IMPACT OF IMPROVED POULTRY PRODUCTION TECHNOLOGIES AMONG SMALLHOLDER INDIGENOUS CHICKEN FARMERS IN KAKAMEGA AND MAKUENI– KENYA

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DECLARATION

Student Declaration

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

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A152/24280/2013

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Supervisor's Declaration

We confirm that the work was carried out by the candidate under our supervision as the official University supervisors

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DEDICATION

This thesis is dedicated to my late father Peter Kung'u Njuru who inspired and always encouraged me to keep on seeking new knowledge. Not forgetting his motivation, financial and moral support. Almighty God may you rest his soul in eternal peace. To my mother, brother, sisters, nephew and my nieces for their financial and moral support of ensuring that the entire process of my study was a success.

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance
ATE	:	Average Treatment Effect
ATT	:	Average Treatment Effect on the Treated
ATU	:	Average Treatment Effect on the Untreated
BWD	:	Bacillary White Diarrhea
CIA	:	Conditional Independence Assumption
FAO	:	Food and Agriculture Organization of the United Nations
GLM	:	General Linear Model
GMA	:	Gross Margin Analysis
IC	:	Indigenous Chicken
IIC	:	Improved Indigenous Chicken
KALRO	:	Kenya Agricultural an Livestock Research Organization
KAPAP	:	Kenya Agricultural Productivity and Agribusiness Project
NCD	:	New Castle Disease
PCA	:	Principal Component Analysis
PSM	:	Propensity Score Matching
PTM	:	Poultry Management Technologies
RIR	:	Rhode Red Island
ROI	:	Return on Investment
ROK	:	Republic of Kenya

TC	:	Total Cost
TFC	:	Total Fixed Cost
TR	:	Total Revenue
TVC	:	Total Variable Cost
USAID	:	United States Agency for International Development
VIF	:	Variance Inflation Factor

ABSTRACT

Indigenous chicken (IC) farming contributes to the livelihoods of many smallholder farmers in Kenya. It constitutes 80% of the poultry population in Kenya. Kakamega and Makueni are Counties where most of smallholder farmers rear IC. However, IC production has been constrained by several bottlenecks including; unimproved genotype, diseases and increased mortalities resulting in low productivity. A strategy by scientists and stakeholders, production technologies such as; improved indigenous chicken (IIC) genotypes and fabricated chick brooders have been developed and disseminated to the farmers with an aim of increasing productivity. However, the status of adoption and the impacts of the IIC technologies on productivity remained scanty. Therefore, the general objective of this study was to determine the level and intensity of adoption and impact of poultry production technologies among smallholder farmers in Kakamega and Makueni. Data were collected through interviews with a sample of 384 household's selected using multi-stage sampling. Results revealed that majority (60%) of the households practised semi-intensive production system. A double hurdle approach was used to analyze the level and intensity of use of IIC and fabricated brooders. Results showed that farm size, gender of the household head, group membership, distance to the training centre, off-farm activities and IIC awareness significantly affected the adoption decisions. Household size, group membership, age of the household head, access to credit, off-farm activities and flock size were major determinants of intensities of adoption. Propensity score matching approach was used to analyze the impact of IIC on egg productivity. Results showed significant impact of IIC on egg productivity/hen/year. Gender of the head negatively affected egg production while level of education, group membership, distance to the training point and other off-farm activities positively affected egg production. Gross margin analysis was used to determine the profitability of IC. Rearing of unimproved IC was a profitable enterprise. However, rearing IIC proved to be even more profitable with annual gross margins of Ksh. 14,238 and Ksh. 9,824 per 100 birds with IIC and IC production system systems, respectively. Based on the findings, it is recommended that policies should target strengthening the IIC farmer's network, in order to access information on IIC production. Second, access to markets for farmers requires improvement to improve profits. Additionally, there is a great need to encourage enterprise diversification among IC farmers. Further, policies should target on developing programs that support more women in poultry production.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Production of Indigenous Chicken (*Gallus domesticus*) accounts for 30% of all white meat consumed globally (FAO, 2012). Moreover, the indigenous chicken (IC) population accounts for over 70% of the total chicken population in Africa (FAO, 2011). Nationally, the estimated population of birds in Kenya is 29 million with 76% of them being free-ranging indigenous chicken (RoK, 2010). The annual poultry production in Kenya is estimated at 20 tons of poultry meat worth Ksh. 3.5 billion and eggs worth Ksh. 9.7 billion (RoK, 2010). These IC products in Kenya account for 47% and 55% of the total poultry eggs and meat, respectively (King'ori *et al.*, 2010).

Indigenous chicken production contributes to nutritional requirements, socio-cultural practices and welfare of the smallholder farmers in Kenya. Firstly, the chicken provides high-quality protein and a source of income generation among small holder farmers (Mapiye *et al.*, 2008; Okello *et al.*, 2010; Magothe *et al.*, 2012). Secondly, rearing of IC is linked to different ceremonial roles among the smallholder farmers in Kenya. Further, rural IC provides rural households with cheap animal protein in the form of table eggs and meat (Adomako *et al.*, 2009). Moreover, it is expected that IC production contributes significantly to animal protein which is projected to increase to 40% by the year 2020 (Delgado *et al.*, 1999). This represents a potential income source and poverty exit strategy for smallholder farmers in Kenya.

There is an increasing demand for IC among the consumers in the urban centres in Kenya. The increased demand for IC products has been linked to different socio economic factors. First, there is a steady growth in the population of health conscious consumers (Mengesha, 2012). Furthermore, urbanization and increase in per capita disposable income among these consumers is anticipated to increase consumption by the year 2020 (USAID, 2010). On the other hand, more smallholder farmers have a preference for IC over exotic chicken based on their different attributes, such as being hardy and ability to scavenge.

According to Badhaso (2012), IC is characterized by extensive scavenging for feeds and limited input requirements. For example they require limited immunization expenses, have a high adaptability and require minimal intervention to increase productivity. Other additional traits that make IC an attractive enterprise include: ability to resist diseases, utilization of low-quality feeds and its diverse products (Mengesha, 2012).

The production systems of IC in Kenya are classified as either commercial or subsistence production system (Menge *et al.*, 2005). The extensive subsistence system is the most used system in Kenya among the smallholder IC farmers and is characterized by a low input - low output. Consequently, the age at first egg of the scavenging IC is between 203– 220 days, which is longer compared to commercialized production. Second, the IC birds under extensive production systems have a maturity body weight of 2.2 Kg for males and 1.6 Kgs for female birds. Third, the eggs are laid in clutches with the total estimated at 30 – 75 eggs/hen/year (Magothe *et al.*, 2012). This low productivity leads to reduced commercialization of the IC enterprise (Okitoi *et al.,* 2007). Therefore, an extensive system may fail to meet the high demand for IC products in the available markets (Kahi *et al.,* 2012).

According to Republic of Kenya (2010), factors related to the low productivity of IC in Kenya include: low genetic potential, feed shortage, disease outbreak and increased chick mortalities. Other studies have revealed different factors leading to low production levels of IC in Kenya. First, most of the IC farmers have difficulties in accessing quality inputs for production (Awuni, 2003; FAO, ECTAD, 2009). The main inputs include the access to veterinary services and adequate number of IC chicks.

Second, IC farmers lack adequate skills on the production of IC for commercial purpose (Hossen, 2010). Hence the farmers are not competitive enough compared to the exotic chicken producers (Menge *et al.,* 2005; FAO, 2012; King'ori, *et al*., 2010). Third, most of the IC flocks are affected by disease outbreak which may lead to loss of flocks (Yitbarek, *et al.,* 2013). Moreover IC farmers experience losses of IC during transportation to the markets (Bwalya and Thomson, 2014).

These losses are mainly due to the poor transportation techniques which expose the IC to diseases and injuries.

Previous studies however assert that development of IC is a sustainable way of targeting increased productivity (Awuni, 2003; Mapiye *et al.*, 2008). The research findings advocate for improved poultry production technologies to increase IC productivity which includes; improved genotype, feed supplementation, vaccination and improved rearing system (Njue *et al.*, 2006; Ochieng *et al.*, 2011).

The performance of IC smallholder farmers in terms of the gross margins from improved IC technologies is better compared to other farmers (Yitbarek, 2013). This adoption of improved IC technologies has resulted in increased productivity and better incomes for smallholder farmers (Bwalya *et al.*, 2014). Moreover, improved poultry management characterized by adoption of genetic improvement has led to improved performance (Awuni, 2003; Kahi *et al.*, 2012). However, adoption of poultry production technologies doesn't automatically translate into an increase in productivity (Wachira and Mailu, 2010). Therefore, manner in which the smallholders adopt improved production technologies leads to variations in IC performance (Ochieng *et al.*, 2011).

In both Makueni and Kakamega Counties, IC has been recognized as an avenue to improve livelihoods of the rural households by increasing productivity (USAID, 2010). The Kenya Agricultural Productivity and Agribusiness Project (KAPAP) has pursued a vital role in improving the IC through promoting the dissemination of improved poultry production technologies to smallholder farmers. They include; improved indigenous chicks (KARI - Kienyeji) and fabricated chicken brooders (KAPAP, 2012). However, no studies have been done to assess the level and intensity of adoption and impact of such improved indigenous chicken ecotypes and their associated brooding technologies. Information from such studies if positive would help to come up with measures to promote dissemination and uptake of the improved technologies leading to higher productivity and incomes. Improved indigenous chicken is a superior crossbreed of different IC ecotypes from various selected Kenyan localities and widely known as KARI-Kienyeji. It was developed through the joint initiative of the Ministry of Livestock and Development and the Kenya Agricultural Research Institute (KARI), currently known as Kenya Agricultural and Livestock Research Organization (KALRO) to serve a dual purpose (meat and eggs) and characterized by the ability to; produce more eggs, mature faster and meet market weight faster (Ondwasy *et al.*,2006). The strategy aims to transform IC industry into a profitable, commercially oriented and internationally and regionally competitive economic activity (RoK, 2010).

1.2 Statement of the Problem

Indigenous chicken production contributes significantly to the socio-economic development and nutritional requirements of rural and peri-urban households. The bird's products (meat and eggs) are preferred for their good quality, texture, taste and health characteristics. This has resulted into an increased demand, which is an indicator of their great potential of generating higher income. This would translate to enhanced long-term national development and better living standards of the rural and peri-urban households.

However, ICs are usually constrained several bottlenecks including; slow growth rate and maturity rate, poor feeding and high chicks mortality rate. This results to low productivity. As an appropriate strategy to improve productivity, improved poultry production technologies such as; improved indigenous chicken ecotypes and fabricated chick brooders have been developed and disseminated to some smallholder farmers in Makueni and Kakamega Counties by stakeholders such as; KAPAP, KALRO and Techno Serve. The improved IC was developed to serve a dual purpose role with the ability to produce more eggs and meat compared to the typical IC, to mature faster and to reach the market size earlier. However, information on adoption and impacts of the disseminated improved Indigenous chicken technologies in Kakamega & Makueni counties remained scanty. Therefore, the current study aimed at filling this existing knowledge gap. It is anticipated that results from this study will be beneficial to the stakeholders involved in promoting dissemination of the improved poultry production technologies and enabling them to evaluate their achievements on the expected goals. To the smallholder farmers, the results would help them in decision making on adoption of improved technologies, as they aim to improve and expand on their stocks.

1.3 General Objective

The general objective of this study was to analyze level and intensity of adoption and impact of improved poultry production technologies on egg production among smallholder indigenous chicken farmers in Makueni and Kakamega Counties in order to proffer relevant recommendations.

1.4 Specific Objectives

The specific objectives of the study were to:

i. Characterize the smallholder indigenous chicken farmers in Kakamega and Makueni Counties.

ii. Determine the level of adoption of improved indigenous chicken and fabricated chicks brooders among smallholder farmers in Kakamega and Makueni counties.

iii. Determine the impact of improved indigenous chicken on egg production among smallholder farmers in Kakamega and Makueni counties.

iv. Determine the profitability of improved indigenous chicken among smallholder farmers in Kakamega and Makueni counties.

1.5 Research Questions

The study had the following research questions;

i. What are the characteristics of smallholder indigenous chicken farmers in Kakamega and Makueni Counties?

ii. What is the level of adoption of improved indigenous chicken and fabricated chick's brooders by smallholder farmers in Kakamega and Makueni counties?

1.6 Research Hypothesis

i. Improved indigenous chicken has no positive significant impact on egg production among smallholder farmers in Kakamega and Makueni counties?

ii. Rearing improved indigenous chicken has no significant effect on profitability as compared to typical indigenous chicken among smallholder farmers in Kakamega and Makueni counties?

1.7 Justification of the Study

Indigenous chicken rearing is vital in the Kenyan poultry sub-sector due to its contribution to smallholder farmers in the country. Increasing productivity is aimed to commercialize the sub-sector and remains an area of interest. Though constrained by major factors such as low genetic potential, diseases, feeds shortage and poor management practices during production, IC production plays a significant role to both the urban and rural households through contributing to nutritional requirement, socio-cultural practices and a source of income generation. There is a critical need for the advocated management practices to be fully practiced in order to realize increase in production of IC.

The current study aimed to analyze adoption and impact of improved poultry production technologies on egg production among smallholder indigenous chicken farmers in Makueni and Kakamega Counties. The results of this study will be beneficial to the stakeholders who have initiative of disseminating the production technologies. Such stakeholders will be able to evaluate their achievements on the anticipated goals. These include among others; KARLO, KAPAP, Techno Serve and Extension Service providers. On the other hand, the findings will help smallholder farmers make decisions on adoption of improved poultry production technologies as they aim at improvement of their IC, expand their current stock and further increase productivity. This will help them maximize profits and reduce the poverty levels. Therefore, the general objective was in line with the Vision 2030 Sustainable Development Goals. Additionally, the study will contribute significantly to the body of knowledge while recommendations will point at further areas warranting more research.

1.8 Scope of the study

The study focused on indigenous chicken smallholder farmers in Makueni and Kakamega Counties. In these two counties, there was a rapid dissemination of improved poultry production technologies such as; improved indigenous chicken and fabricate chicks brooders. Therefore, the emphasis was more on adoption of the disseminated production technologies and their impact on productivity. The target population was covered through sampling units of smallholder households and considered the sample of those smallholders who had been treated with the technologies. A control group generated from propensity score matching was used to give comparative statistics on impact of the improved IC. The study was part of the wider project on Indigenous Chicken Value Chain (ICVC) in Makueni and Kakamega Counties', funded by World Bank under Kenya Agricultural Productivity and Agribusiness Project (KAPAP).

1.9 Limitation of the study

The researcher experienced challenges in accessing data from the smallholder farmers who had limited information. Some of the farmers did not keep record sheets on IC rearing and production, medication and vaccination, mortality and culling, and feed consumption and prices records. There were chances that some smallholder farmers did not give consistent trends on income from the sale of the IC and their products.

1.10 Definition of Terms

Adoption – refers to the decision to use a new technology or a given practice by a farmer at a given period of time after having full information on the potential of that particular technology (Rogers, 1983). A farmer was defined as being an adopter if he or she was found to be keeping improved indigenous chicken or fabricated chicks brooders.

Impact – refers to the change in production because of farmers receiving a treatment or an intervention (Khandker *et al.,* 2010)

Production technologies – they are ideas or objects perceived as new by farmers in the process of agricultural production which affect the growth of agricultural output (Mahajan and Peterson, 1985)

Productivity – refers to the ability of a production system to produce more economically and efficiently (Dewett and Singh, 1966).

Smallholder farmer – this is a farmer whose agricultural orientation is mainly subsistence and cultivates land not exceeding 10 acres

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, literature relevant to the research study is reviewed. The main sub-themes include: contribution of poultry industry to the Kenyan economy, poultry production systems in Kenya, adoption of the agricultural production technologies; production and productivity of indigenous chicken; profitability of the indigenous chicken; and theoretical and conceptual framework adopted for the study.

2.2 Contribution of Poultry industry to Kenya Economy

The livestock sub-sector contributes 10% of the entire Kenya's Gross Domestic Product (GDP). Further, the sub-sector accounts for 42% of the Kenya's agricultural GDP (RoK, 2010). However, poultry production remains one of the key enterprises among the poor smallholder households in Kenya. The poultry industry is categorized by dualism in Kenya. The industry is composed of both large scale and small-scale poultry producers (Aila *et al.*, 2012).

There are two main production systems which are classified into commercial hybrid and indigenous poultry production (King'ori *et al.*, 2010). However, indigenous poultry production system dominates the Kenyan poultry industry where 75 % of the households in the rural areas prefer this system (RoK, 2010).

