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FACTORS AFFECTING ADOPTION AND INTENSITY OF USE OF ORGANIC SOIL MANAGEMENT PRACTICES IN MAIZE PRODUCTION IN BUNGOMA COUNTY, KENYA

GIDO OBEDY ERIC

A thesis submitted to the Graduate School in partial fulfillment for the requirements of the award of Master of Science Degree in Agricultural and Applied Economics of Egerton University

EGERTON UNIVERSITY

MARCH, 2012

DECLARATION AND RECOMMENDATION

DECLARATION

I hereby declare that this is my original work and has not been presented in this or any other university for the award of any degree.

Sign---------- Date----------

Gido Obedy Eric

KM17/2401/09

RECOMMENDATION

This work has been prepared and presented to the graduate school for examination with our approval as University supervisors.

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DEDICATION

I dedicate this work to my parents Mr. Obedy W. Ombuya and Mrs. Loy Obedy, my brother and sisters; Christine, Grace, Lydia, Bathwel and Ebby for their sincere support, and to all smallholder farmers in Bungoma County for their cooperation in providing information.

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ABSTRACT

To reduce poverty, which is a major issue in Kenya, the agricultural sector and development policies emphasize on use of chemical inputs as a means to increase food production. These inputs, however, cause a considerable damage to the natural environment. As an alternative, organic agriculture uses minimal external inputs and enhances an ecosystem's health by minimizing adverse effects on natural resources. Organic soil management practices in Bungoma County have been promoted intensively by SACRED Africa for more than a decade, however, there is still a low uptake of these practices and their levels of utilization by farmers have not been evaluated. This study focused on factors affecting adoption and intensity of use of organic soil management practices in maize production in Bungoma County. In addition, the study determined the farmers' perceptions towards organic soil management practices and also examined a comparative profitability between organic and conventional maize production. A systematic random sampling technique was used to select a representative sample of 150 smallholder farmers and primary data was collected using observations and interviews with the help of a semi-structured questionnaire. In the analysis, descriptive statistics, chi-square test, independent two-sample t-test, a Likert-type five-point continuum scale and a Tobit model were used with the help of STATA, statistical package for social sciences and Excel computer programs. The perception results showed that environmental concern was highly perceived as the most important practice related to organic soil management. The gross margin was higher in organic than conventional maize production, however, result of two-tailed independent t-test was insignificant between organic and conventional maize production. Education level of the household head, age of the household head, household size, farmer's positive perception, ownership of land by title deed, group membership, farm distance from the farmer's homestead, extension contacts and farmer access to credit influenced adoption and intensity of use of organic soil management practices. The recommended policy interventions in enhancing farmers' awareness through extension and training on organic soil management practices, encourage stocking of dried organic manure in shops, improvement on prices of organic products, improving farmer access to credit facilities and enhancing security of tenure through provision of land title deeds. This will promote adoption and intensity of use of organic soil management practices which will in turn lead to environmental sustainability.

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ACRONYMS AND ABREVIATIONS

CA	Conventional Agriculture
CF	Conventional Farming
CMP	Conventional Maize Production
FAO	Food and Agriculture Organization of United Nations
GHG	Greenhouse Gases
GM	Gross Margin
GoK	Government of Kenya
GR	Gross Returns
IFOAM	International Federation for Organic Agricultural Movements
KES	Kenya Shillings
KNBS	Kenya National Bureau of Statistics
MDGs	Millennium Development Goals
NGO	Non-Governmental Organization
OA	Organic Agriculture
OF	Organic Farming
OMP	Organic Maize Production
OSMP	Organic Soil Management Practices
OVF	Organic Vegetable Farming
RUT	Random Utility Theory
SACRED	Sustainable Agriculture Centre for Research, Extension and Development
SPSS	Statistical Package for Social Sciences
TVC	Total Variable Cost
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Kenyan economy largely depends on the agricultural sector as the engine for economic growth. The sector accounts for about 22% of the Gross Domestic Product (GDP) and about 75% of Kenyans owe their livelihood to agriculture (KNBS, 2010). The agricultural sector in Kenya largely relies on conventional farming system yet the country has not been able to produce enough of her food needs. As a way of meeting the food deficiency, Kenya has increasingly depended on food import/Aid which contradicts her policy of self-sufficiency (Kimemia and Oyare, 2006).

The food production and demand projections indicate that Kenya will continue to experience serious food deficits unless greater efforts are made to address the food security situation (Kimemia and Oyare, 2006). The major causes of low agricultural productivity are soil nutrient depletion, pest and disease problems, poor land management systems, climate change and poor implementation of agricultural policies. For a long period of time, application of inorganic farm inputs has been emphasized as a way of addressing soil fertility problem but this is constrained by the high costs which resource-poor farmers cannot afford. In addition, this has contributed to soil erosion, environmental pollution, loss of indigenous crop diversity and poor health among rural people (Kimemia and Oyare, 2006). A study by Odhiambo (1994) revealed that the rising cost of inputs has resulted to farmers reducing or abandoning the use of chemical inputs altogether. Increasing agricultural productivity and therefore output in the agricultural sector using improved technologies is a necessary step towards achieving food security. Since policy objectives of agricultural sector are to attain self-sufficiency in basic food supply and improve individuals' welfare, technological change is an important strategy of ensuring that farmers' welfare is improved by increasing their incomes through agricultural production.

Organic agriculture (OA) is a low-risk farming strategy with reduced input costs (El-HageScialabba and Hattam, 2002) due to availability of local farm inputs hence, it is a viable alternative for poor farmers. The coping capacity of the farm is increased and the risk of indebtedness is lowered (UNFCCC, 2007). It is a sustainable and environmentally friendly production system that offers developing countries a wide range of economic, environmental, social and cultural benefits and has particular advantages for small-scale farmers in Africa (UNEP-UNCTAD, 2006; UNCTAD, 2006). As a farming system without synthetically processed inputs, OA seeks to promote and enhance an ecosystem's health while minimizing

adverse effects on natural resources (IFOAM, 2006; FAO and IFOAM, 1998). OA emphasizes on the use of management practices in preference to use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using agronomic, biological and mechanical methods, as opposed to synthetic materials, to fulfill any specific function within the system (FAO and IFOAM, 1998). The key goals of OA includes: producing food of high nutritional quality in sufficient quantities, encouraging and enhancing biological cycles within the farming system, maintaining and increasing long-term soil fertility, promoting healthy use and proper care of water and water resources, using renewable resources in locally organized agricultural system, minimizing all forms of pollution from agricultural practices and maintaining the genetic diversity of the agricultural system and its surroundings including habitats and ecosystems protection (UNEP-UNCTAD, 2006).

The central farming activity of fertilization illustrates the differences between OA and conventional agriculture (George and Gegner, 2004). OA relies heavily on natural breakdown of organic matter in the soil using techniques like green manure and composting to replace nutrients taken from the soil by previous crops (FAO and IFOAM, 1998). This biological process allows natural production of nutrients in the soil throughout the growing season and has been referred to as feeding the soil to feed the plant. Other organic management practices which positively contribute to soil fertility status include: crop rotation, mulching, use of FYM, planting of leguminous crops and agroforestry and incorporation of crop residues in the soil.

In Kenya, maize *(Zea mays)* is a major food crop and dominates all food security considerations with a per capita consumption of 103 kg per year (Pingali, 2001). Kenya relies on maize as the staple food crop but its production is low (Ouma *et al.*, 2002). Small-scale farmers account for 75% of the overall maize production in Kenya. Despite the great efforts made to increase maize production, demand has occasionally outstripped supply necessitating importation of large quantities of maize grain. The goal of increasing maize output cannot be achieved unless farmers improve their production techniques with a view to overcome declining output resulting from declining soil fertility and productivity.

Bungoma County is one of the areas in Kenya where organic maize production (OMP) is practiced on small scale basis. In this district, OMP has been supported by SACRED Africa which is an indigenous NGO that was established with major objectives of

improving the livelihoods of resource-poor farmers, promoting sustainable use of natural resources and agro-biodiversity that seek to enhance food security and safety. Farmers are trained on sustainable agriculture such as OSMP with emphasis on; natural soil fertility management, integrated environmentally friendly weed, pest and disease protection, on-farm soil and water conservation techniques and farm level seed conservation.

1.2 Statement of the problem

Soil fertility is an essential factor in agricultural productivity since it enhances the farm's capacity to produce enough food for household subsistence and a surplus for revenue generation. Restoration as well as maintaining soil fertility status is an important strategy towards achieving food security in the country. Indigenous organic soil fertilization is common knowledge but the level of practice as well as the determinants of adoption by farmers has not been fully documented in Kenya. OSMP in Bungoma County have been promoted intensively by SACRED Africa for more than a decade with an aim of promoting soil fertility hence, improving maize yields in addition to sustaining ecological development. However, there is still a low uptake of these practices and the levels of utilization of OSMP by farmers have not been evaluated. Therefore, there is lack of information on specific factors affecting adoption and intensity of use of OSMP. It is imperative to understand why such opportunities have not been fully exploited by farmers hence this study is geared towards filling this knowledge gap.

1.3 Objectives of the study

1.3.1 General objective

The general objective of the study is to examine the role of OSMP in improving soil fertility for increased agricultural production and households' income in Bungoma County.

1.3.2 Specific objectives

i. To characterize the existing types of OSMP in the area.
ii. To determine farmers perceptions towards OSMP.
iii. To examine comparative profitability of organic maize production *vis-à-vis* conventional maize production.
iv. To determine socio-economic and institutional factors affecting adoption and intensity of use of OSMP.

1.4 Research questions

i. What are the prevalent OSMP in the area?
ii. What are the farmers' perceptions towards OSMP?
iii. Is organic maize production a profitable farming system as compared to conventional maize production?
iv. What are the socio-economic and institutional factors affecting adoption and intensity of use of OSMP?

1.5 Justification of the study

Attempts were made in this study to determine factors affecting adoption and intensity of use of OSMP among smallholder farmers. The knowledge gained from this study would encourage more farmers to adopt OSMP system as well as allocate bigger proportions of land under OA hence, increasing maize yields. The associated OSMP would lead to many improvements to the natural environment including increased water retention in soils, reduced soil erosion and improved organic matter in the soil.

This study was also in line with MDG1 (to upscale poverty reduction and food security initiatives in the country) and MDG7 (to ensure environmental sustainability) which are highly relevant to OA (GoK, 2007). The study was therefore important and timely since it addresses food security situation, fill the existing information gap and provide necessary information for poverty alleviation in the rural areas. The knowledge of the extent of adoption of OSMP by maize farmers will serve as a guide for formulating policies to bring about increased farm output thus, enhancing farmers' incomes and welfare. In addition, this research was also essential in generating necessary information for achieving the government's endeavor to boost agricultural productivity in Kenya.

1.6 Scope and limitation of the study

The study targeted small-scale maize farmers in Bungoma Central and Bungoma South districts in Bungoma County. The activities under organic soil management practices included; crop rotation, green manure and composting, cover cropping, mulching, planting of leguminous crops and agroforestry. Organic farmers consisted of only those who had continuously practiced OA for at least three years. The findings apply mainly to the study area and do not reflect the views of all farmers in Kenya since the factors affecting adoption

and intensity of use of OSMP might differ between regions. In addition, the study was constrained by time and financial resources which hindered in-depth analysis of all variables.

1.7 Operational definition of terms

a. **Conventional agriculture:** An industrialized agricultural system characterized by mechanization, monoculture and use of synthetic inputs.
b. **Organic agriculture:** Is a farming system which does not incorporate use of synthetic farm-inputs such as chemical fertilizers, herbicides and pesticides
c. **Organic soil management:** It is a farm activity that promotes use of farm-renewable resources and management practices such as; crop rotation, green manure and composting, cover cropping, mulching, poly-culture, agroforestry and planting of leguminous crops.
d. **Smallholder**: Are households who operate on less than five hectares of land
e. **Sustainable agriculture:** Refers to an agricultural system that is ecologically sound, economically viable and socially just. It is a system capable of maintaining productivity indefinitely.

CHAPTER TWO: LITERATURE REVIEW

2.1 Organic agriculture

OA has been defined differently by various authors. According to UNCTAD (2006), OA is a sustainable and environmentally friendly production system that offers a wide range of economic, environmental, social and cultural benefits. The Codex Alimentarius of the FAO and WHO (2001) defines OA as a holistic production management system which promotes and enhances agro-ecosystem health including biodiversity, biological cycles and soil biological activity. It emphasizes use of management practices in preference to use of off-farm inputs, taking into account that regional conditions require locally adapted systems. The International Federation of Organic Agricultural Movements (IFOAM) defines OA as a production system that sustains the health of soils, ecosystems and people (IFOAM, 2009). It relies on ecological processes, biodiversity and cycles adapted to local conditions instead of using inputs with adverse effects. Therefore, this study adopted the IFOAM definition of organic agriculture.

The main aim of OA is to create sustainable agricultural production system (Padel, 2001). OA has the potential to improve sustainability of agricultural production, to stabilize yields, to achieve food security and to provide access to attractive markets through certified products (Kilcher, 2007). A wide range of studies have demonstrated the advantageous aspects of OA in terms of ecosystem functioning, soil fertility conservation and economic impact (Mäder *et al*., 2002). NGOs and farmer groups are increasingly adopting organic techniques as a method of improving productivity and food security in these systems. However, no systematic attempt has previously been made to track the extent to which these approaches are being employed in meeting economic and environmental objectives (Willer and Yussefi, 2006).

2.2 Productivity under organic agriculture

Organic agriculture is based on a combination of traditional and modern agro-ecological research. In traditional farming systems, OA often enables a direct increase in production and this is even possible for high-input farming systems in the long run. In addition, organic farmers harvest more products on the same area thus, providing more food and reducing the dependency on market products (Kilcher, 2007). One criticism of OA is that it produces low yields. However, organic practices in developing countries have greatly increased productivity particularly if the existing system is of low-input. A study by Badgley

et al. (2007) indicated that organic methods could produce enough food on a global per capita basis to sustain the current and potentially larger human population without allocating more land under agricultural production. Contrary to fears of insufficient quantities of organically acceptable fertilizers, leguminous cover crops can fix enough nitrogen to replace large amounts of synthetic fertilizer currently in use.

According to Kilcher (2007), farmers usually experience a decline in yields after stopping the use of synthetic inputs and converting their farm to organic production. Once the agro-ecosystem is restored and organic management systems are fully implemented, yields increase significantly. The development of yields varies and depends on inherent biological factors and natural resources, farmer's expertise and the extent to which synthetic inputs were used under previous conventional management. In the event that conversion to organic takes place on the basis of a low-input system, yields under organic management tend to be more stable compared to previous management system (Kilcher, 2007). Similarly, if conversion is from a high-input system, yield losses are frequent in the initial years due the fact that; soil organic matter and biological activities take time to become established, fertility problems are common until full biological activity has been restored, nitrogen fixation has improved and beneficial insects and natural predators have become established (El-HageScialabba and Hattam, 2002).

The productivity of OA systems varies through different stages of management; in transition from conventional to organic management, organic management based on input substitution and the complete shift to a systems approach. Organic farmers not only produce more crops but also achieve more sustainable yields of better quality and derive higher incomes (Kilcher, 2007). This contribution is mainly due to; a lower risk of crop failure due to higher diversity and improved soil fertility, availability of efficient and local resources such as manure, seeds and irrigation water and finally, a more intensive cultivation is employed due to improved financial situation. In addition, there are lower pesticide residues than conventionally grown foods (El-HageScialabba and Hattam, 2002). However, organic foods are not pesticide free due to external farm factors such as pesticide spray drift from adjacent fields or soil or irrigation water contamination (Kilcher, 2007).

2.3 Benefits of OSMP to environmental conservation and climate change mitigation

By definition, OA reduces harm to the environment through reduction or elimination of synthetic inputs, water and soil conservation practices and soil fertility restoration (El-

HageScialabba and Hattam, 2002). Organic soil management practices mitigate climate change due to less use of fossil fuel-based inputs and have a better carbon footprint than standard agricultural practices. This is because in conventional agriculture (CA), more energy is utilized than in OA due to heavy reliance on energy-intensive synthetic inputs (Zeisemer, 2007). Other studies have found that OA performs better than CA on a per-hectare scale with high efficiency of energy use (El-HageScialabba and Hattam, 2002).

