sort of complication. At its lowest level it is essentially an extension of the logic of ***t-tests*** to those situations in which the ***means*** of three or more samples are compared concurrently.

3.6.3 Step-by-Step Computational Procedure: One-Way Analysis of Variance for Independent Samples

The steps listed below assume that some basic computation has been done to obtain ΣX_i and ΣX_i^2 for each of the sample groups (**k**) and for all **k** groups combined.

For illustration, let **k**=3

Step 1: Combining all **k** groups together, the total sum of squared deviates is calculated as:

$$SS_T = \Sigma X_i^2 - \frac{(\Sigma X_i)^2}{N_T}$$

Step 2: The sum of squared deviates within the group ("**g**") is separately calculated for each of the **k** groups as:

$$SS_g = \Sigma X_{gi}^2 - \frac{\left(\Sigma X_{gi}\right)^2}{N_g}$$

Step 3: The sum of the SS_g values across all **k** groups is taken to get:

$$SS_{wg} = SS_a + SS_b + SS_c$$

Step 4: SS_{bg} is calculated as:

$$SS_{bg} = SS_T - SS_{wg}$$

Step 4a: For verification, SS_{bg} would be calculated separately as:

$$SS_{bg} = \frac{(\Sigma X_{ai})^2}{N_a} + \frac{(\Sigma X_{bi})^2}{N_b} + \frac{(\Sigma X_{ci})^2}{N_c} - \frac{(\Sigma X_T)^2}{N_T}$$

Step 5: The relevant degrees of freedom are calculated as:

$$df_T = N_{T-1}$$

$$df_{bg} = N_{k-1}$$

$$df_{wg} = N_{T-k}$$

Step 6: The relevant mean-square values are calculated as:

$$MS_{bg} = \frac{SS_{bg}}{df_{bg}}$$

and

$$MS_{wg} = \frac{SS_{wg}}{df_{wg}}$$

Step 7: **F** is calculated as:

$$F = \frac{MS_{bg}}{MS_{wg}}$$

Step 8: The calculated value of **F** is referred to or cross-checked with the table of critical values of **F**, with the appropriate pair of numerator/denominator degrees of freedom.

3.6.4 Post-ANOVA Comparisons: The Tukey HSD Test

A significant F-ratio means that the aggregate difference among the means of the several samples is significantly greater than zero but does not reveal whether any particular sample mean significantly differs from any particular other. This might be entirely sufficient for some research works. There are, however, many situations in which the interest is to determine specifically whether M_a significantly differs from M_b, or M_b from M_c, and so on. "HSD" is an acronym for "honestly significant difference." The Tukey test revolves around a measure known as the Studentized range statistic, which is abbreviated as Q. For any particular pair of means among the k groups, we will designate the larger and smaller as M_L and M_S, respectively. The Studentized range statistic can then be calculated for any particular pair as:

$$Q = \frac{M_L - M_S}{\sqrt{MS_{wg}/N_{p/s}}}$$

Where $\boldsymbol{MS_{wg}}$ is the $\boldsymbol{MS}$ within-groups obtained in the original analysis and $\boldsymbol{N_{p/s}}$ is the number of values of $\boldsymbol{X_i}$ per sample (***"p/s"***=per sample)

3.6.5 Assumptions of the One-Way ANOVA for Independent Samples

This particular version of the analysis of variance makes the following assumptions about the data that are being fed into it:

1. that the scale on which the dependent variable is measured has the properties of an equal interval scale;
2. that the **k** samples are independently and randomly drawn from the source population(s);
3. that the source population(s) can be reasonably supposed to have a normal distribution; and
4. that the **k** samples have approximately equal variances

3.6.6 Marginal Analysis

Marginal Analysis as used within this context is a procedure for calculating Marginal Rates of Return (MRR) between technologies, proceeding in a stepwise manner from a lower-cost technology to the next higher-cost technology, and comparing MRR to Minimum Acceptable Rates of Return (Perrin *et al.*, 1988). The procedure is useful for making recommendations to producers and for selecting alternative technologies. The economic principle underlying the analysis is that it is worthwhile for a producer to continue investing up to the point where the return from each extra unit invested equals the cost of the extra unit. As applied to a situation in which the producer is confronted with a set of discrete alternative technologies, the producer should invest in the costlier technology as long as the marginal rate of return (in switching from a lower-cost technology to a higher-cost technology) is greater than the Minimum Acceptable Rate of Return (MARR). Hence, recommending technologies to producers is not based solely on the premise that a technology must be profitable (i.e., added returns are greater than added costs), but that it must also satisfy the added criterion that; the MRR must be above a given MARR. The reason being that, technologies satisfying these criteria, stand the greatest chance of being adopted (Evans, 2005).

Steps of Marginal Analysis

There are several steps in carrying out marginal analysis. The level of complexity in carrying out marginal analysis will vary depending on the nature of the experiment and the level of sophistication employed. As an example, the on-farm trial of four different treatments (soil fertility management methods) namely Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF) and of course a Control (production mode without any fertilizer application) is considered. If the objective of the research is to make a recommendation to the producers to adopt one of the treatment/technologies involved in this trial, the first step in carrying out the marginal analysis will be to determine the net benefits (revenue) attributable to each of the different treatments.

Net Benefits Determination

To determine the “net benefits” of the different technologies, the “gross field benefit” and the “total costs that vary” in switching technologies must first be calculated. The gross field benefit for each technology is obtained by multiplying the “adjusted yield” by the farm gate price. The adjusted yield usually represents a fraction (e.g., 0.9) of the average yield obtained under an experimental condition. The main reason for the adjustment in yield is that the producer, in switching technologies, might not exercise the same level of precision and timeliness as the researcher; and therefore, a more conservative estimate is warranted. However, an adjusted yield is not necessary in this study because the experiment is an on-farm trial, implemented almost entirely by the target group of farmers themselves. The farm gate price is the price that the producer receives less any harvesting and marketing costs. Again, in this study, the producers incur no harvesting and marketing costs because the produce is sold to the buyers while still on the beds (not harvested).

The total costs that vary (total variable costs) for each technology on the other hand is the sum of ***only*** those costs that are expected to change by using any specific technology. If a particular technology results in cost savings, then this should be subtracted from the total cost. In certain situations where market prices are not readily available for various inputs, the researcher will need to estimate the economic or opportunity cost of the resource.

The net benefit for a given technology is then obtained by subtracting the total variable cost from the gross field benefit. It should be pointed out that the net benefit is not the same as net profit since it only takes into consideration those costs that vary by switching from one technology to another (Perrin *et al.*, 1988).

Dominance Analysis

Once the net benefit has been determined for each technology, the next step is to perform a dominance analysis. This is done by sorting the technologies, including the Control treatment, on the basis of costs, listing them from the lowest to the highest, together with their respective net benefits. In moving from the lowest to the highest, any technology that costs more than the previous one but yields less net benefits is said to be "dominated" and can be excluded from further analysis.

Marginal Rate of Return (MRR) Computation

Having eliminated all dominated technologies, the MRR between technologies can be calculated. Proceeding in a stepwise manner, beginning with the lowest-cost technology and the next ascending technology, the MRR is computed by expressing the difference between the net benefits of the pair as a percentage of the difference of the total variable cost. The computed MRR gives an indication of what a producer can expect to receive, on average, by switching technologies. Hence, a 150% marginal rate of return in switching from one treatment/technology to another implies that for each Ghana cedi invested in the new technology, the producer can expect to recover the GH¢1 invested plus an additional return of GH¢1.50. It is important to note, however, that a higher Marginal Rate of Return (MRR) does not necessarily imply that the treatment/technology responsible should be recommended (Evans, 2005).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 SEX DISTRIBUTION OF SAMPLED FARMERS

The data obtained revealed that males dominate urban vegetable farming in the Kumasi metropolis. In all, fifty-seven (57) out of the sixty (60) farmers who were sampled for the study were males, with the remaining three (3) being females. This corresponds to 95% and 5% for the male and female composition of the sampled farmers respectively.

This is reflected in the percentage distribution as captured by the table below:

Table 4.1 Sex Distribution of Sampled Farmers

Sex	Number of Farmers	Percentage Composition (%)
Male	57	95
Female	3	5
Total	60	100

Source: Field Survey, 2005

4.2 EDUCATIONAL BACKGROUND

Overall, there were eleven non-literate farmers in the study, representing 18% of the total sampled farmers. Each of the remaining 82% had attained some degree of formal education, with the minimum level of formal education being either at the Junior Secondary School level or the Middle School Level. Only three (3) farmers, all males, representing 5% of the total sampled farmers had education at the tertiary level.

A single male farmer representing 1.7% of the total sampled farmers was a Post-Secondary school graduate.

Thirty-seven (37) farmers, corresponding to 62% of the total, and comprising thirty-four (34) males and three (3) females were either Basic/Middle school graduates or had had some level of training at this level but could not complete successfully.