The estimated population of chicken in Kenya is 29 million chickens where indigenous chicken constitute 75% of the total estimate (RoK, 2010). It is further estimated that the mean annual poultry meat production is 20000 Metric Tonnes (MTs). On the other hand, the annual egg production is estimated at 1,255million eggs (MoLD, 2008). However, there exists unmet demand of the poultry product in Kenya. As revealed from the previous report, the country per capita poultry eggs and meat consumption is estimated at 36 and 0.65 kilograms, respectively. These estimates are lower than the recommended white meat consumption requirements by World Health Organization on poultry eggs and meat (RoK, 2010).

2.3 Poultry Production Systems in Kenya

Menge *et al.* (2005) studied the bio-economic model to support breeding of indigenous chicken in different production systems. The findings classified production systems in Kenya into three systems namely; free range system (FRS), semi-intensive (SI) and intensive (IS) system. It was identified that the choice of the particular production system depends on the main objective attached to the enterprise and land availability. The two main objectives of rearing IC are to support subsistence and commercialization. The same study further revealed that adopting a free range system was more profitable compared to semi intensive and intensive systems of production. However, rearing IC under the FRS system was constrained by lack of land availability due to increased human population. Therefore, farmers may forego the FRS system for SI or IS.

Okeno *et al.* (2011) carried out a study on characterization of indigenous chicken production systems in Kenya. The results described the production system used as low input – output. Birds were left to scavenge for feeds. The mean flock size was 23 chickens per household. High mortality was attributed to; diseases such as new castle disease, fowl typhoid etc., poor nutrition, poor housing and marketing channels. In addition, the study findings revealed that indigenous chicken ranked the highest in terms of income generation as compared to other livestock units. Therefore, improvement of IC management would increase productivity thereby leading to increased returns from commercialization of IC products (meat and eggs). The findings of this study supports those of Mwobobia *et al.,* (2016) which revealed that indigenous chicken contributed 4% and 27% of the total tropical livestock units in rural and peri-urban areas respectively in Katulani district, Kenya.

Atela *et al.* (2016) compared performance of indigenous chicken in Baringo and Kisumu counties of Kenya. The main objective was to evaluate the production systems used for production of indigenous chicken in the two counties. Results revealed that free range system was the most predominant system which constituted 67% of the total sampled households. However, it's worth noting that 42% of the sampled households in Kisumu adopted the semi-intensive production system. Therefore, the IC producers in Kisumu supplemented their flock with; kitchen left overs, cereal grains and commercial feeds due to semi-confinement. The study also revealed that females dominated in practising IC where they constituted 63% of the total sample. The finding on gender of the household head is consistent with those of Mwobobia *et al.,* (2016) who revealed that 59% of the sampled household heads rearing chicken were female.

Kyule *et al.* (2014) studied indigenous chicken rearing systems and their influence on household income among the small-scale farmers in Mau-Narok, Kenya. Results revealed that majority (62%) of the sampled households used extensive system. On the other hand, 27% and 13% used semi-intensive and extensive system of production, respectively. The findings further revealed that farmers left their birds to scavenge for feeds. Bird's confinement was done at night in their separate IC shelters. However, the commercialization of IC in the study area was hindered by the small flock size for each system due to high cost of production.

King'ori *et al.* (2010) studied indigenous chicken production in Kenya. This study described the common phenotypes of indigenous chicken in Kenya. They include; frizzled feather, bearded feathered shanks, naked neck, barred feather and dwarf sized. However, there existed variance in performance and most of the IC derived their feeds from scavenging. In addition, most of the farmers interviewed preferred rearing indigenous chicken (IC) due to low cost of production. This study further revealed that majority of farmers was foregoing exotic breeds in poultry subsector due to feed demands and increased production cost. However, results revealed low IC productivity which was attributed to IC genotype, poor nutrition and lack of supplementation.

2.4 Adoption of the Agricultural Production Technologies

There is a concurrence in literature that adoption is a sequential process as opposed to a simultaneous event. The process of adoption is characterized by the decision stage that is followed by the intensity stage (Adesina & Zinnah, 1993). A smallholder farmer may consider the specific attributes of the technology in the first step. Subsequently, the second step which is the outcome is manifested in the intensity of adoption (Adesina & Zinnah, 1993). The main assumption is that the smallholder farmer will choose and adopt new technologies that will bring minimal disruption to environment and yields.

Further, smallholder socioeconomic characteristics such as asset endowments (livestock owned), contact with extension and years of experience also influence the decision on adoption of technologies and the intensity of adoption of technologies (Asarat *et al*., 2010; Ghimire *et al.*, 2015). For example a smallholder farmer may have different sources of information and may be located at different distances from centers of training. The effect of these two factors has not been adequately analyzed in the literature on technology adoption.

Gillespie *et al.* (2014) studied how the adoption of new technologies was influenced by socioeconomic characteristics such as; age, education, farm size and diversification. The relationship between socioeconomic characteristics of farmers and the decision to adopt has been shown in several studies. Moreover, some studies have analyzed the effect of socioeconomic characteristics on the intensity of adoption of technology.

Ghimire *et al.* (2014) conducted a study on the adoption of new improved rice varieties in central Nepal using a probit analysis. The results showed that the adoption of the new improved rice varieties was significantly influenced by education, access to seed, land ownership and technology characteristics. Other studies show that the adoption of new technology is influenced by the gender of household head and household size (Challa and Tilahum, 2014; Akpan *et al*., 2012).

Chi and Yamada (2002), analyzed the adoption of new technologies by farmers in Mekong Delta. The variables that had a significant effect on the adoption of new technologies included age, education and male headed households. On the other hand, the adoption of technologies was not significantly affected by older individuals and perception on profitability. The impact of adopted new technology on crop productivity is another factor that influences the adoption of technology alongside environmental and biophysical factors (Food and Agriculture Organization for United Nations, 2015). Further, the adoption of technologies by smallholder farmers may be influenced by the availability of information and the influence of neighbors (FAO, 2015).

A study by Lambert *et al.*,(2015) showed that the adoption of agricultural technologies by farmers was significantly influenced by the scale of operation, access to information and participation in other programs. However, the adoption of technologies e.g. irrigation technologies may be “sensitive” to prices of inputs and cost of technology.

Ochieng *et al.* (2010) studied the patterns of management interventions adoption and their effect on the productivity of IC production in Western Kenya. Principal Component Analysis (PCA) and Cluster Analysis (CA) approaches were used to show the level of adopting management packages. These management packages comprised of; feed supplementation, housing, vaccination and brooding technologies. Results revealed that 76% of farmers modified and selected interventions and only 24 % adopted full management packages. This could be attributed to limited institutional and extension services that were only accessed by 43%. Veterinary services were accessed by 34% and credit which was accessible to 48% of the respondents (Ochieng *et al.*, 2011). However the study did not clearly show the genetic make-up of the IC that was subjected to the above husbandry packages.

Gautam *et al*. (2013) studied the adoption of various scientific poultry farming technologies by broiler farmers in India. The study classified the farmers into: small, medium and high category. Results revealed low adoption by the majority of the farmers in the small category. However those farmers in the medium category were not clearly defined, but the large farmers highly adopted the technologies. The size of the flock determined the adoption but on the other hand, other factors such as knowledge base and resourcefulness led to adoption.

Teklewold *et al*. (2006) studied the determinants of adoption of poultry technology. The results revealed that 42% adopted the exotic breed with a proportion of 0.54. An average farmer had about 40% predicted probability of adopting the technology. The double hurdle model showed that the decision to adopt was positively affected by; sex of the household head, family size, supplement availability, credit and extension services. However, age negatively influenced both tiers and old farmers were likely to be more risk averse.

Gebremichael *et al*. (2014) analyzed the factors that affect the decision and intensity to adopt improved box hive technology in N. Ethiopia. The study used descriptive analysis and double hurdle model for analysis of data. Results revealed that there were 55% adopters whereas 45% were non adopters. Among the adopters 68% used both traditional and improved hives while 32% used improved hives only. In this case, age influenced the level of adoption but had no significant effect on the approval decision. Other off-farm activities and distance to market affected the decision on adoption. The intensity of adoption from the second hurdle was affected by other off-farm activities, extension access, credit access, and distance to weather roads.

Mal *et al*. (2012) studied BT Cotton adoption in North India using a double hurdle approach. The objective of the study was to identify determinants of the Bt-Cotton adoption decision and extent of adoption. Results revealed that intensity of adoption was positively influenced by a number of information sources, group membership, access to credit and costs. However, adoption probability was less among experienced farmers and had significant negative impacts on the level of adoption.

2.5 Production and Productivity of Indigenous Chicken

Magothe *et al*. (2012) reviewed the status of indigenous chicken in Kenya. Results revealed that age at first egg was between 203– 220 days and maturity body weight for males and females was 2.2kg and 1.6kg, respectively. Hens were found to lay an estimate of 30 – 75 eggs per year. Natural brooding was practised for reproduction and hatchability was above 70%. This can be attributed to failure to adopt full practices, and thus holistic approach would increase productivity. Additionally, the indicator on hatchability needs to be reviewed for more specific percentage regarding level.

Melesse *et al.* (2013) conducted an evaluation on reproductive and production trait of local chicken. This also included their F1 crosses with Rhode Island Red and Fayoumi breed under farm management in Beresa, Ethiopia. General Linear Model (GLM) was used for analysis of data. Results revealed that hatchability of 85.8% (Fayoumi), 80% (local chicken- Kei) and 68% (Rhode Island Red crosses). Age at first egg was; for Fayoumi was 154 days, RIR (161 days) and Local Chicken, Kei (183 days). Regarding egg production, both F1 crosses; Fayoumi and RIR crosses showed higher egg number and total egg mass compared to local chicken.

Hossen (2010) compared the performance of IC under management intervention and traditional practices in Bangladesh. Results revealed that early weaning increased hen egg production to an average of 96 compared to an average egg production of 45 per hen in a year in traditional management. Hatchability and survivability of IC was 84% and 43% under traditional management, respectively. On the other hand the hatchability and survivability ranged 88% and 87%, respectively, under intervention. This is a depiction that management interventions boosted IC performance.

Ndegwa *et al.* (2014) carried out an investigation on egg hatchability in IC system with smallholder farms in Kenya. The study analyzed the treatment effect of implementing management packages such as housing, vaccination, and feed supplementation on IC. Inferential statistics was done through the use of analysis of variance (ANOVA) and analyzed production features such as hatchability. Results revealed that mean hatchability was 69%. Similarly, through the use ANOVA, it showed that the cycle had no effect on hatchability. Thus, there was an indication that farmer management and genetic potential influenced the flock hatchability.

According to Fisseha *et al.* (2010), the annual egg production under farm management ranged 24 – 112 eggs. The average hatchability was 81.7% whereas chick survivability was 60.5%. However, an annual report by Kenya Agricultural and Livestock Research Organization (KALRO) showed that application of the recommended management technologies, such as the improved breed produced eggs that ranged 220 – 280 eggs per annum. Additionally, it attained 2 kilograms at 22 weeks which made it viable for sale thereby maximizing profitability (KARI, 2011). Therefore, there is need to assess performance of improved breeds on egg production at the farm level given that farmers are constrained in budgetary allocation.

2.6 Profitability of Indigenous Chicken

Aboki *et al.* (2013) studied productivity and technical efficiency of family chicken production in Kurmi, Nigeria. The study used percentage distribution, profitability index and stochastic frontier function to analyze the collected data. Technical efficiency had a mean of 0.63 on input use. The enterprise was highly profitable with 76% return on investment (ROI). The study however fails to account for costs associated with housing and stocks replacement, and these might have led to overstated profits margins and ROI.

Siyaya *et al.* (2013) conducted an economic analysis of indigenous chicken production in Swaziland. Cost benefit analysis (CBA) was used to compute profits on the production of IC. The study revealed that the feed cost highly affected profits and an increase of 1% in feeds purchased, reduced profits by 2.18%. Therefore, market prices determined the profit of IC since a 1% increase in price amounted to 3.37% growth in profitability. However, the study did not account for other costs of production such as housing, equipment, stock costs.

Ayieko *et al.* (2014) carried out a study on the profitability of IC in Makueni, Kenya. The study used gross margin analysis (GMA) to compute profit by the smallholder farmers of IC. The results revealed that the IC production gave a profit of Ksh.5347/100 per birds and a gross margin of Ksh. 8455/100 birds. However, the analysis did not account for the cost of capital. Inclusively, farmers selling manure from the IC to maximize their returns should not be ignored. Kumar, (2013) identified sale of manure as a source of income while computing gross annual returns/family/ bird.

Hosen (2010) revealed that it was economical to invest in IC management interventions. The profitability under traditional management was US$ 47.3/18 birds in a year .On the other hand the profits under management interventions, was US$ 342/ 40-70 birds in a year. However, the study did not give a specific number of birds used to compute profits under management interventions.

The studies reviewed under this chapter focused mainly on poultry production system in Kenya. Second, the various determinants of adoption of agricultural production technologies were identified. Further, performances of the various indigenous chickens had been assessed and documented. However, it was evident that no studies had been conducted to determine adoption and impact of improved poultry production technologies such as; improved indigenous chicken widely known as KARI-Kienyeji and fabricated chicks breed on productivity. Thus, this study aimed at filling the existing information gap and further contributes to the body of knowledge.

2.7 Theoretical and Conceptual Framework

This study was based on the rational choice theory that assumes that the consumer of the technology is rational. This theory analyses the behavior on decision to adopt a particular technology is motivated by expected gains. Farmers are rational consumers of technologies and will adopt technologies in anticipation of increased productivity. Therefore, the fundamental assumption of this study is that the farmer's decision on whether to adopt or not the new poultry production technologies is based on utility maximization. According to Neuman-Morgenstern theory, before the adoption of a given technology, a farmer has to compare the expected utility with the new technology. Preference of new technology will be made if its expected utility exceeds that of the traditional technology (Neumann and Morgenstern, 1994). Expressed as;

$$\Sigma U_{nt}(Y) = \alpha_n X_i + \varepsilon_{ni} \ldots\ldots\ldots\ldots\ldots 1$$

$$\Sigma U_{ot}(Y) = \alpha_o X_i + \varepsilon_{oi} \ldots\ldots\ldots\ldots\ldots 2$$

$$\Sigma U_{nt}(Y) > \Sigma U_{ot}(Y) \quad \text{– Adopt the new technology}$$

$$\text{And if } \Sigma U_{nt}(Y) < \Sigma U_{ot}(Y) \quad \text{– prefer the old technology}$$

However, the farmer is faced with hurdles of whether or not to adopt and to what extent will he/she adopt. Therefore, the adoption decision was modeled as a binary variable for simplicity and compared with double hurdle model which applies to the Propensity Score Matching Method (PSMM). Additionally, Arnholt, (2001) asserts that adopters of technology also consider profits from using the new technology in deciding whether to adopt more of the new technology.

2.8 Conceptual Framework

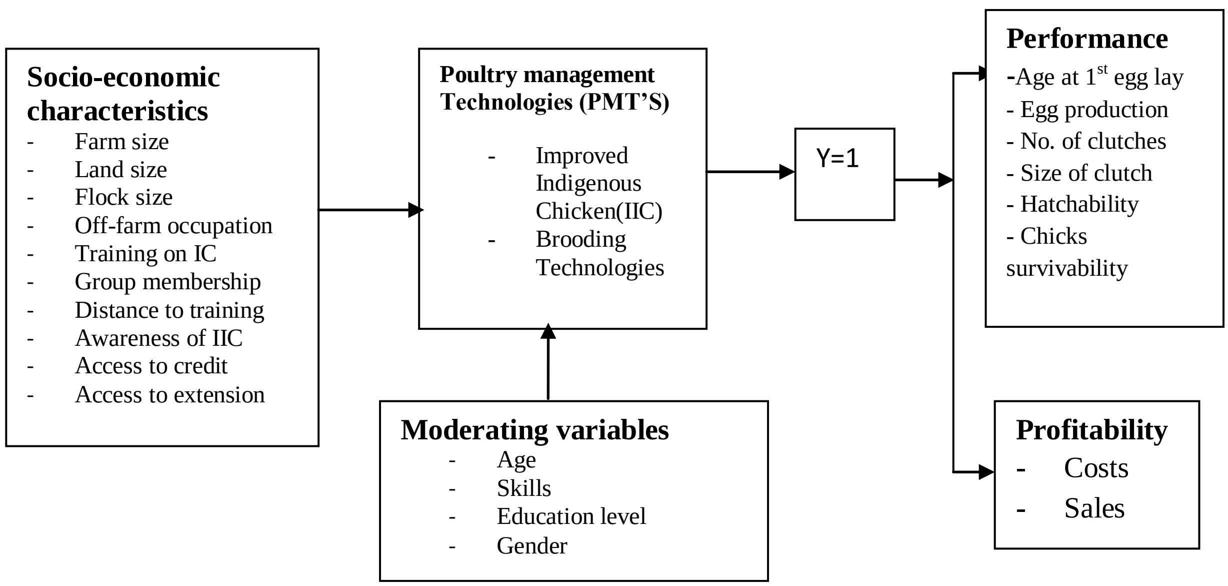

Figure 1 Conceptual framework

Source: Adopted and Modified from Shakya & Flinn, (1985) and Permin and Detmer (2007)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the methodology that was followed in conducting the research. This includes a description of the study area, sample size, and sampling procedure which constitute the research design. Moreover the data collection and analysis procedures are discussed.