Agriculture has the potential to change from being one of the largest greenhouse gas (GHG) emitters to a net carbon sink while offering options for mitigation. The solutions call for a shift to sustainable farming practices that build up carbon in the soil and use less fertilizer (Bellarby *et al*., 2008). There are varieties of sustainable farming practices that can reduce agriculture's contribution to climate change. These include; crop rotations, improved farming design, improved crop land management, manure management, maintaining fertile soils and restoration of degraded land, improved water management and agroforestry (Bellarby *et al*., 2008). According to Khor (2008), the benefits of OSMP regarding climate change includes; reduced emissions, high stabilization of soil organic matter, increased soil water retention capacity and finally organic systems are highly adaptive to climate change due to application of traditional skills and farmers' knowledge, soil fertility-building techniques and a high degree of diversity. Therefore, OMSP has great mitigation and adaptation potential particularly with regard to increasing yields in areas with medium to low-input agriculture and by enhancing farmers' adaptive capacity (Khor, 2008)

2.3.1 Soil management practices

OSMP uses a range of techniques to maintain and improve soil fertility status. These techniques include the use of organic fertilizers, mulching, cover cropping, agroforestry, crop rotation and multiple cropping (GoK, 2007). In Kenya, organic farmers use trees, shrubs and leguminous plants to stabilize and feed the soil. They also use dung and compost manures to provide nutrients and terracing or check-dams to prevent erosion and conserve groundwater (GoK, 2007). In the natural ecosystem of the rain forest, plant growth is vigorous and biomass is rapidly decomposed into humus and organic matter by soil organisms. Due to hot temperatures and high air humidity, organic matter is mineralized very quickly. To maintain a balance in the soil and to increase organic matter content, organic farmers in the tropics cover their soils with dead or living vegetation. Several practical examples of OA systems in arid areas show how OSMP can help restore degraded lands to fertility (Kilcher, 2007).

OSMP employs a number of techniques to conserve precious topsoil from erosion. These include using contour bunds, contour planting, check dams, gully plugs and maintaining cover crops or mulch to protect the soil from heavy rainfall (GoK, 2007). In Kenya, some farmers use zero-tillage approach of cultivation which ensures sufficient soil cover in farms especially at the on-set of the long rains which are predominantly torrential and extremely erosive (GoK, 2007). In addition, soil bunds and terraces, contour cultivation, intercropping and agroforestry play an important role in protection against erosion and landslides because their rooting system stabilizes the soil. Further, these practices increase organic matter content of the soil, which has positive effects on water-holding capacity. At the same time, vegetation cover conserves humidity by protecting the soil from direct solar radiation (Kilcher, 2007).

2.3.2 Farmers' perceptions towards OSMP

The decision to participate in new agricultural technologies depends on farmer's perception which is an important factor in influencing adoption (Negatu and Parikh, 1999; Adesina and Baidu-Forson, 1995). Technology adoption is influenced by factors such as perceived profitability and costs of the technology, its compatibility with production systems, and clarity at which the new knowledge and information is communicated in a recipient population (Boahene *et al*., 1999). Farmers' perceptions regarding compatibility of sustainable practices with their farming systems have emerged as the best predictor of adoption of such practices (Alonge and Martin, 1995). Assessing farmers' perceptions is an important means to evaluate their knowledge level on a particular issue, as perception refers to an individual's current appraisal of an object or program (Hikson and Keith, 2000). People base their perceptions on past experience and knowledge thus, if a person has limited knowledge and experience about a topic then he cannot accurately perceive it or form an opinion on it (May, 1969). If farmers are to adopt sustainable agricultural practices, they need to believe the practices are important. Future strategies for increasing agricultural production should focus on using available natural resources more efficiently, effectively and sustainably than in the past (Gruhn *et al.*, 2000). Besides efficiency of a technology, severity of existing constraints also conditions the decision to invest in new technologies (Mbaga-Semgalawe and Folmer, 2000).

2.3.3 Factors affecting adoption and intensity of use of OSMP

The aim of a technological change is to maximize output by increasing agricultural production in order to meet the high food demand. Adoption of new agricultural technology has long been recognized as one of the key factors in increasing productivity in the agricultural sector and therefore farm productivity will tend to remain low for as long as farmers continue to use low yielding inputs and technology (Langyintuo *et al.,* 2001). Adoption of innovations refers to the decision to apply an innovation and use it (Oladele 2005). On the other hand, intensity of adoption refers to the number of technologies practiced or the extent of adopting a specific technology by the same farmer. The extent of adoption is determined by the farmers' knowledge on a new technology and their decision to adopt it (Saha *et al.,* 1994)

According to Kilcher (2007), the greatest constraints faced by poor farmers on the road to OSMP are lack of knowledge, access to markets, certification, agricultural inputs and lack of organization. In order to overcome these constraints, there is need greatly investment in practice-oriented research, capacity-building and extension, improve accessibility to local certification schemes and harmonized standards as well as organic market initiatives and fair trade relationships. Developing these tools and services in order to enable participatory learning processes can lead to sustainable innovation within the rural communities thereby contributing to sustainable development (Kilcher, 2007). The level of participation to any technology depends on its net economic benefits in relation to other options but also on external constraints that may impede participation in profitable technologies (Menale and Zikhali, 2009). Given evidence indicate that OSMP have multiple benefits including reduction in production costs, environmental benefits and increased food production. It is crucial to understand what drives or constrain resource-poor farmers from participating in such technologies (Menale and Zikhali, 2009).

Heterogeneity in agro-climatic environments implies that no single approach can be applied across the world in a uniform manner. Different techniques and systems are applied and adapted in different agro-ecological conditions giving different results (Menale and Zikhali, 2009). Using a probit model, it was found that local or regional biophysical factors such as land quality and plot characteristics are key determinants of participation in soil conservation technologies (Zikhali, 2008). This indicates that heterogeneity of the environment will condition the need to adopt and the level of utilization of OSMP. Similarly,

same technologies may not fit all households equally because of different endowments in resources and imperfect or non-existing markets such as credit markets.

There is a controversy in the literature when explaining the relationship between age and level of farmer participation in any new technology (Mbaga-Semgalawe and Folmer, 2000). Older farmers are rigid in adopting new technologies. Perhaps this is because of investing several years in particular practices, which makes them unwilling to risk by trying out completely new farming methods (Khanna, 2001). Furruh *et al*. (2007) and Menale *et al*. (2009) used a probit model and a multinomial logit model respectively to determine the likelihood of farmers adopting OA system and found out that age of the farmer had a negative influence. Thus, age of the household head is expected to be negatively associated with farmer participation in a new technology. However, using a binary logit, age had a positive correlation with relatively traditional practices such as manure which farmers are used to (Odendo *et al*., 2009).

It is often believed that higher education gives farmers the ability to perceive, interpret and respond to new information much faster than their counterparts with lower education (Feder *et al*., 1985). Using a probit model on adoption of an OA system, Furruh *et al*. (2007) found that education negatively influence adoption of an OA system. These results were consistent with Gould *et al*. (1989) who found education to be negatively related to adoption of soil and water conservation measures. However, Mbaga-Semgalawe and Folmer (2000) used a Tobit model to determine farmer participation in improved natural resource conservation technologies and reported that education had a positive effect. Adoption of OSMP requires understanding land preparation procedures for land thus; household heads with higher education levels have a higher probability of adopting new technologies (Odendo *et al*., 2009).

In terms of gender, the household head is the implicit key decision–maker for the household (Odendo *et al*., 2009). Empirical evidence using a probit and Tobit models on adoption of new technologies by Kaliba *et al*. (2000) showed that, male-headed households in developing countries have a higher access to resources and information that give them greater capacity to adopt. Using binary logit to determine farmer participation in new technologies, results indicated that male-headed households had a higher probability of adopting than women due to their high likelihood of access to requisite resources and information (Odendo *et al*., 2009). Gopal and Kanokporn (2011) used a logistic regression in determining the

tendency of farmers towards growing organic vegetables and results indicated that more female than male household head planted organic vegetables.

Literature on the impact of farm size on technology adoption is mixed because the relationship depends on many other factors such as fixed adoption costs, risk preferences, human capital, credit constraints, labour requirements and tenure arrangements (Feder *et al*., 1985). Farm size can positively influence adoption because farmers with large farm sizes of land can experiment new technologies on a portion of land without worrying about endangering the family food security. In addition, the benefits from large-scale adoption of new technologies are absolutely large for larger farms (Zepeda, 1994). Despite the fact that there is a linear relationship between farm size and adoption of organic agricultural practices, results by Furruh *et al.* (2007) using a probit model were statistically insignificant. Feder *et al*. (1985) explained that small farmers often farm more intensively and have more labour available per unit of land while larger farmers have higher transaction costs to acquire hired labour. While the higher labour availability per unit of land enables farmers to adopt more labour intensive technologies, smaller portions of land may also be a pressure to farm more intensively especially when there are few alternative employment opportunities.

Labour is an important constraint in adoption of new technologies particularly those technologies that are labour-intensive (Douglas *et al.*, 2005). Labour availability can be measured as the proportion of household members who contribute to farm work. Using a binary logit, Odendo *et al*. (2009) found that the proportion of household members available to provide labour positively influenced adoption of soil fertility management practices. The number of household members who provide farm labour is positively associated with probability of participating in soil fertility management practices. Franzel's (1999) used a Tobit model and indicated that labour constraint negatively influenced farmer participation in improved tree fallows and other intensive technologies such as animal manure use. Due to high labour demand for applying animal manure, households with high number of members working on the farm are more effective since household labour is the most important source of labour supply for smallholder households, given that low incomes constrain hiring labour. Moreover, there are moral hazards associated with hired labour calling for considerable supervision which raises the real cost of household labour beyond the observed wage rate. Therefore, lack of adequate labour accompanied by inability to hire labour can seriously hinder participation in soil fertility management practices (Odendo *et al*., 2009).

Access to extension services exposes farmers to new technologies and their potential benefits (Abdulahi and Huffman, 2005). In addition, contact with extension services gives farmers access to information on innovations, advice on inputs and their use, and management of technologies (Menale *et al*., 2009). In most cases, extension workers establish demonstration plots where farmers get hands-on experience and experiment new farm technologies. Consequently, access to extension is often used as an indicator of access to information (Adesina *et al*., 2000). It is postulated that access to extension positively affects the participation in new agricultural technologies which requires extra knowledge (Abdulahi and Huffman, 2005).

Although the benefits from investing in CA accrue over time, this inter-temporal aspect implies that secure land tenure impacts adoption decisions positively. Plot ownership is a proxy measure for assured land access and this has a positive impact on the decision to adopt conservation tillage methods. Ownership of land increases the assurance of future access to returns on investments (Menale *et al.*, 2009). Similarly, a multinomial logit analysis by Menale *et al.* (2009) on the decision to participate in conservation tillage indicated a positive impact of farm distance from the farmer's homestead. This is because plots far away present tenure security challenges due to difficulties in monitoring. Consequently, farmers might invest more in them as a way of securing tenure.

According to Menale *et al.* (2009), the multinomial logit results showed that the likelihood of households choosing to practice conservation declined with the perceived slope of the farm. This reflects the fact that plots with steeper slopes are more prone to soil erosion which necessitates adoption of farming techniques such as OSMP meant to mitigate soil erosion and subsequent nutrient losses. This was consistent with Noel and Kazim (1995) who used a Heckman model on adoption of mulch tillage and found out that a 1% increase in the slope of land was associated with a 25% increase in the likelihood that mulch tillage was adopted. Sustainable agricultural systems are intuitively site-specific (Lee, 2005) and this further confirmed that plot characteristics influence the decision to adopt conservation tillage. The slope of land thus impacts the decision to combine use of compost and conservation tillage in a similar way. Thus, for sustainable agricultural practices to be successful, they must address site-specific characteristics in order to facilitate adoption as well as the type of technology to be adopted (Menale *et al.*, 2009).

A study conducted by Gopal and Kanokporn (2011) using a logistic regression indicated that training, motivation and capacity building programs influenced adoption behavior of farmers in organic vegetable farming (OVF). Training and motivational programs conducted through the OVF promotion projects significantly contributed to the practice of organic vegetables. Similarly, membership in groups may expose individuals to a wide range of ideas and sometimes give farmers the opportunity to have better access to information which may make them have a positively attitude toward an innovation (Nkamleu, 2007).

Off-farm incomes have proved quite important in fostering participation of OSMP. Cash is essential in hiring labour and purchasing of farm inputs such as seeds and animal manure (Paswel and Barrett, 2007). Using a binary logit, Odendo *et al*. (2009) found that off-farm incomes positively influenced adoption of manure and compost use. Marenya *et al*. (2003) indicated that resource-poor farmers may not generate sufficiently investible surpluses in order to remain self-sustaining in the absence of non-farm incomes. Thus, farmers need off-farm incomes to invest in more sustainable agricultural intensification. Since is cash required to purchase inputs and hire labour to apply them, it is hypothesized that off-farm income positively influence adoption of OSMP.

The literature reviewed in this study revealed controversial results among some variables which were analyzed in different studies. There is consensus with respect to farmer perception, farmer access to credit, farm size, labour, household size, training services, extension services, off-farm income, land tenure, farm distance from the farmer's homestead, and slope of the land. However, there are mixed results with respect to age of the household head, education level of the household head, group membership and gender of the household head. The review also identified that limited studies have been conducted on farmers' access to credit, group membership and slope of the land. In addition, most of the factors discussed in the literature review have extensively focused on adoption studies with little emphasis on the effect they may have on the extent of adoption of new technologies. This study employed the Tobit model to determine the relationship between these variables in terms of adoption and intensity of use of OSMP.

2.4 Theoretical framework and conceptual framework

2.4.1 Theoretical framework

The decision-maker is faced with a number of alternatives which constitutes his or her choice set (Ben-Akiva and Lerman, 1985). The feasibility and attractiveness of any alternative within the choice set depends on a variety of constraints such as physical accessibility, availability of financial resources as well as technical and financial performance of each alternative. To supplement these comparisons, a random utility framework can be used to model farmers' behavior (Greene, 2003). The random utility theory (RUT) is a well-established method for quantifying preferences of farmers choosing a technique from a finite set of alternatives. The simple operating assumption of the RUT is that, the technique chosen by a farmer yields the highest utility among all alternative techniques in a farmer's choice set. On the other hand, farmers' utility is dependent on optimizing productivity and minimizing the cost of cultivation to attain maximum profits (Feder *et al.*, 1985).

RUT has been used frequently in adoption studies related to conservation practices in particular and technology adoption in general. An earlier study by Lohr and Park (1995) used a sample selection approach to model farmer decisions to participate in conservation programs. Caswell *et al*. (2001) applied the RUT to estimate adoption of soil and water management practices in the US. Soule *et al*. (2000) used this random utility approach to determine the relationship between land tenure and adoption of conservation practices. Loftus and Kraft (2003) used a similar discrete choice model in their study of the factors influencing the decision to enroll conservation buffers into land retirement programs.

RUT is used to explain adoption whereby utility of a farmer is specified as a linear function of individual and farm specific characteristics, the attributes of different available technologies and other institutional factors as well as a stochastic component. The probability of choosing a specific technology is equal to the probability that the utility of that particular alternative is greater than or equal to utilities of all other alternatives in the choice set. Approximation of the true underlying utility generated by each alternative can be done as a linear function of individual characteristics, choice attributes or a combination of both. Then one can estimate a discrete choice process using latent regression modeling techniques (Greene, 2003). In the context of choice to adopt OSMP or not, the difference between the benefit and cost of adopting a farming system j by household i can be modeled as follows:

$$Y_{ij}^{*} = \beta X_i' + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (1)$$

where; Y_{ij}^{*} = unobserved variable/response, X_i = a matrix of independent variables affecting farmers-specific characteristics that reflect constraints and preferences, β = vector of parameter estimates, and μ_i = a random disturbance term. Let $C_{ij} = 1$ indicates that farmer i uses the jth farming system, 0 otherwise. Hence, $U_{ij} > C_{ik}$ if $C_{ij} = 1$ and $C_{ik} = 0$ for all other choices. Therefore, the choice of C_{ij} is the maximum utility gained by farmer i among all other choices.