It is also interesting to know that none of these three women hailed from the Ashanti Region, as two were from the Upper East Region and the remaining one was from the Central Region.

Below is a frequency distribution table summarising the findings on educational background of the sampled farmers:

Table 4.2 Educational Level of Sampled Farmers

Level of Educ.	No. of Farmers	Male	Female	Percentage (%)
Tertiary	3	3	-	5
Post-Sec.	1	1	-	2
Sec. / Voc.	8	8	-	13
Basic/MSLC	37	34	3	62
None	11	11	-	18
Total	60	57	3	100

Source: Field Survey, 2005

4.3 CHOICE OF CABBAGE PRODUCTION MODE IN KUMASI

Among the elements contributing to the choice of soil fertility management method (production mode) are; seasonality with specific reference to rainfall, availability, accessibility, and affordability of particular soil fertility management material.

It was gathered from a discussion with respondents that some cabbage farmers switch to the use of Inorganic Fertilizer during the dry season. This is because water is usually in scarcity during this period, while Poultry Manure requires copious amount of water for timely and enhanced decomposition.

Understandably then, almost all the respondents who identified themselves as organic vegetable farmers have their fields or farming sites lying close to perennial water courses or sources. These farmers make use of solely Poultry Manure as a means of augmenting the fertility and/or improving the structure of the soil. They also make use of Neemazal 0.3EC,[1] a Neem extract base insecticide containing Azadirachtin as repellent, anti-feedant, and insect growth regulator.

4.4 SIZE OF PLOT AND MODE OF LAND ACQUISITION

Plot size per farmer ranged from a minimum of 0.042ha to a maximum of 0.20ha, with an average plot size of 0.121ha. This influenced the decision to implement the study trial on a $353.6m^2 \cong 354m^2$ land area so as not to make land area requirement a hindrance to random selection of farmers for the study.

Thirty-nine (39) out of the 60 farmers, constituting sixty-five (65%) of the total number of studied farmers acquired their cultivated lands by the communal mode of land acquisition, fourteen (14), making up 23% of the total obtained their farm plots by freehold/individual mode of land acquisition, five (5) or 8% of the total obtained their plots by leasehold/rent, and two (2) representing 3% operated on a land property belonging to a church.

Those who operated on community lands, freehold lands or land property of religious bodies do not pay rent on these lands. On the other hand, those who operated on leased lands paid an average annual rent of Seventy-five Ghana Cedis (GH¢75.00) per hectare.

[1] Neemazal 0.3EC has been approved for use in organic agriculture by IMO, Switzerland as per guideline EEC-2092/91.

4.5 PLOT PREPARATION AND ASSOCIATED COST

Twenty-three farmers representing 38% of the total respondents depended on hired or casual labour for all their land preparation activities namely clearing of weeds, demarcation and erection of beds. Thirty-seven farmers representing 62% of the total respondents depended on personal/family labour for all their land preparation activities namely clearing of weeds, demarcation and erection of beds. This is a clear indication that use of personal/family labour dominates urban cabbage production in the Kumasi Metropolis, with respect to plot preparation.

The cost of this operation averaged Three Hundred and Twenty-five Ghana Cedis (GH¢325.00) per hectare by the estimation of the respondents

4.6 INPUTS OF PRODUCTION AND THEIR SOURCES

Among the conventional inputs used in cabbage production in the Kumasi Metropolis are; cutlass, hoe, spade, hand fork, knapsack/hand sprayer and watering can. Others include; wellington boot, pesticide, seed, poultry manure, inorganic fertilizer, water and labour.

Apart from water, labour and poultry manure, the rest of the inputs of production are obtained from the open market. Poultry manure is usually obtained from the neighbourhood or a distant poultry farm. Water is usually obtained from nearby streams, dug-outs, or in some few cases, pipe-borne sources. Labour for the production is usually obtained from the family or hired, as in the case of those who operate on larger land areas.

Table 4.3 below shows the various conventional inputs of urban cabbage production and their respective sources:

Table 4.3 Conventional Inputs of Production and their Sources

Input	Source
Cutlass	Open market
Hoe	Open market
Spade/Shovel	Open market
Hand fork	Open market
Knapsack/Hand sprayer	Open market
Watering can	Open market
Wellington boot	Open market
Seed	Open market
Neemazal (pesticide)	Open market
Poultry manure	Neighbourhood/Distant Poultry farm
Inorganic fertilizer	Open market
Water	Stream/dugout/pipe-borne
Labour	Family/Hired

Source: Field Survey, 2005

4.7 PRODUCTION CYCLES PER YEAR AND FERTILIZATION COST

With the exception of four (4) farmers, representing about 7% of the total respondents who claimed to be able to achieve four production cycles within a year, the remaining fifty-six (56), corresponding to about 93% of the total respondents intimated that production was done three times in a year.

Regarding fertilization of subsequent production cycles, the response from all the farmers (100%) was that these attract similar fertilization cost just like the first cycle.

4.8 TOTAL COST OF PRODUCTION PER PRODUCTION MODE

Each of the four production modes (treatments) incurred similar fixed cost of production amounting to GH¢33.91 per each treatment plot of 69.60m^2. Equal fixed cost of production was obtained for each of the production modes due to the fact that;

with the exception of the soil/nutrient amendment method, the same cultural practices were applied to each of the four treatment plots by the farmers. Appendix-1 displays the details of cost computation.

Regarding the variable cost of production per treatment plot, the following amounts; were incurred; GH¢0.50, GH¢1.20, GH¢0.97, and GH¢0.00 as such by the various treatments or production modes namely Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and Control respectively. Please refer to Appendix-1 for details on variable cost computation.

Total cost of production per a $69.60m^2$ treatment plot for the various treatments namely Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and Control was estimated at GH¢34.41, GH¢35.11, GH¢34.88, and GH¢33.91 correspondingly. Appendix-3 shows details of total cost per mode of production for each respondent.

The figure below is a pictorial representation of the various treatments or production modes and their associated production costs:

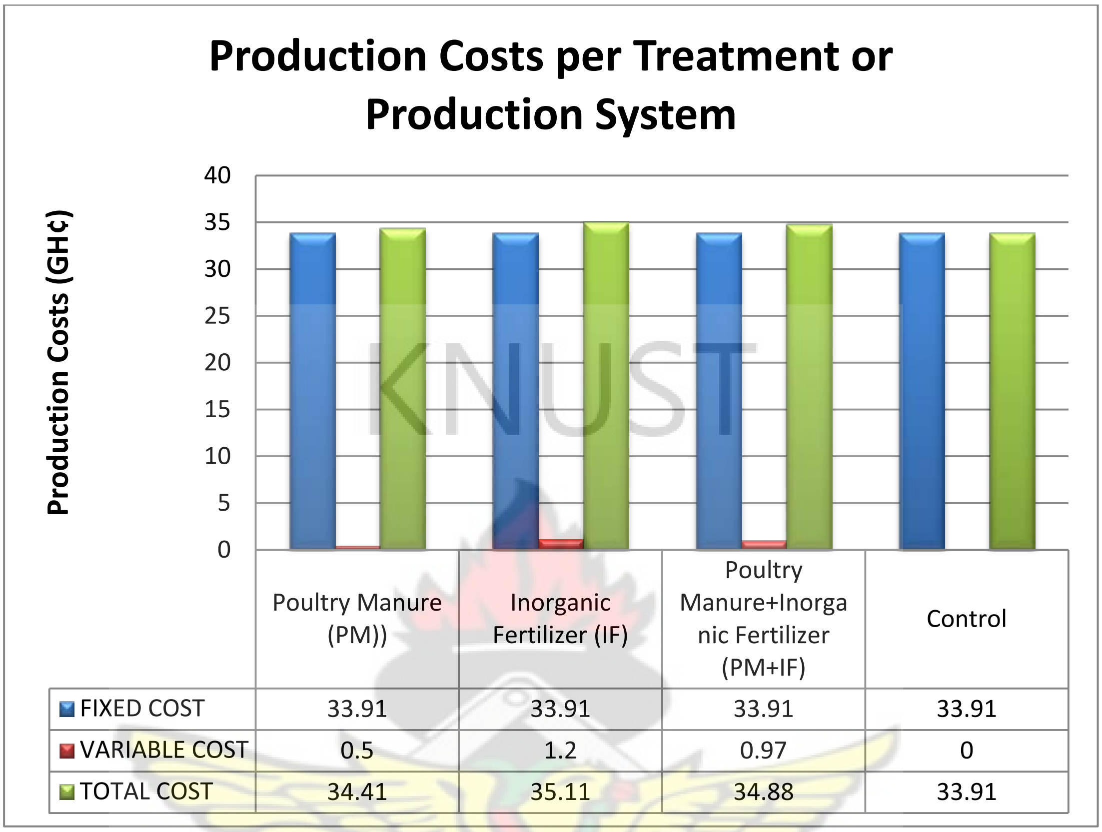


Fig. 4.1 Production Costs per Production mode or Treatment

4.9 HARVESTING AND MARKETING OF PRODUCE

Response from all the farmers (100%) indicated that harvesting of produce does not attract any cost as it is done by the middlemen themselves, who make outright purchase of the heads of cabbage while still on the beds.

