TECHNOLOGY ADOPTION, PRODUCTION AND MARKET PARTICIPATION AMONG SMALLHOLDER INDIGENOUS CHICKEN FARMERS IN TIGANIA WEST SUB-COUNTY, MERU COUNTY

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DECLARATION

This thesis is my original work and has not been presented elsewhere for a degree or any other award.

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DEDICATION

I sincerely dedicate this work to the Almighty God for the gift of life, strength and guidance during my studies. I also dedicate this work to my Dear Wife Wambui Mwiti, to my children and my late Mum Catherine K Mathiu.

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LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
GoK	Government of Kenya
IC	Indigenous Chicken
KNBS	Kenya National Bureau of Statistics
KES	Kenyan Shillings
MoA	Ministry of Agriculture
MoALF	Ministry of Agriculture, Livestock and Fisheries
MT	Metric Tons
NCPD	National Council for Population and Development
SDG	Sustainable Development Goal

DEFINITION OF TERMS

Indigenous chicken	Defined as various breeds of native chicken that are adapted to harsh environmental conditions and are reared extensively.
Production	The amount of output from a given level of input(s) used. In this study, production was considered as the number of eggs and chicken from a given level of inputs used.
Technology adoption	The uptake of modern production technologies such as improved breeds, vaccination, housing and feeding.

ABSTRACT

Majority of the Kenyan population resides in rural areas and are characterised by high levels of poverty due to low income and food insecurity. Poultry production and in particular indigenous chicken has been recognised as an avenue to improve livelihoods among rural households through provision of income. Besides, the enterprise contributes to socioeconomic and nutritional requirements of rural and peri-urban populations. Despite this potential, chicken production continues to encounter low and declining production, inadequate uptake of modern innovations and inefficient market structures that are unreliable in forecasting impending trade relations. This has been ascribed to limitation of measures to improve productivity through poultry friendly technologies and provision of necessary market information. Therefore, this study sought to examine adoption, production and market participation among smallholder indigenous poultry farmers in Meru County. The study applied a cross sectional survey design and Tigania West Sub County was selected since it is a leading producer of indigenous chicken in Kenya. Data were collected by administering structured questionnaires to 359 smallholder farmers, who were identified through multistage stratified and probability proportionate to size sampling techniques. Descriptive statistics used to analyse socioeconomic and institutional characteristics showed that majority of the respondents were aged, with moderate experience and had limited extension access. In addition, the results revealed that respondents had adequate access to market information and financial credits. The binary logit model was used to identify farm and farmer characteristics that affect adoption of technologies. Improved breeds, proper housing structures, improved feeds and disease control measures were used as technology adoption parameters. Results show that experience, household size, extension access, land tenure and income from indigenous poultry were significant and positively influenced technology adoption. Further, age of the respondents, farm size and level of education had negative and significant impact on adoption. The Cobb Douglas production function was used to determine farm and farmer characteristics that affect poultry production. Results revealed that indigenous chicken production was highly responsive to off-farm income, technology adoption and gender of the respondents. The input output relationship presented that amount of credit used, quantity of feeds and frequency of vaccination were significant and positively influenced poultry yield at constant returns to scale. The Heckman's two-stage results show that the decision of smallholders to engage in poultry markets was highly influenced by the frequency of extension and household size, while education and expert contact significantly influenced the intensity of market participation. The study recommends that emphasis should be concentrated on policies that promote youth participation in indigenous poultry production and provision of extension and training among smallholders. Besides, there is a need to emphasize on improved land tenure and increased engagement of farmers in off-farm employment in order to increase the scope of their working capital.

CHAPTER ONE

INTRODUCTION

1.1Background information

Indigenous chicken (IC) production form part of the local assets owned by people living in the rural areas of developing countries (Nduthu, 2015). The IC exhibits low production, late maturity, broodiness, delayed growth and high mortality rates (Mengesha, 2012). Their management however, is characterized by extensive scavenging, lack of disease control programs and increased risk of predators (Bushra, 2012). The global population of IC is estimated at 16.2 billion with 71.6% being in developing countries. In Africa, the subsector contributes over 70% of poultry products and 20% of animal protein intake (Atela, Ouma, Tuitoek, Onjoro and Nyangweso, 2016). In East Africa, over 80% of the human population lives in rural areas, out of which over 75% keep indigenous chicken (Kingori, Wachira & Tuitoek, 2010). Kenya is home to 22 million indigenous chicken (Magothe, Okeno, Muhuyi and Kahi, 2015) and their demand has been increasing as they possess unique attributes such as distinct flavour, leanness and colour (Bett, Musyoka, Peters and Bokelmann, 2012).

Kenya's per capita land size is on the decrease owing to the increasing human population, indirectly resulting in a reduced scale of production (Godfray *et al*., 2010). One of the opportunities for small scale farmers to increase household income is through indigenous chicken production. These birds are genetically diverse, well adapted to harsh climatic conditions and largely resistant to pests and diseases (Magothe *et al.*, 2015), making their rearing vital for food security, employment and self-reliance among the resource-poor rural farmers (Padhi, 2016).

Poultry sub-sector in Kenya contributes about 55% of the livestock sector's GDP and 7.8% of the total national GDP (Godfray *et al*., 2010). According to Kingori *et al*. (2010), indigenous chicken production faces many productivity challenges such as poor breeding, nutrition, housing and general husbandry, which lowers household incomes. Marketing of indigenous chicken and their products is entirely a private sector affair, the marketing chain generally involving the producers, itinerant traders, processors and finally the consumers (Okeno, Kahi, & Peters, 2012). The producer's decision to sell is entirely based on profits

and availability of stock (Magothe *et al.*, 2015). Due to inadequate formal marketing organizations in Kenya for indigenous chicken, the prices fluctuate as a result of market volatility (Okeno *et al*., 2012).

Meru County is a region that is a leading producer of indigenous chicken in Eastern Kenya, with a population of over 1.3 million IC (Ministry of Agriculture, Livestock and Fisheries, 2018). The County has a large potential for IC production that remains untapped. Indigenous chicken keepers in the County face several challenges: unidentified breed types, extensive production systems, poor feeds and feeding management and frequent occurrence of pests, diseases, and predators. Additionally, farmers have limited market structures such as wholesaling and assembling for collective marketing, limited market sheds for poultry marketing and the County has limited poultry slaughter slabs and cold storages. There is no evidence of established linkages among value chain actors and the sector has inadequate extension services (Bwalya and Kalinda, 2014).

Inadequate market information system to the rural poultry producers means that their pricing decisions may not reflect the market situation and this negatively affects the income from the indigenous chicken. Therefore, this formed the basis for this study to explore the effects of factors on technology adoption, production and market participation among indigenous chicken farmers in Tigania West Sub-County Meru County.

1.2 Statement of the problem

Indigenous chicken production has the potential of increasing farm income and food security among the resource-poor farmers in Kenya. However, the sub-sector faces numerous challenges such as low adoption of modern technologies, poor production and market participation that leads to low-income generation. The factors that cause low adoption of modern technologies, low production and market participation are not clear. Furthermore, the policy-makers and farmers lack research-based information on the choice of measures to improve the performance of this important livestock enterprise. Therefore, this study generated a research-based evaluation on the impact of social, economic and institutional factors that are hypothesized to affect technology adoption, production and market participation among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County.

1.3 Objectives

1.3.1 General objective

To evaluate the effects of socio-economic and institutional factors on technology adoption, production and market participation among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County, Kenya.

1.3.2 Specific objectives

1. To assess the effect of socio-economic and institutional factors on adoption of improved production technologies among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County.
2. To determine the effect of socio-economic and institutional factors on production among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County.
3. To assess the effect of socio-economic and institutional factors on extent of market participation among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County.

1.4 Research questions

1. What are the effects of socio-economic and institutional factors on adoption of improved production technologies among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County?
2. What are the effects of socio-economic and institutional factors on production among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County?
3. What are the effects of socio-economic and institutional factors on extent of market participation among smallholder indigenous chicken farmers in Tigania West Sub-County, Meru County?

1.5 Justification of the study

The production of the indigenous chicken in Meru is estimated at 1,303,200 (MoALF, 2018). Increased indigenous chicken production increases farm income among the producers with the potential to reduce poverty levels among smallholder farmers.

Producers are able to access basic needs, hence enhancing livelihood in rural areas which contributes to the attainment of Sustainable Development Goal one (SDG 1) on poverty eradication (Godfray,2010). Agriculture being one of the key drivers of economic development, increased IC production contributes to the growth of the entire poultry subsector, and this will contribute to attainment of Vision 2030 growth target of increasing annual economic growth by 10%. Furthermore, improved farm income as a result of increased poultry production contributes to enhanced access to quality food among rural farmers, which leads to food and nutrition security, which is among the Big Four Agenda of the Kenyan Government.