Limited dependent variables models are often used to evaluate farmers' adoption of agricultural technologies. These models are based on the assumption that farmers are faced with a choice between two alternatives (adoption or otherwise) and the choice depends upon identifiable characteristics (Pindyck and Rubinfeld, 1981). The common statistical functional forms available for analyzing binary choice problems are linear probability model (LPM), cumulative logistic (Logit) and cumulative normal (Probit) models (Aldrich and Nelson, 1984). LPM is commonly used due to its theoretical simplicity (Aldrich and Nelson, 1984) and it typically uses the Ordinary Least Square (OLS) estimator for making predictions. However, prediction from LPM may lie outside the limiting intervals (0–1) hence violating the probability laws. Therefore, such predictions cannot be interpreted as probabilities in dichotomous choice models (Aldrich and Nelson, 1984).

Probit and Logit models are both cumulative probability functions which can be used as an alternative by eliminating the (0–1) problem associated with LPM. The models use the maximum likelihood estimation (MLE) procedures to give unbiased and efficient estimates of the probability that the dependent variable will take on the discrete or dichotomous values. However, the two models forgo valuable information of variables under consideration because of using dummy instead of a continuous variable and do not provide information on use intensity on adoption of a given alternative (Kaliba *et al.*, 2000). Intensity of use is an important aspect of adopting a technology because apart from the choice to use it, how much to apply it is more important. The Tobit model of Tobin (1958) addresses both adoption and intensity use of a given technology.

Many studies that have dealt with investigating the factors influencing the adoption of agricultural practices have been analyzed using a probit model (Hattam, 2006). This study used the Tobit Regression model because the dependent variable has censored distributions.

It also provides both the influence of exogenous factors on the probability of adoption and the intensity of adoption in addition to estimating the marginal effects of the factors (Chukwuji and Ogisi 2006). Structurally, the model is presented as:

$$Y_i^* = \beta_i X_i + \mu_i \text{ ………………………………………………………….} \textit{Equation (2)}$$

$$Y_i = \beta_i X_i + \mu_i \text{ ………………………………………………………….} \textit{Equation (3)}$$

where; the latent variable $Y_i = 1$ if $Y_i^* > 0$ and $Y_i = 0$ if $Y_i^* \leq 0$, $\mu_i \sim N\ (0, \sigma^2)$, β_i are the unknown parameters to be determined, μ is the independent error term with zero mean and constant variance and X_i is a vector of independent variables affecting adoption

2.4.2 Conceptual framework

The decision to adopt OSMP or not is assumed to be determined by socio-economic and institutional factors. It is assumed that these factors along with the farmer's perceptions towards OSMP influence the decision to adopt as well as the level of adoption of OSMP. Farmers who adopt OSMP are expected to have well maintained and sustainable fertile farms which enhance production of high yields and better quality produce among other benefits. At the same time, adopters are assumed to be profit maximizing hence it is expected that high yields would lead to increased farm incomes, assuming the prices are reasonable enough to cover production cost involved and this in turn contributes positively to increased household income. In addition, the effect of adoption will positively contribute to climate change mitigation due to reduced emissions, high stabilization of soil organic matter and increased soil water retention capacity. Finally, OSMP activities such as crop rotation, organic manure and mixed cropping will help to conserve water, soil fertility and soil erosion control hence leading to environmental conservation.

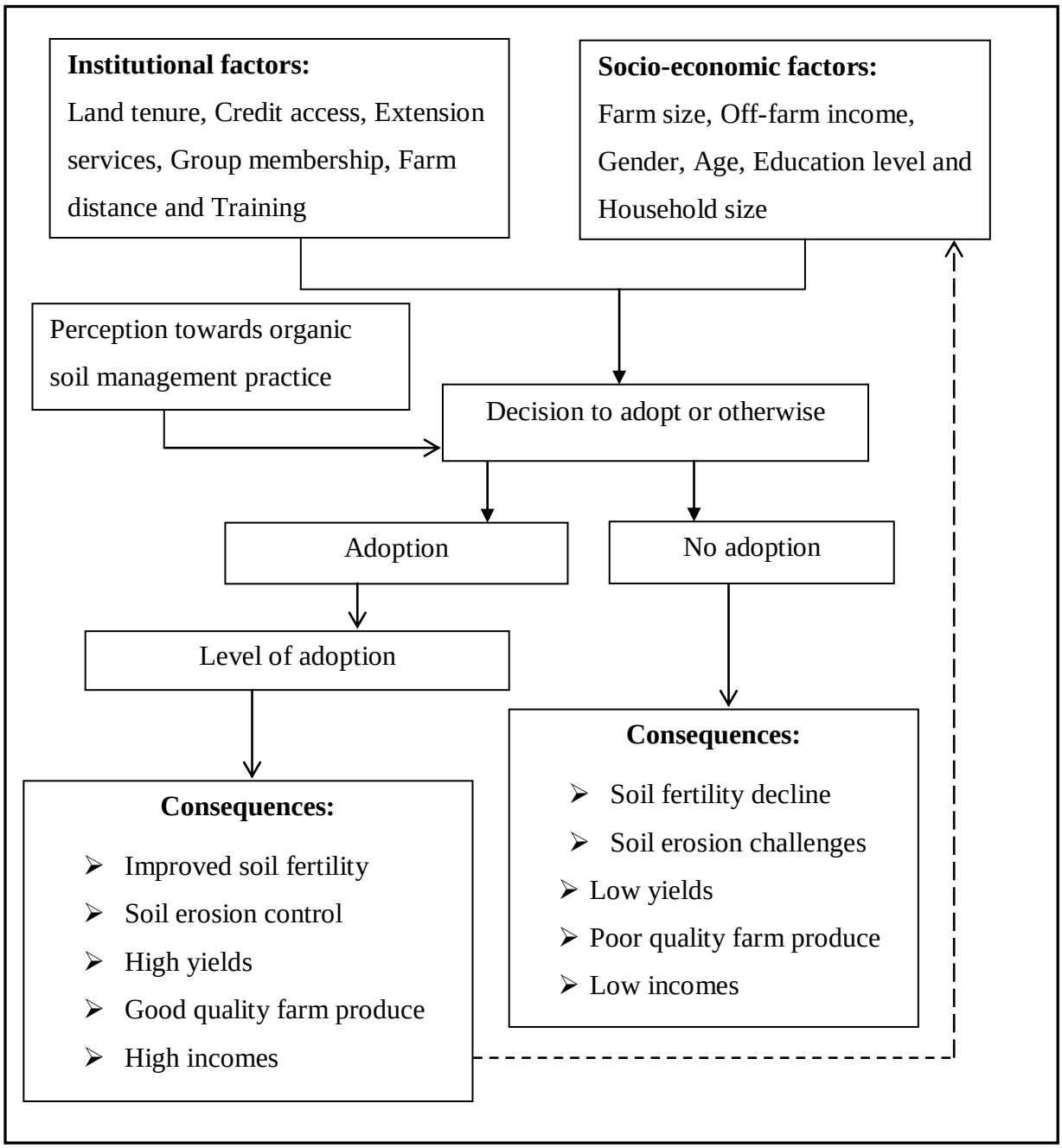

Figure 1: Conceptual framework
Source: Author's conceptualization

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study area

The study covered Bungoma County which occupies a total of about 2,068.5 square kilometers with a population of roughly 1,630,934 people and a population density of 482 persons per square kilometer (KNBS, 2009). The County is located between longitude 34 º 21.4` and 35 º 04` East and latitude 0 º 25.3 and 0º 53.2` North. There is a bimodal rainfall pattern; the long rains (March–July) and the short rains (August-October). The annual rainfall ranges between 1250 and 1800 mm. The altitude ranges between 1200 and 2000 meters above Sea Level (A.S.L) and temperature ranges from 21-25^{0}C during the year (GoK, 2005). The County is endowed with well-drained, rich and fertile arable soils but poor husbandry methods and a bulging population have resulted in declining yields, deforestation and soil erosion. Small scale crop and livestock production has been an important component of agricultural activity in this area. Crops commonly grown include; maize, sunflower, sugarcane, coffee, tobacco, potatoes, beans, kales, groundnuts and bananas. Livestock production includes; dairy cattle, goats, sheep and chicken.

Out of the total labour force of about 565,000 people, 52% are engaged in agricultural production which provides 60% of all household incomes, 19% have wage-employment and 13% are self-employed (GoK, 2005). The number of unemployed is estimated at 200,000 people and 60% of the population lives below the poverty line. The poverty incidence in Bungoma is higher than the national average of 53% (GoK, 2005). Bungoma County was selected because it is one of the areas in Kenya where OA is practiced on small scale basis. Secondly, the population growth rate is high compared to the land resource available hence there is need to implement strategies to cope with OA under intensive farming system.

3.2 Sample size and sampling procedure

The population for this study consisted of all small scale maize farmers in Bungoma County. Out of seven administrative districts in the County, a purposive sample of two districts; Bungoma South and Bungoma Central was made. A systematic random sampling approach was used to select the sample for the study. An alphabetical list was prepared for each district using farmer's last name and names were serially numbered. From each district 75 farmers were selected using a systematic random sampling. Determination of the sample size was based on the formula given by Kothari, (2004) as shown below:

$$n = \frac{(Z^2\ PQ)}{\varepsilon^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (3)$$

where; n is the sample size, Z is confidence level ($\alpha = 0.05$), P is the proportion of the population of interest, smallholder farmers who have adopted OSMP. Variable Q is the weighting variable and this is computed as $1 - P$, and ε is an acceptable error (precision). P was set to 0.5 since statistically, a proportion of 0.5 results in a sufficient and reliable size particularly when the population proportion is not known with certainty. This led to Q of 0.5 (1- 0.5). An error of less than 10% is usually acceptable (Kothari, 2004) thus, the study took an error of 0.08 to approximate a sample size of 150 respondents

3.3. Data collection

Primary data was mainly used to generate information required for the study and data was collected through observations and interviews using a semi-structured questionnaire which was administered to smallholder farmers. Data collected included information on land tenure system, farmer access to credit, training services, farm size, off-farm income, gender of the household head, age of the household head, education level of the household head, household size, extension services, group membership, slope of the land and farm distance from the farmer's homestead.

3.4. Data analysis

Statistical package for social sciences (SPSS) program was used for data entry, generating descriptive statistics and gross margin analysis. Excel program was used in analyzing the farmers' perceptions towards OSMP while STATA program was used to determine factors affecting adoption and intensity of use of OSMP. Descriptive statistics was used to analyze the first objective where the types of OSMP were characterized. For the second objective, to determine farmers' perceptions towards OSMP, descriptive statistics were also applied where the respondents were asked to indicate the extent of their agreement on each indicator using a Likert-type five-point continuum scale. For the third objective, independent two-sample t-test was used to examine a comparative profitability between organic and conventional maize production. Lastly, a Tobit regression model was applied to analyze the fourth objective of determining the socio-economic and institutional factors affecting adoption and intensity of use of OSMP.

3.4.1 Characterization of OSMP

The first objective was to characterize the types of organic soil management practices in the area. Various activities were identified and their percentage prevalence was determined.

3.4.2 Perception of smallholder farmers towards OSMP

The second objective was to determine the farmers' perceptions towards OSMP. The respondents were asked to indicate the extent of their agreement on each indicator using a Likert-type five-point continuum scale of strongly agree, agree, undecided, disagree and strongly disagree with assigning a weight of 5, 4, 3, 2 and 1, for positive statements respectively and vice versa for negative statements. For each indicator a weighted mean was obtained as follows:

$$WM = [(fSA * 5) + (fAG * 4) + (fUN * 3) + (fDA * 2) + (fSD * 1)]/n \quad \ldots\ldots\ldots Equation\ (4)$$

where; WM = weighted mean, f = frequency, n= the total sample size, values 5, 4,3,2,1 are attached weights, SA, AG, UN, DA, and SD are perceptions of strongly agree, agree, undecided/neutral, disagree and strongly disagree respectively. Adopting Bagheri (2010) and Babheri *et al*. (2008) perception analysis, the means for all indicators were then categorized as follows; the means 1.00-1.49 = strongly disagree (SD), 1.50-2.49 = Disagree (DA), 2.50-3.49 = Undecided/Neutral (U/N), 3.50-4.49 = Agree (AG) and 4.50-5.00=strongly agree (SA).

3.4.3 Comparative profitability

The third objective was to examine the comparative profitability of organic maize production *vis-à-vis* conventional maize production. To compute the comparative profitability, all fixed and overhead costs were assumed to be constant between the two farming systems. Only variable costs were considered hence leading to a gross margin analysis. Therefore, gross margin was used as a proxy for profitability in this study. Relative gross margin of the two farming systems is essential for farmers' decision making concerning the type of system to practice. For financial analysis, the costs of inputs was computed and then deducted from the value of output.

Land use cost was measured based on the average rental value of land per hectare. The unsold by-products such as maize stalks which are used as fodder were estimated according to the farmer's assessment. Existing market prices were considered both for product and by-products. In calculating the production costs, the following components of costs were considered; seeds, fertilizer, land operating cost (tilling, weeding and harvesting), insecticides, herbicides, human labour and interest on operating capital.

Gross returns

Gross Returns was calculated by multiplying the total volume of production of an enterprise by the average prices of that production at the harvesting period as follows:

$$\sum GR_i = \sum Q_{mi} P_{mi} + \sum Q_{bi} P_{bi} \dots\dots\dots\dots\dots\dots\dots\dots\dots Equation\ (5)$$

where; GR_i = gross return (KES/ha) for the ith farming system, Q_{mi}= quantity of the main product (kg/ha) of ith farming system, P_{mi} = per unit price (KES/kg) of main product of ith farming system, Q_{bi} = quantity of by-product (KES/ha) for the ith farming system, P_{bi} = per/unit price (KES/kg) of the by-product of ith farming system and $i = 1, 2, \dots, n$ are the number of alternative farming system.

Total variable cost

Total variable cost includes all types of variable cost items in the production process and this is estimated as follows:

$$TVC_i = \sum P_{xi} X_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \textit{Equation (6)}$$

where; TVC_i = Total variable cost (KES/ha) of ith farming system, P_{xi} = per unit price (KES/kg) of the ith input and X_i = Quantity (Kg/ha) of the ith variable input

Gross Margin

To obtain the Gross margin, the following mathematical formula was used:

$$GM = \sum Q_{mi} P_{mi} + \sum Q_{bi} P_{bi} - \sum P_{xi} X_i \dots\dots\dots\dots\dots\dots \textit{Equation (7)}$$

A two-tailed independent t-test was used to determine if the gross margin per hectare of the ith crop under organic production was significantly different from the gross margin per hectare of the same crop under conventional production

3.4.4 Tobit model specification

The fourth objective involved determining socio-economic and institutional factors affecting adoption and intensity of use of OSMP. To facilitate this analysis, the Tobit model was used to examine the probability that an individual farmer makes a decision to adopt OSMP or not and conditional on adoption, the extent of adoption. The proportion of land, in percentage hectares, planted with maize under organic production system presented a censored distribution since some farmers assumed a value of zero for not adopting (non-users). Accordingly, there is a cluster of households with zero adoption of organic maize production at the limit. The application of Tobit analysis is preferred in such cases because it employs both data at the limit as well as those above the limit. The Tobit model, used in the analysis of adoption and intensity of use of OSMP can be stated according to McDonald and Moffit (1980) as follows; Let Y be the intensity of use of OSMP, and then Y^* is equal to an index reflecting the combined effect of explanatory variables influencing the use of OSMP. Y^* is not observable and is recorded as zero for not having an area under OSMP and thus Y^* is expressed as:

$$Y_i^* = x_i' \beta + e_i = f(x_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (8)$$

$$i = 1,2, \ldots\ldots, n \text{ and } e_i \sim N\ (0, \sigma^2)$$

Equation (8) represents a censored distribution of intensity of use of OSMP where; Y_i^* is a latent variable representing household i's propensity to adopt, x_i is a vector variables relevant in explaining the extent of adoption, β is corresponding vector of parameters to be estimated (or a vector of Tobit maximum likelihood estimates), and μ_i is a homoscedastic and normally distributed error term assumed to be normal with a mean of zero and a constant variance, σ.