3.2 Study area

Makueni County is located in Southern part of Eastern Kenya. It lies between Latitude 1°35′, South and Longitude 37°10′ East and 38°30′ East (RoK, 2013). This county comprises of an area of 8008.8 Km^2. Temperatures in Makueni county ranges between 12 ºC - 28 ºC and bimodal rainfall ranging from 150 mm to 650 mm per annum, which is typical of ASALs in Kenya (RoK, 2013). Low rainfall and temperatures in this county hinder crop production thus livestock production remains a priority. Magothe *et al.*, (2012) identified that improved IC breeds have been developed for better production in ASAL areas. Kakamega county is located in Western Kenya and lies between longitudes 34^0 32’’ and 35^0 57’30 East of the prime meridian and latitudes 0^0 07’30’’ North and North 0^0 15’’ of the equator (RoK, 2010). It covers a total area of 1394.8Km^2. Annual rainfall ranges between 1250 – 1750mm (RoK, 2010).

There was a rapid dissemination of the improved indigenous chicken by the various stakeholders such as; KAPAP, KALRO and Techno serve in the two counties which are known to be main producers of indigenous chicken (Muthee, 2009 & KALRO, 2012). Consequently, the two counties are located in areas that have favorable agro-ecological conditions that are required for the production of IC and are listed as leading areas in IC production (MoLD, 2011). Furthermore, the two counties had been targeted by KAPAP project for the great potential in IC production. Therefore, the various poultry production technologies aimed at increasing productivity, boost income and reduce poverty by improving rural livelihoods of the smallholder farmers in the two counties.

3.3 Research design

A descriptive cross-sectional survey research design was adopted to achieve the purpose of this study. Therefore, this design enabled the researcher to make inferences and generalizations about the population of interest.

3.4 Sample Size and Sampling Procedure

According to Mugenda and Mugenda (2003), when the population is more than 10,000 individuals, 384 of them are recommended as the desired sample size. The total population of households who have ventured in the rearing IC in both areas of study are greater than 10,000 (ROK, 2013) and to get a representative population sample, Mugenda and Mugenda (2003) recommend the formula as shown below. The sample size is determined using statistical population surveys whereby:

$$N=Z^2pq / d^2$$

Where N = desired minimal sample size; Z = Standard normal deviation which is equal to 1 at 95% confidence level; P = Proportion of the target population estimated to have a particular characteristic being measured. In this case it is estimated to be 0.5; d = the level of statistical significance set which in this case is 0.05.

$$\text{Thus, } N = 1.96^2 \text{ X } 0.5 \text{ X } 0.5/0.05^2$$

$$= 384 \text{ Households}$$

Table 3.1: Sampling frame and distribution of the sampled households

Counties	Sub-county	Number of Households	Sampled Households
Kakamega	Shinyalu	11548	$\frac{11548 \times 384}{63350}$ = 70 Households
	Lugari	13693	$\frac{13693 \times 384}{63350}$ = 83 Households
	Lurambi	14353	$\frac{14353 \times 384}{63350}$ = 87 Households
	Sub-Total	***39594***	***240 Households***
Makueni	Makueni	14620	$\frac{14620 \times 384}{63350}$ = 83 Households
	Kaiti	9136	$\frac{9136 \times 384}{63350}$ = 83 Households
	Sub-Total	***23756***	***144 Households***
Combined	**Total**	**63350**	**384 Households**

Source: DLPO, Kakamega and Makueni (2013)

A multi-stage sampling technique was used for this study. The first stage used purposive sampling of Kakamega and Makueni Counties which has a large population of small-scale farmers practicing IC production. The two counties had rapid dissemination of the improved poultry production technologies. The second stage used stratified random sampling to select regions within the sub counties located in Kakamega and Makueni counties. The random stratified sampling was preferred since it was able to reduce the biases associated with sampling. This ensured that there was no over presentation or under presentation of the smallholder farmers in the different strata. Subsequently the researcher randomly picked Lugari, Shinyalu and Lurambi districts from Kakamega County. Furthermore, the researcher randomly sampled Makueni and Kaiti from Makueni County.

3.5 Data Collection

Structured questionnaires and direct observations were used to collect primary data from the respondents. The secondary information that was used in this study was accessed from KARLO -Naivasha and from the County agricultural offices, Department of Livestock Production Offices located in Makueni and Kakamega counties. Trained enumerators were used to collect data from the households.

3.6 Econometrics Framework for Analysis per objective

The explanatory variables were checked for problems of multicollinearity and the results on correlation and Variance Inflation Factor (VIF) (Appendix 3). As a rule of thumb, if the VIF of a given variable is more than 10 and the R^2 exceeds 0.90, then the variable is then said to be highly collinear. Based on the results of this study, the value of VIF were less than 10, depicting no problem of multicollinearity. Breusch Pagans test / Cook Weisberg test for heteroskedasticity in this study was insignificant (Prob> chi2=0.2244). Further, the Ramsey RESET test confirmed that there were no omitted variables in the process of analysis (Prob> F=0.2593) (Appendix 4).

3.6.1 Analyzing the level of adoption of poultry production technologies

A Double Hurdle approach was used to analyze objective one. It's a parametric generalization of Tobit model developed by Cragg, (1971). According to Cragg (1971), adoption is faced by 2 tiers. The first is whether to adopt or not adopt the technology and second stage is related to level of adoption. The relationship between the two tiers is hypothesized to be linked (Berhanu and Swinton, 2003). Therefore, various recent studies have analyzed this hypothesized relationship (Asfaw *et al.*, 2011, Kuti, 2015; Gebremichael and Gebremedhin, 2014; Katengeza *et al.,* 2012; Akpan *et al.,* 2011 & Mal *et al.*, 2012).

The model specification by Cragg (1971), the 2 tiers are represented as;

$$D^*_i = \alpha Z_i + V_i \text{ ………………………… } (3)$$

$$Y^*_I = \beta X_i + U_i \text{ ………………………… } (4)$$

Where D_i = {1, if D_i^* >0; 0 if $Di^* \leq 0$} and Y_i = {Y*, if Y_i> 0 and Di*> 0; 0, if otherwise}

D_i^* - latent variable that makes the value 1, if the farmer adopt poultry technologies; 0 otherwise.

Z_i– Vector of household characteristics explaining adoption decision

X_i- Vector explaining the level of adoption and U_i and V_i– Stochastic terms.

The total flock sold and survivability rate of chicks to weaning stage were used to determine the intensity of adoption of IIC and fabricated chick's brooders, respectively in the second hurdle of Craggs model.

The log likelihood function for the double-hurdle model is represented by equation below.

$$LogL = \sum_{/0} ln\left[1 - \Phi(\alpha Z_i')\left(\frac{\beta X_i'}{\sigma}\right)\right] + \sum_{/+} ln\left[\Phi(\alpha Z_i')\frac{1}{\sigma}\varphi\left(\frac{Y_i - \beta X_i'}{\sigma}\right)\right] \quad \ldots.. (5)$$

Where Σ/0 = summation over the zero observations; Σ/+ stands for summation over positive observations; and Φ and φ are the standard normal cumulative distribution functions and probability distribution functions respectively.

The study further carried out a regression using the Tobit model to compare Likelihood Ratio tests (LR) with results from combination of Probit and truncated estimates. This was done in order to determine whether these two regressions were statistically significantly different from each other. Further this was done to confirm which model was superior on adoption decision. Cragg's assumption of independence between error terms V_i and U_i which entails combination of probit model and truncated model was considered.

The Tobit model was represented as; $\lambda = \frac{\beta}{\sigma}$ *and X=Z ……………….. (6)*

According to Greene (2000), the Likelihood Ratio statistic is computed using the following expression;

$$\Gamma = -2[lnL_T - (lnL_p + lnL_{TR}] \sim \chi^2_k \quad \text{.. (7)}$$

Where L_T – Tobit model likelihood; L_P – Probit model likelihood; L_{TR}- Truncated Model likelihood; k – independent variables.

Table 3. 2: Summary of independent variable used in double- hurdle model

Variable	Code	Type	Measurement
Adoption decision	D	Dummy	Yes = 1, No = 0
Age of the Household Head	AGE	Continuous	Years
Sex of the Household head	SEX	Dummy	Male = 0, Female = 1
Years of schooling	EDUC	Continuous	Number of years in school
Farm size	FARMSIZ	Continuous	Acres
Social group membership	SOCGRP	Dummy	Yes = 1 , No = 0
Type of social group	TYPESOC	Dummy	Main activities
Source of information on IC	INFSOU	Continuous	Number
Training on poultry production	TRAINPOUT	Dummy	Yes = 1, No = 0
Number of times trained	NOTRAIN	Continuous	Number
Distance to training center	DISTTRAIN	Continuous	Kilometers
Access to credit	ACCECRED	Dummy	Yes = 1, No = 0
Other off-farm activities	OFFFRMACT	Dummy	Yes = 1, No = 0

Source: Survey, (2015)

3.6.2 Determining the impact of improved indigenous chicken on egg production

The study adopted the approach used by Rosenbaum & Rubin, (1983) assessment on impacts aims at comparing performance from the households that adopt the technologies with counterfactual. Therefore, Propensity Score Matching (PSM) was estimated through use of STATA version 13. Equation expressed as;

$$P(X) \stackrel{\text{def}}{=} \Pr(T = \frac{1}{X} = X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

Also simplified as;

$$P(X) = Pr\ (T=1/X) = E\ (T/X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (9)$$

Where; P= propensity score; Pr = the probability

T= Binary treatment showing the indicator of exposure to treatment where if adoption (T=1, otherwise, T=0);

X= Background variable such as age, farm size, group membership

E = Expected outcomes

Average treatments effects were computed for the adopters and non-adopters and included: the Average Treatment Effect on the Treated (ATT), Average Treatment effect on the Untreated (ATU) and Average Treatment Effect (ATE). The average treatment effect was expressed as;

$$ATE = E\ (Y_1\text{-}Y_0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (10)$$

Where, the subscripts 1 and 0 denote adopters and non-adopters, respectively.

Becker & Caliendo, (2007) identified that matching technique using propensity score has gained popularity in estimation of average treatment effect. Mendola (2007) asserts that while estimating impact of adopting a given technology, its remains appropriate to use Logit model to derive at propensity scores. However, PSM depends on two assumptions; conditional independence and common support. Conditional independence assumption allowed the researcher to observe all the variables influencing adoption of improved indigenous chicken. Thus, the value of outcome variable remains independent on receiving the treatment. Wooldgridge, (2002) asserts that conditional independence assumption is based on decision to adopt a technology and it's random, conditional on observed variables. This can be expressed as;

$$E\ (Y_0|X,\ T=1) = E\ (Y_0|X,\ T=0) = E\ (Y_0|\ X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (11)$$

Where in this case E $(Y_1|T=1)$ represented the observations of outcome variable for the adopters. Thus, the matching estimation for the study assumed counterfactual analysis by matching the outcome for adopters and non-adopters of the improved indigenous chicken. The conditional independence assumption (CIA) depicted the counterfactual outcome for the treated group is similar to the outcome parameter for the control

On the other hand, the common support assumption (CSA) is considered since the average treatment effect of the treated (ATET) is defined within the region of common support. This assumption on common support assumes that there is no independent variable that can predict the treatment perfectly.

It can be expressed as; $0< P\ (Y=|\ X) <1$ ………………………………………… (12)

Where P is the i^{th} farmer propensity score estimate to adopt the technology

Therefore based on the two assumptions above; CIA and CSA, ATT was computed as follows;

$$ATT= E\ (Y_1\text{-}Y_0|X, T=1) =E\ (Y_1|\ X, T=1) - E\ (Y_0|X=1) \text{………….. …… (13)}$$

Where; Y_1- is the treated outcome (number of eggs/hen/year) and Y_0 is the untreated outcome (for the non-adopters). T indicates the treatment status where if the respondent received treatment = 1 and 0 otherwise.

3.6.3 Determining the profitability of the improved indigenous chicken

Gross Margin Analysis was used to carry out computations on profits between the adopters and non-adopters. It was determined by the following calculation;

Total Cost (TC) = TFC + TVC ………………………………………. (14)

TR = Total sales from(IC + Eggs)…………………………………… (15)

Gross Margin (GM) = Total Revenue (TR) – Total Variable Cost (TVC)… (16)

Profit (π) = Gross Margin (GM) – Total Fixed Cost (TFC) ……………… (17)

The total variable costs used to compute the margins included: cost of day old chicks, feed cost, labor cost, fuel cost, and medication and vaccination costs. Total revenue was derived from sale of indigenous chicken and eggs.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the findings of the study. The general objective of the study was to analyze adoption and impacts of improved poultry production technologies among smallholder farmers in Makueni and Kakamega Counties, Kenya. Consequently the researcher obtained a total of 240 households from Kakamega County. This sample size was made of 70 households from Shinyalu, 83 households from Lugari and 87 households from Lurambi. On the other hand the study covered a total of 144 households from Makueni County. This sample comprised of 100 households from Makueni District and 44 households from Kaiti District. Consequently a total sample of 384 households from Kakamega and Makueni Counties was used for this study. Moreover the results are discussed based on the objectives of the research.

4.1 Socioeconomic characteristics of the sampled households

The descriptive results of the socioeconomic characteristics in the sampled households are shown in Table 3. The table constitutes of the variable, mean of the variable, standard error and t-test.

Table 4. 1: Summary of characteristics of the sampled households in Kakamega and Makueni Counties

Variable	Kakamega (N=240)		Makueni (N=144)		
	Mean	Std.Err	Mean	Std.Err	T-test
Age of Household Head (Years)	48.09	0.706	46.37	0.974	1.457
Flock size (No. of birds/household)	90.84	6.225	66.22	4.859	2.774**
No. of times trained	3.54	0.096	1.8	0.143	10.49***
Distance to training (Kms)	2.075	0.064	1.77	0.136	2.276**

Source: Survey Data (2015); N=384

The mean age of the farmers in Kakamega and Makueni was approximately 48 and 46 years, respectively. This may suggest that the household heads ages for the two groups were fairly in their active years. The mean age difference between the farmers in the two counties was insignificant. The average household flock size was 91 and 66 birds for Kakamega and Makueni respectively (Table 4.1). The total flock size included all the categories of chicken (chicks, growers, hens and cocks). Results revealed that the sampled households in Kakamega had higher flock size compared to farmers in Makueni. The mean difference was found to be statistically significant at 5% (Table 4.1).

Table 4.2 presents findings on difference of dummy variables in the sampled households. The Pearsons Chi-Square test used to test the differences between the two counties.

Table 4.2: Dummy variables in the sampled households in Kakamega and Makueni Counties

Variable	Dummy	Kakamega (N=240)	Makueni (N=144)	*Pearson chi2(1)*
Gender of Hhead(Male)	Yes	70%	77.08%	*2.27*
	No	30%	22.92%	
Group Membership	Yes	95%	61.11%	*70.93****
	No	5%	38.89%	
Training on Poultry	Yes	97.08%	33.33%	*67.85****
	No	0.03%	66.67%	
Access to credit	Yes	37.92%	20.83%	*12.17****
	No	62.08%	79.17%	
Other off-farm activities	Yes	50.83%	36.81%	*7.14**
	No	49.17%	63.19%	
Awareness of IIC	Yes	97.5%	94.44%	*2.39*
	No	2.5%	5.56%	

Source: Survey Data (2015); N=384

Results in table 4.2 showed that there were more male headed households as compared to female headed in both counties. The households are mainly headed by male and this is 70% and 77% of all those households that were sampled in

Kakamega and Makueni, respectively. However, the variable was insignificant between the two counties.

Majority (78%) of the total sampled households participated in a social group. However, participation in group membership in Kakamega was higher compared to Makueni county with 95% and 61%, respectively. The membership in different farmers associations between the two counties was found to be statistically significant at 1% level (Table 4.2). Most of the households participated in farmers groups and common interest groups. The main activities carried out by the groups included IC production and marketing. This indicated that farmers were more nourished with information regarding improved poultry production technologies.