CHAPTER TWO

LITERATURE REVIEW

2.1 Status of poultry production in Kenya

Indigenous chicken production plays an important role in the economic and social life of resource-poor households. It is practiced wherever there are human settlements and its economic strength lies in its low production cost, making it affordable by the resource-poor rural households. Additionally, it is adapted to the harsh scavenging conditions, poor nutrition and parasite challenges (Magothe *et al*., 2015). Demand for IC fresh meat is an increase due to awareness that it is leaner than the exotic breeds. However, reports indicate that its productivity is on decreasing trend especially under free-range production systems. This leads to the undersupplying of IC to the market (Kryger, Thomsen, Whyte & Dissing, 2010).

In Africa, poultry production is practiced by farmers who face challenges of high prices of feed's raw materials such as maize and soya, inadequate extension or advisory services, and underdeveloped infrastructure such as roads (Nkukwana, 2018). In Kenya, despite increasing demand; high disease incidences, inadequate nutrition, low genetic ability, and poor marketing channels constrain their productivity hence lowering their contribution towards rural development (Magothe *et al.,* 2015). The chicken is kept under scavenging production systems with limited application of management interventions to improve flock productivity. With constraints such as diseases, lack of proper housing and insufficient feed, the productivity of these chickens is usually low (Siyaya and Masuku, 2013). Similar constraints were earlier reported by Habte, Debele, Admassu and Yinnessu (2015) that poor management, lack of food supplementation, lack of disease control measures and inappropriate housing have constrained indigenous chicken production. However, information on the impact of selected social, economic and institutional factors that are hypothesized to affect technology adoption, production and market participation among smallholder indigenous chicken farmers are still limited.

2.2 Effects of socio-economic and institutional factors on the adoption of improved production technologies

Access to extension services, gender, education level, membership to farmers' groups and off-farm income were found to significantly influence the adoption of management interventions in indigenous chicken production in Western Kenya, using a multinomial logit model (Lestari, Natsir, Sirajuddin, Kasim, Ali, Saadah & Mawardi, 2012). Other institutional factors such as market access, market information at the farm level which might significantly influence the adoption of improved production technologies among smallholder indigenous chicken farmers were not captured by this study.

Sex of the household head, family size, availability of supplementary feeding, credit and extension services were found to influence the rate and intensity of adoption of poultry technology in East Shewa and Welayeta in Ethiopia, using double-hurdle class of model (Kassie, Teklewold, Jaleta, Marenya & Erenstein, 2015). This study did not consider key institutional factors such as farmers' organization which might be crucial in influencing the adoption of indigenous chicken.

Farm size, expected benefits from technology adoption, access to credit and extension services, significantly influence technology adoption decision of farm households in Ghana using binary logit model (Akudugu, Kwesi and Dadzie, 2012)**.** The study did not consider marketing aspects which can influence farm lever technology adoption decisions.

Distance to the training centre, off-farm activities, improved indigenous chicken, the gender of household head, farm size and group membership awareness significantly affected the adoption decision of improved indigenous chicken in Makueni and Kakamega counties using a double hurdle model (Kamau, Kabuage and Bett, 2019). The study emphasized less on institutional factors such as membership to farmer organizations. The double hurdle model showed that the decision to adopt was significantly influenced by credit and extension services (Lestari *et al*, 2012). In Nigeria technical constraints cited included lack of farmers training system and dearth of information about cost effective chicken and production at the level of decision makers (Adebayo and Adeola, 2005).

2.3 Effects of socio-economic and institutional factors on IC production among smallholder farmers

Land size affects indigenous poultry production significantly in Machakos County using both inferential, descriptive and multi-variant statistics (Nduthu, 2015). The current study considers other socio-economic factors such as labour, farmer's experience and off-farm income which might significantly influence indigenous poultry production.

The gender of respondent and household income had a significant relationship with chicken production in Katangi and Ikombe divisions of Yatta Sub-county, Machakos County using descriptive statistics and Pearson's correlation coefficients (Mutombo, 2014). The study did not consider other key variables such as land, labour and extension services which might also influence chicken production

Family labour, household size, gender, and education level had a significant effect on chicken production in Katulani Sub-county, Kitui County (Mwobobia, 2016). This study did not look at other socioeconomic factors such as land, off-farm income that might significantly affect indigenous chicken production.

Shortage of labour, chicken theft, and poor marketing information are found to be some of the socio-economic constraints in chicken production in Njoro Sub-county of Nakuru County (Miriam, Agnes, & Konyango, 2015). The socio-economic constraints such as low and lack of knowledge on the basic chicken production requirements and low availability of drugs for diseases and pest management were found to affect chicken production positively (Ndathi, Muthiani, Kirwa, Kibet & Cheruiyot, 2006). These studies did not consider other socio-economic factors such as land, labour, farmers' experience, extension services that are key variables in influencing indigenous chicken.

2.4 Effect of socio-economic and institutional factors on the extent of market participation

Inadequate market information was found to affect the marketing of chicken products among the stakeholders involved in the supply chain of live chickens and eggs in Western Zone of Tigray (Shishay, Berhanu & Tadelle, 2014). The aspect of other key variables such

as off-farm income, market prices, extension services and access to credit were not considered and therefore this study sought to fill the existing gaps.

A study by Mailu, Wachira and Munyasi (2012) investigated the influence of prices on market participation decisions of indigenous poultry farmers in the former Eastern Province of Kenya. This study found that although the indigenous production system possesses enormous potential for improving livelihoods, its marketing systems are not well defined and are variable. Furthermore, the influence of prices on market engagements are frequently assumed. The study also evaluated the probability of market participation by employing a binary logistic regression model. The results suggest that while farmers complain of poor farm gate prices for indigenous chicken offered by middlemen, volumes of sale are also an important drawback to market participation. Other economic and institutional factors such as land, labour, extension services, access to credit and market access in conjunction with variables in the study to assess their effects on market participation were not captured in the analysis.

Contract farming, market infrastructure, market information had the highest level of significance on chicken market participation in Baringo County using regression and descriptive statistical technique (Kamau, 2018). This study did not consider other key variables like market access and market prices that may greatly influence the value chain in the marketing of indigenous chicken.

The market participation of IC producers was found to be constrained by the household head, household size, distance to market, membership to farmers group, demand price, flock size among smallholder farmers in Busia County (Mirembe, 2018). This study included other crucial factors such as extension services, access to credit, training that may influence market participation of the IC producers.

The household size, level of education, extension services, family size, breed type and number of poultry owned were found to significantly influence poultry producers' participation decision in Kaffa of Southern Ethiopia using both descriptive and probit regression model (Tarekegn and Yosefe, 2017). This study left out other factors such as access to credit, market access, market information, farmers' organization that might

significantly influence the decision to participate in the marketing of the indigenous chicken.

2.5 Research gaps

The reviewed literature shows that some socio-economic and institutional factors affects the adoption of improved indigenous chicken production technologies. These factors include access to extension services, gender, education level, membership to farmer's groups and off-farm income (Akudugu *et al*., 2012; Kamau *et al*., 2019; Kassie *et al*., 2015; Lestari*et al.,* 2012). However, there is limited information on the factors affecting the extent of adoption of these improved production technologies among smallholder IC farmers. Furthermore, studies have looked at socio-economic and institutional factors that affect the production of IC chicken and this includes family labour, household size, gender, education level, farmer's experience and off-farm income (Miriam *et al*., 2015; Mutombo, 2014; Mwobobia, 2016; Ndathi *et al*., 2006; Nduthu, 2015). However, there is limited information on the institutional factors in conjunction with the variables considered to look at their effects on the production of IC.

Studies have also looked at socio-economic and institutional factors that affect the market participation and includes household size, level of education, extension services, family size, breed type and number of poultry owned (Kamau, 2018; Mailu *et al*. 2012; Mirembe, 2018; Shishay *et al*., 2014). However, these studies have not looked at the effects of these factors on the extent of market participation among smallholder IC farmers. Attempts have been made at different times to improve the local chicken production through the introduction of exotic chicken breeds. However, adoption has been limited by different factors such as lack of knowledge on chicken husbandry, high disease prevalence and predation and lack of access to credit (Teklewold, Dadi, Yami and Dana, 2006). In the light of the above-mentioned gaps, there is need for further studies on the selected socio-economic and institutional factors that affect IC technology adoption, production and market participation as well as the extent of adoption of these improved technologies.

2.6 Theoretical framework

2.6.1 Rational choice theory

This study is based on the rational choice theory that postulates that the consumer of technology is rational (Herfeld, 2012). This theory postulates that the behaviour on the 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 to adopt the new indigenous chicken 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 of new technology with the existing technology. Preference of new technology will be made if its expected utility exceeds that of traditional technology (Chu & Chu, 1994). The Chu and Chu model is expressed as;

$\Sigma Un(Y) > \Sigma U\text{nt}\ (Y)$ - Adopt the new technology …….. ….. (2.1)

$\Sigma Un(Y) < \Sigma Uot(Y)$ - prefer the old technology ……..…. (2.2)

Where ΣU the summation of adoption of technologies is, nt is the new technology adopted, ot is the old technology adopted and Y is the output from the adoption of technologies. The farmer is faced with hurdles of whether or not to adopt and to what extent will he or she adopt. Therefore, the adoption decision was modelled as a double hurdle model that applies the propensity score matching model. Arnholt, Batte and Prochaska (2001) asserts that adopters of technology also consider profits from using the new technology in deciding whether to adopt more of the new technology. The current study was grounded on the above theory since farmer's adoption decision on improved poultry technologies is influenced by the anticipated returns.