The Tobit model coefficients do not directly give the marginal effects of the associated independent variables on the dependent variable. Instead it gives a vector of maximum likelihood estimates which can be decomposed into two parts, change in probability of adoption and the marginal intensity of adoption due to changes in the respective explanatory variables (Amemiya, 1984). Thus, each marginal effect in a Tobit equation is a summation of the elasticity of the expected use intensity and that of the probability of adoption. According to Adesina and Baidu-Forson (1995), the total (marginal) effect accounts for the simultaneous effects on the number of adopters and the extent of

adoption by the current and new adopters. Given Y_i as the actual adoption of OSMP then actual adoption cannot be negative thus, the relationship between Y_i^* and Y_i is given as:

$$Y_i = \max(Y_i^*, 0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation (9)}$$

The log likelihood function for the Tobit model is thus:

$$LogL = \sum_0 ln\left[1 - \varphi\left(\frac{x_i'\beta}{\sigma}\right)\right] + \sum_+ ln\left[\frac{1}{\sigma}\,\emptyset\left(\frac{y_i - x_i'\beta}{\sigma}\right)\right] \ldots Equation\ (10)$$

where; "0" indicates summation over the zero observations in the sample while "+" indicates summation over positive observations, $\varphi\,(.)$ is the standard normal cumulative distribution functions (CDF) and $\emptyset\,(.)$ is probability distribution functions (PDF).

To decompose the relevant effect of changes in explanatory variables on the dependent variable, the McDonald and Moffit (1980) decomposition is employed. Following Tobin (1958) the expected intensity of use of OSMP, $E(Y)$ is given as:

$$E(Y) = x\beta F\left(\frac{Y_m}{\sigma}\right) + \sigma f\left(\frac{Y_m}{\sigma}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (11)$$

where; x is a vector of explanatory variables, $\left(\frac{Y_m}{\sigma}\right)$ is the cumulative normal distribution function at $\left(\frac{x\beta}{\sigma}\right)$, $f\left(\frac{Y_m}{\sigma}\right)$ is the value of the derivative of the normal curve at $\left(\frac{x\beta}{\sigma}\right)$, and $\left(\frac{Y_m}{\sigma}\right)$ is the value of the normalized index at the mean values of all explanatory variables and represents the scores for the area under the normal curve. β is a vector of the Tobit maximum likelihood estimates, and σ is the standard error of the error term. The marginal effect of an explanatory variable on the expected value of the dependent variable is given as:

$$\frac{\partial E(Y)}{\partial x_i} = F\left(\frac{Y_m}{\sigma}\right)\beta_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (12)$$

The change in the probability of using a technology as independent variable x_i changes is given as:

$$\frac{\partial F\left(\frac{Y}{\sigma}\right)}{\partial x_i} = f\left(\frac{Y_m}{\sigma}\right)\frac{\beta_i}{\sigma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (13)$$

Finally, the change in the intensity of use of OSMP with respect to a change in an explanatory variable among users is:

$$\frac{\partial E(Y^*)}{\partial x_i} = \beta_i \left[1 - \frac{Y_m}{\sigma}\left(\frac{f\left(\frac{Y_m}{\sigma}\right)}{F\left(\frac{Y_m}{\sigma}\right)}\right) - \left(\frac{f\left(\frac{Y_m}{\sigma}\right)^2}{F\left(\frac{Y_m}{\sigma}\right)^2}\right)\right] \ldots\ldots\ldots\ldots\ldots..Equation\ (14)$$

The empirical specification for examining the influence of explanatory variables on adoption and intensity (Y) of use of OSMP is based on the assumption that the two decisions (adoption and intensity) are taken at the same time (Chukwuji and Ogisi, 2006). The empirical model is represented as follows:

$$Y_i = \beta_0 + \beta_1 EducYrs + \beta_2 Age + \beta_3 Gender + \beta_4 HhSize + \beta_5 FmSize + \beta_6 Credit + \beta_7 OffInc + \beta_8 LdTenure + \beta_9 FmgExper + \beta_{10} SlopErosn + \beta_{11} Training + \beta_{12} Extn + \beta_{13} GmShip + \beta_{14} FmDista + \beta_{15} Percep + \mu \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (15)$$

Table 1: Description of variables used in the Tobit model and their expected signs

Variables	Full definition	Descriptions of the variable	Expected sign
PgOgMzFm	Percentage of land	Percentage of under organic maize production in hectares	
EducYrs	Education in years	Education level of a household head (years of schooling)	±
Age	Age in years	Age of the chief decision maker (continuous)	±
Gender	Gender	Gender of the chief decision maker (Dummy 1 = Male, 0= Female)	±
H/hSize	Household size	Number of household members (continuous)	±
FmSize	Farm Size	Size of the farm available in hectares (Continuous)	±
FmgExp	Farming Experience	Years of farming (continuous)	±
OffInc	Off-farm income	Total amount off-farm income famer I received, in thousands Kenya Shillings (continuous)	±
LdTenure	Land Tenure	Land ownership by title deed (1= owned by title deed, 0 = Otherwise	+
Credit	Credit	Total amount credit access by farmer i, in thousands Kenya Shillings (continuous)	–
Extn	Extension contacts	Total number of extension contacts access by farmer i, (continuous)	–
Training	Training contacts	Total number of training sessions farmer i, attended (continuous)	+
SlopErosn	Slope of the land on erosion	If the slope of the land leads to soil erosion(1=Yes, 0= No)	±
GmShip	Group membership	If farmer i belongs to an agricultural related group (1= belong to a group, 0= Otherwise)	±
FmDista	Farm distance	Distance of the farm from the farmer's homestead in kilometers (continuous)	±
Percep	Perception	Farmer's perception towards organic soil management practices activities. (5= strongly agree 4= Agree 3=Neutral Undecided 2= Disagree 1= strongly disagree)	±

CHAPTER FOUR: RESULTS AND DISCUSION

This chapter presents findings from the study and this is divided into four sections. The first section presents descriptive results on household characteristics as well as the types of OSMP carried out by smallholder farmers. The second section presents results on farmers' perception towards OSMP which were categorized into three groups; agree, neutral and disagree categories of perception based on a Likert scale measure. The third section presents gross margin results on comparative profitability between organic and conventional maize production. Finally, the fourth section presents the Tobit results on socio-economic and institutional factors hypothesised to influence adoption and intensity of use of OSMP.

4.1 Descriptive results

4.1.1 Household characteristics of farmers in Bungoma County

The mean age for adopters of OSMP was about 45 years while that for non-adopters was about 49 years (Table 2). Age of the household head plays a key role in determining the decision to adopt as well as the intensity of adoption of new technologies. Result of two-tailed t-test show that age was statistically significant at 10% indicating that non-adopters of OSMP were more elderly than adopters.

Table 2: Description of farm and farmer characteristics in Bungoma County, Kenya.

Characteristic	Mean		Overall	t-ratio	Sig
	Adopters	Non-adopters			
Age(Years)	44.78	48.78	46.98	-1.777*	0.078
Household size(Number)	8.83	5.21	7.21	-8.358***	0.000
Farm size(Ha)	1.76	2.12	1.92	1.760*	0.080
Experience(Years)	19.10	17.64	18.45	-0.675	0.501
Extension(Contacts)	2.75	0.16	1.59	-6.873***	0.000
Training(contacts)	3.37	1.37	2.48	-3.584***	0.000
Farm distance(Km)	0.12	1.93	0.93	5.312***	0.000
Off-farm income(KES)	40566.07	52723.88	40566.67	1.307	0.193

***** Significant at 1% level; and * significant at 10 % level**

The mean household size was about 9 members for adopters of OSMP and about 5 for non-adopters. Result of two-tailed t-test show that household size was statistically significant

at 1% indicating that adopters of OSMP had more household members than non-adopters. Household size has been used as a proxy measure for the numbers of members available to provide farm labour. Large household size positively influences adoption of labour-intensive agricultural technologies since they have the capacity to relax the labour constraints required during introduction of new technologies.

The mean farm size was 1.76 hectares for adopters of OSMP and 2.12 hectares for non-adopters (Table 2). Result of two-tailed t-test show that farm size was statistically significant at 10% indicating that non-adopters of OSMP had larger farm sizes than adopters. Small land holding hinder adoption of technologies compared to large land holding. Big portions of land allow farmers to practice both crop production and animal rearing. In addition, big farm sizes enable farmers to practice agroforestry, planting of leguminous crops and crop rotation which are ingredients for OSMP.

In terms of farming experience, the mean number of years of farming was about 19 for adopters of OSMP and about 18 for non-adopters (Table 2). However, result of two-tailed t-test show that experience was statistically insignificant indicating that adopters and non-adopters of OSMP were equally experienced in farming.

Adopters of OSMP had a mean of 2.75 contacts per year with extension officers as opposed to a mean of 0.16 contacts for non-adopters. Result of two-tailed t-test show that extension was statistically significant at 1% indicating that adopters of OSMP had more extension services than the non-adopters. The number of contacts with extension officers is a proxy measure for access to information (Adesina *et al*., 2000) and this positively contributes to awareness and subsequent adoption of new technologies. Agricultural extension agents frequently provide different messages throughout the year depending on prevailing activities and this could impact farmers differently.

In terms of training sessions, adopters of OSMP had a mean of about 4 training contacts per year compared to non-adopters who had a mean of about one training contact (Table 2). Result of two-tailed t-test show that training was statistically significant at 1% indicating that adopters of OSMP had more training sessions than non-adopters. Training exposes farmers to a wide range of ideas such as OSMP which enable them to improve agricultural production.

The mean farm distance from the farmer's homestead to the farm for adopters of OSMP was 0.12 kilometres while that for non-adopters was 1.93 kilometres (Table 2). Result of two-tailed t-test show that farm distance was statistically significant at 1% indicating that non-adopters of OSMP had their farms located much far from their homestead than the adopters of OSMP. Perhaps this could be a factor hindering many farmers from adopting OSMP. Farms that are located close to the homestead positively influence adoption of new innovations (Olawale *et al.,* 2009)

The mean off-farm income was KES. 30753.01 for adopters of OSMP and KES. 52723.88 for non-adopters. Result of two-tailed t-test show that off-farm income was statistically significant at 1% indicating that non-adopters of OSMP had more off-farm income compared to adopters of OSMP. Perhaps this is due to the fact that both adopters and non-adopters of OSMP are not equally engaged in off-farm employment activities. Part of off-farm income can be allocated for agricultural production to facilitate in purchasing of farm inputs and payment of labour requirements.

Education level of the household head between adopters and non-adopters of OSMP was characterized as presented in Table 3. Adopters of OSMP had the highest percentage in tertiary (39.8%) and university (16.9%) educational levels while non-adopters had the highest percentage in primary (34.3%) and secondary (49.3%) educational levels. This implies that OSMP is more likely to be understood by farmers who had more years of education. Overall, a low percentage of farmers (11.33%) had attained university education. Result of a chi-square show that education was statistically significant at 1% indicating that adopters of OSMP were generally more educated than the non-adopters.

Among the occupational options identified in the study area, mixed farming had the highest number of respondents (66.2%) for adopters of OSMP and 64.2% for non-adopters (Table 3). Business was not a priority of most household heads. Only 6% of adopters of OSMP owned business and 6% for non-adopters. Adopters of OSMP had the highest frequencies in all the occupational option except for the salaried employment where non-adopters of OSMP dominate with 17.9% against 13.3% for adopters. However, result of a chi-square show that occupation was statistically insignificant indicating that both adopters and non-adopters were equally employed across all the occupational categories in the area. Mixed farming was the main source of livelihood for the smallholder farmers. Perhaps this is

due to the linkage that exists between crops and animals as well as due to enterprise diversification in terms of risk.

Table 3: Categorical characteristics of the household head in Bungoma County.

Characteristic	Category	Percentage			Chi-square	Sig
		Adopters	Non-adopters	overall		
Education	Primary	7.2	34.3	19.33		
	Secondary	36.1	49.3	42		
	Tertiary	39.8	11.9	27.33		
	University	19.9	4.5	11.33		
	Total	55.33	44.67	100	31.117***	0.000
Occupation	Crop farming	14.5	14.9	14.67		
	Mixed farming	66.2	64.2	65.33		
	Business	6	3	4.67		
	Salaried	13.3	17.9	15.33		
	Total	55.33	44.67	100	1.288	0.732
Gender	Male	74.7	76.1	75.33		
	Female	25.3	23.9	24.67		
	Total	55.33	44.67	100	0.040	0.841
Group membership	Yes	79.5	46.3	64.7		
	No	20.5	53.7	35.3		
	Total	55.33	44.67	100	17.938***	0.000

***** Significant at 1% level**

Among the adopters of OSMP, 25.3% of the household heads were female and 74.7% were male while 23.9% of the household heads were female and 76.1% were male among the non-adopters (Table 3). Result of a chi-square show that gender of the household head was statistically insignificant indicating that gender of the household head between adopters and non-adopters of OSMP was equally distributed. Male-headed households, particularly in developing countries, have a higher accessibility to the requisite resources and information that gives them a higher chance of adopting new innovations (Odendo *et al.*, 2009).

In terms of group membership, 79.5% of the adopters of OSMP belong to a farmer group while 20.5% were not in farmer groups (Table 3). Among the non-adopters of OSMP,

46.3% were in farmer groups while 53.7% do not belong to a farmer group. Result of a chi-square show that group membership was statistically significant at 1% indicating that more adopters of OSMP were in farmer groups than the non-adopters. Group membership enhance uptake of new technologies largely due to information sharing among the farmers.

4.1.2 Types of OSMP carried out by smallholder farmers in Bungoma County.

Characterization of OSMP was performed in order to determine how the practices vary across farmers in the study area. The results in Figure 2 show the proportion of farmers (in percentages) practicing each activity in the study area.

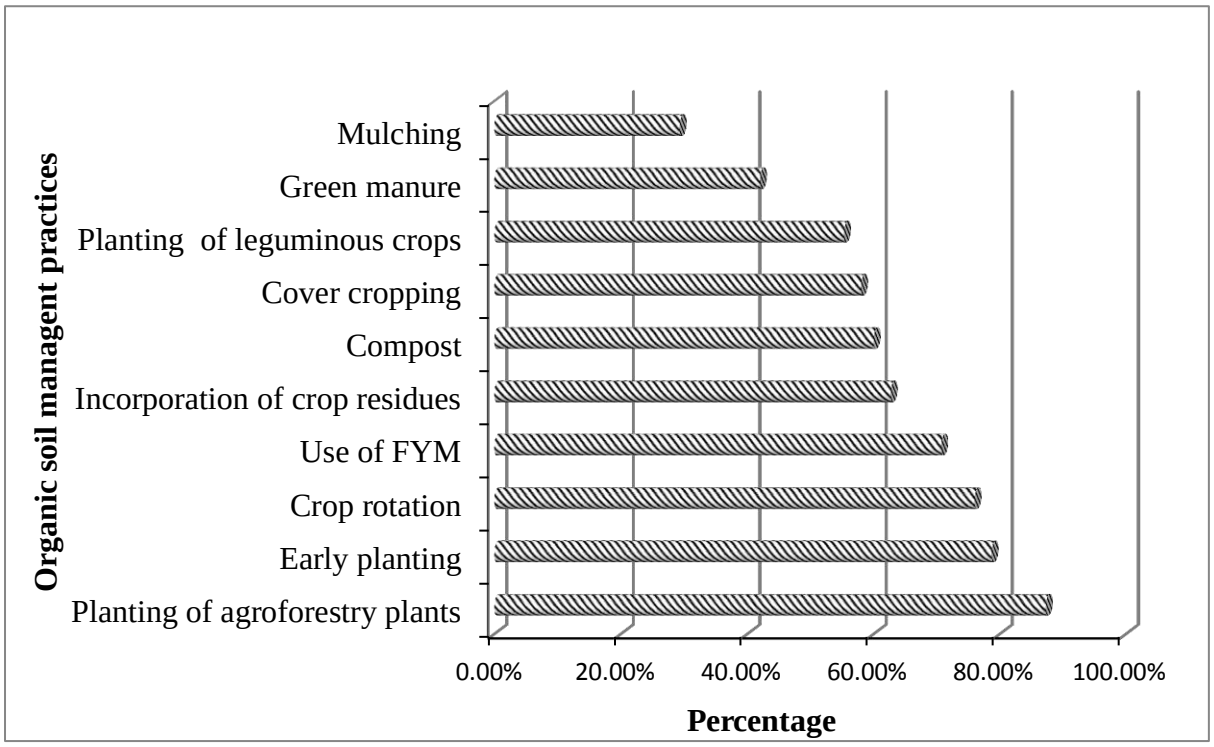

Figure 2: Types of OSMP carried out by smallholder maize farmers in Bungoma County.