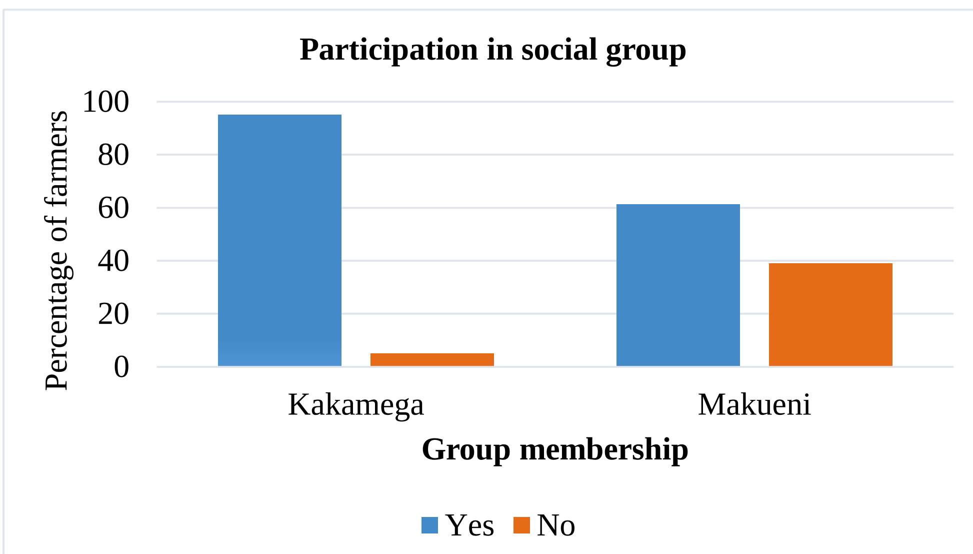

Figure 2 : Participation in a social group

Figure 3 shows that majority (82%) of the households had been trained on indigenous chicken production for the last one year in both counties. Kakamega County had 97% of the households that had received training on poultry production while Makueni had 67% of the households (Table 4.2). Results revealed that Kakamega had a relatively higher percentage of household's heads that had been trained on poultry production. The main source of information regarding IC production was the extension officers.

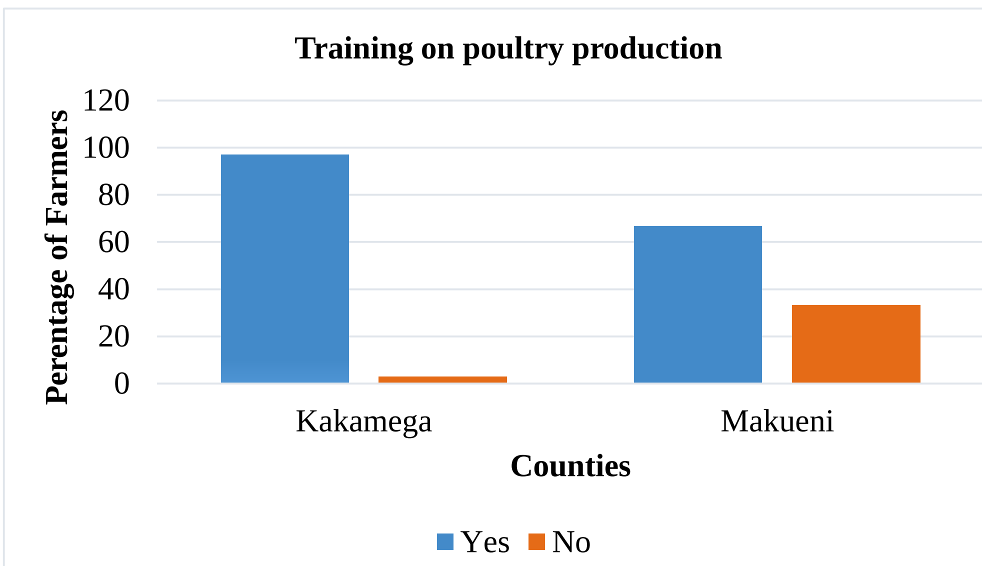

Figure 3: Training on poultry production

The average number of times that farmers in Kakamega had been trained was four times in the last one year (Table 4.2). On the other hand, farmers in Makueni County had been trained twice in the last one year. This revealed that access to training on poultry production among smallholder farmers in Kakamega was higher compared to Makueni County. This may have enabled them to access more information on IC production and marketing. Despite the significant difference on number of times farmers got trained on poultry production, results also revealed that farmers in Kakamega would walk longer distances to the training point compared to farmers in Makueni. The mean distance to the training point was approximately 2.08 and 1.77 kilometers for Kakamega and Makueni counties, respectively. The difference was statistically significant at 5% level (Table 4.2).

Figure 4 reveals the percentages of households that had access to credit in both counties. Results show that 38% and 21% of the sampled households in Kakamega and Makueni respectively had accessed credit in the previous year in order to facilitate IC production. Makueni had a relatively lower percentage of the households that had access to credit compared to Kakamega County. The overall mean on access to credit was 29% of the total sampled households. The difference in access to credit between the two counties was highly statistically significant at 1% level (Table 4.2). Credit was accessed from the various microfinance institutions located within the areas of study such as; LUFAD, Kenya Women Fund Trust, KARDEP, Equity Bank and Faulu Kenya.

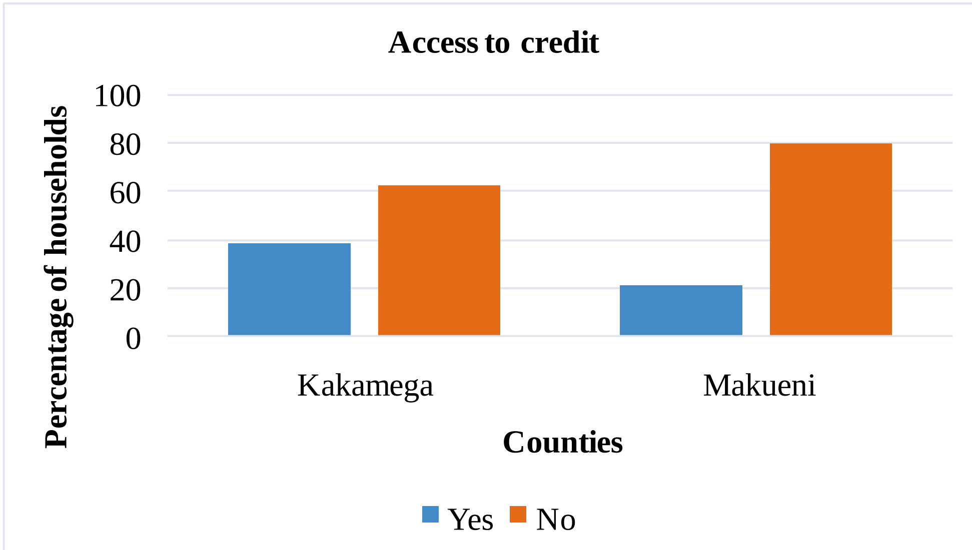

Figure 4: Access to credit in Kakamega and Makueni

Figure 5 showed that 51% and 37% of the sampled households in Kakamega and Makueni counties respectively had other off-farm income generation activities. The overall mean for both counties was 44%. Makueni County had a relatively higher percentage of sampled households (63%) that were not involved in other off-farm income generating activities. The various activities were; formal employment, wages and salaries and a business ownership. These activities generated an overall average of Ksh. 16,257 per month for the households with other off-farm activities for both counties. However, the mean difference on participation in other off-farm-activities between the two counties was significant at 10% statistical level (Table 4.2).

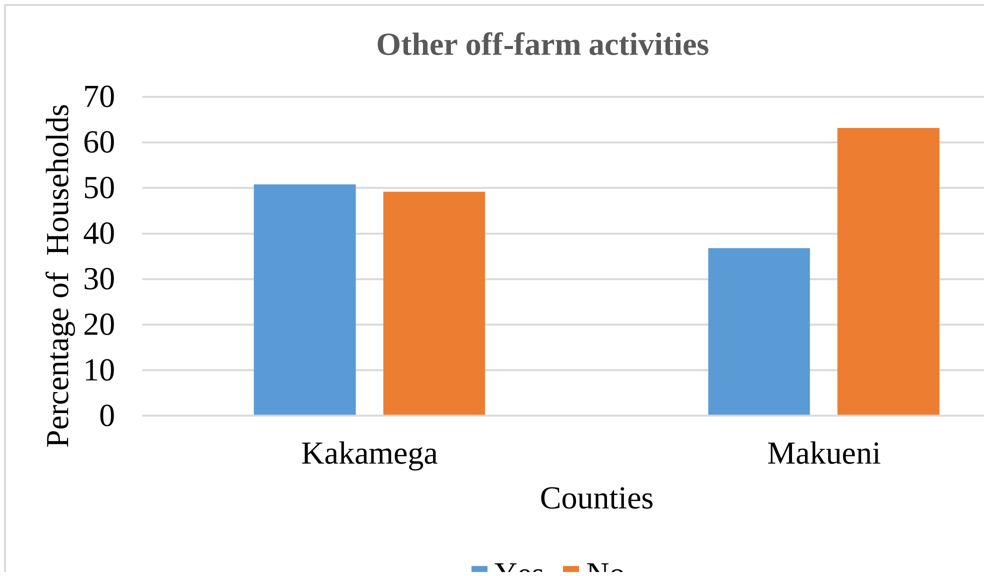

Figure 5 : Participation in other off-farm activities

Results in Table 4.2 also revealed that majority (98% and 94 %) of the sampled farmers in Kakamega and Makueni respectively were aware of the improved indigenous chicken technology. Therefore, farmers in both counties were likely to be knowledgeable and equipped with skills on IIC production. However, the difference in proportions between the farmers in the two counties was statistically insignificant (Table 4.2).

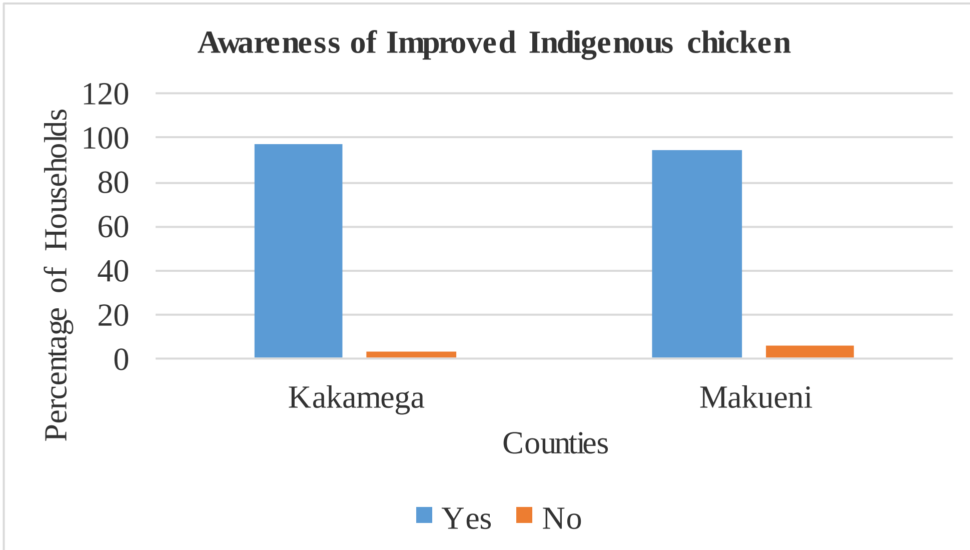

Figure 6: Awareness of improved indigenous chicken

Table 5 show the level of education, household size and farm size of the sampled households in both Kakamega and Makueni counties. Fisher's Exact test was used.

Table 4. 3: Percentages of the categorical variables of the sampled households

Categorical Variables	Unit of measure	Kakamega (N=240)	Makueni (N=144)	*Fisher's Exact*
Education of Household head	Never gone to school	2.5%	0.69%	*0.000****
	Primary	22.08%	28.47%	
	Secondary	40.41%	55.56%	
	Tertiary	30.42%	11.11%	
	University	4.58%	4.17%	
Household size	< 3	2.92%	6.25%	*0.000****
	3—5	31.25%	51.39%	
	6—8	46.67%	31.25%	
	9—11	15%	9.03%	
	> 11	3.75%	2.08%	
Farm Size	< 1 acre	22.92%	0	*0.000****
	1- 3 Acres	58.75%	37.5%	
	4- 6 Acres	14.58%	32.64%	
	> 6 Acres	3.75%	29.86%	

Source: Field Survey (2015) N= 384

Results also revealed that 40% of the farmers had attained secondary education in Kakamega (Table 4.3). Out of the 240 sampled households, 22.08%, 30.42% and 4.5% had attained primary, tertiary and university education respectively (Table 4.3). However, 2.5% of the sampled household head had never gone to school. On the other hand, majority (55.56%) of the farmers in Makueni had attained secondary school education.

Out of the 144 sampled households, 28.47%, 11.11% and 4.1% had attained primary, tertiary and university education respectively. Only 0.69% of the sampled households in Makueni had never gone to school. This revealed that majority of the household heads had accessed formal education. However, there was a mean difference on education level between the two counties. There was a depiction that farmers in Kakamega had attained higher level of education as compared to the farmers in Makueni County (Table 4.3). Caswell *et al.,* (2001) postulated that education develops a positive mental attitude towards accepting new agricultural technologies.

The average household size of the respondents in Kakamega County was seven members. On the other hand, the mean household size in the sampled households for Makueni County was four members as shown in Table 4.3. The difference in means between farmer's family size in Kakamega and Makueni was found significant at 1% level (Table 4.3). This is an indicator that Kakamega County had a higher household size as compared to Makueni County.

The average farm size owned by the sampled households ranged between 1-3 acres for Kakamega whereas in Makueni it ranged between 4-6 acres. There was a significant difference in farm sizes at 1% level between farmers in Kakamega and Makueni counties. As shown in Table 4.3, farmers in Makueni had bigger size of land compared to Kakamega. It is worth noting that most of the smallholder farmers in Kakamega owned small sizes of land which ranged from less than one acre to 3 acres. On the other hand in Makueni, majority (62%) of the sampled households had more than 4 acres.

4.2 Production Systems of the Indigenous Chicken in Makueni and Kakamega

The production systems used by the smallholder farmers in the sampled households are as shown in Figure 7. The systems considered for this study include: extensive system, semi-intensive system and intensive system.

Figure 7 shows that majority of the households (59.64%) used the semi-intensive system in managing their IC. These households provided supplements for their IC and confined their flocks within structures. King'ori *et al.,* (2007) have characterized this system with low to medium level of input for supplementation and later birds are left to scavenge on insects, earthworms and feed on grass among other available feed resources.

Figure 7 show that, 31% of the households across the two counties used extensive system where the IC scavenged with limited prospects of supplementation. However, only 9.4% of the households practiced intensive system in managing their indigenous chicken flock. Most of the households in Kakamega (42.97%) practised semi-intensive system in contrast to Makueni where a higher percentage of the households used extensive system (18.75%). There was no huge deviation between them and those who used semi-intensive system (16.67%) in the same county.

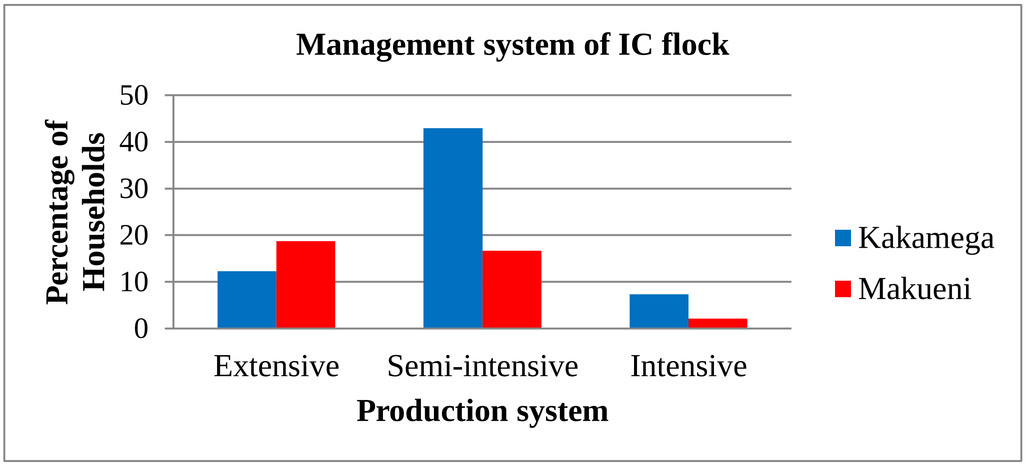

Figure 7: Production system of the indigenous chicken

Table 4.4 presents the percentages of households that practiced various management practices in Makueni and Kakamega counties. The management practices include: feed formulation and supplementation, housing management and disease control.

Table 4. 4: Management practices on IC production in Makueni and Kakamega

Practice	Unit	Kakamega (N=240)	Makueni (N=144)	Pearson Chi2(1)	Pr
Feed Supplementation	Yes	81.67%	81.94%	0.0047	0.946
	No	18.33%	18.06%		
Housing Management	Yes	96.25%	77.78%	32.201	0.000***
	No	3.75%	22.22%		
Disease Control	Yes	98.33%	98.61%	0.832	0.832
	No	1.67%	1.39%		

Source: Field Survey (2015) N=384

On-farm feed formulation and supplementation as shown in Table 4.4 was practiced by majority (81.77%) of the sampled households. Maize grains, sorghum, sunflower cakes, kitchen wastes and commercial feeds were used for supplementation. These practices of supplementation were carried out twice a day (morning and evening). The frequency of feeding was in line with Meseret, (2010) and Addisu *et al.*,(2013) whose results revealed that majority of the sampled households in Ethiopia supplemented their chicken twice a day and left to scavenge.