Again, all the farmers (100%) indicated that they produced mainly for sales even though it was admitted by most them that they do consume an insignificant proportion at home.

In practice, the heads of cabbage are priced based on their sizes or grades. Grading is however done by visual judgement coupled with a crude estimation of weight by carrying the head in the palm of one hand.

Employing this criterion, four (4) categories or grades were recognised by both the middlemen and the farmers namely; small (0-1kg), medium (1-2kg), large (2-3kg), and very large (3-4kg). With the exception of the heads belonging to the small category/grade (0-1kg), fairly uniform prices were offered by the middlemen for the other three categories. The prices per the various categories were; GH¢0.40, GH¢0.30, and GH¢0.20 for very large, large, and medium grades respectively.

From the farmers point of view, produce that fell within the small grade (0-1kg) used not to be saleable, and were basically used for either home consumption or left for interested persons in the neighbourhood to harvest. However, this trend has changed with the advent of numerous fast food joints. These fast food operators provide market for the hitherto non-commercial grade of heads but farmers show little interest in determining the unit price. This leaves price determination solely in the hands of the fast food operators or their agents, resulting in a very low average unit price of GH¢0.10. Unsold produce in this category that is not harvested by interested people in the neighbourhood are usually gathered, heaped and burned when dried.

In all instances, the farm gate served as the point of sale of produce. This practice, though convenient to farmers, deprives them of appreciable amount of revenue to the tune of more than 100% the prices offered them by the middlemen, in some instances.

Doubtless, the revenue forfeited would be more than enough to offset the cost of getting the produce to the final consumers.

4.10 SOIL FERTILITY PROBLEMS AND MANAGEMENT

Fifty-one (51) farmers, representing 85% of the total respondents admitted to having soil fertility problems. Thirty-eight (38) out of these fifty-one (51) farmers, however, believe that poultry manure offers the best hope of a lasting solution to this soil fertility problem. Thirteen (13) of them, however, asserted that the poultry manure will have to be complemented with an application of inorganic fertilizer.

The remaining nine (9) farmers, constituting 15% of the total claimed they were satisfied with the productivity of their fields. It is noteworthy, however, that all these nine farmers have been using poultry manure exclusively for over the past five years, and recommended its use as the most effective and sustainable means of addressing soil fertility problems in urban vegetable production.

All sixty (60) respondents, representing 100% claimed to have some knowledge of the long term effects of inorganic fertilizers on the soil and /or environment as whole but in all instances, soil acidity, apparently being referred to as; "destruction of soil properties," was the only known long term effect of inorganic fertilizer usage. No mention was made of poisoning of aquatic life and humans alike, when components of the inorganic fertilizers are leached into nearby water bodies.

Again, each of the sixty (60) respondents was familiar with compost but none of them made use of it in his/her production, citing uncertainty about its productivity as main reason for not adopting it. Pertaining to Co-compost, only eight (8) respondents, corresponding to about 13% of the total had heard of it but had never even seen it before, let alone made use of it. None of them had heard anything about enriched Co-compost or Comlizer.

4.11 FARMER GROUPS

Few of the respondents belonged to a farmer group or association, which explains why they are easily exploited by middlemen. In all, sixteen (16) farmers, representing about 27% of the total respondents were members of a farmer group or association. It is interesting to note, however that, in almost all instances, respondents had an idea about the existence of a farmer group as well as the total number of cabbage farmers in the vicinity.

4.12 YIELD (OUTPUT) OF CABBAGE PER PRODUCTION MODE

Average economic yield (output) per treatment of 2.79kg, 2.65kg, 2.91kg, and 0.52kg were recorded for Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and the Control treatments respectively. The table below depicts the minimum and maximum yields (outputs) of cabbage obtained from the various treatments:

Table 4.4 Yield of Cabbage per Treatment

Treatment	Yield (Output) in Kilogrammes (kg)	
	Minimum	Maximum
Poultry Manure (PM)	2.20	3.50
Inorganic Fertilizer (IF)	2.00	3.40
PM+IF	2.20	3.60
Control	0.30	0.80

Source: Field Survey, 2005

Employing their conventional mode of grading, which is grading by visual judgement and estimation by feeling the weight of a head in the palm of one hand, eight (8) farmers, corresponding to about 13% of the total respondents admitted noticing significant difference in the weights of heads of cabbage obtained from the Poultry Manure+Inorganic Fertilizer (PM+IF) and the Poultry Manure (PM) treatments. It was however, quite an easy task for each of the respondents to notice the difference in weight between the heads of cabbage obtained from the exclusive Poultry Manure (PM) treatment and that from the Inorganic fertilizer. Likewise, there was no difficulty for any of the respondents when it came to differentiating the heads of cabbage obtained from the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment and those from the Inorganic Fertilizer (IF) treatment.

A prominent observation made on the plot of each of the farmers had to do with the colour of heads of cabbage from the various treatment. In all cases, heads of cabbage from the control plot appeared very pale and light in weight. The heads of cabbage from the Inorganic Fertilizer (IF) treatment appeared to be of a lighter colouration than those of the Poultry Manure+Inorganic Fertilizer (PM+IF) and the exclusive Poultry Manure (PM) treatments. Heads from the Poultry manure (PM) treatment also appeared a little darker in colouration than those from the poultry Manure+Inorganic Fertilizer (PM+IF) treatment. These observations were corroborated by the responses from the farmers, who admitted also detecting the differences in colouration of the heads from the various treatments. Even though the heads from the exclusive Poultry Manure (PM) treatment appeared bigger in size than those from the other treatments, heads from the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment looked more compact and heavier.

It was gathered from the farmers that middlemen would usually prefer cabbage produced from poultry manure to that produced from inorganic fertilizer, citing longer shelf life for heads produced from organic means (poultry manure) as the main reason for this preference. And even so, no premium price is paid by the middlemen for this kind of produce. This is an indication that preference for quality produce by the middlemen is not matched by willingness to pay for it.

Regarding productivity, thirty-seven (37) of the respondents, corresponding to about 62% of the total farmers involved in the study ranked treatment by exclusive Poultry Manure (PM) above that of Poultry Manure+Inorganic Fertilizer (PM+IF), Inorganic Fertilizer (IF) and Control, in that order. The remaining twenty-three (23) respondents, representing 38%, however, ranked treatment by Poultry Manure+Inorganic Fertilizer (PM+IF) above that of Poultry Manure (PM), Inorganic Fertilizer (IF) and Control, in that sequence.

All sixty (60) respondents would prefer poultry manure to any other soil/nutrient amendment factor/method, when made an offer, to make a choice from Poultry Manure, Inorganic Fertilizer, Poultry Manure+Inorganic Fertilizer, and enriched Co-compost (Comlizer). The reason for this choice was either sustainability or affordability, in all cases.

Results from a One-Way ANOVA revealed a significant difference among the ***means*** of economic yield (output) from the various production modes (treatments) of cabbage ($F(3,236) = 845.41$, $p < 0.05$). Employing the Tukey's HSD[2] test, the Post

[2] HSD stands for 'honestly significant difference.'

Hoc analysis revealed a significant difference between the mean of economic yields (outputs) of cabbage obtained from Poultry Manure (PM) and Inorganic Fertilizer (IF) treatments at the 0.05 α level.

By the same procedure, a significant difference was revealed between the mean of economic yield (output) from the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment and that obtained from the Inorganic Fertilizer (IF) at the 0.05 α level. Appendix-4 shows details of output for the One-Way ANOVA.

However, it was revealed by this same procedure that ***no*** significant difference existed between the mean yields (outputs) obtained from Poultry Manure+Inorganic Fertilizer (PM+IF) and that obtained from Poultry Manure (PM).

Fig. 4.2 Data Collection on Yield of Cabbage from a Farmer's Plot

Fig. 4.3 An Informal Interview on the Field with a Sampled Farmer

4.13 REVENUE PER PRODUCTION MODE (TREATMENT)

Average revenue per treatment or production mode plot of 69.60m^2 were GH¢96.00, GH¢92.50, GH¢100.00, and GH¢30.00 for the various treatments namely Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and Control respectively.

Estimating the average revenue per treatment or production mode on a per hectare basis results in GH¢13,793.28, GH¢13,290.40, GH¢14,368.00, and GH¢4,310.40 for the Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and Control treatments respectively.