From the results, 87.3% of smallholder maize farmers planted agroforestry trees. This is because agroforestry plays an important role in food security as well as environment conservation. In addition, agroforestry produces organic matter which serves as fertilizer and saves the farmer from expenses of buying and transporting fertilizer from off-site. The most common grown agroforestry tree species were *Grevillea robusta* and *Azadirachta indica*. Integrating tree growing with crop production on the farm helps in solving the problems of wood shortages and environmental degradation. Waste products or surpluses from agroforestry trees are used as fodder. In terms of services, agroforestry trees provide service

as windbreaks and shade, they control soil erosion and also demarcate land when planted along the farm boundaries.

Early planting is one of the most important factors in production which can lead to high yields. The results show that 78.7% of the households practice early planting. Early planting provides a greater window of an opportunity for replant decisions, minimizes the first yield-limiting barriers such as weeds and pest and diseases (Iken and Amusa, 2004; Legere, 1997). On average, farmers in the study area plant their maize crop in mid-March and therefore those farmers who plant in late February or early March are considered to have planted their crop early. Similarly, farmer who plant their crop after March are considered to have planted their crop late.

Crop rotation was practiced by 76% of the households. Crop rotations help to reduce pests and diseases in the cropping system as well as controlling weeds by including smothering crop species or green manure cover crops in the rotation. In addition, crop rotations give other benefits by improving soil quality, better distribution of nutrients in the soil and increases biological activity (Liebman and Dyck, 1993; Litterick *et al.*, 2002).

To improve soil fertility, farm yard manure (FYM) was applied by 70.7% of the respondents, 62.7% incorporated crop residues into the soil, 60% applied animal manure, 55.3% planted leguminous crops and 42% used green manure on their farms. The practice of these activities was mainly to increase soil fertility as well as reduce the high costs of purchasing inorganic fertilizers. The use of FYM by a majority of farmers indicates that farmers have realized its importance in crop production. In addition to supplying nutrients to the soil, FYM improves the physical, chemical and biological properties of the soil which helps to maintain the soil productivity and soil health (Tolessa and Friesen, 2001).

Cover cropping was practiced by 58% of the respondents while a few respondents (29.3%) practiced mulching on their farms. Cover cropping and mulching are important practices in crop production since they control soil erosion, suppresses the growth of weeds and improves soil moisture content during the season of inadequate rainfall.

In regard to agroforestry techniques that were practiced by smallholder farmers in the area, about 83% of the respondents practiced boundary tree-planting (Figure 3). Seventy nine percent of the respondents practiced intercropping, 33% planted woodlots while 7% of the respondents planted tree nurseries.

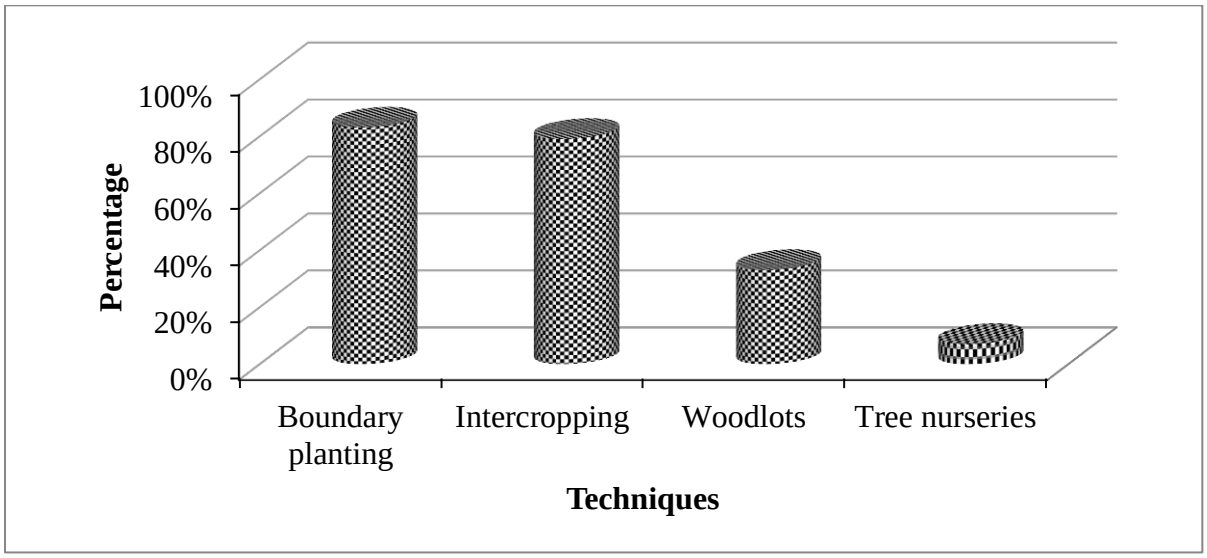

Figure 3: Agroforestry techniques practiced in Bungoma County

About 86% of the smallholder farmers who experienced soil erosion problem planted cover crops to control surface runoff on their farms (Figure 4). Sixty three percent of the respondents dug terraces to control running water, 37% practiced intercropping and 31% planted trees to control wind erosion, but only11% applied mulches on their farms to control soil erosion.

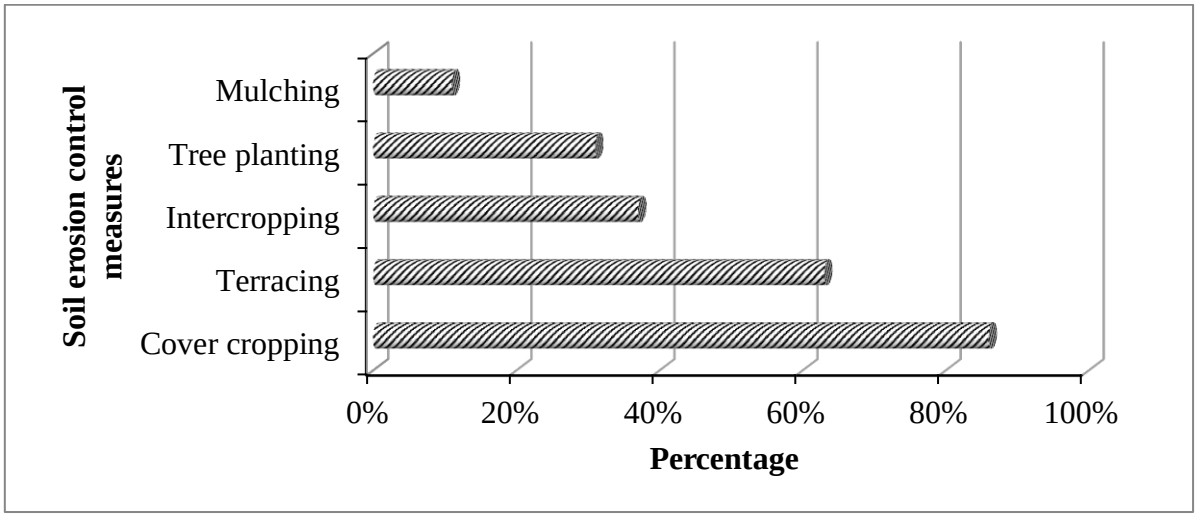

Figure 4: Techniques used in controlling soil erosion problems in Bungoma County

Among the adopters of OSMP, about 75% of the respondents practiced these techniques because they found it cheap and easy to use (Figure 5). About 49% of the respondents practiced OSMP to improve soil fertility, 30% of the respondents attributed this

to improving farm yields while 21% of the respondents practiced OSMP because organic materials were locally available.

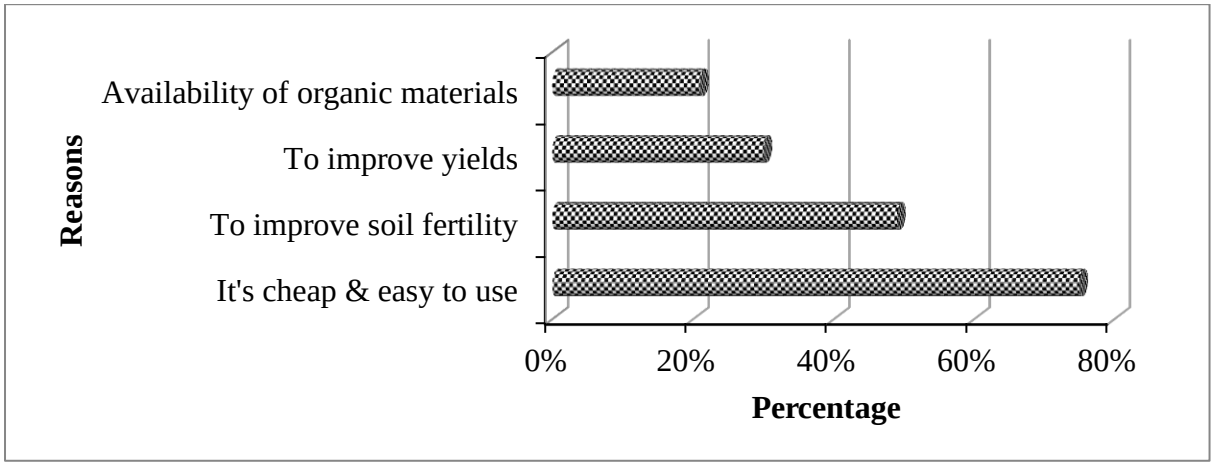

Figure 5: Reasons for practicing OSMP in Bungoma County.

About 43% of the non-adopters of OSMP indicated that lack of organic inputs was a major constraint hindering them from practicing OSMP (Figure 6). Thirty five percent of the non-adopters of OSMP indicated that their small pieces of land did not allow them to invest in OSMP. Twenty one percent of the non-adopters of OSMP indicated that it is difficult to control pest and diseases using biological methods under OSMP but only 14% of the respondents indicated OSMP as a labour-intensive technique.

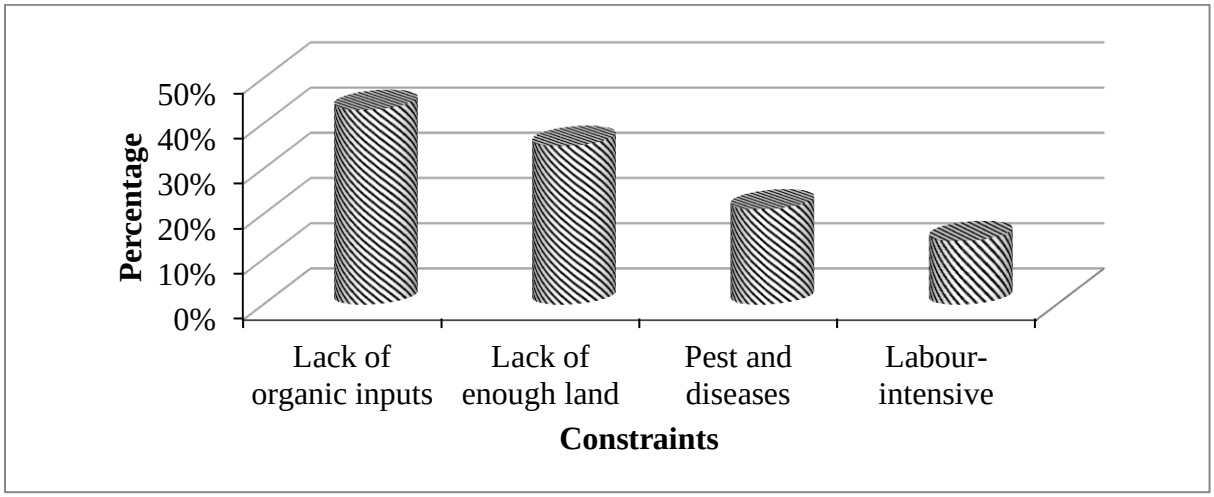

Figure 6: Reasons for not practicing OSMP in Bungoma County.

4.2 Farmers' perception results towards OSMP in Bungoma County

This section presents results on farmers' perception towards OSMP. Twenty three statements (Appendix 2) on various OSMP were evaluated. The respondents' perceptions

were prioritized according to the mean on 23 statements. The perception on OSMP was calculated by obtaining a weighted mean on the farmers' responses (Appendix 3). A 5-point Likert-type scale was used to measure farmers' perception on these practices. The responses were then categorized as follows; the means 1.00-1.49 = strongly disagree (SD), 1.50-2.49 = Disagree (DA), 2.50-3.49 = Undecided/Neutral (U/N), 3.50-4.49 = Agree (A) and 4.50-5.00 = strongly agree (SA).

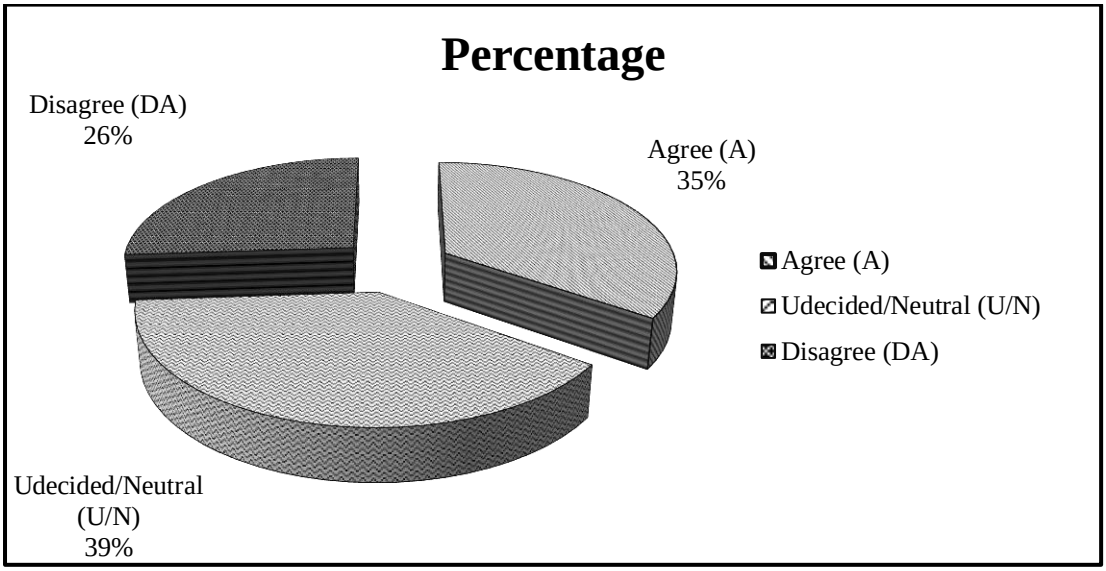

Figure 7: Categorized perception results on OSMP in Bungoma County.