Farmers aimed at supplementing their flock to improve on performance and health of their indigenous chicken by provision of required nutrients including vitamins and minerals. Further, these farmers aimed to increase the growth rate of the birds in order to meet the market size requirements and to support egg production. However, the above findings on percentage of households supplementing their IC was lower compared to the findings by Mapiye and Sibanda (2005), Moreda *et al.*, 2013 and Moges *et al.*, (2010),who reported a value of 96.8%, 96.3% and 96.3% respectively among the smallholder chicken farmers in Ethiopia.

As shown in Table 4.4, majority (89.32%) of the farmers practised some form of management of their indigenous chicken houses. They frequently cleaned and disinfected the houses before introducing a new stock. It was apparent that majority of the sampled households provided decent housing for the birds' confinement thus reducing prospects of predation. The finding on the proportion of farmers contradicts those of Tarwireyi and Fanadzo, (2013) where only 34% of the sampled households had put up structures for their IC in Kwa Zulu-Natal, South Africa.

The results in table 4.4 reveal that majority (98.44%) of the sampled households practiced disease control for their flock. The most common diseases reported were; New Castle Disease (NCD), Gumboro, Fowl Typhoid, Fowl pox and Coccidiosis, with NCD being the most devastating for the majority (99%) of the farmers.

The various findings showed the aforementioned diseases were economically important and prevalent in affecting indigenous chicken despite their ability to resist diseases (Kaundia and Kitalyi, 2002; Ssewannyana *et al.*, 2008; Olwande *et al.*, 2010 and Addisu *et al.*, 2013). Thus, protecting the IC against these diseases remained crucial among the resource poor farmers as they aimed at commercializing and improving food and nutrition through increased productivity.

4.3 Percentage of adopters of improved poultry production technologies among smallholder farmers in Kakamega and Makueni counties.

Table 4.5 presents the percentage of adopters of improved poultry production technologies in the total sampled households in Makueni and Kakamega counties. They include; improved indigenous chicken and fabricated chick brooders.

Table 4. 5: Percentage of households that had adopted improved poultry production technologies in both Makueni and Kakamega Counties

Technology	Mean	Std. Deviation	Min	Max
Improved Indigenous chicken	0.6016	0.4902	0	1
Chick brooders	0.6615	0.4738	0	1

Source: Field Survey (2015) N= 384

The results of the survey reveal that approximately 60% of the sampled households had adopted the Improved Indigenous Chicken (IIC) and 66% used brooders in management of their flock as shown in Table 4.5.

4.4 Factors influencing adoption decision of Improved Indigenous Chicken (IIC)

The results in table 4.6 show the factors that influenced the decision of smallholder farmers to adopt improved indigenous chicken. Gender of household head, size of the farm, group membership, awareness of IIC, other off-farm activities and distance to the training point had a significant effect on adoption of IIC (Table 4.6).

Table 4. 6: Probit model on Adoption of the improved indigenous chicken

Variable	Marginal Effect $\partial y/\partial x$	Robust Std. Err.	Z	P>|z|
Age of the respondent	-0.0019	0.0022	-0.86	0.387
Gender of Household head	-0.1114	0.0491	-2.27	0.023**
Level of education	0.0315	0.0282	1.12	0.263
Household size	-0.0009	0.0275	-0.03	0.974
Size of the farm	0.0540	0.0278	1.94	0.052*
Social group	0.1776	0.0773	2.3	0.022**
Type of social group	0.0209	0.0144	1.45	0.147
Source of information on IC	0.0018	0.0046	0.38	0.702
Training on poultry production	0.0150	0.1110	0.13	0.893
Number of times trained	0.0080	0.0177	0.45	0.652
Distance to the training centre	0.0688	0.0235	2.93	0.003***
Access to credit	0.0736	0.0511	1.44	0.15
Other off-farm activities	0.0815	0.0473	1.72	0.085*
Awareness of IIC	0.2936	0.1513	1.94	0.052*

*Source: Own computation *** significant at 1%, ** significant at 5%, * significant at 10%; N=384*

The results in table 4.6 indicate that the gender of the household head had a negative effect on probability of adopting the improved indigenous chicken. It was statistically significant at 5% (p=<0.050) level of significance. The coefficient implied that if the gender of the household was male, then the probability of making decision on adoption would decrease by 11.14 per cent while holding other variables constant. This may imply that rearing of IC is more perceived to be an activity for women. Therefore these women were more willing to embrace improved poultry production breeds. However, the variable does not cross to the second hurdle, thus insignificant. The findings contradict those of Beshir, (2014) where gender of the household head was significant and had a positive relationship on intensity of use of improved forages in Ethiopia.

Farm size had a positive significant effect on decision to adopt IIC as shown in Table 6. It was statistically significant at 10% level. The results on marginal effect indicate that if the land size increased by one unit (acre), the probability of adoption decision increased by 5.18 per cent while holding other variables constant. Farmers tend to apportion a relatively higher share of the land size in favour of the IIC. Moreover, adoption of IIC does not require huge capital to invest in and thereby serves as an incentive to allocate more resources on it. The results concurred with those of Akudugu *et al.,* (2012) where farm size had a positive significance effect on adoption of modern agricultural production technologies by farm households in Ghana. The results also concur with results by Challa & Tilahun, (2014) where farm size had a positive effect on determinants and impacts of modern agricultural technology adoption in West Wollega, Ethiopia. However, it contradict with results by Beshir (2014) where farm size had a negative influence on the decision to adopt improved forages in North East Highlands of Ethiopia though significant at 5% level of significance.

The results shown in Table 4.6 indicate that group membership of the farmer had a positive effect on decision to adopt IIC. It was statistically significant at 5% (p=<0.050) level of significance. The marginal effect indicated that participating in a social group increased the probability of adoption decision by 17.76 per cent while holding other variables constant. This may imply that farmers who participated in a social group were able to access and share information on IIC production, access market information and participate in collective action. The results of this study are consistent with those of Mal *et al.*, (2012) which showed that membership in a club/society positively influenced the decision on adoption of Bt Cotton in North Indian state.

On the other hand, other off farm activities passed the first hurdle and positively affected the decision to adopt as shown in Table 4.6. This factor was statistically significant at 10% level of significance. This suggests that farmers who had adopted the IIC were endowed with additional sources of income from the non-farm activities and were able to purchase the IIC. The coefficient implied that while holding other variables constant, the probability of making the decision to adopt the IIC increased by 8.15 percent. Therefore, off farm incomes had a strong positive role on the decision of the household adopting the technologies. This finding was consistent with the results of Beshir (2012) that revealed that the availability of off-farm income had a positive significant effect on adoption. The results contrast with findings of Akudugu *et al.* (2012) which indicated that off farm activities negatively affected adoption decision of modern agricultural production technologies by farm households in Ghana.

The awareness of improved indigenous chicken (IIC) had a positive significant effect on the decision to adopt IIC. It was significant at 10% level of significance as shown in Table 4.6. The coefficient implied that by holding other variables constant, the probability of making the decision to adopt the IIC increased by 29.36 per cent. This may imply that farmers who have heard or read on IIC are more likely to adopt IIC or other new agricultural technologies compared to those who have not. Farmers accessed education on IIC through trainings by the extension officers and service providers among other stakeholders. Hence, awareness on IIC has positive impact on the probability to adopt IIC. The results of this study are consistent with those of Tambo and Abdoulaye (2011) who found that climate change awareness was significant and positively influenced adoption decision of drought tolerant maize (DTM) in rural Nigeria.

Distance to the training centre was positively and significantly associated with the decision to adopt the IIC as shown in Table 4.6. It was statistically significant at 1% (p=<0.001) level of significance. The marginal effect indicated that by holding other variables constant, as the distance from the farmer's residence to the training centre increased by one unit (kilometer), the probability of the farmer to adopt IIC increased by 6.95 per cent while holding other variables constant. This may be justified by the eagerness among farmers who travel for longer distance seeking for information on the new improved IIC based on the embedded benefits. However, these findings contradict those of Asfaw *et al.*, (2011) whose differences in distance while in attempt to access extension services was found insignificant between the treated and the control group in Ethiopia. Additionally, Gebremichael and Gebremedhin, (2014) results showed insignificant differences in distance to farmers training center between the adopters and non-adopters of improved box hive technology in Ahferom district, Northern Ethiopia.

The results of the intensity of use of IIC are presented in Table 4.7. These are the factors that influence the intensity of use of IIC. There were four independent variables that were found significant to influence the intensity of adoption of improved indigenous chicken. These included; age of household head, flock size, group membership and number of times trained on poultry production.

Table 4. 7: Intensity of use of Improved Indigenous Chicken among smallholder farmers

Variable	Coef.	Std. Err.	z	P>z
Age of the Household Head	-0.0221	0.008	-2.84	0.004**
Gender of Household head	-0.0712	0.180	-0.4	0.692
Level of education	0.1471	0.092	1.6	0.111
Household size	0.0948	0.094	1.01	0.315
Size of the farm	-0.0518	0.093	-0.56	0.577
Flock size	0.0045	0.001	5.43	0.000***
Social group membership	0.7879	0.347	2.27	0.023**
Source of information on IC	0.0139	0.017	0.82	0.410
Training on poultry production	-0.0769	0.437	-0.18	0.860
Number of times trained	0.1070	0.060	1.78	0.074*
Distance to the training centre	-0.1084	0.074	-1.47	0.142
Access to credit	0.1331	0.165	0.81	0.420
Other off farm activities	0.2563	0.159	1.62	0.106
Awareness on IIC	-0.1610	0.793	-0.2	0.839
_cons	3.2400	0.948	3.42	0.001
/sigma	1.078	0.0525	20.54	0

Source: Own computation *** significant at 1%, ** significant at 5%, * significant at 10%; N=384

Age of the household head had a negative significant effect on intensity of use of improved IIC. The coefficient implied that if age of household head was increased by one unit (year), intensity of use reduced by 2.21 percent. This was significant at 5% statistical levels (Table 4.7). The result supports the expected hypothesis on risk aversion behavior of old aged farmers due risks and uncertainties related to production and marketing. Old farmers are found to have accumulated experience about new agricultural innovations and therefore hesitate in their use. The findings concur to those Gebremichael and Gebremedhin, (2014) in their study on adoption of improved box hive technology in Northern Ethiopia. However, the finding contradicts those of Darko, (2015) where age revealed a positive significant effect on intensity of adoption of cocoa research innovations in Ghana.

Flock size was found to have a highly significant effect on intensity of adoption of IIC. The coefficient implied that if a farmer increased his/her flock by one unit, intensity of adoption increased by 0.45 percent, while holding other variables constant (Table 4.7). The positive trend is a depiction that most of the farmers had embraced the idea of commercialization of indigenous chicken which remained the main purpose of adopting IIC. Akpan *et al.,* (2012) on their study on fertilizer adoption and optimum use among farmers in Nigeria asserts the importance of increasing the poultry flock size. However, their result on effect of poultry birds on intensity of use of fertilizer contradicts the findings of this study.

Participation in social group had a positive significant effect at 5% statistical level. Being a member in a farmer group increased intensity of adoption by 78.78 percent. In such associations, farmers would be taught on poultry production and would discuss pertinent issues bordering on the enterprise. The issue may include; improved poultry breeds, cost of production, market availability among others, poultry related policies. Therefore, collective action on production and marketing group membership remained an avenue of sourcing key information. This finding is in line with those of Martey *et al.,* (2014) on fertilizer use intensity among smallholder farmers in in Northern Ghana. Further, Olwande (2010) asserts that farmers association improves information access which remains crucial in making decisions on production and marketing.

Results also revealed that the number of times trained on poultry production had a positive influence on intensity of adoption of IIC. Attendance to the training boosted intensity of adoption of IIC by 10.7 per cent while holding other variables at *ceteris paribus.* This is a depiction that extension services improved intensity of adoption of IIIC and access to information remained crucial among IC farmers in the study area. It is therefore important that training should be intensified to promote adoption and intensity of improved poultry production technologies. This finding concurs with those of Kuti, (2015) on use intensity of improved maize varieties in Osun state, Nigeria.

4.5 Determinants of Improved Indigenous Chicken Adoption

Table 4.8 illustrates the LR –test results which suggest the rejection of the Tobit model. The test statistic Γ = exceeds the critical value of the χ^2distribution as shown in Table 4.8.

Table 4. 8: T-statistics on double hurdle (Probit + Truncated model) versus Tobit model

	Probit, D	Truncated, Y>0	Tobit, $0 \leq Y \leq 1$
Log likelihood	-219.36	315.24	-337.22
No. of observation	384	211	384
Test statistics: $\Gamma = 484.68 > \chi^2_{0.05,14} = 23.68$			

Probit model likelihood = -219.36; Truncated Model likelihood = 315.24 and Tobit model likelihood = -337.22. Thus, the computation was;

$$\Gamma = -2\ [-337.22 - (-219.36 + 315.24)]$$

$$\Gamma = -2\ [-242.34] = 484.68$$

The above test statistics was $\Gamma = 484.68$ and above the tabulated value [χ_k^2 (14) =23.68] at a 5% level of significance. Thus, the double hurdle fitted the data better in comparison to Tobit Model. This implied that farmer's decision on adoption and the level of adoption of the improved indigenous chicken were made at two separate stages. The test conforms to the previous studies whose results revealed that decision to adopt and intensity of agricultural technologies was made in two separate stages (Asfaw *et al.,* 2011; Kuti, 2015; Gebremichael and Gebremedhin, 2014; Katengeza *et al.,* 2012; Akpan *et al.,* 2012; Weyessa, 2014).

Table 4. 9: Results on probit model on adoption of brooder technology among farmers.

Brooders	Marginal effect $\partial y/\partial x$	Std. Err.	Z	P>|z|
Age of the respondent	-0.0013	0.0022	-0.58	0.560
Gender of household head	-0.0668	0.0496	-1.35	0.179
Level of education	-0.0285	0.0282	-1.01	0.311
Household size	0.0101	0.0280	0.36	0.718
Size of the farm	-0.0788	0.0262	-3	0.003***
Social group	0.0876	0.0771	1.14	0.256
Type of social group	0.0053	0.0148	0.35	0.723
Source of information on IC	-0.003	0.0044	-0.29	0.773
Training on poultry production	0.1986	0.1050	1.89	0.059*
Number of times trained	0.0028	0.0169	0.16	0.870
Distance to the training centre	0.0027	0.0231	0.12	0.905
Access to credit	0.0646	0.0523	1.23	0.217
Other off- farm activities	0.0034	0.0461	0.07	0.942
Awareness of IIC	0.4466	0.1335	3.35	0.001***

Source: *Own computation ***significant at 1%, **significant at 5%, *significant at 10%; N=384*

Farm size had significant effect with negative sign in decision to adopt brooding technology (Table 4.9). It was statistically significant at 1%(p=<0.001) level of significance The marginal effects indicate that an increase in land size by one unit while holding other variables constant, decreased the probability of adoption decision by 7.88 per cent (Table 4.9). This implied that the subsistence nature of IC farming which might have influenced the decision due to small size farm requirements of the brooding technology in the areas of study. The results for the first hurdle are consistent with findings of Mal *et al.,* (2012) where farm size negatively influenced the decision of adopting Bt Cotton in North Indian farmers. However, the findings contradict those of Katengeza *et al.,* (2012) where farm size positively influenced adoption decision of improved maize variety in drought prone areas of Malawi.

Training on IC production had a positive effect on decision to adopt brooders (Table 4.9). The variable was statistically significant at 10% (p=<0.100) level of significance. The marginal effect showed that a unit increase in training on IC production increased the adoption decision by 19.86 percent (Table 4.9). This is an implication that farmers who access training are most likely to use brooders in rearing their IC. Therefore this will increase productivity and reduce prospects of predation and reduce mothering period. The results are consistent with those of Gebremichael and Gebremedhin (2014) where farmer access to trainings from the extension officers had positive significant effect on adoption of improved box hive technology among smallholder farmers in Northern Ethiopia.

The results in Table 4.9 show that awareness of improved indigenous chicken positively influenced the decision to adopt the brooders at 1% (p=<0.001) probability level. The possible justification was that farmers who have read, heard or educated on improved indigenous chicken are more likely to adopt brooders. Farmers will tend to allocate more resources in order to acquire more brooders hence accommodating more chicks. These findings are consistent with those of Tambo and Abdoluaye (2011) which revealed positive significant effect on adoption of climate change and agricultural technology of drought tolerant maize in rural Nigeria.

The results of the intensity of use of brooders are presented in Table 4.10. These are the factors that influence the intensity of use of brooders.