2.6.2 Theory of the firm

The theory of the firm states that firms exist and make decisions in order to maximize profit. They interact with the market to determine pricing and demand and then allocate resources according to models that ensure they maximize net profits (Argandoña, 2011). In measuring the economic efficiency of a firm, we require an understanding of the decision-making behaviour of the producer. Rational producer, producing a single output from a number of inputs, that are purchased at given input prices is thought to be efficient if operating on a production frontier (Hussain, 2014). But if the producer is using a combination of inputs in such a way that they fail to maximize output, or fewer inputs can be used to attain the same level of output, then the producer is not economically efficient (Dobrowsky, 2013). In this study, the theory of the firm will be used to describe how the farmers can use the available resources and inputs such as the housing structure, feeds and breeds in order to maximise the output, which is the number of indigenous chickens produced per unit of each input used.

2.6.3 Market theory

In market theory, the decision to participate in the market is postulated to be a binary choice that is built on utility maximization theory. This is because the decision on whether or not to participate is considered under the framework of utility or profit maximization. In the context of this study, economic agents will be indigenous chicken producers whose decision to participate in the market will be assumed to depend on perceived utility or expected net benefits. Although utility will not be directly observed, the actions of the economic agents will be observed through the choices that they will make. The market theory is based on the linear utility model.

Suppose that U_j and U_k represents household utility for the two choices, which are correspondingly denoted by Y_j and Y_k respectively. The stochastic linear utility model will be then specified as follows (Deb, Kitamura, Quah & Stoye, 2017):

$U_j = \beta_j X_i + e_j$ and $U_k = \beta_k X_i + e_k$ ……..... (2.3)

Where: U is the utility, j represents farmers' participation in the market and k represents non-participation in the market. In this study, U_j and U_k are perceived utilities of IC market participation and non-IC market participation choices respectively. X_i are the vectors of

explanatory variables that influence the perceived desirability of each choice. From market theory, an individual j makes a decision to participate in the market if the utility associated with that participation choice U_j is greater than the utility associated with the decision not to participate.

2.7 Conceptual framework

Figure 2.1 shows the conceptual framework for this study. It shows the relationship between the dependent variables and independent variables. It is conceptualized that institutional factors such as extension services, access to credit, and group membership and the economic factors such as off-farm income, farm size, labour, land and, the social factors such as age, gender, education level and farmers' experience have an influence on technology adoption, production and market participation among smallholder indigenous chicken producers. Adoption of the improved technologies will enable the farmer to increase production, which will increase the rate of market participation hence improved incomes. This will lead to access of meat-based proteins hence farmers will be food secure. Increased income will lead to high living standards among the rural farmers hence poverty reduction.

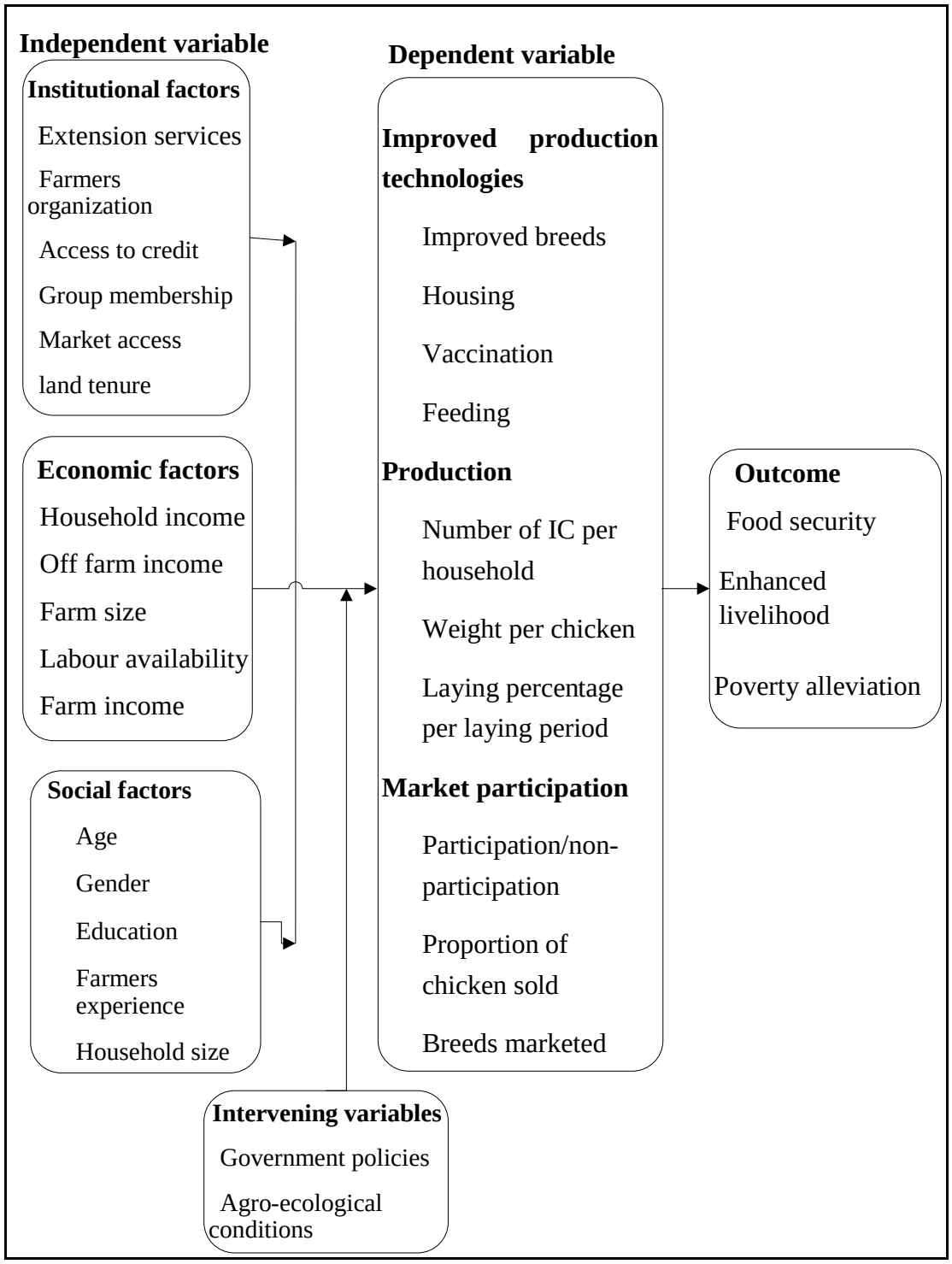

Figure 2. 1: Conceptual framework

2.8 Operationalization of study variables

Table 2.1 shows the study variables, descriptions, measurements and their expected signs.

The positive effect is shown by sign (+) and the negative effect is shown by sign (-).

Table 2. 1: Table of variables

Variable	Description	Measure	Expected relationship with variable
Adoption	Vaccination, improved breeds, housing, and feeding	1) Adopters 2) Non-adopters Adoption percentage	
Production	Output in term of number of indigenous chickens	-No. of IC -Number of eggs laid per given laying period	
Market participation	Farmer participation in the marketing of products Extent of farmers market participation	1= Participation 0= Non- participation Percentage of chicken and products sold. Breeds marketed	
Age	Age of respondent.	Age in years	+
Gender	Gender of the respondent	1 = Male 0 = Female	
Education	Level of education of the respondent	Number of years spent in school	+
Household size	Family members, household head included	Number of household members	+
Household income	Respondent's monthly income	Income in Kenya shillings	+

Farmer's experience	Respondent's farming experience	Years in IC farming	+
Farm size	Respondent's farm acreage	Farm acreage (acres)	+
Credit access	Access to credit by the respondent	Amount of credit in cash or kind, farmers perception (1 = Access 0 = No access)	+
Extension contact	Contacts between the respondent and extension agent	Number of extension contacts 1=access 0=no access	+
Market access	Nearest market accessible to the respondent	Distance to the nearest market in kilometres	+
Information access	Access to market/ extension information	Information source and type, farmer's perception (1= Access 0 = No access)	+
Farmer associations/ groups	Respondent's membership in farm associations	1= Member, 0= Non-member	+
Labour	Number of days worked in IC farming	Labour in Mandays	+
Off-farm income	Monthly income from off/non-farm sources	Amount in Kenya shillings	+
Farm income	All the farm incomes	Amount in Kenya shillings	+
Land tenure	Land owned or rented by a farmer	1) Rented, 2) owned	+

CHAPTER THREE

RESEARCH METHODOLOGY

3.1Study area

The study was conducted in Tigania West Sub-County, Meru County (Figure 3.1). Tigania West Sub-County has a population of 135,983 (KNBS, 2019). The study area experiences bimodal rains with long rains lasting from March to June and short rains lasting from October to December. Tigania West Sub-County experiences annual temperature range from 19.2℃ - 22.9℃