Below is a graphical representation of the revenue per hectare accrued to each of the production modes:

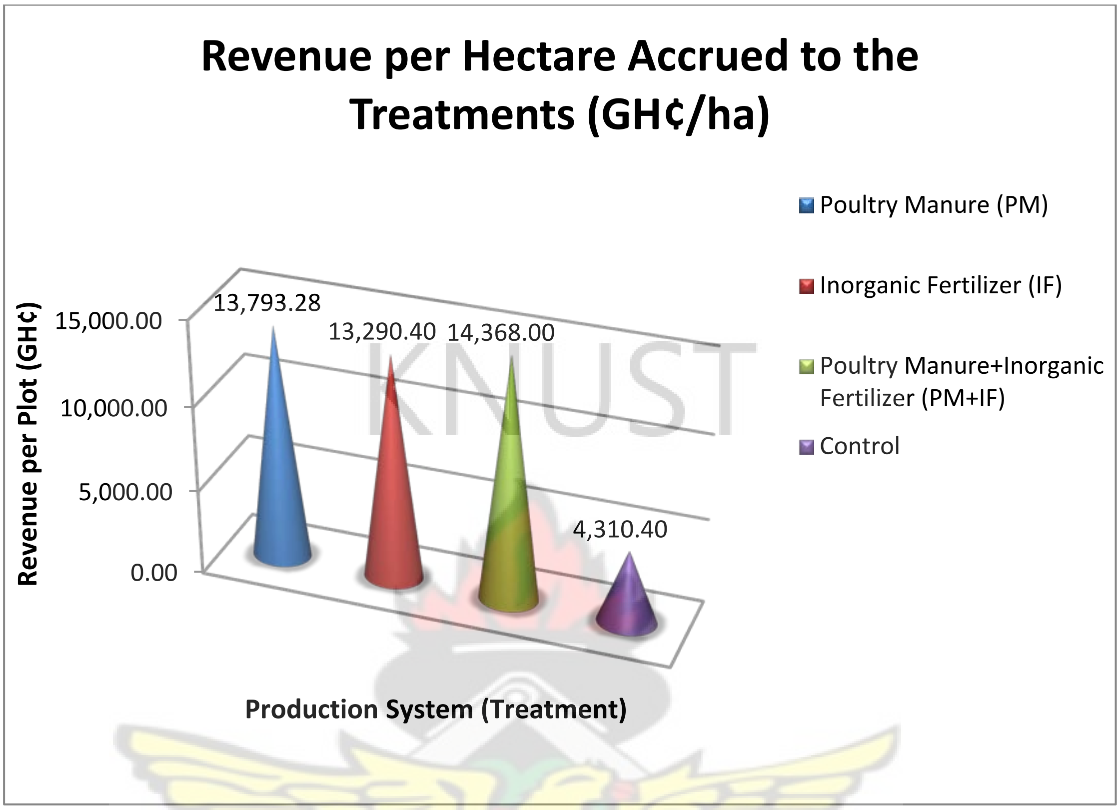


Fig. 4.4 Revenue per Hectare (GH¢/ha) Accrued to the Treatments

4.14 PROFITABILITY (COST-BENEFIT RATIO) PER TREATMENT

Using the estimated cost and revenue per production mode (treatment) under each of the 60 farmers, cost-benefit ratios were computed for the various treatments and used as proxies for their financial viability or profitability. These proxies when used as input data for a One-Way ANOVA resulted in average cost-benefit ratios of 0.3632, 0.3820, 0.3553, and 1.1303, for the Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and Control treatments respectively.

Results from the One-Way ANOVA revealed a significant difference among the ***means*** of profitability (Cost-Benefit ratio) from the various production modes (treatments) of cabbage ($F(3,236) = 8053.35$, $p < 0.05$). Again, a Post Hoc analysis, using the Tukey's HSD test revealed there was a significant difference between the mean of profitability of cabbage obtained from Poultry Manure (PM) and Inorganic Fertilizer (IF) treatments at the 0.05 α level.

By the same procedure, a significant difference was revealed between the mean of profitability from the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment and that obtained from the Inorganic Fertilizer (IF) at the 0.05 α level.

However, it was revealed by this same procedure that ***no*** significant difference existed between the mean of profitability obtained from Poultry Manure+Inorganic Fertilizer (PM+IF) and that obtained from Poultry Manure (PM) at the 0.05 α level.

Findings from the study contradicted the a priori expectation that; chemical or inorganic fertilizer was an economically viable alternative to organic fertilizer (poultry manure) in the attainment of urban food security under efficient land management. This is because the Poultry Manure (PM) treatment for urban cabbage production proved to be more profitable than that of the Inorganic Fertilizer (IF).

Below is a graphical representation of the financial viability or profitability of the different production modes or treatments, as generated by their respective Cost-Benefit ratios.

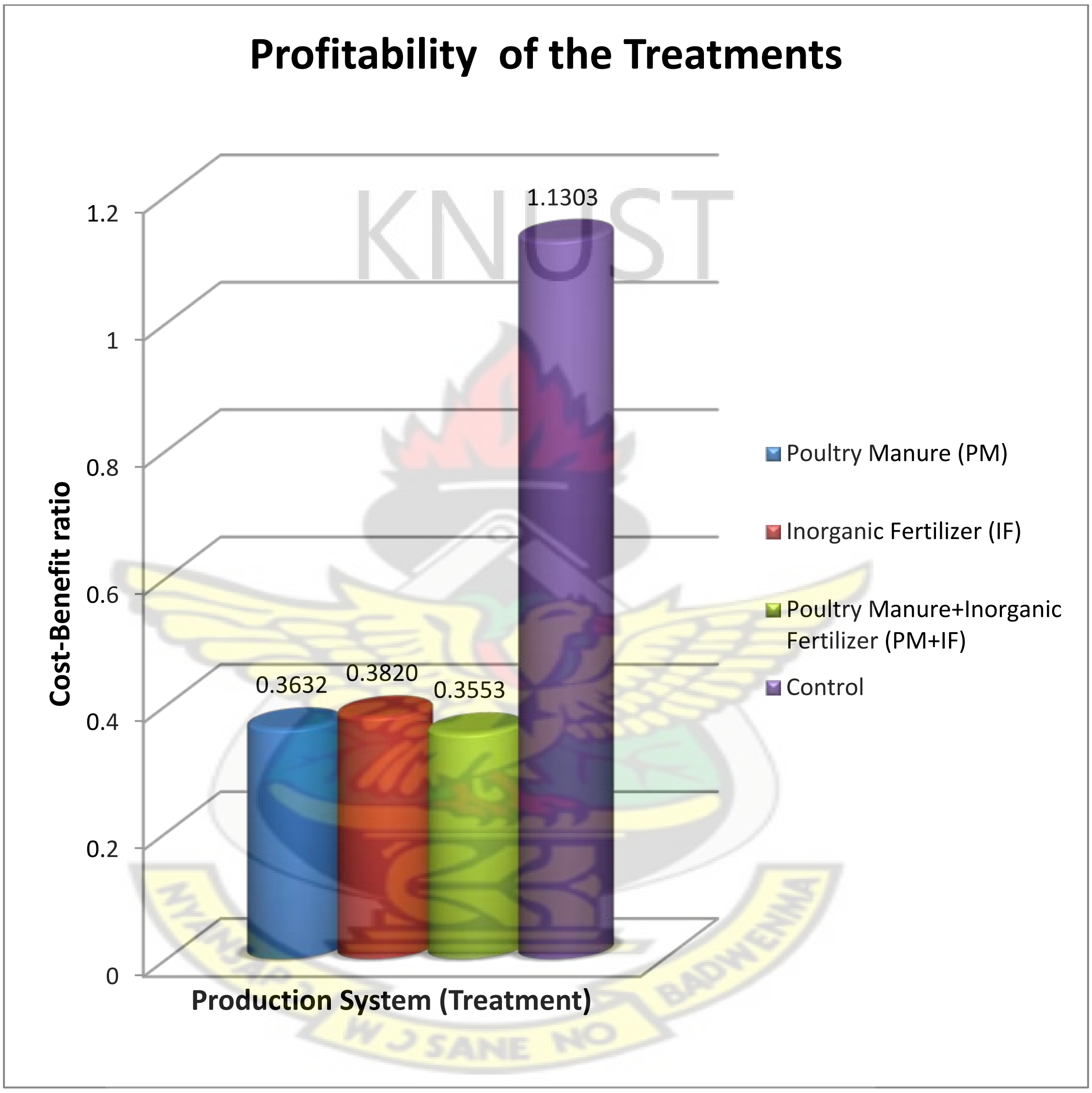


Fig. 4.5 Financial Viability of the Different Production modes

With the least Cost-Benefit ratio of 0.3553, the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment was ranked the most profitable production mode followed by the Poultry Manure (PM), Inorganic Fertilizer (IF), and the Control treatments with Cost-Benefit ratios of 0.3632, 0.3820, and 1.1303 respectively.