Table 4. 10: Intensity of use of brooding technology among smallholder farmers sampled households

Variable	**Coef.**	**Std. Err.**	**z**	**P>z**
Age of the Household head	0.000	0.001	-0.100	0.923
Gender of Household head	0.019	0.027	0.710	0.475
Level of education	-0.002	0.015	-0.130	0.897
Household size	0.028	0.015	1.830	0.068*
Size of the farm	0.007	0.016	0.430	0.667
Social group membership	0.105	0.058	1.810	0.070*
Type of social group	-0.004	0.007	-0.560	0.578
Source of information on IC	0.001	0.002	0.580	0.559
Training on poultry production	-0.003	0.072	-0.040	0.971
Number of times trained	-0.011	0.008	-1.280	0.200
Distance to the training centre	0.004	0.012	0.300	0.766
Access to credit	0.085	0.026	3.310	0.001***
Other off farm activities	0.788	0.346	2.270	0.023**
Awareness of IIC	-0.170	0.135	-1.260	0.207
_cons	4.510	0.155	29.060	0.000
/sigma	0.182	0.008	22.540	0.000

*Source: Own computation *** significant at 1%, ** significant at 5%, * significant at 10%; N=384*

Results in Table 4.10 revealed that household size had a positive and significant effect on the intensity of adoption of brooders. It was statistically significant at 10 % level of significance. This implied that an increase in family size by one unit (family member) increased adoption intensity by 2.8 percent. The finding supports the hypothesis that households with more number of members were likely to intensify adoption of brooder technology because of family labor availability. Similar result of the positive effect of household size on use intensity of tissue culture banana adoption in Western Kenya has been reported (Wanyama *et al.,* (2016).

Access to credit had a positive and significant influence on intensity of adoption of brooding technology. The variable was highly significant at 1% level of significance. The coefficient implied that access to credit increased intensity of use of brooding technology by 8.5 percent (Table 4.10). This is a depiction that access to credit enabled farmers in the study area procure brooders with an aim to improve the survivability rate of the chicks. Therefore, assurance of financial support through various institutional arrangements may encourage farmers in this scenario. The finding is consistent with those of Mal *et al.,* (2012) on intensity of adoption of Bt Cotton in North Indian farmers.

The off-farm activity of the household head was positive and significant at 5 percent. This implied that an increase in the number of households with off-farm income leads to an increase by 78.8 percent in brooders adoption intensity.

Farmers engaged in off farm occupation were likely to intensify brooding technology by increasing survivability rate for enhanced production. Alternative sources of income may be more attractive for these poultry farmers; they invest less capital, effort and time in poultry farming. The finding is consistent to those of Beshir *et al.,* (2012) on intensity of use of chemical fertilizer technology in Ethiopia.

Finally, participation in group association (social group) by farmers in the sampled households had a positive significant effect on adoption intensity of brooder. It was significant at 1 percent statistical level. The coefficient implied that involvement of a farmer in association increased intensity of brooders by 10.5 percent while holding other variables constant (Table 4.10). This is a depiction that farmers gathered information and knowledge about brooding technology due to interaction with different sources, clubs or societies. The finding on positive effect of members association on intensity is consistent with those of Ghimire *et al.,* (2015) on adoption intensity of agricultural technology of maize smallholder farmers in Nepal.

Table 11 illustrates the LR –test results which suggest the rejection of the Tobit model. The test statistic Γ = exceeds the critical value of the χ^2distribution (Table 4.11).

Table 4. 11: T-statistics on double hurdle (Probit + Truncated model) versus Tobit model

Brooder	Probit, D	Truncated, Y>0	Tobit, $0 \leq Y \leq 1$
Log likelihood	-214.53	171.77	-320.23
No. of observation	384	254	384
Test statistics: $\Gamma = 725.98 > \chi^2_{0.100,14} = 21.68$			

Probit model likelihood = -214.53; Truncated Model likelihood = 171.77 and Tobit model likelihood = -320.23. Thus, the computation was;

$$\Gamma = -2\ [-320.2285 - (-214.5344 + 171.77)]$$

$$\Gamma = -2\ [-362.99)$$

$$\Gamma = 725.98$$

The above test statistics was Γ = 769.16 and above the tabulated value [χ_k^2 (14) =21.68] at a 5% level of significance. Thus, the double hurdle better fitted the data compared to Tobit Model. The results on the likelihood test ratio test is in line with the previous findings by Mal *et al.*, (2012); Akpan *et al.*, (2012); Tambo and Akpene, (2011); Akudugu *et al.*, (2012); and Beshir, (2014).

4.6 Performance of improved indigenous chicken(IC) and unimproved IC

Results on performance of improved indigenous chicken are presented in Table 12. Parameters used to measure productive performance included; age at onset lay, number of clutches, size of the clutch, hatchability, weaning stage and survivability. The variable on size of clutch was found to be significant.

Table 4. 12: Performance of Improved Indigenous Chicken among the smallholder farmers

Parameters	Treated (IIC)		Control (LIC)		Sig
	Mean	Std. Err.	Mean	Std. Err	
Age at first egg lay(weeks)	21.27	0.43	22.99	0.71	0.4036
Number of clutches (counts)	2.94	0.05	2.82	0.07	0.174
Size of clutch(No. of eggs)	33.51	1.77	18.76	1.00	0.000***
Hatchability (percentage)	78.52	2.19	79.38	1.76	0.7578
Weaning stage (percentage)	79.51	2.33	79.30	2.10	0.9469
Survivability (percentage)	69.86	2.30	67.55	2.19	0.4675

*Source; Survey Data, (2015)(N=384) *** significant at 1%*

The mean age at first egg lay for improved indigenous chicken was 21 weeks while for the local indigenous chicken it was 23 weeks (Table 4.12). The improved IC took shorter period to lay first egg compared to the overall mean of 21.65 weeks for both the ecotypes though the difference was not significant. The results are in line with those of Melesse *et al.,* (2013) who reported that

Fayoumi(improved IC) breed took 154 days for the first egg lay though with some variance with other types of IC breeds. Additionally, Mengesha, (2012) findings on first egg lay of IC ranged between 151 to 167 days.

The pooled average on the number of clutch per chicken in the area of study was 2.87/hen/year. The pooled mean on number of clutches was lower compared to the improved IC (2.94) clutches and higher for local IC (2.82). However, the difference was not statistically significant. Various studies reported that IC had an average of 3 clutches/hen/year (Okeno *et al.,* 2011; Addisu *et al.,*2013; Hagan *et al.,* 2013).

The average size of clutch for improved IC and local indigenous chicken was 34 and 19 eggs, respectively. The results revealed that there was significant difference ($p<=0.05$) in average number of eggs/clutch/hen. This depicts that Improved IC laid more eggs compared to local indigenous chicken per clutch. Therefore this increased egg production/hen/year given the average number of clutches/hen/year. This could be attributed to the genetic potential and the different feeding management used for egg production. Findings on average number of eggs per clutch/hen deviates from various reports by Mellese and Melkamu, (2014) and Addisu *et al.,* (2013) which reavealed an average of 18 and 13eggs/hen/clutch, respectively.

The production performance feature on hatchability was obtained as percentage of the eggs hatched divided by the number of eggs set for each hen. The mean hatchability values for the adopters was approximately 79% and non-adopters 79%, respectively. However, the parameter results among the two groups was not statistically significant. It is worth noting that the pooled mean on hatchability was lower compared to reports by Fisseha *et al.,* (2010) and Hosen, (2010) whose findings revealed 82% and 84%, respectively on hatchability rate. However, findings by Ndegwa *et al.*,(2014), Magothe *et al.*,(2012) and Melesse *et al.*,(2013) reported lower hatchability rate at 69%, 70% and 69.7%, respectively.

As shown in the Table 4.12, 79.4% of the chicks hatched reached the weaning stage (8weeks). The results depict that weaning for the non-adopters was lower (79.30%) compared to the adopters (79.51%) though statistically it was insignificant. The results obtained indicate that 68.65% of the overall number of chicks survived to adulthood categories (more than 8 weeks).

The production performance on survivability was obtained as a percentage by dividing the number of chicks that survived to adulthood by the number of chicks that had been hatched. These results revealed that survivability mean for adopters was 69.68% and for non-adopters at 67.55% (Table 4.12). However the differences were statistically insignificant and may be attributed to the proper controls on diseases, feeding, handling and predation which are as a result of utilizing brooding technologies. Report on pooled mean on survivability rate contradicts findings of Hosen, (2010) who reported a survivability rate of 87%. However, Fisseha *et al.,* (2010) reported a lower survivability rate of 61%.

4.7 Results on impact of improved indigenous chicken on egg productivity among smallholder farmers in Kakamega and Makueni counties.

The results of the analysis of factors that impact on egg productivity of IIC are presented on Table 4.13. There were 5 independent variables that were found to significantly impact on egg productivity.

Table 4. 13: Factors impacting on egg productivity of improved indigenous chicken per hen/year

Variable	Coef.	Std. Err.	Z	P>|z|
Age of the household head	-0.0041	0.0135	-0.3	0.761
Gender of household head	-0.8370	0.3101	-2.7	0.007**
Level of education	0.3040	0.1701	1.79	0.074*
Household size	-0.0187	0.1695	-0.11	0.912
Size of the farm	0.0004	0.1724	0	0.998
Social group	0.9881	0.5134	1.92	0.054**
Type of social group	0.1074	0.0885	1.21	0.225
Source of information on IC	-0.0123	0.0279	-0.44	0.658
Training on poultry production	-0.1158	0.7075	-0.16	0.870
Number of times trained	0.1511	0.1065	1.42	0.156
Distance to the training centre	0.3342	0.1486	2.25	0.024**
Access to credit	0.3068	0.3186	0.96	0.336
Other off-farm activities	0.6141	0.2977	2.06	0.039**
Awareness on IIC	1.1234	0.8308	1.35	0.176

*Source: Own computation (Survey, 2015) ** significant at 5%, * significant at 10%; N=384*

The matching algorithms that were used included; NN (1), NN (5), Caliper and Kernel based matching. Further the likelihood test of goodness of fit and values of Pseudo R^2 for the matched sample were analyzed and found to be significant (Table 4.13). This is a depiction that the Logit model used fitted the regression estimator. Five variables were found significant at various levels of statistical significance. They included; gender of the household head negatively affected the egg production while; level of education, participation in social group, distance to the training point and other off-farm activities affected the egg production positively.

Table 14 presents the results on average treatment effect of the treated (ATT) estimation based on their propensity score using various matching algorithms. These included; Nearest Neighbor Matching, Kernel Based Matching and Caliper Matching Method.

Table 4. 14: Estimating the impact of improved indigenous chicken on egg production/hen/year

Matching Algorithm	Outcome variable	Treated	Control	Diff.	Std.Err.	T-stat
Nearest	ATT	98.06	70.78	**27.29**	9.05	3.01***
Neighbor	ATU	55.29	98.47	43.18		
Matching(1)	ATE			35.59		
Neighbor	ATT	98.06	62.75	**35.31**	6.92	5.10***
Neighbor	ATU	55.29	95.39	40.10		
Matching(5)	ATE			37.81		
Kernel	ATT	98.06	66.17	**31.90**	6.64	4.81***
Based	ATU	55.29	93.76	38.47		
Matching	ATE			35.33		
Caliper	ATT	98.06	70.78	**27.29**	9.05	3.01***
Based	ATU	55.29	98.47	43.18		
Matching	ATE			35.59		

Source: *Own computation (Survey, 2015)*

Table 4.14 showed the ATT estimation on impact of the improved indigenous chicken on the total egg production /hen/year based on propensity scores. The outcome variable was analyzed for the average treatment of the treated, average treatment of the untreated and average treatment/causal effect to determine the impact of egg production on adopting the improved indigenous chicken.

Results revealed that adopting indigenous chicken had a positive impact on egg productivity among the smallholder farmers in Kakamega and Makueni Counties. Adoption of improved indigenous chicken increased eggs production by; 27.29 for Nearest Neighbor (N1), 35.31 for Nearest Neighbor (NN5), 31.90 for Kernel based matching (KBM) and 27.29 for caliper based matching (CBM) where the impact for both groups were significant (Table 4.14). This depict that the results based on the four matching algorithms revealed that the ATT estimate was robust. The overall average gain of the total number of eggs produced ranged from 27.29 to 35.31 which were significant at 95% confidence level for all the matching (Table 4.14). The implication was that assuming there was no selection bias due to unobservable characteristics; eggs production/hen/year for farmers who adopted the improved indigenous chicken was significantly higher than of the non-adopters.

4.8 Balancing Tests for the Propensity Score Matching quality indicators

Results on evaluation of PSM quality indicators are as shown in Table 4.15. Results in Table 15 revealed that Pseudo R^2 was low and depicted that there were no systematic difference in the distribution of the covariates between the treated and the control group. P-value before and after matching shown reduction in biasness.

Table 4. 15: Evaluation of Propensity Score Matching quality indicators

Matching	Pseudo R^2 Unmatched	Pseudo R^2 Matched	P-value Unmatched	P-value Matched	Mean Bias before match	Mean Bias after matching	%bias reduction.
NN1	0.180	0.046	0.000	0.214	35.30	9.30	73.65
NN2	0.180	0.021	0.000	0.878	35.30	6.20	82.43
Kernel	0.180	0.016	0.000	0.961	35.30	6.30	82.15
Caliper	0.180	0.046	0.000	0.214	35.30	9.30	73.65

Source: Own computation (Survey, 2015)

The unmatched P-values were significant levels before matching of biasness which reduced after matching to become insignificant (Table 4.15). The mean biasness reduction after matching ranged 82.15% to 73.65% across the matching algorithms. The mean bias after matching ranged from 9.30 to 6.20.

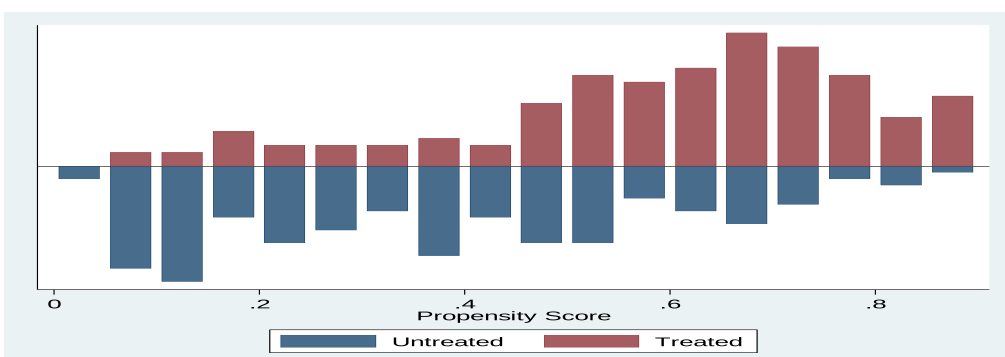

Figure 8: Distribution of propensity scores on region of common support using Caliper matching method (CMM)

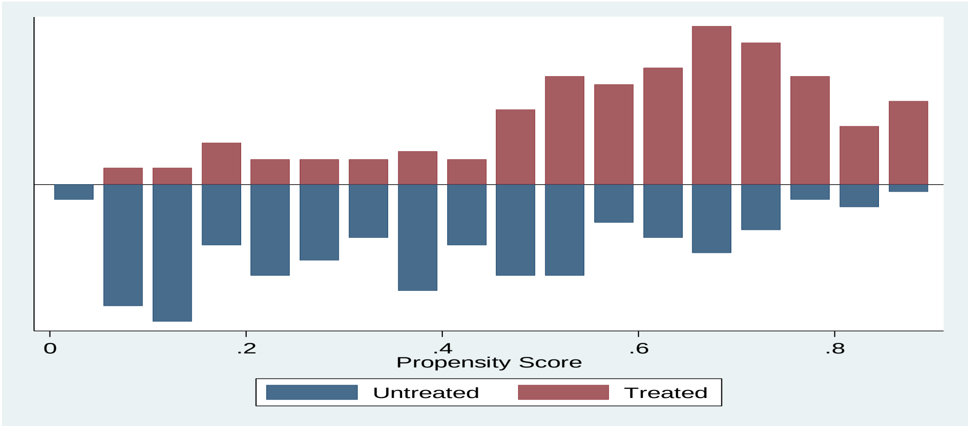

Figure 9: Propensity score on common support using Nearest Neighbor Matching (NNM1)

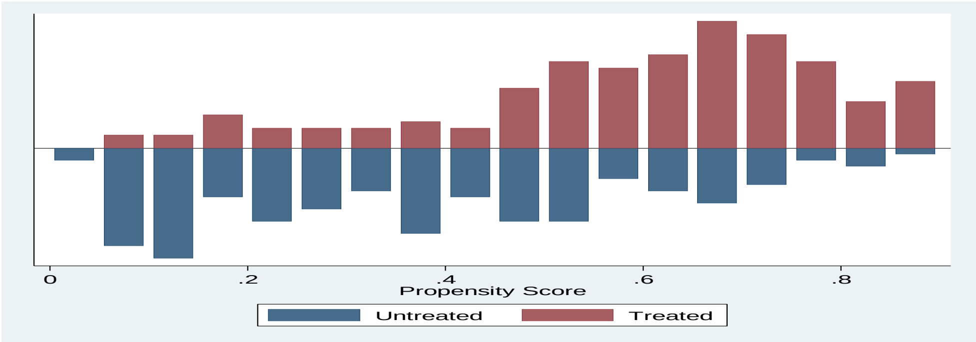

Figure 10: Propensity score on common support using Nearest Neighbor Matching (NN5)

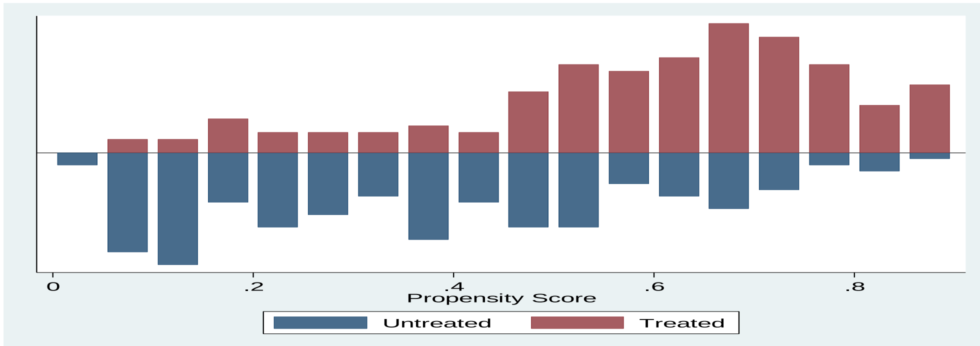

Figure 11: Propensity score on common support using Kernel Based Matching (KBM)

4.9 Sensitivity analysis for Estimated Average Treatment Effects (ATT)

The concept of sensitivity analysis of the study is as shown in Table 4.16. The results in the Table 4.16 revealed that when $\Gamma=1$, the p-value is quite close to the one estimated in the matching analysis. This is a depiction that the p-value holds assuming that there is no hidden bias due to unobserved confounder. Additionally, there were no prospects of outliers on the estimated parameters.