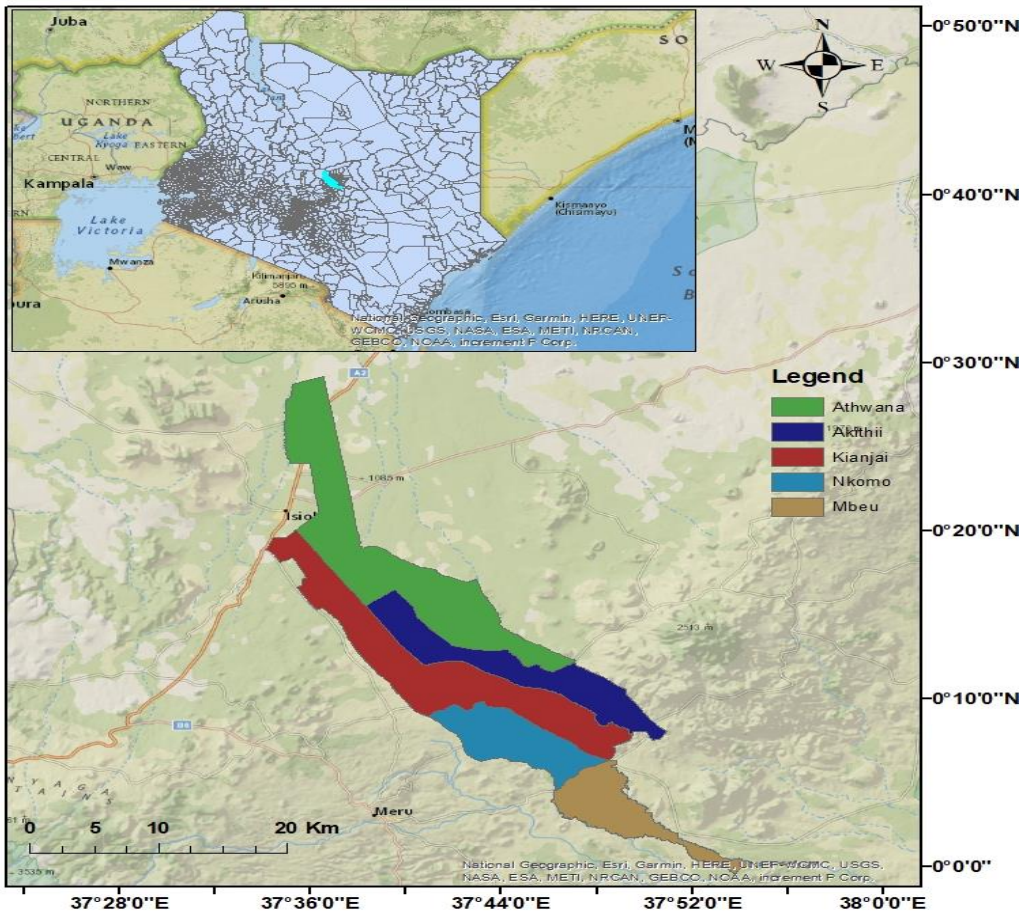

Figure 3. 1: Study area

3.2 Research design

This study employed a cross-sectional survey design. This design was appropriate for this study because it enables the researcher to collect data at a single time period without manipulating the environment. It also enables the researcher to describe, analyse and interpret the variables under study more appropriately. This is also the most efficient design that a researcher uses to easily obtain the data using an interview schedule (Sedgwick, 2014).

3.3 Sample size and target population

The target population was smallholder indigenous chicken farmers in Tigania West of Meru County. This study adopted Watson (2001) formula as used to calculate sample size. This formula was most preferred for this study because the population size was above 10,000.

$$n = \left(\frac{p(1-p)}{\frac{e^{2}}{z^2} + \frac{P(1-P)}{N}} \right) \div R \qquad \ldots\ldots (3.1)$$

p - estimated variance (0.3), e- desired precision (0.05),

Z - confidence level (95% = 1.960), R - response rate – 90%. N= 135,983 and n is the sample size.

Therefore, 359 Indigenous chicken farmers were sampled from the target population.

3.4 Sampling design and techniques

This study employed a multi-stage sampling procedure. First, Meru County was purposely selected for this study based on its high IC production (MoALF, 2018). Secondly, Tigania West Sub County was selected for the study due to its high IC production and marketing. The farming household heads in all five wards in the sub-county were sampled for this study. A location was randomly sampled from each ward. From each location selected a sub-location was randomly sampled. Then a village was randomly sampled from each sub-location. The probability proportionate to size method was used to obtain the number of IC

smallholder farmers to be interviewed from the five villages. First, the number of households from each village was determined. Proportion to size formula was applied where the number of households in the selected village was divided by the total number of households in all five villages and then multiplied by the sample size as shown below (Ndirangu, Mbogoh and Mbatia, 2018).

$$M = \frac{n}{N} * 359 \quad \text{.....} \quad (3.2)$$

Where M is the number of households to be interviewed, n is the number of households in the village and N is the total number of farming households in the wards.

The number of households interviewed in each randomly selected village are given in Table 3.1

Table 3. 1 Households sampled and interviewed per village

Ward	Location	Village	No. of respondents
Akithii	Ncooro	Maathi	94
Athwana	Matiro	Kuani	48
Kianjai	Kianjai	Uuru	97
Nkomo	Kunene	Kimachia	67
Mbeu	Kibuline	Makandi	56
Total			**359**

3.5 Data collection instruments

Questionnaires were used to collect data from smallholder indigenous chicken farmers. Questionnaires were considered for this study because they are easy to administer and analyse the data compared to other tools.

3.6 Reliability and validity of research instruments

A pilot test was done with 10 questionnaires administered to randomly sampled farmers in all the five wards to ascertain the reliability of the questionnaire. The split-halve method was used to test for the reliability of the questionnaire. The correlation coefficient (r) between halves of the items was calculated using Pearson Product linear correlation coefficient formula (Heale and Twycross, 2015) as follows:

$r = N\Sigma Y - [\Sigma(X)(\Sigma(Y)]/\sqrt{[N\Sigma X^2 - (\Sigma(X^2)]\,[N\Sigma Y^2 - (\Sigma(Y^2)]}$ ……..…. (3.3)

Where: X = odd scores, Y = even scores, Σ(X) = sum of X scores, Σ(Y) sum of Y scores, $\Sigma(X^2)$ = sum of squared X scores, ΣY^2= sum of squared Y scores, ΣXY = sum of the product of paired X and Y scores, N = number of paired scores and r = coefficient correlation between halves. Since *r* represents one half of the instrument, Spearman-Brown Prophesy was used to determine the reliability of the full instrument.

$\text{Reliability} = \frac{2r}{1+r}$= 2 × reliability for ½ tests / 1 + reliability for ½ tests; r lies between 0 and 1; reliability is stronger when *r* value approaches one.

3.7 Data analysis methods

Data was analysed using statistical package for social sciences (SPSS) and STATA. Descriptive statistics results were obtained as mean, frequencies, percentages and standard deviation. Analysed data was presented in tables and charts/graphs.

3.8 Empirical models

3.8.1 Effects of selected factors on adoption of improved production technologies

Adoption was measured as a binary variable which takes the values 1 for adopter and 0 for non-adopters. The effect of the selected factors on adoption was determined using a binary logit model which was empirically specified as shown below (Zou, 2004):

$P_i = (Z_i) = 1/1 + e^{-(\alpha+\Sigma\beta_i X_i)}$ ……. (3.4)

Where: P_i is the probability of adoption of improved production technologies on indigenous chicken, (Z_i) is the function of the technology adopted by the farmer. X_i represents the i^{th} explanatory variables, α and β_i are the parameters to be estimated and *e* is the base of the natural logarithm. The equation can further be written in terms of odd ratios and the log of odds as follows:

$\frac{P_i}{1 - P_i} = e_i^Z$ ……..... (3.5)

Where: 1 - P_i is the probability of household not adopting indigenous chicken production. Taking the natural log of the equation gives:

$ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + U_i$ ……..…. (3.6)

Where: α is the vertical intercept, β_1 *to* β_n is the multiplier effect or coefficient of the regressor and X_1 *to* X_n are the selected factors influencing the adoption of the technology.

3.8.2 Effects of selected factors on production of indigenous chicken

Cobb-Douglas production function was used to estimate the key factors affecting the production of indigenous chicken and chicken products. The main advantage of using Cobb-Douglas production function is that it provides parameters that are easy to estimate and interpret. The model was specified as shown below (Tadesse & Krishnamoorthy, 1997):

$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + ... + \beta_n \ln X_n + \alpha_1 Z_1 + \cdots + \alpha_n Z_n + \varepsilon$ ..... (3.8)

Where Y is the output, β_0 is the vertical intercept showing values of Y when variables X_1 *to* Xn are equal to zero, β_1 *to* $\beta_n$are the inputs co-efficient, X_1 *to* X_n are the quantities of inputs used in production, Z_1 *to* Z_n are the socio-economic and institutional factors, α_1 to α_n are the co-efficient for socio-economic and institutional factors and ln is natural logarithm and ε is the composite error term.