4.15 MARGINAL ANALYSIS OF THE TREATMENTS

Net Benefit per treatment (production mode) was GH¢95.50, GH¢91.30, GH¢99.03 and GH¢30.00 for Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF) and the Control treatments respectively. Table 4.5 summarizes the computation of net benefit from the different treatments or production modes.

Table 4.5 Net Benefit per Production Mode or Treatment

Treatment (Production mode)	Quantity of Variable Input per Plot	Total Variable Cost (GH¢)	Average yield per head (Kg)	Gross Benefit (Revenue) (GH¢)	Net Benefit (Revenue) (GH¢)
Poultry Manure (PM)	100kg bag of Poultry Manure	0.50	2.79	96.00	95.50
Inorganic Fertilizer (IF)	2.5kg N.P.K	1.20	2.65	92.50	91.30
Poultry Manure+Inorganic Fertilizer (PM+IF)	1.5kg N.P.K +50kg bag of Poultry Manure	0.72 (IF) + 0.25 (PM) = 0.97	2.91	100.00	99.03
Control	-	-	0.52	30.00	30.00

Source: Field Survey, 2005

Combining a total variable cost/plot of GH¢0.00 with a net benefit/plot of GH¢30.00 under the dominance analysis, the Control treatment came up as the treatment with the lowest cost followed by the Poultry Manure (PM) treatment, with a total variable cost/plot of GH¢0.50 and a net benefit/plot of GH¢95.50 Rated third under the dominance analysis is the Poultry Manure+Inorganic Fertilizer (PM+IF), with a total variable cost/plot of GH¢0.97 and a net benefit/plot of GH¢99.03 Fourthly and lastly placed is the Inorganic Fertilizer (IF) treatment with a total variable cost/plot of GH¢1.20 and a net benefit/plot of GH¢91.30.

Table 4.6 summarizes the dominance analysis and illustrates how switching treatments increases cost.

Table 4.6 Dominance Analysis of the Production Modes or Treatments

Treatment (Production mode)	**Total Variable Costs/Plot (GH¢)**	**Net Benefits/Plot (GH¢)**
Control	0.00	30.00
Poultry Manure (PM)	0.50	95.50
Poultry Manure+Inorganic Fertilizer (PM+IF)	0.97	99.03
Inorganic Fertilizer (IF)	1.20	91.30

Source: Field Survey, 2005

As realised from table 4.6, the Inorganic Fertilizer (IF) treatment costs more than the preceding Poultry Manure+Inorganic Fertilizer (PM+IF) treatment, and yet yields less net benefit. The Inorganic Fertilizer (IF) treatment is thus said to be "dominated" and is excluded from further analysis.

Table 4.7 illustrates the computation of the Marginal Rate of Return (MRR) between the treatments. And the figures reveal that a Marginal Rate of Return (MRR) of 13,100% was obtained between the Control treatment and the Poultry Manure (PM) treatment, against that of 751% obtained between the Poultry Manure (PM) and the Poultry Manure+Inorganic Fertilizer (PM+IF) treatments.

Table 4.7 Marginal Rate of Return between Production Modes/Treatments

Treatment (Production mode)	**Total Variable Costs**		**Net Benefits**	**Marginal Rate of Return**	
	(GH¢/plot)	*(GH¢/switch)*	*(GH¢/plot)*	*(GH¢/switch)*	(%)
Control	0.00	0.00	30.00	-	-
Poultry Manure (PM)	0.50	0.50	95.50	65.50	13,100
Poultry Manure+Inorganic Fertilizer (PM+IF)	0.97	0.47	99.03	3.53	751

Source: Field Survey, 2005

This means that for each Ghana cedi invested in switching to the Poultry Manure (PM) treatment or the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment, the producer can expect to recover the GH¢1 invested plus an additional return of GH¢131.00 or GH¢7.51 respectively.

Consequently, a producer would be well-off by switching from the Control treatment to the Poultry Manure (PM) treatment, and even more well-off by switching to the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment. This is simply because the MRR between the Poultry Manure (PM) treatment and the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment is above the assumed Marginal Acceptable Rate of Return (MARR) of 100%. Hence, notwithstanding the fact that a switch from Control to Poultry Manure (PM) yields the highest MRR, a producer's overall net income could improve if an additional investment is made to adopt Poultry Manure+Inorganic Fertilizer (PM+IF). And from the financial point of view, the best technology to recommend would thus be the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment. Of course, this conclusion is in line with the recommendation by Evans (2005) who proposed that; "as applied to a situation in which the producer is confronted with a set of discrete alternative technologies, the producer should invest in the costlier technology as long as the marginal rate of return (in switching from a lower-cost technology to a higher-cost technology) is greater than the minimum acceptable rate of return." Again, it conforms to his assertion that a higher Marginal Rate of Return (MRR) does not necessarily imply that the treatment/technology responsible should be recommended.

4.16 PRODUCTION MODES AND PERCEIVED RELATED PROBLEMS

Four (4) respondents, representing about 7% of the total respondents cited streams and dugouts used for watering as breeding grounds for mosquitoes as health-related problem posed by any of the production modes to the community as whole.

Thirteen (13) respondents, corresponding to about 22% of the total respondents pointed out that neighbours at times complained about the repugnant odour generated by the decomposing poultry manure, and as such perceived this as a social-related problem associated with this particular system of cabbage production namely the Poultry Manure (PM) treatment.

All sixty (60) respondents reasoned that inorganic fertilizer production mode weakens the soil, and thus threatens sustainability. Interestingly, this reasoning is corroborated by this remark from the Cambridge Encyclopedia: "In some countries, legal limitations are imposed on the total quantity of fertilizer which may be added to the land during each season. Little wonder then, that there is the public perception that inorganic fertilizers "poison the soil" and result in "low quality" produce in many countries."

4.17 OBSERVATIONS

Observation from the study shows that the model of farming in the Kumasi Metropolis conforms to that described by Von Thunen. Von Thunen (1826) described a model of farming systems in the cities, and concluded that farm produce would be grown in a series of concentric zones outward from a central market city. Perishable crops which are high yielding would be grown nearest to the city because, readily accessible farmland would be in great demand and, therefore, quite expensive.

Again, the results of this study confirmed the findings by Smith, O. B. (1999) that often larger urban centres have conspicuous inner and outer zones where cultivation of food crops and market gardening are being pursued vigorously.

With respect to citing of cabbage production fields in the Kumasi Metropolis, surveillance from this study confirms that of similar study which was conducted in Kumasi by Brook and Davila. Brook and Davila (2000) identified two main forms of urban cropping system in Kumasi namely backyard farming and "agriculture in the gaps."

Fig. 4.6 Heads from the Different Production Modes or Treatments

Moving in a clockwise direction from the top left corner, are images of heads of cabbage from the PM, IF, PM+IF, and Control treatment plots.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

Increased demands for food and soil nutrient amendment by urban dwellers and their intensive farming systems respectively, coupled with the issue of urban waste management, which are all consequences of the rapid surge in urban population growth, pose threat to urban centres like the Kumasi Metropolis. And organic farming is envisaged as a single concept that could be relied upon to provide remedy to these major problems, with minimum trade-offs, if any at all. Notwithstanding its potential, however, little or nothing has been done regarding the financial viability of organic farming vis-a-vis the use of inorganic fertilizer in the Kumasi Metropolis. Justifiably against this background, this study was undertaken using cabbage as the study crop, with the objective of assessing the financial viability of poultry manure, an organic soil/nutrient amendment factor, as an economic and sustainable alternative to inorganic fertilizer in cabbage production in the Kumasi Metropolis. To be able to do this we needed to identify the different modes of cabbage production in the Kumasi Metropolis, identify the inputs used by each of these and the associated cost, and then compute for the returns to each of these by valuing the economic yield. A Cost-Benefit ratio is then computed for each of the production modes and used as proxy for financial viability, which was used as input data for a One-Way ANOVA.

Cost-Benefit ratio, the One-Way ANOVA, Marginal Analysis, histogram, pie chart, tables and percentages, as well as descriptive statistics like, the mean, were the analytical tools used.

Plot size per farmer ranged from a minimum of 0.042ha to a maximum of 0.20ha, with an average plot size of 0.121ha. Average total cost of production per treatment plot of GH¢34.41, GH¢35.11, GH¢34.88, and GH¢33.91 for the Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and Control treatments respectively.

All the farmers (100%) indicated that they produced mainly for sales even though it was admitted by most them that they do consume an insignificant proportion at home.

All sixty (60) respondents, claimed to have some knowledge of the long term effects of inorganic fertilizers on the soil and /or environment as whole but in all instances, "weakening of soil," was the only known and cited long term effect of inorganic fertilizer usage. They however reasoned that continuous application of mineral fertilizer threatens sustainability of production.