Table 4. 16 : Sensitivity test for Estimated Average Treatment Effects (ATT)

Gamma	sig+	sig-
1	0.000315	0.000315
1.05	0.001112	0.000078
1.1	0.003291	0.000018
1.15	0.008367	4.10E-06
1.2	0.01864	8.70E-07
1.25	0.037015	1.80E-07
1.3	0.066487	3.50E-08
1.35	0.109386	6.60E-09
1.4	0.166659	1.20E-09
1.45	0.237423	2.20E-10
1.5	0.318977	3.80E-11

Source: Own computation, survey data (2015)

Gamma - Represents the log odds of differential assignment due to unobserved factors.

Sig+ - Upper bound significance level

Sig- - Lower bound significance level

t-hat+ - Upper bound Hodges-Lehmann point estimate

t-hat- - Lower bound Hodges-Lehmann point estimate

CI+ - Upper bound confidence interval (a= .95)

CI- - Lower bound confidence interval (a= .95)

As per the results, a small increase of 0.05 in gamma, the p-value increases to 0.001 which is below the usual threshold of 0.05. This suggests that that the odds are only 1.05 higher which might be attributed to different values on an unobserved covariate despite being identical on the matched covariates. However, the inference made would not change.

Hodges point estimate suggests that the median differences in output should have a value of 12 if there is no hidden bias. As shown in the Table 4.16, the gamma level at which insignificant level is noted is at 1.35. This finding is above 1 which is the threshold for sensitivity tests. The implication is that the results are insensitive to possible hidden biases due to unobserved confounders. Hence, the conclusion and interpretation on impact can be made with some level of caution. However, at higher level the results revealed that sensitivity to bias is greatly reduced and conclusions can be made with confidence. Becker and Caliendo, (2007) asserts that sensitivity checks on estimated results remains vital and it's a strong identifying assumption thereby need to justify.

4.10 Results on profitability of the improved indigenous chicken (IIC) and local Indigenous Chicken (LIC)

The results in Table 4.17 show the main components of production costs and gross profit for a flock size of 100 birds for both ecotypes. The major components of production cost included; cost of day old chicks, feed cost, labor cost, fuel cost and medication cost and depreciation cost on housing and equipment.

Table 4. 17: Comparison on profitability of the improved indigenous chicken (IIC) and local Indigenous Chicken (LIC)

Variable	Improved Indigenous Chicken Cost (Kenya shillings)	Local Indigenous Chicken
Day old chick (100 chicks)	10000	10000
Feed cost	31952	27098
Labor cost	7520	3247
Fuel cost	9832	6476
Medication cost	10797	7553
Total variable cost	**70101**	**54374**
Housing cost	18227	17785
Depreciation Housing cost (10%)	1823	1779
Equipment cost	3590	2695
Depreciation Equipment cost (10%)	359	270
Total fixed cost	**23999**	**22529**
Total cost (TFC+TVC)	**94100**	**76903**
Sale of chicken	63839	50098
Sale of eggs	20500	14100
Gross income	**84339**	**64198**
Less: Total Variable Cost	(70101)	(54374)
Gross margin(GI – TVC)	**14238**	**9824**
Less: Total Fixed Cost	**(2182)**	**(2049)**
Net Profit	**12056**	**7775**

Source: Own computation, survey data (2015)

The results in Table 4.17 revealed that the total cost of production was Ksh. 94100 for IIC and Ksh. 76903 for LIC respectively. Variable cost constituted the highest proportion of 74.50% in IIC and 70.70% for LIC of the total cost (Table 4.17).

Feed cost comprised the highest percentage of the total variable cost at 46% and 50% for IIC and LIC respectively as shown in Table 4.17. Majority of the farmers sourced ingredients from the nearby shops and local farm produces such as; grains, sorghum & sunflower and carried out feed formulation both as a group and as at the farm level. The findings concur with those of Ayieko *et al.,* (2014); Siyaya *et al.,* (2013) & Kumar *et al.,* (2013) whose results revealed that feed cost constituted the highest proportion thus resulting to reduce gross profit.

Labor cost for the production of IIC constituted 11% as compared to 6% for the LIC of the total variable cost (Table 4.17). This cost was computed based on man hour's basis. However, findings on labor composition for both enterprises contradicts with those of Menge *et al.,* (2005) whose findings revealed higher proportion of labor cost at an average of 31% of the total variable cost. Additionally, results from the study by Sumy *et al.,* (2010) reported a higher proportion of 24% of the total variable cost on profitability of backyard chicken in Pabna District, Bangladesh.

Medication costs for the IIC was 14% of the total variable cost while that of LIC was also 14% as shown in the Table 4.17. The proportion on medication cost for the study is in line with Ayieko *et al*., (2014) whose findings revealed that cost of medication constituted 15% of the total variable cost on determining the profitability of IC producers in Makueni County constituted 15% of the total variable cost. However, results by Kumar *et al.,* (2013) revealed lower percentage on medication cost which constituted 2% of the total variable costs in production performance of indigenous chicken in Rajshahi, Bangladesh.

The cost of the day old chick constituted 15% of the total variable costs for IIC while that of LIC was 18% for the local indigenous chicken. Fuel cost shows a proportion of 14% for IIC and 12% for LIC of the total variable cost. Sumy *et al.,* (2010) findings reported that cost of day old chick constituted 11% of the total variable cost. The percentage composition on the day old chick contradicts those of Kumar *et al.,* (2013) whose findings was higher at 41% of the TVC in production performance of the indigenous chicken in Bangladesh.

On the other hand, fixed costs comprised of; housing cost, depreciation of the housing (10% of the housing cost), equipment costs and depreciation cost of the equipment (10% of the total cost of equipment). Depreciation costs for equipment constituted the least proportion of the total cost for both ecotypes as shown in the table above. Previous studies revealed lower proportion of depreciation costs for both housing and equipment costs of the total costs. Depreciation costs for both housing and equipment were considered in calculation of the net profit in production of indigenous chicken (Ayieko *et al*., 2014; Kumar *et al*., 2013; Sumy *et al*., 2010)

Venturing in indigenous chicken enterprise was profitable for both ecotypes with gross income of Ksh. 14238 and Ksh. 9824 for IIC and LIC, respectively. However, results revealed that rearing improved indigenous chicken was more profitable compared to the local indigenous chicken. As shown on the table above, the average profit per bird was Ksh. 121 and Ksh. 78 for IIC and LIC, respectively. The differences in net profits may be attributed to smaller flock size and low productivity for the local indigenous chicken farmers. However, various studies revealed that rearing of indigenous chicken was a profitable venture. (Aboki *et al*., 2013; Adomako *et al*., 2010; Ayieko *et al*., 2014; Bwalya and Kalinda, 2014; Kumar *et al*., 2013; Kyule *et al.*, 2014; Hosen, 2010; Siyaya *et al*., 2013 & Sumy *et al*., 2010)

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusion and recommendations based on the results from this study. The policies are based on variables affecting the decision to adopt the IIC technologies, intensity of IIC adoption, impact of IIC on eggs production and their profitability upon commercialization. These recommendations provide an insight on policy interventions by the indigenous chicken production stakeholders.

5.2 Conclusion

Based on the objective, the study analyzed the determinants of adopting IIC technology and the intensity of adopting IIC technology. The results revealed that the decision to adopt IIC technology and the intensity of adopting IIC was significantly influenced by socioeconomic characteristics and infrastructure. The results showed size of farm, participation in social group, distance to training center, off farm activity and awareness of IIC positively and significantly influenced the decision to adopt IIC. However, it is worth noting that gender of the household head had a negative influence on adoption decision on IIC.

On the other hand, the intensity of adopting IIC technology was significantly influenced by; level of education, household size, size of farm, source of information and awareness of IIC technology. The aforementioned variables had a positive influence on use intensity of IIC. The results of the study have shown consistency with those of studies done in determinants of adoption and intensity of technology adoption among the smallholder farmers.

The theoretical and empirical approaches that were adopted by this study produced satisfactory results. These results can be used in understanding the factors that underlie the adoption and the intensity of adopting IIC technologies in the context of smallholder farmers. Moreover the study included, group membership, off farm activities, number of trainings, household size in analysis of adoption and intensity of adoption. Furthermore, the study showed that the adoption and intensity stages are made successively which concurred with finding of previous studies. Thus, the double hurdle fitted the data better in comparison to Tobit Model. This implied that farmer's decision on adoption and the level of adoption of the improved indigenous chicken were made at two separate stages.

The results from analysis in the second objective, revealed the performance of improved indigenous chicken among the smallholder farmers in the area of study. Yield is one of the preferred traits of the technology in influencing its adoption. The study concluded that the impact of the IIC technology on the production of egg was higher compared to the LIC. The socioeconomic characteristics that impacted on the production of eggs by IIC based on the various algorithms included; gender of the household head, level of education, participation in social group, distance to the training point and other off-farm activities.

The results of the profitability analysis showed that investing on indigenous chicken was profitable for both ecotypes. However, rearing IIC proved more profitable with annual gross margins of Ksh. 14238 and Ksh. 9824 per 100 birds for IIC and IC respectively. Majority of the farmers sold their IC at the farm gate and measures to determine on prices per flock was based on general appearance of the bird for majority of the farmers.

5.3 Policy Implications and recommendations

The findings of this study provide policy options to policy makers in terms of promoting IIC technologies adoption and the intensity of adoption. Therefore the policy makers are able to know which socioeconomic factors have a significant influence on the adoption of IIC technology, estimates on impact on yields and commercialization of the indigenous chicken. The policy makers can therefore consider investing on the factors to improve on the current adoption levels of IIC in Kakamega and Makueni counties. Therefore this study has been able to inform on the determinants of the adoption of IIC and the intensity of adoption of IIC technology, impact on eggs production and profitability. Hence the current study had the following recommendations;

1. Researchers should be prioritize improvement of the yield potential of the local and improved indigenous chicken. Policies should target strengthening the IC farmers to have access to information on improved poultry production systems

and technologies. This will help in the acceptance and dissemination of information to smallholder farmers in the rural households.

2. More programs targeting women should be designed and supported by both the national and county government. Poultry production is an enterprise that is more related and associated with women as compared to men.

3. The stakeholders should also prioritize on strengthening farmers network and aim at improving access to markets. This approach will benefit farmers in accessing high valued markets for their poultry products (meat and eggs) which translate to improved profits.

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APPENDICES

Appendix 1: Household Questionnaire

"*We are conducting a farm survey in this area. The survey is investigating the adoption and impact of improved poultry production technologies among smallholder farmers in Kakamega and Makueni counties in order to support policies to improve farmer livelihoods. All information collected is completely confidential.*

Accurate information will improve the quality of any recommendations.

Your time and assistance is greatly valued. Thank you very much"

SECTION A: HOUSEHOLD CHARACTERISTICS

County ……………… Sub county…………………………Location ……………………

Name of the Respondent ……………………………………Mobile No.…………………

1. Gender of the respondent 0 = Male ☐ 1 = Female ☐
2. Age of the respondent ……… years

Name of the Enumerator…………………………………….Mobile No …………………

Date of interview (DD/MM/YY) /_ / _/ 2015

3. Name of the Household Head ……………… (b) Gender 0 = Male ☐ 1 = Female ☐ (*If respondent in above then DONT ASK)*

NB* Head of the Household is the decision maker

4. What is the highest level of education attained by the farmer?

☐ Illiterate ☐ Primary ☐ Secondary ☐ Tertiary ☐ University ☐ others

5. Household size …………

Time taken to complete interview ………………… (Mins)

Starting time ………………………………….. Ending Time ……………………

SECTION B. PART 1. FARM PROFILE

6. a. What is the size of your farm? ……………… (Acres)

b. Which enterprises do you practice in your farm? (*Rank them in order of priority indicating size of land allocated and income for each)*

Activity	Tick	Land allocation	Amount per year	Rank
Sugar cane farming				
Maize farming				
Poultry farming (IC)				
Poultry Farming (Exotic)				
Banana farming				
Dairy rearing				
Bee Keeping				
Other crops (specify)				
…………………………				
Others livestock (specify)				
…………………………….				

7. a. What is the size of your flock in numbers? (***Indicate in the table below***)

7.1 Improved Indigenous Chicken	
7.2 Local Indigenous Chicken	
7.3 Exotic breeds	

b. Indicate the number under the following categories.

Young chicks< 8 wks	Growers 8- 20 weeks	Hens >20 weeks	Cocks > 20 weeks

8. a. Do you participate in a social group? ☐ Yes ☐ No

b. If yes above, what type of group do you belong?
....

☐ Farmers group ☐ Common Interest Group ☐ Women group

☐ Others (specify ……………………………………………………

c. What are the main activities your group is involved in?

☐ IC production ☐ IC marketing ☐ Dairy farming ☐ Fish farming

☐ Bee keeping ☐ Crop farming ☐ others (specify) ……………

9. What is your source of information regarding IC production?

☐ Radio ☐TV☐ Mobile phone. ☐ Extension staff /Research station

☐ Newspaper ☐ Others (Specify)
……………………………………………………

10. a. Have you been trained on poultry production for the last one year? ☐ Yes ☐ No

b. If yes above, how many times have you been trained on IC? ………….

c. What is the distance from your home to the trainingpoint? ....

11. a. Do you access credit services? ☐ Yes ☐ No

b. If yes, where do you get the credit from?(*Specify)* ……………..…………..

c. What is the interest rate charged on credit? ....

12. a. Do you have other off-farm income generating activities? ☐ Yes ☐ No

b. If yes, how much do you generate per month in Ksh? (*please indicate in the table below)*

Activity	**Amount per month**
Formal employment	
Wages	
Business(specify) ……………………..	
Others (specify)	

<u>SECTION B: PART II. INFORMATION ON PRODUCTION TECHNOLOGIES</u>

13. How do you manage your indigenous chicken flock?

☐ Extensive system (Free range) ☐ Semi- confined ☐ Intensive system

14. a. Are you aware of improved indigenous chicken? ☐ Yes ☐ No

b. Have you adopted any of the following IC production technologies? (*tick appropriately*)

Technology		Rank
14.1 Planned feed supplementation		
14.2 Housing management		
14.3 Disease control		
14.4 Biosecurity management		
14.5 Incubators		
14.6 Brooders		

15. a. Have you been trained on feed formulation and supplementation? ☐ Yes ☐ No

b. If yes, which feeds do you use for supplementation?

☐ Commercial feeds ☐ On-farm formulated feed ☐ Any farm produce

☐ Kitchen left-overs ☐ others (specify) ……………………………………….

c. How many times do you give supplement to your chicken per day?