3.8.3 Effect of selected factors on market participation

Heckman's two-stage model was used to determine the effects of economic and institutional factors on market participation. First, a Probit model was used to determine the market participation of smallholder indigenous chicken farmers

(1 = participant 0 = non- participants). The model by Heckman (1979) is expressed in the form shown below:

$q_{i\,(0,1)} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + \varepsilon$..... (3.9)

Where $q_{i\,(1)}$, is farmers participating in the market $qi_{\,(0)}$ represents farmers not participating in market, β_0, β_1 *to* β_n are parameters to be estimated by the model and X_1toX_n are factors affecting market participation.

The second stage involved a truncated regression model that showed the effects of this factors on the extent of market participation. The model was represented as shown below:

$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots .... + \beta_n X_n + \varepsilon$ ..... (3.10)

Y_i is the extent of market participation β_0, $\beta_1$to $\beta_n$are parameters to be estimated by the model, $X_1 to\ X_n$ are factors affecting the extent of market participation and $\varepsilon$is the error term.

CHAPTER FOUR

RESULTS AND INTERPRETATION

4.1 Overview

This chapter presents the descriptive and inferential statistics from the analysis of the data collected. Descriptive results on social, economic and institutional characteristics as well as the rate of adoption and market participation of the respondents are presented. Further, the chapter gives results on binary logit multiple regression on the effect of selected factors on adoption of modern production technologies. The results of Cobb Douglas production function on effect of production factors on poultry production are also given and interpreted. Moreover, the chapter gives a highlight on the factors influencing poultry production. In addition, the results of Heckman two stage on factors influencing both the propensity and intensity of market participation among smallholder indigenous poultry farmers have been presented in this chapter.

4.2 Social characteristics of the IC farmers

From the results of descriptive analysis of social characteristics of the IC farmers given in Table 4.1, the average age of household heads among indigenous poultry farmers was 46.6 years with the youngest aged 21 years and the oldest having lived for 82 years. The wide variation in age indicates the predominance of old farmers noting that indigenous chicken farming in the study area was perceived as a reserve for the aging population. In addition, a sizeable proportion (29.5%) of farmers were in the age bracket 31 to 40 years. This elucidates that most of the sampled farmers were middle aged thus sufficiently energetic to engage in agricultural labor force. In addition, farmers had an average experience of 20.02 years in indigenous poultry farming which ranged from 1 and 50 years. Most (41.2%) of the respondents had experience varying from 11 to 20 years while only 21.4% had engaged in the enterprise for less than 10 years. Besides, 37.3% had practiced indigenous poultry for more than 20 years. This elucidates that majority of the smallholders were not new in poultry production thus were well knowledgeable in indigenous poultry farming. Further, the results imply that the farmers were adequately skilled in poultry management, which is a key element in achieving a profitable enterprise.

Table 4. 1: Descriptive results on analysis of social characteristics

Variables	Categories	Frequency	Percentage
Age (Years)	21 to 30	26	7.5
	31 to 40	106	29.5
	41 to 50	100	27.9
	Above 50	126	35.1
	Mean = 46.55, Min = 21, Max = 82, Std. Dev= 11.08, Mode=60		
Experience (Years)	1 to 10	77	21.4
	11 to 20	148	41.2
	21 to 30	92	25.6
	Above 30	42	11.7
	Mean = 20.02, Min = 1, Max = 50, Std. Dev = 10.44, Mode = 20		
Household size (No.)	1 to 4	100	27.9
	5 to 8	229	63.8
	9 to 12	30	8.4
	Mean = 5.62, Min = 1, Max = 12, Std. Dev = 1.97, Mode = 5		
Education (Level)	None	36	10.0
	Primary	216	60.2
	Secondary	83	23.1
	Tertiary	24	6.6
Marital status	Married	286	79.7
	Single	19	5.3
	Widow/Widower	54	15.1
Gender	Male	225	62.7
	Female	134	37.3

Concerning the size of household, sampled farmers had an average of 5.62 members with the smallest household having 1 member and 12 members for the largest. Majority (63.8%) had a minimum of 5 members and a maximum of 8 members showing that respondents had adequately large households to offer sufficient family labor thus reduced production costs. This was attributed to the aspect that 79.7% of the respondents were married thus managed to raise large families compared to only 5.3% and 15.1% who were single or had a deceased partner, respectively. Further, majority (62.7%) of the household heads were males compared to 37.3% of female respondents. This implies that indigenous poultry production was more preferred by males possibly due to relatively higher returns compared to other agricultural enterprises and that men mostly assume the responsibility of ensuring household food security.

The quality education sustainable development goal regard education as a critical element in rural areas of developing countries. Among smallholder farmers, education equips skills and knowledge necessary in poverty eradication. However, Table 4.1 shows that about 10% of the respondents did not have any form of formal education. In addition, 60.2% managed primary education with only 23.1% attaining basic education to completion. However, only 6.6% of the respondents had tertiary level of education. The results reveal that education in the study area was below expectations with a sizeable proportion of smallholders unable to understand basic information regarding markets and contemporary innovations.

4.3 Institutional characteristics of IC farmers

Results illustrated in Table 4.2 reveal that more than half (52.1%) of the IC farmers had no access to extension and training regarding indigenous poultry production. This implies that most of the farmers were not adequately informed on current and emerging issues in both input and output markets in poultry production. In addition, only 47.9% of the farmers received proper training on poultry management and prevailing production innovations. This limits the knowledge and skills necessary for farmers to optimally benefit from indigenous poultry farming. Further, a large proportion (93.9%) of the IC farmers were members of organized groups. This implies that they had enriched bargaining powers in

both input and output markets. In addition, farmer groups can be used as channels for provision of information regarding modern innovations appropriate production and marketing. This was ascertained by the fact that 88.3% of the IC farmers had access to firsthand market information with improved market bargaining power.

Table 4. 2: Descriptive analysis of institutional characteristics

Variable	Category	Frequency	Percentage
Extension access	Yes	172	47.9
	No	187	52.1
Group membership	Yes	337	93.9
	No	22	6.1
Information access	Yes	317	88.3
	No	42	11.7
Credit access	Yes	285	79.4
	No	74	20.6
Contract markets	Yes	5	1.4
	No	354	98.6
Land tenure	With title	225	62.7
	Without title	134	37.3

The results show that, 79.4% of the IC farmers had access credits while 20.6% had no financial aid. This implies that most of the smallholder farmers were financially empowered to timely procure inputs and adopt technologies that boost production. This was achievable owing to the fact that 62.7% of the farmers had guaranteed tenure for their farms thus can use the title deeds as collateral to acquire loans. Contract markets for poultry products were available but only 1.4% of the IC farmers engaged in this avenue. This was

possibly due to unfair contractual obligation and unrewarding product prices offered by participants this market.

4.4 Economic characteristics of the IC farmers

Results displayed in Table 4.3 show that among indigenous poultry farmers, family labor was commonly used in production at 48.2% while only 18.1% of the IC farmers engaged hired labor. In addition, 33.7% of the famers employed both family and hired labor in production. The large proportion of family labor was attributed to existence of large families among IC farmers.

Table 4. 3: Descriptive analysis of economic characteristics

Variable	Description	Frequency	Percentage
Labor	Hired	65	18.1
(Man-days)	Family	173	48.2
	Both	121	33.7
Farm size	0 to 5	352	98.1
(Acres)	6 to 10	6	1.7
	Above 10	1	0.3
	Mean = 1.75, Min =.01, Max = 20, Std. Dev = 1.70, Mode = 1.0		
IC income	0 to 50	32	8.9
(Ksh'000' per	50 to 100	60	16.7
annum)	100 to 150	38	10.6
	Above 150	229	63.8
	Mean =25.3, Min = 0, Max = 200, Std. Dev = 22, Mode = 20		
Off farm	0 to 50	199	55.4
income	50 to 100	69	19.2
(Ksh'000' per	100 to 150	91	25.3
annum)	Mean = 8.9, Min = 0, Max = 80, Std. Dev = 12.2, Mode =5		

The use of hired labor by a sizeable proportion of the farmers was attributed to their understanding of constraints involved in separating farm operations from family activities. Besides, farmers were informed that the involvement of family labor in agricultural production increases inefficiencies. Majority of the farmers had farms of atmost 5 acres implying that farms were highly fragmented and that poultry production encountered competition from other enterprises such as crop production. The size of the farms ranged from 0.01 to 20 acres with an average size of 1.75 acres while majority had farms that measured 1 acre. This implies that most household own relatively small pieces of land which may deter crop-livestock farming diversity.

On average, farmers earned an annual income of Ksh 25,300 from indigenous chicken with the highest returns being 200,000 while majority managed to earn Ksh 20,000. Most of the farmers had earned at least Ksh 150,000 from indigenous chicken while 8.9% earned utmost Ksh 50,000. Compared to off farm activities, farmers earned an average of Ksh 8,900 annually with the highest off farm employment generating Ksh 80,000. Majority of the respondents who engaged in off farm employment earned utmost Ksh 5,000. This implies that indigenous poultry production was more lucrative than off farm employment while the latter enabled farmers generate extra income for use in procurement of critical farm inputs and technologies. Moreover, farmers who engaged in non-farm activities concentrated less in farm operations with limited resources and time allocated for poultry production consequently reducing their working capital.