The results presented in Figure 7 show how the practices were perceived by farmers. It was revealed that farmers disagreed on 26% of the practices as contributing to organic soil management. Farmers were undecided on 39% of the practices but agreed on 35% of them.

4.2.1 Perceptions of farmers agreeing on OSMP in Bungoma County

Environmental concern received the highest consideration among smallholder farmers with a positive attitude towards OSMP (Table 4). The respondents perceived that natural resources should be protected both for the present use and for future generations even if this will lead to farmers incurring losses in the short run. These findings tally with those of Rahman (2003). Cultivation of legume crops and application of green manure was ranked third as practices which improve soil fertility, soil structure and help to suppress weed population. The results are consistent with those by Bagheri *et al.* (2008).

Crop rotation was ranked fourth as a practice that helps in weed control. This is because crop rotation makes rational use of the land, assures steady high yields and permits

greater diversification. This is because different crops are planted, tilled and harvested at different times and agricultural work is spread out more evenly over the year. In addition to providing ground cover and in the case of a legume fixing nitrogen, cover crops also help suppress weeds and reduce insects' pests and diseases. These findings tally with those by Bagheri (2010) where potato farmers had a positive perception about the role of crop rotation in Ardabil Province of Iran.

Table 4: Perceptions of farmers agreeing on OSMP in Bungoma County, Kenya

Statement	Mean	Standard deviation	Rank
Natural resources should be protected even if it will lead to incurring losses in the short run	4.35	0.91	1
Natural resources must be protected for the next generations	4.34	1.10	2
Soil fertility can be improved by application of green manure and cultivation of legume crops	4.21	0.98	3
Crop rotation helps in weed control	4.15	1.12	4
Pesticide overuse may lead to pest resistance to pesticides	3.88	1.15	5
Green leaf manure helps to improve soil structure and reduce weed population	3.81	1.05	6
Successive cultivation of a single crop increases pests' invasion	3.73	1.47	7
Agrochemicals have negative effects on human and animal health	3.66	1.23	8

The respondents highly perceived that pesticide overuse may lead to pest resistance to pesticides. A study by Roling and Pretty (1997) contrast these results by indicating that farmers insisted on insecticide application as the easiest way to combat against pests, despite the awareness that insecticides are the major environment pollutants and their over-application makes insects resistant. Farmers agreed that successive cultivation of a single crop increases pests' invasion hence there is need to practice crop rotation as a way of reducing the build-up of pests. Agrochemical inputs were also perceived as environmental pollutants but only for human and animal health. These results tally those of Roling and Pretty (1997) and Rahman (2003).

4.2.2 Perceptions of farmers' undecided on OSMP in Bungoma County

The results on perception of farmers' undecided on OSMP are presented in Table 5. Farmers had a neutral perception on biological control as the best method of pest control. This was because of past unsuccessful experience of plant protection from stem borer. Perhaps this was due to lack of technical knowledge on how to apply the biological pest control techniques. These results contrast those by Bagheri *et al.* (2008) who indicated that most of the respondents had a negative perception about biological control of pest in Mazandaran province of Iran.

Table 5: Perceptions of farmers undecided on OSMP in Bungoma County, Kenya.

Statement	Mean	Standard deviation	Rank
Biological control is the best methods of pest control	3.41	1.48	9
Retaining plant residues may increase weeds (n*)	3.31	1.14	10
By decreasing chemical fertilizer, use in the long run, maize farmers' benefit will increase	3.31	1.26	11
Organic farming leads to reduced cost of production	3.29	1.42	12
Minimum tillage reduces soil erosion, disturbance and exposure	3.29	1.75	13
Retaining plant residues help in soil and water conservation	3.19	1.65	14
Application of animal manure cannot increase maize production (n*)	2.68	1.43	15
Application of animal manure can increase soil fertility	2.65	1.69	16
Preparation of farm yard manure is labour intensive	2.51	1.64	17

(n*) = negative statement

Despite the numerous emphases on retaining plant residues in the preservation of soil texture and nutrients, the respondents were not sure if this could increase weed population during the next growing season. At the same time, they were uncertain if plant residues would help in soil erosion control as well as protect the soil from exposure to harsh environmental conditions. This calls for the need for extension agents to train farmers on importance of plant residues in crop production. The respondents were not sure if substituting chemical fertilizer use with organic fertilizer in the long run maize output will increase.

Contrary to these results, a study by Bagheri *et al.* (2008) indicated that most farmers perceived agrochemicals as the best means to increase production at the present time.

Despite minimum utilization of external farm inputs under OF, the respondents were neutral on the argument that OF would reduce the cost of production. Perhaps this is because more labour is required in preparation and application of FYM and compost manure which are the key sources of soil fertility under OF. The respondents were not sure if minimum tillage would reduce soil erosion, soil disturbance and soil exposure. However, the advantages of minimum tillage include reduced costs and time, betterment of soil structure and drainage (Hao *et al.,* 2001). The respondents were not sure if animal manure could lead to desired maize output and therefore preferred it to be added to the farm in order to supply deficit nutrients. These results contrast those of Bagheri (2010) where farmers had a positive perception about the contribution of animal manure on soil fertility in Ardabil province of Iran.

4.2.3 Perceptions of farmers disagreeing on OSMP in Bungoma County.

The perceptions of farmers disagreeing on OSMP are presented in Table 6. Although the respondents agreed that mixed cropping increase total production, they thought it does not reduce soil erosion. Mixed cropping is an insurance against crop failure in case of abnormal weather conditions, pests and diseases (Gold, 1993; Fonndong *et al.,* 2002). It also reduces soil erosion and keeps down weeds due to improved soil cover (Howeler, 1998). In addition, it helps to increase the overall farm productivity as well as in the utilization of scarce resources to the fullest degree (Olasantan *et al.,* 1994).

The respondents disagreed that plant residues are useless and should be burned and thus, they recognized the contribution of crop residues to soil fertility. They understood that crop residue can protect soil from water erosion and this is an important indicator of soil sustainability. Instead of burning crop residues after the harvest, the respondents prefer to use them as fodder. A study by Bagheri *et al.* (2008) indicated that most of the respondent of lowlands in Mazandaran province of Iran were opponents to retaining of plant residue and regarded setting fire on plant residue as the easiest way to get rid of stem borer. In addition, Tatlidil *et al.* (2009) argued that burning of plant residues in the fields is the easiest way of doing tillage practice although this ignores the long term impact.

Table 6: Perceptions of farmers disagreeing on OSMP in Bungoma County, Kenya.

Statement	Mean	Standard deviation	Rank
Cultivation of mixed crops not only increase total production but also reduces soil erosion	2.39	1.07	18
Plant residues are useless, and hence they should be burned (n*)	2.37	1.16	19
Minimum tillage operation decreases soil fertility (n*)	2.33	1.02	20
Release of crop residues in maize farm will decrease soil fertility (n*)	2.29	1.21	21
Maize yield can be increased only by increased use of chemical fertilizer	2.18	1.18	22
Cover cropping cause soil erosion (n*)	2.15	1.16	23

(n*) = negative statement

Farmers disagreed that minimum tillage operations decrease soil fertility. Instead, they recognized over-cultivation as one of the farm operations that destroy the soil structure, facilitate soil erosion hence leading to nutrients being washed away. These results tally with those of Bagheri (2010). In addition, Rabiee *et al.* (2006) indicated that minimum tillage gives the best paddy residual management in regard to reduced costs and time, betterment of soil structure and drainage.

The respondents disagreed on agrochemical use as the major farm input such that the use of chemical fertilizer alone cannot lead to the highest yields hence, they advocate for OSMP. Excess or uncontrolled use of chemical inputs can spoil the soil properties such as water holding capacity. It may also affect adversely the population of micro-organisms in addition to damaging water resources (Kang, 1993). Regarding the role of cover cropping, the respondents disagreed that this practice would lead to soil erosion. This is because cover crops protect soil from erosion, improves soil fertility by reducing nutrient leaching, improve soil structure and water holding capacity.

4.3 Comparative profitability between organic and conventional maize production

Gross margin analysis tool was used to compare profitability of maize enterprise between OMP and CMP as the two main type of farming system in the area. This tool was used to determine whether OMP was a more profitable farming system as compared to CMP. In the analysis, variable costs were deducted from the total revenues in order to obtain the

total GM on land under maize production for each farmer per type of farming system. The calculated GM was averaged to obtain the gross margin per hectare and the results were tabulated as shown in Table 7. From the results, the mean gross margin for OMP and CMP were KES. 35,132.79 and KES.25,607.89 respectively. A comparison of the means between OMP and CMP showed that OMP was more profitable than CMP by a mean gross margin of KES. 9,524.48. The difference between OMP and CMP was tested for statistical significance at 95% confidence level as presented in Table 7. Result of two-tailed t-test show that the GM between OMP and CMP was statistically insignificant suggesting that both farming systems generate similar levels of farm income. This can be attributed to insufficient organic manure to promote high maize yields. Perhaps this constrained farmers from allocating more land to maize production under organic farming system. This is because most farm residues and by-products which are usually utilized as mulching materials, green manure and compost manure are directly fed to animals. Further, maize yields from both farming systems are sold at the same price in the area and yet the effort involved in producing them as well as the quality of the two products is different. This is because the niche for marketing organically produced maize is largely undeveloped although the general population may be aware of the quality differences of maize from OF and CF systems.

Table 7: Comparative analysis of GM and inputs between organic and conventional maize farmers in Bungoma County, Kenya

Productivity per hectare	Mean		Total mean	Mean difference	t-ratio	sig
	OMP	CMP				
Gross margin(KES)	35132.79	25607.89	30878.33	9524.48	-1.090	0.277
Yield (Bags)	28.23	28.48	28.45	0.48	0.084	0.933
Labour(KES)	4441.71	2858.57	3565.71	1583.16	0.902	0.369
Variable costs (KES)	15694.79	26091.80	20338.41	10397.70	2.744	0.007***

***Significant at 1% level

Although there is no significant difference in the GM between OMP and CMP in the long run, OF practices have a wide range of economic, environmental, social and cultural benefits (UNEP-UNCTAD, 2007). Economically, organic production is well-suited for smallholder resource-poor farmers, who are less dependent on external resources and in turn experience higher yields and enjoy enhanced food security. In addition, the expanding markets and attractive premium prices indicate that organic farmers can earn higher incomes than their

conventional counter parts. In regard to environment benefits, OA causes less pollution, less soil erosion, builds soil fertility and enhances biodiversity on and around the farm. It is more energy efficient than CA and holds carbon in the soil and finally, it is more resilient to climatic stress. Socio-cultural benefits are attributed to the fact that OA strengthen communities and give youth incentives to keep farming, thus reducing rural-urban migration.

To maintain soil fertility, OF relies heavily on locally available materials such as green manure, compost manure, FYM and crop residues to replace nutrients taken from the soil by previous crops (FAO and IFOAM, 1998) unlike conventional farming where chemical fertilizers are only available in the shops. Practices such as mulching, cover crops, agroforestry, crop rotation and multiple cropping help to maintain and improve soil fertility status (GoK, 2007). In addition, the cost of production under OF is much less due to minimal utilization of external farm inputs (El-HageScialabba and Hattam, 2002).

In terms of yield per hectare, CF had a higher mean (28.72 bags) compared to OF (28.23 bags) and the mean yield difference between the two farming systems was 0.48 bags (Table 7). Result of two-tailed t-test show that the mean difference between OF and CF in terms of maize yield was statistically insignificant suggesting that the productivity of CF and OF was similar.

The cost of labour input per hectare was higher in OF (KES. 4441.73) than in CF (KES. 2858.89) with a mean difference of KES.1583.16 (Table 7). Result of two-tailed t-test show that the mean difference between OF and CF in terms of labour input was statistically insignificant suggesting that there is equivalent labour requirement in both farming systems.

Capital input per hectare was higher in CF (KES.26091.80) than in OF (KES.15694.10) with a mean difference of KES.10397.70 (Table 7). Result of two-tailed t-test show that the difference between OF and CF in terms of capital input was statistically significant at 1% indicating that CMP requires more capital input than OMP system. Perhaps this is because more cash is required for purchasing chemical inputs such as inorganic fertilizers, herbicides and pesticides which are foregone in OMP system

4.4 Socio-economic and institutional factors affecting adoption and intensity of use of OSMP in Bungoma County, Kenya

A double censored Tobit model was used to examine the role of socio-economic and institutional factors on adoption and intensity of use of OSMP. The results of the Tobit model

are presented in Table 8. The obtained log likelihood ratio was 33.68 and the chi-square statistic for the goodness of fit of the model was 153.08, significant at 1%. The pseudo R^2 value of the model was 0.69. Thus, the overall model was significant and all the explanatory variables used in the model were collectively able to explain the farmers' decisions regarding adoption and intensity of use of OSMP.

Table 8: Tobit results on adoption and intensity of use of OSMP in Bungoma County, Kenya

PgOgMzFm	Coeff.	Std. Error	P> |z|	Total change	Change in Probability among adopters	Expected level of use intensity
				$\left[\frac{\partial E(Y)}{\partial x_i}\right]$	$\left[\frac{\partial F\left(\frac{Y}{\sigma}\right)}{\partial x_i}\right]$	$\left[\frac{\partial E(Y^*)}{\partial x_i}\right]$
Constant	-1.5076	0.2715	0.0000			
Gender (Male/Female)	0.0385	0.0642	0.5500	0.1107	0.0604	0.0503
Educ (Years)	0.0451	0.0118	0.0000***	0.0426	0.0177	0.0249
Age(Years)	-0.0069	0.0036	0.0580*	-0.0657	-0.0384	-0.0273
H/hSize (Number)	0.0373	0.0125	0.0030***	0.0354	0.0147	0.0207
FmgExper (Years)	0.0015	0.0032	0.6300	0.1101	0.0601	0.0500
Percep (Likert scale)	0.2421	0.0520	0.0000***	0.2293	0.0953	0.1340
FmSize (Ha)	-0.0141	0.0249	0.5710	-0.1041	-0.0568	-0.0473
OffInc (KES)	0.0156	0.0673	0.8170	0.0181	0.0099	0.0082
Extn (Contacts)	0.0175	0.0104	0.0940*	0.1068	0.0583	0.0485
Training (Contacts)	0.0076	0.0074	0.3040	0.0724	0.0395	0.0329
Credit (KES)	0.0149	0.0064	0.0210**	0.1731	0.0945	0.0786
GmShip (Yes/ No)	0.1245	0.0641	0.0540*	0.3088	0.1686	0.1402
LdTenure (Yes/ No)	0.1724	0.0720	0.0180**	0.4618	0.2521	0.2097
FmDista (Km)	-0.0504	0.0258	0.0530*	-0.1790	-0.0977	-0.0813
SlopErosn (Yes/ No)	0.0291	0.0672	0.6650	0.0268	0.0146	0.0122

*** Significant at 1% level; ** significant at 5% level; and * significant at 10 % level. Number of obs = 150; LR chi2 (15) = 153.08; Prob > chi2 = 0.0000; Pseudo R2 = 0.6944; and Log likelihood = -33.6771

Out of the 15 variables included in the analysis, 9 variables were statistically significant and influenced adoption and intensity of use of OSMP. Seven out of the 9 significant variables, namely education level, size of the household, farmer's perception towards OSMP, extension contacts, farmer access to credit, group membership and ownership of land by title deed positively influenced adoption and intensity of use of OSMP. The remaining two significant variables, age of the household head and farm distance from the farmer's homestead, negatively influenced adoption and intensity of use of OSMP.

The level of education (Educ) of the household head was statistically significant at 1% and positively influenced adoption and intensity of use of OSMP. The decomposed results revealed an anticipated total change of 4.26% in the number of hectares of farm land under OSMP due to an increase in education level by one year. Out of this total change, an increase in education level by one year increases the probability of adoption of OSMP by 1.77% and intensity of use of OSMP rises by 2.49% among adopters. Adoption of organic practices requires understanding of the procedures in preparation of land, FYM and compost manure. Higher education gives farmers the ability to perceive, interpret and respond to new information much faster than farmers with lower education level (Feder *et al.*, 1985) thus, those household heads with higher education level have a higher probability of adopting new technologies. These results tally those from other studies (Chukwuji *et al.*, 2006; Mbaga-Semgalawe and Folmer, 2000; Odendo *et al.*, 2009). However, these results contradict those of Furruh *et al*. (2007) on adoption of OA system and Gould *et al*. (1989) on adoption of soil and water conservation measures.