…………………........

d. Which chicken category above (7.b) do you supplement? ………………….

16. a. If yes (14.2), have you been trained on housing structure standards?

Yes ☐ No ☐

b. If yes, do your IC housing facility have ventillation? ☐ Yes ☐ No

c. Do you keep the house clean and disinfect before stocking? ☐ Yes ☐ No

d. How frequent do you clean the housing facility?

☐Regular basis ☐ Before introducing a new stock ☐ Cleans in an ad-hoc manner

☐ Never clean ☐ Others ………………………………………………………………

17. a. Have you been trained on disease control? ☐ Yes ☐ No

b. Do you follow the recommended vaccination schedule? ☐ Yes ☐ No

c. List major diseases in order of priority that you have administered vaccine against?…………………………………………………………………………………

……………

SECTION C. INFORMATION ON PERFOMANCE OF THE INDIGENOUS CHICKEN

18. a. What is the source of your indigenous chicken?

☐ Market ☐ Own stock ☐ Agricultural Institute (KARLO)

☐ Other farmers Others(specify)……….................................

b. When did you stock your current flock?............

c. If you bought the stock from outside, what was the age at the time of buying? ….....

d. How many of your IC are laying eggs? …………..

e. At what age did the IC start laying eggs (weeks) ………..

19. a. How many clutches do your IC lay per year?

☐ One ☐ Two ☐ Three ☐ Four ☐ others(specify)………

b. What is the average number of eggs per clutch? ………

c. What is the average size of your eggs?

☐ Small (<45g) ☐ Medium (45- 50g) ☐ Large (50 – 55g) ☐ Extra Large (> 55g)

20. a. Do you hatch your own chicks? ☐ Yes ☐ No

b. If yes, which method do you use? ☐ Natural ☐ Artificial

c. If natural, how many eggs does each hen hatch at a time?

☐ 1 - 5 ☐ 6 – 10 ☐ 11 – 15 ☐ > 15

d. Which technique do you use?

☐ Synchronized hatching ☐ Each hen hatching own eggs ☐ Others (specify) ………

e. Do you exercise egg selection for hatching purposes? ☐ Yes ☐ No

21. a. Which criterion do you use for egg selection?

☐ Egg size ☐ Age of an egg ☐ Both size & age ☐ No system used

b. How many eggs do you set for hatching and how many do hatch?(*indicate as per the method*)

	Number of eggs set	Number of eggs hatched
Natural (Per hen)		
Artificial		

c. How many of the chicks reached weaning age (About 8wks)? ………………

d. How many chicks survived to adulthood (> 20 weeks) …….

22. a. Which technique do you use for brooding?

☐ Natural/ Mother hen ☐ Hay box brooder ☐ Chepkubi brooder

☐ Charcoal brooder ☐ Others (specify) …………………………

b. Have you experienced problems during brooding in your flock? ☐ Yes ☐ No

c. If yes, what are some of the brooding constraints facing your flock?
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

SECTION D. COMMERCIALIZATION OF THE CHICKEN AND PRODUCTS

23. Do you sell your indigenous chicken? ☐ Yes ☐ No

24. Have you sold IC in the last one year? ☐ Yes ☐ No

25. At what price did you sell your IC in the last one year at the indicated outlet? (*Record prices per class*)

		May	Jun	Jul y	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	April
Year													
Cocks	No.sold												
	Price												
Hen	No.sold												
	Price												
Chicks	No. sold												
	Price												
Growers	No. sold												
	Price												

26 a. How do you sell your IC? ☐ Live ☐ Dressed carcasses

b. Where did you sell your IC? (***Indicate below***)

	Chicks	Growers	Hens	Cocks
Farm gate				
Local market				
Hotel				
Butchery				
Urban Market				
Others(*specify*)				

27. a. Do you have a contract for selling your IC? ☐ Yes ☐ No

b. If yes, do you face any constraints selling your IC? ☐ Yes ☐ No

c. If yes above (27b), please specify

....
....
....

28. a. If dressed, do you usually consider age and weight while selling?

Yes ☐ No ☐

b. If yes (28.a), fill in the table below on category sold *(indicate below)*

	Pullets	Cockerels	Hen	Cocks
Age				
Weight				

29. a. Do you usually sell eggs? ☐ Yes ☐ No

b. If yes, in which form do you sell? ☐ Tray ☐ Per egg

30. Do you grade your eggs when selling? ☐ Yes ☐ No

31. At what price on average did you sell your IC eggs in the last one year? (*Record prices*)

		Mar	April	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Year													
Trays	No.sold												
	Price												
Per unit	No.sold												
	Price												

32. a. Do you sell the chicken manure? ☐ Yes ☐ No

b. If yes, how do you sell the manure?

☐ Kilograms ☐ Standard sacks ☐ Wheelbarrows ☐ Donkey cart load

☐ Pick-up load ☐ Lorry load ☐ Others (specify) ………..

c. How much manure did you sell in the last one year? ……….

d. How much money did you got on selling IC manure in the last one year? ………….

SECTION E : COSTS OF INVESTMENT ON INDIGENOUS CHICKEN

33. What are the costs that you have incurred while producing your Indigenous Chicken? (please indicate below)

Production & Marketing Costs			
Type of cost	**Quantity**	**Ksh.**	**Total**
Housing costs - Construction materials			
Labour cost			
Repair and maintainence			
Feeders & drinkers			
Day old chicks / Eggs			
Brooding (Fuel cost) - Electricity			
Charcoal/ firewood			
Paraffin			
Transportation of the Day old Chicks			
Feeds cost (Supplements & Transport)			
Vaccination & Treatment cost			
Service providers fee			
Costs of vaccines & drugs			
Extension contact fee			
Labor cost			
Transport to and from the market			
Group contribution			
Market charges/costs			
Transaction Costs			
Search for information – Credit card/ Airtime			
Bundles for internet			
Pre-visit to source of stock			
Opportunity cost			
Contract premium			
Others(specify)			

34. What was your intention of rearing Improved Indigenous Chicken?

☐ For chicks ☐ Commercialization ☐ Eggs

☐ Others (specify)……………………..

35. a. Have you ever stopped rearing the Improved IC at one point? ☐ Yes ☐ No

b. If yes, was it? ☐ Permanently ☐ Partial

c. If partially, did you aim at? ☐ Up scaling ☐ down scaling

d. Give reasons for (c) above

………………………………………………………………………………………

e. If permanently, what led to withdrawal from rearing the improved indigenous chicken?

....……..

36. a. In your own opinion, what is your future plan on IC?

☐ Expand the size of the flock ☐ Maintain the same size ☐Reduce the size of flock

b. Give reasons for your answer in (36.a) above

………………………………………………………………………………………

c. Which type of IC would you prefer to rear? ☐ Local IC ☐ Improved IC ☐ Both types

d. Give reasons for your answer above (36.c)…………………………………………

THANK YOU FOR YOUR COOPERATION

Appendix 2: Correlation matrix of variables

Variable	Ageoft ~t	Gender ~d	Levelo ~n	Househ ~e	Sizeof~ m	Social ~p	Typeof ~p	Source~ C	Tr~cti on	Nooftra in	DstTra in	CreditA cc	OtherOffr m	AwaII C
Ageofthere~t	1													
GendeHh~d	-0.0456	1												
LevofeduHh	-0.1481	-0.1055	1											
Housldsze	0.2697	-0.025	-0.0692	1										
Sizeofthef~m	0.277	-0.196	-0.1002	-0.0346	1									
Socialgroup	0.1131	0.1249	0.092	0.182	-0.182	1								
Typeofsoci~p	0.1392	0.0726	0.0994	0.1852	-0.181	0.5236	1							
Sourceofin~C	-0.0174	0.0165	0.1035	-0.0912	-0.1868	-0.0304	0.071	1						
Traini~ction	0.1178	0.1613	0.1029	0.2253	-0.1496	0.577	0.3397	0.0717	1					
Numboftimtr	0.0951	0.1483	0.0073	0.1355	-0.1833	0.4689	0.3108	-0.0052	0.7021	1				
Distanceto~e	0.0633	0.0258	0.1793	0.102	-0.0165	0.4467	0.1816	-0.0134	0.6358	0.4784	1			
Accesstocr~t	0.0045	-0.0108	0.0457	0.0411	-0.119	0.278	0.3438	0.1075	0.1981	0.1924	0.1204	1		
Otherofffa~s	-0.0283	-0.1069	0.2094	-0.0275	-0.0673	-0.0427	0.0177	0.1739	0.0342	-0.0928	-0.0963	0.2144	1	
Awarenesso~C	0.1358	0.0665	-0.039	-0.0314	0.0314	0.1347	0.1162	0.0833	0.2107	0.1872	0.196	0.1104	0.0206	1

Source: Survey, (2015)

Appendix 3: Results of multicollinearity test

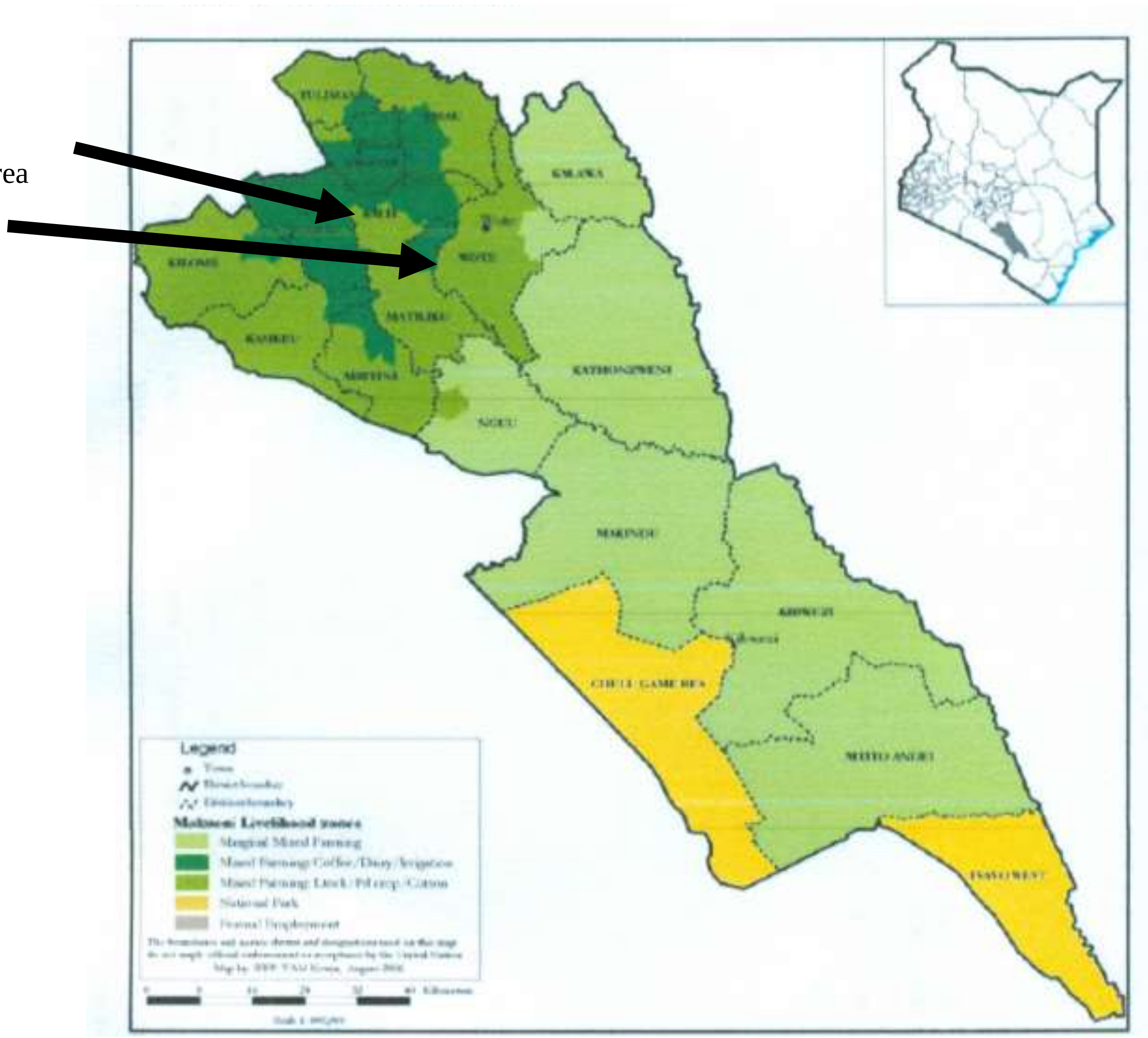
Variable	Variance Inflation Factor (VIF)
Training on poultry production	1.97
Number of times trained	1.88
Social group	1.88
Distance to the training center	1.84
Type of social group	1.50
Age of the household head	1.22
Size of the farm	1.22
Access to credit	1.20
Household size	1.15
Level of education	1.14
Other off farm activities	1.14
Source of information on IC	1.10
Awareness on IIC	1.09
Gender of household head	1.05
Mean VIF	1.38

Source: Survey, (2015)

Appendix 4: Results of heteroskedasticity and Ramsey RESET test

```
. reg Adoptionofimprovedingigenouschic Ageoftherespondent GenderofHhead Levelofeducation Househo
> ldsize Sizeofthefarm Socialgroup Typeofsocialgroup SourceofinformationonIC Trainingonpoultrypr
> oduction Numberoftimestrained Distancetothetrainingcentre Accesstocredit Otherofffarmactivitie
> s AwarenessonIIC

      Source |       SS       df       MS              Number of obs =     384
-------------+------------------------------           F( 14,   369) =    6.21
       Model |  17.5545631    14  1.25389736           Prob > F      =  0.0000
    Residual |  74.4844994   369  .201855012           R-squared     =  0.1907
-------------+------------------------------           Adj R-squared =  0.1600
       Total |  92.0390625   383  .240310868           Root MSE      =  .44928

------------------------------------------------------------------------------------------------
Adoptionofimprovedingigen~c |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------------------+-------------------------------------------------------------------
         Ageoftherespondent |  -.0021511   .0022586    -0.95   0.342    -.0065925    .0022903
              GenderofHhead |  -.1261724   .0526182    -2.40   0.017    -.2296416   -.0227033
           Levelofeducation |   .0323959    .028782     1.13   0.261    -.0242015    .0889933
              Householdsize |    .001452   .0285713     0.05   0.959     -.054731    .0576351
              Sizeofthefarm |   .0552623   .0285941     1.93   0.054    -.0009656    .1114901
                Socialgroup |   .1932792   .0822443     2.35   0.019     .0315529    .3550055
          Typeofsocialgroup |   .0230404    .014805     1.56   0.121    -.0060724    .0521532
    SourceofinformationonIC |   .0016933   .0046372     0.37   0.715    -.0074253    .0108119
Trainingonpoultryproduction |   .0296897    .112779     0.26   0.793    -.1920804    .2514599
       Numberoftimestrained |   .0083974   .0176107     0.48   0.634    -.0262324    .0430272
Distancetothetrainingcentre |   .0687512   .0243998     2.82   0.005      .020771    .1167314
             Accesstocredit |   .0771916   .0541125     1.43   0.155     -.029216    .1835991
     Otherofffarmactivities |   .0817943   .0491601     1.66   0.097    -.0148748    .1784634
             AwarenessonIIC |   .2952693   .1277996     2.31   0.021     .0439624    .5465761
                      _cons |  -.2159545   .1891826    -1.14   0.254    -.5879659    .1560568
------------------------------------------------------------------------------------------------

. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of Adoptionofimprovedingigenouschic

         chi2(1)      =     1.48
         Prob > chi2  =   0.2244

. ovtest

Ramsey RESET test using powers of the fitted values of Adoptionofimprovedingigenouschic
       Ho:  model has no omitted variables
                 F(3, 366) =      1.35
                  Prob > F =      0.2593
```

Appendix 5: Map of Makueni County



Source: RoK 2010

Appendix 6: Map of Kakamega County

JOURNAL PAPERS PUBLISHED FROM THESIS

1. **Determinants of Adoption and Intensity of use of Brooding Technology in Kenya: The Case of indigenous chicken farmers in Makueni and Kakamega Counties, Kenya.**

   Authors: Christopher .N. Kamau*. Lucy.W. Kabuage and Eric. K. Bett.,

   Published in Journal of Agricultural Economics and Rural Development

   Year of Publication, 2017

   Available online at: http://internationalscholarsjournals.org/journal/ijaerd/articles

2. **Economic Analysis of Indigenous Chicken Production: The Case of Smallholder Farmers in Makueni and Kakamega Counties, Kenya.**

   Authors: Christopher .N. Kamau*. Lucy.W. Kabuage and Eric. K. Bett.,

   Published in International Journal of Agricultural Extension and Rural Development

   Available online at: http://internationalscholarsjournals.org/journal/ijaerd/articles

   Year of Publication, 2017