4.5 Adoption of improved production technologies

4.5.1 Rate of adoption of improved production technologies

This subsection gives descriptive analysis on technology adoption among indigenous poultry farmers. The study considered four common technological practices that improve production and productivity among indigenous poultry farmers. These technologies are: use of improved feeds (homemade rations/commercial feeds), embracing of proper housing (slated floor/deep litter) practices, uptake of disease control (vaccination) methods and improved indigenous chicken breeds (breeding). From the results given in Table 4.4, improved breeds (78.6%) were the most adopted technology followed by good housing

(54.6%), vaccination (49.3%) and use of improved feeds (45.4%) in production. Table 4.4 illustrates that only 21.4% of the IC farmers reared the native breeds of indigenous chicken while majority (78.6%) of the IC farmers embraced improved breeds such as kuroiler, kenbro and rainbow rooster.

Further, of the adopters 55.3% reared native breeds, 17.0% kept crosses of various breeds while 27.7% reared a mixture of the crosses and the native breeds. This shows that given the rising demand of poultry products, farmers were able to reduce their cost of production by adopting poultry birds that had superior traits such as fast growth and maturity, high egg production and tolerance to some common poultry diseases.

Table 4. 4: Descriptive analysis on rate of technology adoption

Technology adoption		**Description**	**Freq.**	**Percent**
Improved breeds		Native breed	156	55.3
Yes	No	Native breed and crosses	78	27.7
282(78.6%)	77 (21.4%)	Cross breeds	48	17.0
Improved housing		Proper Spacing	50	25.5
Yes	No	Feeders and drinkers	85	43.4
196	163 (45.4%)	Laying nest	20	10.2
(54.6%)		Proper ventilation	41	20.9
Disease and pest control		Vaccination: Newcastle disease	70	39.5
Yes	No	Vaccination: fowl pox and typhoid	52	29.4
177	182 (50.7%)	Deworming	43	24.3
(49.3%)		Pest and predator control	12	6.8
Improved feeding		Free-range with supplementation	85	52.1
Yes	No	Semi-intensive with home-made ration	30	18.4
163(45.4%)	196(54.6%)	Commercial feeds only	48	29.5

In addition, more than half (50.7%) of the farmers did not practice disease control measures. This shows that most of the indigenous birds in Tigania were highly exposed to

fatal disease such as Newcastle disease which increases bird mortality and production losses. This was attributed to limited availability of extension which weakened market survey information thus constraining access and affordability of vaccines among other treatment facilities. On the contrary, 49.3% were familiar with the benefits of disease control and its effects on poultry production. Among farmers who controlled diseases, 39.5% and 29.4% administered vaccines against diseases such as Newcastle, fowl pox and typhoid, respectively. Further, 24.3% of adopters regularly dewormed their birds with only 6.8% managing to protect indigenous chickens against pest and predator attacks. The plausible explanation is that farmers were adequately trained on maintaining good flock health. Further, farmers had skills and techniques on methods of protecting their birds from attack thus reducing mortality rate.

From the results, 54.6% of the respondents embraced good housing procedures in rearing indigenous chicken. Proper spacing of 25 chicks/m^2, 10 growers/m^2 and four adult birds/m2 was embraced by 25.5% of the respondents during the construction of poultry houses. This supported easy movement of birds while exercising, increased access to food and water. Further, 10.2% of the respondents embraced use of laying nest while proper ventilation, provision of feeders and drinkers was ensured by 20.9%, and 43.4% of the respondents, respectively. This helped control the behavior of the birds such as cannibalism and ensure hygiene standards thus reduced disease occurrences and mortality rates. However, 45.4% of the sampled smallholder farmers reared their birds on free range without proper housing thus exposing them to predators and uncontrolled pest and disease infestation.

Given that a sizeable proportion of the farmers embraced the free-range system of rearing, majority (54.6%) of the respondents allowed their birds to scavenge for their feeds. Further, only 45.4% embraced improved feeding criterion which included energy, protein, mineral and vitamins feeds. Further, 52.1% of the farmers supplemented their birds with either commercial or raw feeds after scavenging. In addition, 18.4% of the adopters of improved feeds had intensive systems that facilitated the formulation of homemade poultry feed rations. The low proportion in this category was attributed to limited availability of local ingredients used in the preparation of a balanced feed ration. Additionally, 29.5% of the

smallholder farmers fed the indigenous birds purely on commercially manufactured feeds. This was constrained by lack of appropriate feeds for indigenous chicken which has made it difficult to improve productivity and meet the increasing demand for meat and eggs. In addition, the prices of commercially manufactured poultry feeds are beyond the reach of most small-scale farmers. Further quality of commercial feeds is not guaranteed due to limited capacity and logistical challenges among the feed regulators.

4.5.2 Assessment of factors affecting technology adoption

Results presented in this section elaborate on the factors that influence the decision of smallholder indigenous poultry farmers to adopt modern innovations in production. Adoption of four technologies was considered namely; improved breeds, improved housing, disease control (Vaccination) and use of improved feeds. The study employed the binary logit multiple regression to assess socio-economic and institutional factors that affect technology adoption among respondents. The model was reciprocated four times to accommodate the technologies regarded in this study. The results revealed significant factors and demonstrated their influence on technology adoption as construed in the subsequent subsections.

4.5.2.1 Effects of selected factors on adoption of improved indigenous poultry breeds

The results displayed in Table 4.5 show the influence of selected factors on adoption of improved indigenous poultry breeds. Twelve factors were considered out of which six were found to significantly affect the dependent variable.

From table 4.5, the Wald statistic value of household size (21.364) was the largest and significant at 1% percent level. The implication of this is that households with more members are more likely to embrace modern indigenous poultry breeds compared to their counterparts with small households. The reasonable justification is that large households provide more family labor to manage the mobility of indigenous poultry birds during scavenging, feeding and maintaining their welfare. The odds ratio of household size was 1.642 implying that smallholder farmers with large families are 1.642 times more likely to adopt improved breeds. This is possibly due to the reduced production cost due to increased

use of family labor. In addition, household size had a positive influence suggesting that an increase by one member, enhanced the decision to embrace improved breeds by 49.6% since each member of the family anticipated better returns from the enterprise.

Table 4. 5: Results of binary logit multiple regression on factors influencing adoption of improved indigenous poultry breeds

Variable	B	S. E	Wald	Sig.	EXP. (B)	VIF
Age	-0.075	0.020	14.304	.000***	.928	1.869
Experience	0.061	0.021	8.155	.004***	1.063	1.466
Household size	0.496	0.107	21.364	.000***	1.642	1.667
Education	-0.034	.049	0.470	.493	.967	1.209
Gender	0.299	0.351	0.728	.394	1.349	1.195
Extension	1.638	0.387	17.920	.000***	5.146	1.289
Group membership	-0.490	0.574	0.729	.393	.612	1.206
Contract marketing	17.954	16.71	0.000	.999	.000	1.153
IC income	0.000	0.000	1.221	.269	1.000	1.236
Off farm income	0.000	0.000	0.732	.392	1.000	1.205
Farm size	-0.265	0.086	9.507	.002***	.767	1.567
Land tenure	1.317	0.355	13.787	.000***	3.733	1.664
Constant	0.205	0.0919	-2.23	0.278	0.845	

Source: Own analysis (2020), *** significance at 1%

The Wald statistic of age was 14.304 with a negative coefficient (-0.075) that was statistically significant at 1% level. This implies that the rate of adoption for improved breeds among smallholder indigenous poultry farmers decreases as farmers get older. In addition, an increase in age of the IC farmer would reduce the likelihood of using improved breeds in production by a factor of 0.075. This is informed by that older farmers rely on

obsolete and traditional production practices which do not have any significant impact on productivity. This denotes that younger experienced farmers are more likely to adopt improved breeds in production of indigenous poultry compared to older farmers. This prevails since young farmers with a wide range of experience in poultry production understand that use of improved indigenous breeds would increase poultry productivity.

The Wald statistic of IC farming experience (8.155) in indigenous poultry production was highly significant at 1% level and had a positive relation with adoption of improved poultry breed. This entails that farmers who had been in the poultry enterprise for a long period were more likely to engage in use of improved poultry breeds in production unlike newly established farmers. In addition, increase in experience by one year in indigenous poultry production would increase the possibility of embracing improved breeds by a factor of 0.061. This is explicated by the fact that experienced farmers were exposed to more challenges involving poultry breeds thus had a better understanding on the need to use breeds that are highly productive, Furthermore, increase in years of experience among smallholder farmers increased the chances of adopting improved breeds by 1.063 times. This is so since experience provides smallholder farmers with the knowledge and techniques to manage a poultry enterprise which is an essential tool towards achieving a rewarding venture.