Average economic yield (output) per treatment of 2.79kg, 2.65kg, 2.91kg, and 0.52kg were recorded for Poultry Manure (PM), Inorganic Fertilizer (IF), Poultry Manure+Inorganic Fertilizer (PM+IF), and the Control treatments respectively.

Results from a One-Way ANOVA revealed a significant difference among the ***means*** of yield (output) from the various production modes (treatments) of cabbage. Employing the Tukey's HSD[3] test, the Post Hoc analysis revealed a significant difference between the mean yields (outputs) of cabbage obtained from Poultry Manure (PM) and Inorganic Fertilizer (IF) treatments at the 0.05 α level.

[3] HSD stands for 'honestly significant difference.'

By the same procedure, a significant difference was revealed between the mean yield (output) from the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment and that obtained from the Inorganic Fertilizer (IF) at the 0.05 α level.

However, it was revealed by this same procedure that ***no*** significant difference existed between the mean yields (outputs) obtained from Poultry Manure+Inorganic Fertilizer (PM+IF) and that obtained from Poultry Manure (PM).

The Poultry Manure+Inorganic Fertilizer (PM+IF) treatment recorded the highest average revenue per treatment or production mode followed by the Poultry Manure (PM), Inorganic Fertilizer (IF), and Control treatments in that order.

Again, the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment recorded the lowest Cost-Benefit ratio per treatment or production mode followed by the Poultry Manure (PM), Inorganic Fertilizer (IF), and Control treatments in that order.

Results from the One-Way ANOVA revealed a significant difference among the ***means*** of profitability (Cost-Benefit ratio) from the various production modes (treatments) of cabbage. Again, a Post Hoc analysis, using the Tukey's HSD test revealed there was a significant difference between the mean of profitability of cabbage obtained from Poultry Manure (PM) and Inorganic Fertilizer (IF) treatments at the 0.05 α level.

By the same procedure, a significant difference was revealed between the mean of profitability from the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment and that obtained from the Inorganic Fertilizer (IF) at the 0.05 α level.

However, it was revealed by this same procedure that ***no*** significant difference existed between the mean of profitability obtained from Poultry Manure+Inorganic Fertilizer (PM+IF) and that obtained from Poultry Manure (PM) at the 0.05 α level.

From the Marginal Analysis, the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment emerged as the best technology to recommend, with regard to financial viability, followed by the Poultry Manure (PM) treatment.

Provision of breeding grounds for mosquitoes by streams and dugouts used for watering, and repugnant odour generated by the decomposing poultry manure were cited by some respondents as health-related and social-related problems associated with irrigated urban cabbage production in general, and the Poultry Manure (PM) production mode in particular.

5.2 CONCLUSIONS

Three modes of cabbage production were identified in the Kumasi Metropolis, with regard to soil/nutrient amendment method namely; exclusive use of Poultry Manure (PM), exclusive use of Inorganic Fertilizer (IF) and the combination of Poultry Manure and Inorganic Fertilizer (PM+IF).

The financial benefits or revenue from each of the three modes of cabbage production outstrips the respective costs. Consequently, Cost-Benefit ratios for all of the three modes of cabbage production revealed that each of them was profitable or financially viable. The basis for arriving at such a conclusion is the fact that each of the three modes of production obtained a Cost-Benefit ratio, which is less than unity.

Results from the One-Way ANOVA at the 5% α level revealed that; the Null Hypothesis be rejected in both instances of the hypothesis testing namely; economic yield (output), and profitability. Post-Hoc analyses, however, disclosed that there was significant difference between the means of the exclusive Poultry Manure (PM) and the Inorganic Fertilizer (IF) treatments for both tests. Likewise, the means of the Poultry Manure+Inorganic Fertilizer (PM+IF) and the Inorganic Fertilizer (IF) treatments differed significantly at the 5% α level. Interestingly, though, there was ***no*** significant difference between the means of the exclusive Poultry Manure (PM) treatment and those of the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment in both tests.

Results from the Marginal Analysis rated the Poultry Manure+Inorganic Fertilizer (PM+IF) treatment as most recommendable with regard to financial returns or benefits.

Employment and food for the household were identified by respondents as some of the positive externalities associated with all modes of cabbage production as against the negative externality of enhanced breeding of mosquitoes caused by the streams and dugouts used for watering. Soil acidity or weakening of soil and repugnant odour, however, were identified as specific negative externalities related to the Inorganic Fertilizer (IF) treatment and the Poultry Manure (PM) treatment respectively.

Findings from the study also made known that, considering the direct and indirect impacts of the various modes of cabbage production in the Kumasi Metropolis, most respondents preferred the Poultry Manure (PM) treatment or production mode to that of the Poultry Manure+Inorganic Fertilizer (PM+IF) and the Inorganic Fertilizer (IF) treatments.

5.3 RECOMMENDATIONS

Improving upon urban vegetable production to enhance benefits to the farmers, their households, and the community as a whole calls for certain requirements. And on the basis of the present study the following recommendations are made:

1. Strong efforts should be made to educate the farmers about the importance of compost (recycled nutrient from waste) and enriched Co-compost as a sound sustainable measure for improving and/or maintaining soil fertility.
2. There is the need for the cabbage farmers to belong to associations, in order to be able to eliminate or minimize the exploitative power of middlemen for better returns.
3. Urban cabbage production can be very lucrative when undertaken as a serious business, and for the prospective urban farmer, the venture is worth the investment.
4. Producers who adopt the Poultry Manure (PM) treatment could receive premium price for their produce should they make the necessary effort to be recognised and certified by the appropriate government agency as organic vegetable producers.
5. Lastly, the government should facilitate the operations of national institutions responsible for urban planning and management, and empower these to prevent people from encroaching on open spaces in and around the urban centres, which could serve as greenbelts when kept under urban agriculture.

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APPENDICES

APPENDIX-A

ESTIMATION OF FIXED (COMMON) COST PER INDIVIDUAL FARMER (REPLICATE)

INPUT	USED QUANTITY	UNIT COST (GH¢)	ESTIMATED LIFE SPAN (YRS.)	UNIT DEPRECIATING RATE/YR (GH¢)	TOTAL DEPRECIATED VALUE (GH¢)	PRODUCTION CYCLES/YR.	TOTAL COST/ PRODUCTION CYCLE (GH¢)
Seed	5g packet	2.50	-	-	-	-	2.50
Neemazal for pest control	500ml	5.50	-	-	-	-	5.50
Water	-	-	-	-	-	-	-
Labour	90 man-days	1.33	-	-	-	-	120.00
Watering Can	2	8.00	2	4.00	8.00	3	2.67
Knapsack Sprayer	1	50.00	5	10.00	10.00	3	3.33
Hoe	1	2.50	5	0.50	0.50	3	0.17
Cutlass	1	3.00	3	1.00	1.00	3	0.33
Spade/Shovel	1	3.50	2	1.75	1.75	3	0.58
Hand Fork	1	1.50	3	0.50	0.50	3	0.17
Wellington Boot	1	7.00	6	1.17	1.17	3	0.39
Total							**135.64**

NB: using the straight line method of depreciating fixed assets, $\text{Annual Depreciation rate} = \frac{\text{Original value of asset} - \text{Salvage value}}{\text{Useful life}}$

From the table, it is realised that the total fixed cost of production per individual farmer or replicate is GH¢ 135.64. To obtain the total fixed cost of production per particular treatment or means of production, we divide GH¢ 135.64 by the number of the different treatments within a replicate, which is four (4) to obtain GH¢ 33.91 per each treatment plot of 69.60m^2.