Age of the household head negatively influenced adoption and intensity of use of OSMP. This variable was statistically significant at 1%. The decomposed results revealed an expected total change of 6.57% in the number of hectares of farm land under OSMP due to an increase in age by one year. Out of this change, an increase in age by one year decreases the probability of adoption of OSMP by 3.84% and intensity of use of OSMP reduces by 2.73% among adopters. Perhaps this is because older farmers tend to invest several years in a particular practice hence may not want to risk themselves by trying out completely other methods of farming (Khanna, 2001). Young household heads are more interested in trying out new agricultural technologies because of their risk taking character than old household heads who are risk averse. These results are consistent with those of Furruh *et al*. (2007) on adoption of organic dried fig agriculture system, Menale *et al*. (2009) on adoption of OA techniques and Chukwuji *et al.* (2006) on adoption and intensity of use of fertilizer by

smallholder farmers. However, Nchinda *et al.* (2010) indicated a positive relationship between age of the household head and adoption and use intensity of improved yam seed technology. In addition, Maddison (2006) argued that as farmers get older they tend to intensify adoption of new agricultural technologies in their farming business as a result of more years of farming experience.

Household size (H/hsize) was statistically significant at 1% and positively influenced adoption and intensity of use of OSMP. The decomposed results revealed a total expected change of 3.53% in the number of hectares of farm land under OSMP if the number of household member was increased by one more person. Further, an increase in the number of members who provide farm labour by one more person increases probability of adoption of OSMP by 1.47% and intensity of use of OSMP rises by 2.07% among adopters. Taking labour as one of the constraints facing farm production, then the number of household members who contribute fully to farm work, can be used as one of the indicators of labour availability. OSMP is a labour intensive technology particularly in preparation and application of FYM thus, households with a high number of members working on the farm are more effective given that household labour is the most important source of labour supply among smallholder households. The number of household members who provide farm labour positively influence the probability of adopting soil fertility management practices and therefore lack of adequate labour can seriously hinder adoption of these practices (Odendo *et al.*, 2009). These results tally with those of Alene *et al.* (2000) on adoption and intensity of use of improved variety of maize, Ayuya *et al.* (2011) on adoption of clean development mechanism projects and Amsalu and De-Jan (2007) on adoption and continued use of stone terraces for soil and water conservation. However, a study by Franzel's (1999) indicated a negative relationship between household sizes and farmer participation in improved tree fallows and other intensive technologies such as animal manure use. Perhaps this is because the size of agricultural land was smaller than the number of household members available to provide farm labour.

The results demonstrate that farmers' perception (Percep) towards OSMP positively influenced adoption and intensity of use of OSMP. This variable was statistically significant at 1%. The decomposed results revealed an expected total change of 22.93% in the number of hectares of farm land under OSMP due to an increase in the farmer's level of perception by one unit based on a Likert scale measure. This total change would be accounted by an increase in probability of adoption of OSMP by new adopters (9.53%) and increased intensity

of use of OSMP among adopters (13.4%). Positive perception increases the probability of adoption and the extent at which the farmer is willing to put land under OSMP. It is rational to expect that if a farmer has a positive perception on OSMP then the likelihood of adopting OSMP is high. These results tally with those of Sarker and Itohara (2009) on organic agriculture extension programme and Neupane *et al.* (2002) on adoption of agroforestry. However, a study by Odendo *et al.* (2009) on adoption of integrated soil fertility management practices contradicts this result.

The number of extension contacts per year (Extn) was statistically significantly at 5% and positively influenced adoption and intensity of use of OSMP. This suggests the importance of extension as a source of information and knowledge to rural farmers. The decomposed results revealed an anticipated total change of 10.68% in the number of hectares of farm land under OSMP due to an increase in the number extension contact by one visit. Out of this total change, an increase in the number of extension contacts by one visit increases the probability of adoption of OSMP by 5.83% and intensity of use of OSMP rises by 4.85% among adopters. Extension exposes farmers to a wide range of ideas which may give them the opportunity to have better access to information on new innovations, advice on inputs and their use and management of technologies (Menale *et al.*, 2009) and this may positively influence them towards adopting new innovations. These results tally with those of Mazvimavi and Twomlow (2009) on adoption of conservation farming. However, a study by Ayuya *et al.* (2011) on adoption of clean development mechanism projects contrasts this result because agricultural extension services were more focused on intensifying crop and livestock production on tree planting.

Farmer access to credit was statistically significant at 5% with a positive influence on adoption and intensity of use of OSMP. The decomposed results revealed an expected total change of 17.31% in the number of hectares of farm land under OSMP due to an increase in credit access by KES.1000. Out of this total change, an increase in credit access by KES.1000 increases the probability of adoption of OSMP by 9.45% and intensity of use of OSMP rises by 7.86% among adopters. This implies that farmers who access credit are more likely to be adopters of OSMP than those with no access to credit and at the same time the level of adoption would increase accordingly. Credit is necessary in hiring of labour and purchasing farm inputs. These results tally with those of Chukwuji *et al.* (2006) on adoption and intensity of use of fertilizer, Degu *et al.* (2000) on adoption of seed and fertilizer packages and Feleke and Zegeye (2006) on adoption of improved maize varieties.

Being a member of agricultural related groups or organization (GmShip) had a positive influence on adoption and intensity of use of OSMP and this variable was statistically significant at 1%. The decomposed results revealed an expected total change of 30.88% in the number of hectares of farm land under OSMP due group membership. Out of this total change, farmers who were members of agricultural related groups would increase the probability of adopting OSMP by 16.86% and intensity of use of OSMP would increase by 14.02% among adopters. Groups expose farmers to a wide range of ideas and sometimes give farmers the opportunity to have better access to information on new innovations. Group membership also enables farmers to have a collective bargaining power when marketing their produce as well as when purchasing farm inputs. These results are consistent with those of Nkamleu, (2007) on adoption of organic and inorganic fertilizers separately and in combination and Nchinda *et al.* (2010) on adoption and use intensity of improved yam seed technology in Cameroon.

Ownership of land by title deed (LdTenure) positively influenced adoption and intensity of use of OSMP and this variable was statistically significant at 5% (Table 8). The decomposed results revealed an anticipated total change of 46.18% in the number of hectares of farm land under OSMP due to ownership of land by title deed. Of this total change, ownership of land by title deed increases the probability of adopting OSMP by 25.21% and raises intensity of use of OSMP by 20.97% among adopters. Land ownership increases the assurance of future access to returns of investments. At the same time, title deed also serves as a security tool to acquire credit facilities from financial institutions. Addressing permanent ownership of land is therefore a way of overcoming this constraint. These results tally with those of Mwirigi *et al.* (2009) on land tenure security and adoption of a new technology. However, these results contrast those of FAO (2001) which indicated that privatization of land do not automatically increase investment in more sustainable agricultural practices.

Farm distance from the farmer's homestead (FmDista) was statistically significant at 10% and negatively influenced adoption and intensity of use of OSMP. The decomposed results revealed an anticipated total change of 17.9% in the number of hectares of farm land under OSMP due to an increase in distance by one kilometer. Out of this total change, an increase in distance by one kilometer reduces the probability of adoption of OSMP by 9.77% and intensity of use of OSMP drops by 8.13% among adopters. This is probably due to high cost of labour and capital and also the cost of transporting manure to far distant fields hence, this would be more convenient for fields closer to the homestead. At the same time it is more

tedious to carry compost manure and FYM from the homestead to the farm and this may require employing more labour to facilitate this activity thereby increasing the cost of production. In addition, plots far away present tenure security challenges due to difficulties in monitoring. These results are consistent with those of Olawale *et al.* (2009) and Chukwuji *et al.* (2006) on intensity and adoption of fertilizer use by smallholder farmers and Alene *et al*. (2008) on adoption of inorganic fertilizer in Western Kenya.

The decomposed results revealed an anticipated total change in the number of hectares of farm land under OSMP due to an adjustment in the independent variables. Out of the total change, variations in the independent variables changed the probability of adoption of OSMP and intensity of use of OSMP among adopters. These results indicate that ownership of land by title deed, being a member of agricultural related group, farmer's positive perception towards OSMP and farmer access to credit facilities would increase adoption and intensity of use of OSMP among adopters. Similarly, availability of agricultural extension services, creating an atmosphere for educated people to go into farming and availability of households with high number of members would increase adoption and intensity of use of OSMP. However, younger farmers are more likely to adopt OSMP and most farmers who are willing to adopt OSMP are constraint by the long distances they have to travel transporting organic inputs to their farms. On average, the elasticity for the probability of adopting OSMP was higher than that of intensity of use of OSMP. This indicate that the effect of adjustment in the explanatory variable would be felt more by the non-adopters of OSMP who would be more motivated to become adopters of OSMP by changes in the prevailing constraining factors.

CHAPTER FIVE: CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Conclusions

Descriptive results on OSMP in terms of type and prevalence indicated that the top OSMP preferred were planting of agroforestry plants, early ploughing, crop rotation and use of FYM. On the other hand, application of mulches was least practiced by the respondents.

The results on farmers' perceptions towards OSMP showed that environmental concern was ranked top as the most important activity related to OSMP. Smallholder farmers were invariably concerned about the environment and were interested in protecting agricultural resources both for the present use and for future generations. Application of green manure and cultivation of legume crops were greatly perceived as organic practices that improve soil fertility and soil structure. Further, agrochemicals were perceived as farm inputs that have a negative effect on both human and animal health. In the same vain, over-application of pesticides was perceived as a practice that may lead to development of pest resistance to pesticides.

The gross margin analysis results showed that organic maize production was more profitable than conventional maize production. However, results of two-tailed t-test indicated that the mean difference between OMP and CMP was statistically insignificant implying OMP was as competitive as CMP in the generation of farm surplus for smallholder maize farmers in Kenya. The insignificant mean difference was perhaps due to insufficient organic manure to promote high maize yields. In addition, both products fetch the same price yet their quality is not the same.

The Tobit results showed that education level of the household head, size of the household members, positive farmer's perception towards OSMP, group membership, land ownership by title deed, training contacts and farmer access to credit positively influenced of adoption and intensity of use of OSMP. However, age of the chief decision maker and farm distance from the farmer's homestead negatively influenced adoption and intensity of use of OSMP.

5.2 Recommendations

The study drew attention to information that can guide policy towards influencing adoption and intensity of use of OSMP which can have a potential benefit to soil fertility conditions, increased productivity and environmental sustainability. Efforts to promote

OSMP on small-scale farms should focus on enhancement of farmer-awareness of the environmental, economic and other benefits (such as livelihoods and living conditions) of organic agriculture, as well as trading opportunities for developing countries.

Provision of training and technical advice on organic farming practices through agricultural extension services and developing information networks among farmers is vital. This strategy will require both the government and NGOs concerned with agricultural production to hire more staff members and equip them with the necessary facilities to execute this role. In addition, there is need to organize for seminars and workshops regularly where farmers are invited and educated on the importance of organic farming systems as well as the technicalities involved in preparation of compost manure and FYM.

There is need for institutional arrangements such as developing niche markets and certification of organic products to fetch premium prices due to their superior quality over conventionally produced products. This will ensure all production costs are covered thus, motivating smallholder farmers to alter their enterprise combinations with respect to organic production systems. Consequently, more farmers would adopt OSMP leading to environmental sustainability.

Improving farmer access to credit facilities needs to be enhanced. This will help to eliminate liquidity constraints experienced in the purchase organic manure from stockist or from other sources.

The government should facilitate acquisition of security of tenure by farmers through provision of title deeds to create an incentive for adoption of agricultural technologies. Security of tenure motivates farmers to undertake long term investments such as OSMP on the farm. Title deeds will act as collateral documents to acquire credit from financial institutions.

A deliberate effort to promote shops that stock dried organic manure. This could be achieved through encourage farmers to rear animals under intensive livestock management systems that support more livestock units per unit of land for provision of manure. In this regard, the stockist will be obliged to purchase organic manure from farmers with a surplus or from other regions of the country and sell to OSMP farmers.

5.3 Further research

The main intention of the study was to assess the factors affecting adoption and intensity of use of OSMP in smallholder maize production. The study proposed the following avenues for future research:

i. To determine whether it is economically profitable to tradeoff between organic crop production and livestock production in the area. This is due to the fact that crop residues that are to be converted directly into composed and green manure are instead utilized as animal feeds and thus compromising on soil fertility status under organic crop production.

ii. To evaluate the impact of farmer group in small scale crop production on household welfare in the area. This is because various NGOs have been successive by organizing farmers into farmer groups through provision of extension and training services for a long period of time. It is therefore important to find out whether these groups have improved their agricultural production as well as household welfare.

iii. Explore possibilities of developing niche markets for organically produced maize and other agricultural products.

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APPENDICES

Appendix 1: Questionnaire for OSMP in Bungoma County.

Questionnaire No. ☐

This study intends to assess the factors affecting adoption and intensity of use of organic soil management practices with reference to maize production in Bungoma County. Your response to the questions will be used to assess the current position and help to formulate workable approaches to these factors which will contribute to increased participation in organic agriculture, and hence leading to improved production and environmental conservation. The information you provide will be treated as private, highly confidential and will be used only for the purpose of this study. In case of any problem or questions, contact 0724415131

QUESTIONNAIRE IDENTIFICATION

District.....Division……..…… Location……..……

Name of enumerator……

Name of the farmer ……. Mobile No…….....……

Date …… Starting time ……. Ending time ……..

Type of farmer (Tick) ☐ **0.Non-adopter** ☐ **1.Adopter**

A. FARMERS' BACKGROUND (HOUSEHOLD) INFORMATION

1.1 Gender of the household head ☐ 0.Female ☐ 1.Male

1.2 Gender of the respondent ☐ 0.Female ☐ 1.Male

1.3 Relation of the respondent to household head *(Please tick where appropriate)*

☐ 1. Head ☐ 3. Sibling

☐ 2. Wife ☐ 4. Others (Specify) ……

1.4 What is the occupation of the household head? *(Please tick where appropriate)*

☐ 1. Crop farming ☐ 5. Salaried Employee

☐ 2. Livestock Farming ☐ 6. Labourer

☐ 3. Mixed farming ☐ 7. Others (Specify)……

☐ 4. Business person

1.5 Age of the household head (in years) ……

1.6 Education level of the household head (***see codes below***) ……..

☐	1. None	☐	4. Tertiary colleges
☐	2. Primary level	☐	5. University
☐	3. Secondary level		

1.7. On average, how many years did the household head spent in school? ……

1.8. Household size (*number of people living and eating together*) ……

1.9. How many years have you been in the current farming system? …….

B. FARMER PERCEPTION

2. What is your expected effect of the following organic practices on your farm? (Use the following Key***: 5****= strongly agree;* ***4****= Agree;* ***3****=Neutral / Undecided;* ***2****= Disagree;* ***1****= strongly disagree)*

Indicators	**Statement: (Do you think :)**	**perception**
a. General information	i. Natural resources must be protected for the next generations?	
	ii. We have to protect natural resources even if it will lead to incurring losses in the short run?	
	iii. Organic farming requires more labour input?	
b. Effects of agrochemicals	i. Agrochemicals have negative effects on human and animal health?	
	ii. By decreasing chemical fertilizer, use in the long run, maize farmers' benefit will increase?	
	iii. Maize yield can be increased only by increased use of chemical fertilizer?	
c. Application of animal manure	i. Application of animal manure can increase soil fertility?	
	ii. Application of animal manure cannot increase maize production?	
	iii. Preparation of farm yard manure is labour intensive	
d. Application of green manure and cultivation	i. Soil fertility can be improved by application of green manure?	
	ii. Green leaf manure helps to improve soil structure and	

of legume crops	reduce weed population	
e. Retaining plant residues	i. Retaining plant residues increases weed population?	
	ii. Release of crop residues in maize farm will decrease soil fertility?	
	iii. Plant residues are useless and hence they should be burned?	
	iv. Retaining plant residues help in soil and water conservation?	
f. crop rotation and cover-cropping	i. Crop rotation and cover cropping helps in weed control?	
	ii. Crop rotation and cover cropping cause soil erosion?	
g. Crop diversification	i. Successive cultivation of a single crop increases pests' invasion?	
	i. Cultivation of mixed crops not only increase total production but also reduces soil erosion	
h. Minimum tillage	i. Minimum tillage reduces soil erosion, disturbance and exposure?	
	ii. Minimum tillage operation decreases soil fertility?	
i. IPM	i. Biological control and weeding are the best methods of pest control?	
j. Reduction in pesticides and herbicides use	i. Pesticide overuse may lead to pest resistance to pesticides?	