Extension services was highly significant at 1% level of probability with a Wald statistic of 17.920. This elucidates that smallholder indigenous poultry farmers who have regular access to extension are more likely to adopt improved breeds in production compared to their colleagues with limited or no access to the respective service. The plausible explanation is that regular contacts with extension agents enable smallholders to access information about modern technologies and ultimately, use them for enhancing adoption and ensuring food security at the household level. The odds ratio of extension services was 5.146 denoting that increased access and provision of extension services, increased the likelihood of embracing improved breeds by 5.146 times among smallholder indigenous poultry farmers in the study area. This is attributed to the aspect that extension contact determines the quality of information that farmers obtain on production activities and the advantages of improved indigenous poultry breeds. The variable displayed a positive

relation with adoption of the respective technology. This suggests that an increase in contact with extension agents by one visit, adoption of improved breeds in the study area would increase by a factor of 1.638. This explicates that extension provided meaningful skills on poultry production to farmers.

In regard to farm size, the Wald statistic was 9.507 with a negative (-0.265) influence on uptake of improved indigenous poultry breeds. This implies that smallholders who have large pieces of land are less likely to embrace improved poultry breeds. In addition, an increase in farm size by one unit reduced the choice of using improved breeds in production by a factor of 0.265. However, the odds ratio of 0.767 means that an increase in the size of farm reduce the likelihood of adopting the respective technology by 0.767 times.

In regard with the type of land tenure, the Wald statistic was 13.787 and statistically significant at 1% level. This designates that farmers who had no security of tenure in land ownership were more expected to take on improved breeds in indigenous poultry production compared to their contemporaries who had guaranteed land ownership. This is possibly due to the fact that smallholders who did not have title deeds were operating on either leased, community or had permission to use the land from their owners. The possible explanation is that adoption of improved breeds enabled them to produce optimally during the period of lease. Land tenure had odds ratio of 3.733 which postulates that an increase in number of smallholders with no title deeds improved the likelihood of adopting modern breeds by 3.733 times. Furthermore, land ownership displayed a positive coefficient (1.317) denoting that by smallholder farmers leasing or utilizing community land led to an increase in use of improved breeds by 1.317 units. This would be attributed to the reason that smallholders intended to recoup their investment costs which would enable them expand and acquire more land for poultry production.

4.5.2.2 Effect of selected factors on adoption of improved poultry housing

Results in Table 4.6 show the influence of selected factors on improved housing practices among smallholder indigenous farmers in Tigania sub-county. Years spent while schooling, access to extension services and income from indigenous chicken were found to influence adoption of good housing practices among respondents.

Table 4. 6: Results of binary logit multiple regression on factors influencing adoption of improved poultry housing

Variable	B	S. E	Wald	Sig.	EXP. (B)	VIF
Age	-.009	.019	0.219	.640	.991	1.14
Experience	.034	.019	3.095	.079	1.035	1.16
Household size	.161	.083	3.747	.0538	1.174	1.33
Education	-.129	.046	7.923	.005**	.879	2.33
Gender	.147	.309	.226	.634	1.158	1.14
Extension	2.020	.254	63.003	.000***	7.536	2.21
Group membership	.805	.562	2.049	.152	2.237	1.36
Contract marketing	-19.31	17.69	0.000	.999	.000	1.38
IC income	.000	.000	4.681	.030**	1.000	1.87
Off farm income	.000	.000	0.927	.336	1.000	1.94
Farm size	.000	.078	0.741	.389	.935	1.38
Land tenure	.297	.299	0.981	.322	1.345	1.15
Constant	-0.392	0.981	0.160	0.689	0.676	

Source: Own analysis (2020), ** significance at 5%, *** significance at 1%

The Wald statistic of number of years spent while schooling was 7.923 and was significant at 5% level. Contrary to expectation, education negatively influenced the decision to engage in modern methods of poultry housing. This indicates that as the number of years of education increased, the willingness of farmers to promote modern housing structures decreased. That is, farmers with less years of education were more likely to embrace modern housing practices unlike farmers with more years of schooling. In addition, a unit increase in years of education reduced the possibility of farmers having modern structures by a factor of 0.129. Besides, as farmers advanced their education, the possibility of enhancing modern housing in poultry production reduced by 0.879 times. This is attributed

to the likelihood of educated farmers to focus on off farm employment to the detriment of investing in indigenous poultry production. As a result of engaging in off farm employment, there is limited time to engage in farm activities and provision of supervision in indigenous poultry farming.

The Wald statistic for access to extension was 63.003 and was highly significant at 1% level. In addition, extension contact among IC farmers influenced the decision to embrace good housing practices positively. This implies that increased contact between farmers and extension agents increased the possibility of farmers to adopt IC production. In addition, increase in extension contact translated to an increase in the farmer's willingness to construct modern structures by a factor of 2.020. Further, farmers with more extension contacts were 7.536 times more likely to adopt to modern ways of constructing poultry houses compared to their counterparts with less extension contact. A possible explanation is that extension equips farmers with adequate and timely information on the importance of proper spacing, ventilation and provision of feeders. This provides a conducive environment for chicken thus reduced disease infestation and promoting the welfare of the scavenging birds.

Income generated from indigenous chicken (IC) displayed a Wald statistic of 4.681 that was statistically significant at 5% level of significance. Further, IC income had a positive effect on adoption of good housing practices. This implies that smallholder farmers with more farm generated income were more likely to adopt modern methods of housing in poultry production. Besides, an increase in IC income resulted to an upsurge in the likelihood of smallholder farmers to embrace improved housing by a factor of one (1). The possible explanation is that with more income farmers had no financial limitation in the construction of spacious and well-ventilated poultry houses. In addition, increased income enabled farmers to timely procure laying nest, feeders and drinkers thus guaranteeing hygiene.

4.5.2.3 Effect of selected factors on adoption of modern disease control methods

From the results in Table 4.7, the respondent's years of schooling and contact with extension agents were found to influence the decision to control poultry diseases among smallholder indigenous poultry farmers.

Table 4. 7: Factors influencing disease control in indigenous poultry production

Variable	B	S. E	Wald	Sig.	EXP. (B)	VIF
Age	-.011	.017	.419	.517	.989	1.077
Experience	.012	.018	.437	.508	1.012	3.832
Household size	.108	.077	1.983	.159	1.114	2.584
Education	-.095	.041	5.371	.020**	.909	1.829
Gender	-.168	.276	.369	.544	.845	3.213
Extension	1.443	.189	58.560	.000***	4.232	1.518
Group membership	-.121	.597	.041	.839	.886	1.113
Contract marketing	-20.199	17.72	.000	.999	.000	1.374
IC income	.000	.000	3.436	.064	1.000	1.652
Off farm income	.000	.000	.102	.749	1.000	2.628
Farm size	-.017	.077	.048	.827	.983	2.261
Land tenure	.389	.275	2.000	.157	1.476	1.077
Constant	-0.472	0.812	0.216	0.895	0.762	

Source: Own analysis (2020), ** significance at 5%, *** significance at 1%

The results (Table 4.7) reveal that, years of education were statistically significant at 1% level and had a Wald statistic of 5.371 with a negative (-0.095) influence on adoption of disease control mechanisms. This implies that contrary to expectations, more educated farmers were less likely to adopt modern disease control methods unlike their counterparts who had little or no formal education. That is, less educated farmers were more receptive to measures of disease control compared to their educated counterparts. Further, increase in years of schooling reduced the possibility of farmers controlling diseases by a factor of 0.095. More educated farmers were 0.909 times less likely to adopt disease control mechanism unlike less educated farmers. The probable justification is that educated farmers abandon farm operations and task other persons to manage the enterprises most likely due to other engagements. In addition, educated farmers could also be uninformed on technological ways of disease control since they may have limited time to consult experts.

Extension contact had a Wald statistic of 58.560 that was highly significant at 1% level. In addition, Extension positively influenced the IC farmers' decision to actively control diseases. This explains that farmers with more extension contacts are more likely to adopt measures of disease control such as vaccination compared with farmers with limited access to the respective service providers. Besides, smallholders with more extension contacts are 4.232 time more likely to embrace disease control mechanisms than farmers with few or no extension access or contact. The possible explanation is extension agents offer important information on the impact of disease on poultry production. Further, farmers apply the knowledge and skills of disease control in their farms thus ensuring reduced losses and increased productivity.

4.5.2.4 Effect of selected factors on adoption of improved poultry feeds

From the results displayed in Table 4.8, farmer experience was statistically significant at 1% level and positively influenced the use of improved feeds in indigenous poultry production. The Wald statistic was 0.019 with more experienced farmers 1.070 times more likely to feed their poultry with modern feeds compared to farmers with few years of

experience. In addition, an increase in experience by one year increases the possibility of farmers using improved feeds by a factor of 0.067.