ESTIMATION OF VARIABLE COST PER TREATMENT

Treatment (Production mode)	Quantity of Variable Input per Plot	Total Variable Cost (GH¢)
Poultry Manure (PM)	100kg bag of Poultry Manure	**0.50**
Inorganic Fertilizer (IF)	2.5kg N.P.K	**1.20**
Poultry Manure+Inorganic Fertilizer (PM+IF)	1.5kg N.P.K +50kg bag of Poultry Manure	0.72 (IF) + 0.25 (PM) = **0.97**
Control*	-	-

* Not Applicable

TOTAL COST OF PRODUCTION PER TREATMENT

Treatment (Production mode)	Total Cost Of Production
Poultry Manure (PM)	**GH¢34.41**
Inorganic Fertilizer (IF)	**GH¢35.11**
Poultry Manure+Inorganic Fertilizer (IF+PM)	**GH¢34.88**
Control	**GH¢33.91**

APPENDIX-B

MODES OF CABBAGE PRODUCTION AND THEIR RESPECTIVE YIELDS (KG) AND REVENUE (GH¢)

SS#	Poultry manure (PM)		Inorganic fertilizer (IF)		PM + IF		Control	
	Av. Kg Yield	Revenue (GH¢)	Av. Kg Yield	Revenue (GH¢)	Av. Kg Yield	Revenue (GH¢)	Av. Kg Yield	Revenue (GH¢)
1	2.6	90	2.5	90	2.8	90	0.4	30
2	3.3	120	3.0	90	3.4	120	0.7	30
3	3.1	120	3.0	90	3.3	120	0.7	30
4	2.7	90	2.6	90	2.8	90	0.5	30
5	2.8	90	2.7	90	2.9	90	0.5	30
6	2.8	90	2.7	90	2.9	90	0.5	30
7	3.0	90	2.9	90	3.2	120	0.7	30
8	2.8	90	2.6	90	2.9	90	0.5	30
9	3.0	90	2.9	90	3.2	120	0.6	30
10	2.7	90	2.6	90	2.9	90	0.5	30
11	2.5	90	2.3	90	2.6	90	0.4	30
12	2.2	90	2.1	90	2.4	90	0.3	30
13	3.0	90	2.8	90	3.1	120	0.6	30
14	2.8	90	2.7	90	2.9	90	0.5	30
15	2.6	90	2.5	90	2.8	90	0.4	30
16	2.6	90	2.5	90	2.7	90	0.4	30
17	3.4	120	3.1	120	3.5	120	0.8	30
18	3.5	120	3.2	120	3.6	120	0.8	30
19	2.9	90	2.7	90	2.9	90	0.6	30
20	2.4	90	2.2	90	2.4	90	0.3	30
21	2.8	90	2.7	90	2.9	90	0.5	30
22	3.4	120	3.1	120	3.5	120	0.8	30
23	2.6	90	2.5	90	2.8	90	0.4	30
24	2.6	90	2.5	90	2.7	90	0.4	30
25	2.8	90	2.7	90	2.9	90	0.6	30
26	2.5	90	2.4	90	2.6	90	0.4	30
27	3.1	120	3.0	90	3.3	120	0.7	30
28	2.6	90	2.5	90	2.7	90	0.4	30
29	2.3	90	2.2	90	2.4	90	0.3	30
30	3.0	90	2.8	90	3.1	120	0.6	30
31	3.1	120	3.0	90	3.3	120	0.7	30
32	2.7	90	2.6	90	2.9	90	0.5	30
33	3.0	90	2.9	90	3.2	120	0.6	30
34	2.6	90	2.5	90	2.8	90	0.4	30
35	3.0	90	2.9	90	3.1	120	0.6	30
36	3.0	90	2.9	90	3.1	120	0.6	30
37	3.5	120	3.4	120	3.6	120	0.8	30
38	2.4	90	2.3	90	2.5	90	0.3	30
39	2.6	90	2.5	90	2.7	90	0.4	30
40	2.5	90	2.4	90	2.6	90	0.4	30

41	3.0	90	2.8	90	3.1	120	0.6	30
42	2.4	90	2.3	90	2.5	90	0.3	30
43	2.4	90	2.3	90	2.5	90	0.3	30
44	2.5	90	2.4	90	2.6	90	0.4	30
45	3.5	120	3.2	120	3.6	120	0.8	30
46	2.3	90	2.2	90	2.4	90	0.3	30
47	2.9	90	2.7	90	2.9	90	0.6	30
48	3.2	120	3.0	90	3.4	120	0.7	30
49	3.3	120	3.0	90	3.4	120	0.7	30
50	2.7	90	2.6	90	2.9	90	0.5	30
51	2.4	90	2.2	90	2.4	90	0.3	30
52	2.2	90	2.0	90	2.2	90	0.3	30
53	2.9	90	2.8	90	3.0	90	0.6	30
54	2.5	90	2.4	90	2.6	90	0.4	30
55	2.2	90	2.1	90	2.3	90	0.3	30
56	2.9	90	2.8	90	3.0	90	0.6	30
57	2.9	90	2.7	90	3.0	90	0.6	30
58	2.8	90	2.6	90	2.9	90	0.5	30
59	2.5	90	2.3	90	2.5	90	0.4	30
60	3.2	120	3.0	90	3.4	120	0.7	30

NB: $Revenue = Unit\ price\ (P) \times Quantity(Q)$

Estimation of Total Revenue per plot based on the category of average weight (Kg)

Average Weight/Head (Kg)	Unit Price (GH¢)	Harvested Quantity /Plot	Total Revenue (GH¢)
0-1	0.10	300	30
1-2	0.20	300	60
2-3	0.30	300	90
3-4	0.40	300	120

APPENDIX-C

MODES OF CABBAGE PRODUCTION AND THEIR RESPECTIVE TOTAL COSTS (GH¢) AND C/B RATIOS

SS#	Poultry manure (PM)		Inorganic fertilizer (IF)		PM + IF		Control	
	Total Cost (GH¢)	C/B Ratio	Total Cost (GH¢)	C/B Ratio	Total Cost (GH¢)	C/B Ratio	Total Cost (GH¢)	C/B Ratio
1	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
2	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333
3	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333
4	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
5	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
6	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
7	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
8	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
9	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
10	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
11	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
12	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
13	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
14	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
15	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
16	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
17	34.41	0.28675	35.11	0.292583	34.88	0.290667	33.91	1.130333
18	34.41	0.28675	35.11	0.292583	34.88	0.290667	33.91	1.130333
19	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
20	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
21	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
22	34.41	0.28675	35.11	0.292583	34.88	0.290667	33.91	1.130333
23	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
24	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
25	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
26	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
27	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333
28	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
29	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
30	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
31	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333
32	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
33	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
34	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
35	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
36	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
37	34.41	0.28675	35.11	0.292583	34.88	0.290667	33.91	1.130333
38	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
39	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
40	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333

41	34.41	0.382333	35.11	0.390111	34.88	0.290667	33.91	1.130333
42	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
43	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
44	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
45	34.41	0.28675	35.11	0.292583	34.88	0.290667	33.91	1.130333
46	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
47	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
48	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333
49	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333
50	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
51	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
52	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
53	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
54	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
55	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
56	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
57	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
58	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
59	34.41	0.382333	35.11	0.390111	34.88	0.387556	33.91	1.130333
60	34.41	0.28675	35.11	0.390111	34.88	0.290667	33.91	1.130333

NB: Cost-Benefit Ratio is expressed mathematically as; $C/_B = \dfrac{\sum[Inputs\cos ts]}{\sum[Benefits(\mathrm{Re}\,venue)]}$

Where C/B = Cost-Benefit Ratio, and Benefits = Revenue.

APPENDIX-D

OUTPUT OF THE ONE-WAY ANOVA

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Yield of cabbage per treatment	Poultry Manure (PM)	60	2.7917	.34262	.04423	2.7032	2.8802	2.20	3.50
	Inorganic Fertilizer (IF)	60	2.6467	.31271	.04037	2.5659	2.7274	2.00	3.40
	PM+IF	60	2.9083	.35810	.04623	2.8158	3.0008	2.20	3.60
	Control	60	.5167	.15532	.02005	.4765	.5568	.30	.80
	Total	240	2.2158	1.03236	.06664	2.0846	2.3471	.30	3.60
Cost-Benefit Ratio as proxy for profitability	Poultry Manure (PM)	60	.363217	.0385560	.0049776	.353257	.373177	.2868	.3823
	Inorganic Fertilizer (IF)	60	.381984	.0271827	.0035093	.374962	.389006	.2926	.3901
	PM+IF	60	.355259	.0460593	.0059462	.343361	.367158	.2907	.3876
	Control	60	1.130333	.0000000	.0000000	1.130333	1.130333	1.1303	1.1303
	Total	240	.557698	.3330595	.0214989	.515347	.600050	.2868	1.1303