B. SOCIO-ECONOMIC AND INSTITUTIONAL INFORMATION

i) SOCIO-ECONOMIC FACTORS:

3. FARM SIZE

3.1 What size of land do you practice crop farming? .....acres

3.2 What acreage is under maize production? ……acres

3.3 What acreage is under organic maize production? ……acres

4. OFF-FARM INCOME

4.1 Apart from farm income, do you receive income from other sources?

☐ 1=Yes ☐ 0=No

4.2 If yes, please indicate details on other sources of income

Type of earning(income)	**No. of months earned**	**Average monthly income (KES.)**
Salary/wages		
Transfer earnings from relatives		
Value of gifts received		
Income from Land rented out		
Income from buildings rented out		
Income from other structures rented out		
Motor vehicle rented out income		
Other incomes (specify) ……..		

4.3 How much of this income did you allocate to maize production? KES…….

5. LABOUR

5.1 Please tell us about the labour allocation on farming activities in your farm for the past 12 months

Activity *(use codes below)*	**Type of labour** *(use codes below)*	**No. of days**	**No. of hours per day**

Activity type: ***1****=land preparation;* ***2****=Weeding;* ***3****=planting;* ***4****= spraying;* ***5****=mulching;* ***6****= compost preparation;* ***7****=manure application;* ***8****=collection of farm yard manure;* ***9****= others (specify)……..*

Type of labour: ***1****=Family;* ***2****= Casual;* ***3****=Permanent worker;* ***4****=Gang labour; 4=others (specify)……..*

ii) INSTITUTIONAL FACTORS:

6. EXTENSION SERVICES

6.1 Has any household member receive extension contacts in the last 12 months?

☐ 1= Yes ☐ 0 = No

6.2 If yes, fill in the details in the table

Household member*(see codes below)*	**Extension services offered *(see codes below)***	**Extension Provider *(see codes below)***	**Number of times *(past 12 months)***	**Did you pay? 1=Yes 0=No**	**Cost per each time (*KES)***

Household member: ***1****= head;* ***2****= spouse;* ***3****= son;* ***4****= daughter;* ***5****= Grandchild; 6= others (specify)……..*

Extension Services codes: ***1****= crop production;* ***2****= livestock production;* ***3****=Agroforestry;* ***4****=crop rotation;* ***5****= green manure;* ***6****=compost making; 7= cover cropping; 8= mulching; 9= planting of leguminous crops,* ***10*** *= others (specify) ……*

Extension service provider: ***1****=Government extension workers;* ***2****=private extension providers;* ***3****=Private Company;* ***4*** *= NGOs/development agencies;* ***5*** *= other farmers;* ***6****= others (specify) ……..*

6.3 If yes in (6.1) can you say the extension services influenced your current farming system? (*Tick*)

☐ 1= Yes ☐ 0 = No

7. TRAINING AND MOTIVATION

7.1 Has anyone in the household attended a farmer training in last 12 months?

☐ 1= Yes ☐ 0 = No

7.2 If yes in (7.1), then complete the table below

Training technique ***(See codes below)***	**Number of times**	**Training venue** ***(See codes below)***	**Training organizers** ***(See codes below)***

Codes for training*: **1**= soil erosion control; **2** = manure use; **3**= Crop rotation; **4**= crop management; **5**= Livestock management; **6**= Water conservation; **7**= Record keeping; **8**= Farm business kills; 9= Pest control; **10**= Land preparation; 11 = other (specify) ……*

Codes for training venue: ***1****=Farmer's field;* ***2****=Farmer's home;* ***3****=Farmer's meeting place* ***4****. Sub-county offices;* ***5****=others (Specify) ……..*

Codes for training organizers: ***1****=Government extension Workers; 2=Farmers; 3=NGOs (Specify)..... 4=others (Specify)……*

8. CREDIT ACCESS

8.1 Did any household member access credit in last 12 months?

☐ 1= Yes ☐ 0 = No

8.2 If yes, fill the table below:

Credit source ***(See codes below)***	**Granted? 1=Yes 0=No**	**Credit type 1=Money 0=In kind**	**Amount of credit requested**	**What was the purpose of credit?** ***(See codes below)***	**If not granted, give reasons** ***(See codes below)***

Source codes*: **1**= Commercial bank, **2**= AFC, **3**=Cooperative, **5**= Local money lender.* ***6****= others (specify) ……*

Purpose of credit codes: ***1****=school fees,* ***2****= business capital,* ***3****= household consumption,* ***4****=farm inputs (crops),* ***5****= livestock, 6= medication,* ***7****=other (specify) ……*

Not granted reasons codes: ***1****= lack of security,* ***2****= had outstanding loan,* ***3****=lack of enough savings,* ***4****=defaulted previously,* ***5****= other (specify)* ……

9. **GROUP MEMBERSHIP**

9.1 Is anybody in the household a member of an agricultural related group?

☐ 1= Yes ☐ 0 = No

9.2 If yes in (9.1), which type of group?

☐ 1. Self Help group ☐ 3. Cooperative Society

☐ 2. Welfare group ☐ 4. Other (Specify) …….

9.3 If yes in (9.1), in what ways has the group benefit you as member?

☐ 1. Income generation ☐ 4. Livestock husbandry improvement

☐ 2. Improved crop production ☐ 5. Accessibility to safe water supply

☐ 3. Crop and livestock sale ☐ 6. Soil conservation

☐ 7. Water conservation ☐ 10. Business skills training

☐ 8. Tree seedlings sale ☐ 11. Merry go round

☐ 9. Brick making ☐ 12. Other (specify) ……

10. LAND TENURE AND DISTANCE FROM THE HOMESTEAD

10.1 Do you own land by title deed?

☐ 1=Yes ☐ 0=No

10.2 If yes, is this an ancestral land?

☐ 1=Yes ☐ 0=No

10.3 If No in (10.2), how did you acquire this land?

☐ 1. Bought ☐ 3. Gift

☐ 2. Reclaimed ☐ 4. Others (specify)……

10.4 Which type of farming do you practice?

☐ 1. Crop farming ☐ 3. Mixed farming (crop and livestock)

☐ 2. Livestock production ☐ 4. Others (specify)……..

10.5 Is the farm next to your homestead?

☐ 1=Yes ☐ 0=No

10.6 If No in 10.5, how far is the farm from your homestead? ……Kilometers

11. SLOPE OF LAND

11.1. What is the slope of your land?

☐ 1= Gentle ☐ 2= Moderate ☐ 3= Steep

11.2 Does the slope of your land render it vulnerable to the problem of soil erosion?

☐ 1=Yes ☐ 0=No

11.3 If yes in (11.2), then how do you manage (control) this problem?

☐ 1. Cover cropping ☐ 2. Digging of terraces
☐ 3. Mulching ☐ 4. Construction of gabions
☐ 5. Intercropping ☐ 6. Planting of trees
☐ 7. Others (specify) …….

E. FARM OPERATIONS

12. ORGANIC SOIL MANAGEMENT PRACTICE

12.1 Do you practice organic soil management? (*Tick*)

☐ 1=Yes ☐ 0=No

12.2 If yes in (12.1), what attracted you to organic soil management practice?

……

……

12.3 If yes in (12.1), what factors are limiting the expansion of your organic soil management practices?

☐ 1 Lack of capital ☐ 5 High initial cost of production
☐ 2 Lack of land ☐ 6 Lack of access to organic seedlings
☐ 3 Poor soils ☐ 7 Pests and diseases
☐ 4 Lack of market ☐ 8 Others (specify)……

12.4 If no in (12.1), what are the reasons for not adopting organic soil management practices?

☐ 1 Lack of capital ☐ 5 High initial cost of production
☐ 2 Lack of land ☐ 6 Lack of access to organic seedlings
☐ 3 Poor soils ☐ 7 Pests and diseases
☐ 4 Lack of market ☐ 8 Others (specify)……

12.6. How often do you use the following soil improvement measures on your farm?

	Soil management measure	How often do you use it 0=Never, 1=Regularly; 2= Occasionally	On what crops	For how many years have you practiced?
1	Crop rotation			
2	Incorporate crop residue			
3	Mulching			
4	Early planting			
5	Use of FYM			
6	Compost			
7	Green manure			
8	Planting leguminous crops			
9	Cover crops			
10	Plant Agroforestry trees			
11	Others (specify)……			

Codes for crops: ***1****=Beans;* ***2****=Maize;* ***3****=Millet;* ***4****=Sorghum;* ***5****=Cassava;* ***6****=Soya beans;* ***7****=Potatoes;* ***8****=Onions;* ***9****=Tomatoes;* ***10****=Cow peas;* ***11****=Green pepper;* ***12****=Cabbage;* ***13****=Others (specify)*…….....

12.7 Among the above practices which one do you mainly practice on the farm? ☐

13. AGROFORESTRY

13.1 Which of the following agroforestry techniques do you practice? *(Please tick where appropriate)*

☐ 1. Intercropping ☐ 5. Boundary planting

☐ 2. Woodlots ☐ 6. Leguminous fallows

☐ 3. Tree nurseries ☐ 7. *Growing high value trees (Jatropha, eucalyptus)*

☐ 4. Alley cropping ☐ 8. *Others (Specify)* ……

13.2 From the list above which one is the main agroforestry technique on your farm? ☐

14. YIELDS

14.1 Have you ever experienced any crop-yield reduction in the last 3 years?

☐ 1=Yes ☐ 0=No

14.2 If yes in (15.1), give reasons……

……

14.2 If No in (15.1), give reasons……

……..……

……..……

D. PROFITABILITY

15.1 Cost details

Indicate details on all inputs used on maize production within the last 12 month

Type of input ***(see codes below)***	**Quantity used**	**Quantity units** ***(see codes below)***	**Cost per unit**	**Total costs**

Input type codes: 1*= agrochemicals (herbicides pesticides, and fungicides);* ***2****=seeds;* ***4****=Gunny bags;* ***5****=Manure;* ***6****=Chemical fertilizer;* ***7****=labour;* ***8****= Land operating cost (tilling, weeding and harvesting); 9=others (specify)* ……

Units: 1*=50 Kg bags;* ***2****= 25 Kg bag;* ***3****=Kgs;* ***4****= Grammes;* ***5****=Litres;* ***6****=Wheelbarrow*

15.2 Maize crop output information

Acres	**Quantity produced**	**Quantity in units** ***(see codes below)***	**Unit price (KES)**	**Total Returns**

Output Units: ***1****=90 Kg bags;* ***2****= 50 Kg bag;* ***3****= 50 Kg bag;* ***4****=Kgs*

Appendix 2: Farmers perception results on OSMP in Bungoma County.

STATEMENT	Code	Mean	standard deviation	C.V
1. We have to protect natural resources even if it will lead to incurring losses in the short run	S1	4.35	0.91	0.21
2. Natural resources must be protected for the next generations	S2	4.34	1.1	0.25
3. Soil fertility can be improved by application of green manure and cultivation of legume crops	S3	4.21	0.98	0.23
4. Crop rotation helps in weed control	S4	4.15	1.12	0.27
5. Pesticide overuse may lead to pest resistance to pesticides	S5	3.88	1.15	0.3
6. Green leaf manure helps to improve soil structure and reduce weed population	S6	3.81	1.05	0.28
7. Successive cultivation of a single crop increases pests' invasion	S7	3.73	1.47	0.39
8. Agrochemicals have negative effects on human and animal health	S8	3.66	1.23	0.33
9. Biological control is the best methods of pest control	S9	3.41	1.48	0.43
10. Retaining plant residues increases weeds population (n*)	S10	3.31	1.14	0.34
11. By decreasing chemical fertilizer, use in the long run, maize farmers' benefit will increase	S11	3.31	1.26	0.38
12. Organic farming leads to reduced cost of production	S12	3.29	1.42	0.43
13. Minimum tillage reduces soil erosion, disturbance and exposure	S13	3.29	1.75	0.53
14. Retaining plant residues help in soil and water conservation	S14	3.19	1.65	0.52
15. Application of animal manure cannot increase maize production (n*)	S15	2.68	1.43	0.53
16. Application of animal manure can increase soil fertility	S16	2.65	1.69	0.64
17. Preparation of farm yard manure is labour intensive	S17	2.51	1.64	0.65

18. Cultivation of mixed crops not only increase total production but also reduces soil erosion	S18	2.39	1.07	0.45
19. Plant residues are useless and hence they should be burned (n*)	S19	2.37	1.16	0.49
20. Minimum tillage operation decreases soil fertility(n*)	S20	2.33	1.02	0.44
21. Release of crop residues in maize farm will decrease soil fertility (n*)	S21	2.29	1.21	0.53
22. Maize yield can be increased only by increased use of chemical fertilizer	S22	2.18	1.18	0.54
23. Cover cropping cause soil erosion (n*)	S23	2.15	1.16	0.54

(n*) = negative statement

Appendix 3: Results on farmers' perceptions towards OSMP in Bungoma County.

Code	Strongly agree	Agree	Undecided /Neutral	Disagree	Strongly disagree	Mean	Category	standard deviation	C.V	Rank
S1	86	40	15	8	1	4.35	A	0.91	0.21	1
S2	96	31	7	10	6	4.34	A	1.10	0.25	2
S3	66	67	5	6	6	4.21	A	0.98	0.23	3
S4	84	23	30	8	5	4.15	A	1.12	0.27	4
S5	50	64	13	14	9	3.88	A	1.15	0.30	5
S6	41	60	36	5	8	3.81	A	1.05	0.28	6
S7	69	31	6	28	16	3.73	A	1.47	0.39	7
S8	34	79	2	22	13	3.66	A	1.23	0.33	8
S9	50	34	18	24	24	3.41	U/N	1.48	0.43	9
S10	22	51	40	26	11	3.31	U/N	1.14	0.34	10
S11	30	49	18	43	10	3.31	U/N	1.26	0.38	11
S12	34	48	23	17	28	3.29	U/N	1.42	0.43	12
S13	66	16	6	19	43	3.29	U/N	1.75	0.53	13
S14	54	19	17	22	38	3.19	U/N	1.65	0.52	14
S15	5	68	4	20	53	2.68	U/N	1.43	0.53	15
S16	39	18	5	28	60	2.65	U/N	1.69	0.64	16
S17	29	27	2	25	67	2.51	U/N	1.64	0.65	17
S18	5	19	38	55	33	2.39	D	1.07	0.45	18
S19	7	30	6	75	32	2.37	D	1.16	0.49	19

S20	9	9	44	43	51	2.33	D	1.02	0.44	20
S21	15	9	20	67	39	2.29	D	1.21	0.53	21
S22	6	23	14	56	51	2.18	D	1.18	0.54	22
S23	6	17	26	45	56	2.15	D	1.16	0.54	23

Appendix 4: Maize plantation farm in Bungoma County.

Appendix 5: Fertile organic soils in Bungoma County.

Appendix 6: Early stages of FYM preparation in Bungoma County.

Appendix 7: FYM ready to be used in Bungoma County.

Appendix 8: Preparation of compost manure in Bungoma County.

Appendix 9: Mulching activity on tomato crop in Bungoma County.

Appendix 10: Application of green manure in Bungoma County.