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Yield of cabbage per treatment	Between Groups	233.035	3	77.679	845.409	.000
	Within Groups	21.684	236	.092		
	Total	254.720	239			
Cost-Benefit Ratio as proxy for profitability	Between Groups	26.255	3	8.752	8053.348	.000
	Within Groups	.256	236	.001		
	Total	26.512	239			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Means of production with regard to nutrient amendment	(J) Means of production with regard to nutrient amendment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Yield of cabbage per treatment	Poultry Manure (PM)	Inorganic Fertilizer (IF)	.14500*	.05534	.046	.0018	.2882
		PM+IF	-.11667	.05534	.153	-.2599	.0265
		Control	2.27500*	.05534	.000	2.1318	2.4182
	Inorganic Fertilizer (IF)	Poultry Manure (PM)	-.14500*	.05534	.046	-.2882	-.0018
		PM+IF	-.26167*	.05534	.000	-.4049	-.1185
		Control	2.13000*	.05534	.000	1.9868	2.2732
	PM+IF	Poultry Manure (PM)	.11667	.05534	.153	-.0265	.2599
		Inorganic Fertilizer (IF)	.26167*	.05534	.000	.1185	.4049
		Control	2.39167*	.05534	.000	2.2485	2.5349
	Control	Poultry Manure (PM)	-2.27500*	.05534	.000	-2.4182	-2.1318
		Inorganic Fertilizer (IF)	-2.13000*	.05534	.000	-2.2732	-1.9868
		PM+IF	-2.39167*	.05534	.000	-2.5349	-2.2485
Cost-Benefit Ratio as proxy for profitability	Poultry Manure (PM)	Inorganic Fertilizer (IF)	-.0187671*	.0060187	.011	-.034340	-.003194
		PM+IF	.0079574	.0060187	.550	-.007615	.023530
		Control	-.7671167*	.0060187	.000	-.782690	-.751544
	Inorganic Fertilizer (IF)	Poultry Manure (PM)	.0187671*	.0060187	.011	.003194	.034340
		PM+IF	.0267245*	.0060187	.000	.011152	.042297
		Control	-.7483495*	.0060187	.000	-.763922	-.732777
	PM+IF	Poultry Manure (PM)	-.0079574	.0060187	.550	-.023530	.007615
		Inorganic Fertilizer (IF)	-.0267245*	.0060187	.000	-.042297	-.011152
		Control	-.7750741*	.0060187	.000	-.790647	-.759501
	Control	Poultry Manure (PM)	.7671167*	.0060187	.000	.751544	.782690
		Inorganic Fertilizer (IF)	.7483495*	.0060187	.000	.732777	.763922
		PM+IF	.7750741*	.0060187	.000	.759501	.790647

*. The mean difference is significant at the .05 level.

Homogeneous Subsets

Yield of cabbage per treatment

Tukey HSD[a]

Means of production with regard to nutrient	N	Subset for alpha = .05		
		1	2	3
Control	60	.5167		
Inorganic Fertilizer (IF)	60		2.6467	
Poultry Manure (PM)	60			2.7917
PM+IF	60			2.9083
Sig.		1.000	1.000	.153

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 60.000.

Cost-Benefit Ratio as proxy for profitability

Tukey HSD[a]

Means of production with regard to nutrient	N	Subset for alpha = .05		
		1	2	3
PM+IF	60	.355259		
Poultry Manure (PM)	60	.363217		
Inorganic Fertilizer (IF)	60		.381984	
Control	60			1.130333
Sig.		.550	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 60.000.

APPENDIX-E

QUESTIONNAIRE FOR SAMPLED FARMERS

The Financial Viability of Organic Urban Vegetable Production

A Study of Cabbage in the Kumasi Metropolis

Part I – Pre-implementation of Field Trial Session

Name of Enumerator:..Date of interview:………………..

Locality/Town/Village:..District/Region:............................

Name of Farmer (optional):...

Sex: Male ( ) Female ( ) Level of Education: None ( )

Basic ( ) Secondary/Vocational ( ) Post-Sec ( ) Tertiary ( )

1. Which of the following systems of cabbage production have you adopted? Organic/Poultry manure ( ) Inorganic/Chemical fertilizer ( ) Mixed (Poultry manure+Chemical fertilizer) ( ) Others ( ) Specify………………

2a. Have you ever been engaged in any of the other listed systems of production? Yes ( ) No ( )

2b. If *Yes*, specify the system, and indicate why the switch to this one?.................
………………………………………………………………………………
………………………………………………………………………………

3a. What is/are the size(s) of your plot(s)?...

3b. What is the mode of land acquisition? Rent/leasehold ( ) Communal ( ) Freehold/individual ( ) Others ( ) Specify…………………………………

3c. If rent/leasehold at what cost per acre/hectare/land area per year? ¢…………...

3d. If any other, what are the terms and how much does it cost?..............................
....
....

4a. How do you prepare your plot for production? Personal/family labour ( ) Casual labour ( ) Tractor service ( ) Others ( ) Specify………………

4b. At what cost per acre/hectare/land area? (Reference to 4a) ¢…..………………

5a. How are inputs conveyed to the field? Vehicle ( ) Porterage ( )

5b. What are the inputs that go into the production, their sources, various quantities, unit costs and cost of conveying them to the fields/plots?

INPUTS	SOURCE	Q'TY	COST/UNIT (GH¢)	CONVEYING (GH¢)
Seed				
Fertilizer (inorganic)				
Poultry manure				
Compost				
Enriched Co-compost				
Chemicals				
Water				
Watering can/equipment				
Labour (cultural practices)				
Hand fork				
Hoes and cutlass				
Spade/shovel				
Spraying equipment's				
Others (Specify)				

6a. How many times in a year do you engage your plot in production?....................

6b. If more than once, do subsequent productions attract similar fertilization cost?

Yes ( ) No ( )

6c. If *No*, roughly estimate the cost of subsequent fertilization(s) ¢………………..

7. What is the cost of harvesting the produce? ¢..

8a. What is the purpose of your production?

Home consumption ( ) Sales ( ) Both ( )

8b. If for sales, what is the grading mechanism employed? (In other words, how is the produce graded?)……………………………………………….....................

9a. What is the average unit weight of a produce per grade?

Very Large…..kg Large..…kg Medium..…kg Small..…kg

9b. What is the average unit price/grade?

Very Large ¢…… Large ¢……. Medium ¢…… Small ¢……

10a. Where do you normally offer the produce for sale?

Markets ( ) Farm gate ( ) Hotels/Restaurants ( )

10b. How does the produce get to the sales point(s) from the production sites?

Porterage ( ) vehicle ( )

10c. What is the cost of conveying the produce to the sales points? ¢........................

11. When do you offer the produce for sale?
Immediately after harvesting ( ) Stored for sometime ( )

12. After harvesting, what use do you make of the waste if any?.............................
……………………………………………………………………………………..…
……………………………………………………………………………………..

13a. Do you have any problem with soil fertility? Yes ( ) No ( )

13b. If *Yes*, what are some of the feasible measures you would use to improve soil fertility? Inorganic fertilizer application ( ) Poultry manure application ( ) Fallowing ( ) Crop rotation ( ) Composting ( ) Others ( ) Specify)………………...

13c. If *No*, how do you maintain the soil fertility of your plot?
Inorganic fertilizer application ( ) Poultry manure application ( )
Fallowing ( ) Crop rotation ( ) Composting ( )
Others ( ) (Specify) ……………….

14a. Do you have any knowledge of the long term effects of inorganic fertilizers on the soil and/or environment as a whole? Yes ( ) No ( )

14b. If *Yes*, what are some of the effects?...
……………………………………………………………………………………..
……………………………………………………………………………………..

15a. Do you have any knowledge of compost? Yes ( ) No ( )

15b. If *Yes*, do you make use of compost in your production? Yes ( ) No ( )

15c. If *No*, why?..

16a. Do you have any knowledge of Co-compost? Yes ( ) No ( )

16b. If *Yes*, do you make use of Co-compost in your production? Yes ( ) No ( )

16c. If *No*, why?..

17a. Do you have any knowledge of enriched Co-compost or Comlizer?
Yes ( ) No ( )

17b. If *Yes*, do you make use it in your production? Yes ( ) No ( )

17c. If *No*, why?..

18a. Are there any farmers association in this community? Yes ( ) No ( )

18b. If *Yes*, are you a member of the association? Yes ( ) No ( )

19a. Do you have any idea about the total number of farmers in this area? (with respect to this farming system) Yes ( ) No ( )

19b. If *Yes*, how many are you?..

Part II – Post-implementation of Field Trial Session

20. What is the quantity of output (yield) per total plot obtained from the production? (w.r.t. particular soil/nutrient amendment factor)

NB: use the information to complete the table below:

Poultry Manure					
Size of head	Very Large	Large	Medium	Small	**Total**
Number of heads					
Inorganic Fertilizer					
Size of head	Very Large	Large	Medium	Small	**Total**
Number of heads					
Poultry Manure+Inorganic Fertilizer					
Size of head	Very Large	Large	Medium	Small	**Total**
Number of heads					
Control					
Size of head	Very Large	Large	Medium	Small	**Total**
Number of heads					

21a. Comparatively, do you observe any significant difference in yield regarding the different systems of production, namely Inorganic fertilizer, Poultry manure, Inorganic fertilizer+Poultry manure, and the Control? Yes ( )No ( )

21b. If yes, rank the productivity of the various systems of production, starting with the most productive.

I.________________________________ II.______________________________

III.______________________________ IV.______________________________

22a. When made available, which of these will you choose? Inorganic fertilizer ( )

Poultry manure ( ) Inorganic fertilizer+Poultry manure ( ) Comlizer ( )

22b. What is/are your reason(s) for making that choice?..

……………………………………………………………………………………..

....

23. What problem do you think each of these production modes poses to the household and /or community as whole, if any?

....

……………………………………………………………………………………..