Table 4.8: Factors influencing use of improved feeds in indigenous poultry production

Variable	B	S. E	Sig.	EXP. (B)	VIF
Age	-.037	.018	.039	.963	3.95
Experience	.067	.019	.000***	1.070	2.33
Household size	.191	.080	.017	1.210	2.35
Education	-.085	.042	.046**	.919	3.40
Gender	-.325	.281	.248	.722	2.34
Extension	.991	.156	.000***	2.695	1.34
Group membership	-1.323	.831	.111	.266	1.90
Contract marketing	-21.199	16.945	.999	.000	1.94
IC income	.000	.000	.002**	1.000	1.87
Off farm income	.000	.000	.331	1.000	1.39
Farm size	-.178	.101	.077	.837	1.34
Land tenure	-.194	.280	.489	.824	1.46
Constant	0.2932	0.168	0.125	0.958	

Source: Own analysis (2020), ** significance at 5%, *** significance at 1%

Years of education had a Wald statistic of 0.046 that was statistically different at 5% level with a negative influence on use of improved feeds. Further, contrary to expectation, more educated farmers were 0.919 times less likely to feed their birds on improved feeds compared to less educated farmers. This implies that as farmers advance their education the likelihood of adopting improved feeds in the production of indigenous poultry reduced. This is so because educated farmers were more engaged in off farm activities with limited

time to learn more on poultry feeds. This could have resulted to the assumption that indigenous poultry production was a preserve for the less educated thus the neglect by learned respondents.

The Wald statistic for extension contacts was 0.156 and was significant at 1% level. Extension had a positive influence with farmers that had more extension agents 2.695 times more likely to use improved feeds compared to their counterparts with limited extension contact. The coefficient for extension indicates an increase in number of extension contacts improved the decision to use modern feeding mechanisms by a factor of 0.991. This is because extension has been found to provide important information on the composition of poultry feeds and procedures for the computation of homemade rations. Concerning income from indigenous chicken farming, the coefficient was positive with a slight influence on use of modern and high-quality poultry feeds. Farmers with more income were highly empowered to timely procure better feeds for their poultry birds compared to farmers with limited income from indigenous poultry farming. This is explicated by the fact that with more income, farmers are endowed to procure ingredients that are required to prepare feed computations that are of balanced diets. In addition, more income enables farmers to afford commercially manufactured feeds and supplements that increase indigenous poultry production thus guaranteed returns for smallholder farmers.

4.6 Assessment of indigenous chicken production among smallholder farmers

4.6.1 Descriptive analysis of poultry production and input use

Table 4.9 shows descriptive statistics on inputs and poultry products in indigenous chicken production among smallholder farmers in Tigania West Sub-county. The results in Table 4.9 clarify that respondents had a flock size that averaged 30 birds with the highest flock being 395 birds while majority kept only 35 birds per year. Besides, the annual egg production averaged 628 eggs with majority recording 500 eggs whereas the maximum egg yield recorded among smallholders in the study area was 7,500 eggs. From the results, respondents apportioned an average of Ksh 9,496 of credit in indigenous poultry production with majority allocating Ksh 4,000 for poultry production ranging from Ksh 200 to Ksh 200,000. This implies that smallholder farmers were able to timely procure key

inputs required in poultry production and adopt modern production techniques since they were financially empowered. Additionally, the manpower involved in poultry activities annually averaged at 124-man days with majority employing 94-man days ranging from 57 to 436-man days. This explains that indigenous poultry production is a labor- intensive endeavor with the high availability of manpower attributed to existence of large household sizes among respondents.

Table 4. 9: Descriptive analysis of indigenous chicken production

Variable	Mean	Mode	Min	Max	Standard deviation
Poultry production					
Eggs	628	500	0	7500	760
Indigenous birds	30	35	0	395	37.93
Input use					
Credit (Ksh)	9496.77	4000	200	200000	20597.073
Land size (Acres)	0.176	0.10	0.001	2.0	0.17
Labor (Man-days)	124	94	57	436	60.62
Feeds (Ksh)	24	20	10	71	7.29
Vaccination (Ksh)	7	6	1	9	2.22

Land under poultry production ranged from 0.001 to 2 acres with majority recording a land size of 0.1 acres and the average land size among respondents was 0.176 acres. A possible explanation is that agricultural farms in the study area were highly fragmented possibly due to increased population growth and due to competition resulting from the need by farmers to practice crop diversification in the study area.

In regard to poultry feeds, farmers incurred an average of Ksh 24 to feed their birds during the study period which oscillated between Ksh 10 and Ksh 71 with majority having an expenditure of Ksh 20 on feeds per bird annually. The low expenditure on feeds was attributed to the fact that majority of the farmers fed their birds on kitchen leftovers given the high costs of commercial feeds and ingredients required in the formulation of home-

made rations. The expenditure on vaccination in the study area averaged Ksh 7 per bird annually with most of the farmers spending approximately Ksh 6 to control common poultry diseases such as Newcastle and fowl pox. The cost ranged from Ksh 1 to Ksh 9 depending with the rate of disease infestation among respondents.

4.6.2 Input-output relationship

Agricultural production entails the conversion of inputs into outputs. In indigenous poultry production among respondents in the study area, poultry output comprised the birds and eggs. The total output among smallholder farmers was arrived at through a combination of eggs and birds by converting them into monetary value using the prevailing product prices. To achieve an appropriate explanation involving indigenous poultry production, inputs and outputs were converted into log form thus facilitating the use of the Cobb Douglas (CD) production function. In relating output to inputs and selected factors, a single step multiple regression analysis was conducted with the total value of poultry output as a dependent variable against log of inputs, social-economic and institutional factors. The estimated coefficients and related statistics of the Cobb-Douglas production functions are presented in Table 4.10.

From the results given in Table 4.10, the coefficient of multiple determination was 0.826 denoting that 82.6% of the variation in poultry production was explained by the explanatory variables included in the model. In addition, the remaining 17.4% was accounted for by the error term and variables not considered in the model. The results revealed an F-value of 95.97 which was highly significant at 1% level signifying that all variables in the model were paramount in explaining the variation of indigenous poultry production.

The study revealed that farmers were operating under the constant return to scale. That is, production would increase by the same proportional change if all factors of production are changing. The return to scale of 1.0 shows that if all factors of production are doubled, poultry production will also exactly double. Besides, it is still possible for the smallholder farmers to enjoy economies of scale while experiencing constant returns to scale, since

they may experience bulk buying economies (purchasing larger quantities of inputs lowering their cost per unit) financial and marketing economies.

The regression coefficient of the amount of financial credit apportioned for indigenous chicken production was positive and statistically significant at 1% level. The positive relation implies that indigenous poultry production can be increased by increasing monetary allocations. In addition, a 1% increase in amount of credit used in production would increase indigenous poultry total proceeds by 0.29% among smallholder farmers in the study area. The coefficient of human labor employed in indigenous poultry production was negative and insignificant.

Table 4. 10: Result of Cobb Douglas multiple regression analysis on the effect of farm inputs on poultry production

Variable	Parameter	Coefficient	St. Error	z	P>/z/
Constant	β_0	6.472129	.6013218	10.76	0.000***
Credit	β_1	.2989679	.0396618	7.54	0.000***
Labor	β_2	-.0954435	.1317903	-0.72	0.469
Land	β_3	.0810764	.0501495	1.62	0.106
Feeds	β_4	.3764175	.1463357	2.57	0.010**
Vaccines	β_5	.3577402	.089883	3.98	0.000***
R^2		0.826			
Return to scale		1.0			
F-value		95.97***			

*** significance at 1%, ** significance at 5%

In regards to expenditure on feeds, the coefficient was positive and significant at 5% level. This implies that increased availability of feeds among smallholder farmers would increase poultry production. The results show that 1% increase in the expenditure on feeds, keeping other factors constant, would increase returns by 0.38%. The expenditure on vaccination had a positive coefficient that was significant at 1% level. This implies that production and productivity would increase by ensuring regular treatment of indigenous chicken. Further, 1% increase in the expenditure on vaccination and treatment would increase total revenue

in indigenous poultry production by approximately 0.36% among smallholder indigenous chicken farmers.

4.6.3 Effect of selected factors on indigenous chicken production

Indigenous poultry production is not only affected by factors of production but is also affected by social, economic, demographic and institutional factors. The selected factors were included in the Cobb Douglas production function and the model analyzed in a single step other than a two-step procedure. This is because the single step generates estimates which are not biased compared to the two-step method. Results of the analysis of selected factors influencing indigenous poultry production are displayed in Table 4.11.

Table 4. 11: Results of Cobb Douglas multiple regression on effect of selected socio-economic factors on poultry production

Variables	Coefficient	Std. Error	t-value	P>/t/	VIF
Age	0.0035	0.0259	0.776	0.438	1.052
Education	0.0949	0.0649	1.463	0.145	1.932
Gender	0.1969	0.0966	2.040	0.042**	1.211
Experience	0.0589	0.0861	0.686	0.493	1.986
Off farm income	0.3694	0.1362	2.715	0.005**	1.646
Improved feeds	0.2819	0.2560	2.543	0.001***	1.667
Improved housing	0.0985	0.0255	1.364	0.154	1.053
Disease control measures	0.0598	0.0756	0.675	0.495	1.892
Improved breed	0.2519	0.1623	2.062	0.043**	1.732
Market access	0.0120	0.0098	1.223	0.222	1.092
Household size	0.0374	0.0266	1.409	0.159	1.095
Group membership	-0.1741	0.1974	-0.882	0.378	2.689
Extension contacts	0.0944	0.0504	1.874	0.062*	2.702
Flock size	0.0143	0.0022	6.757	0.000***	1.153
Type of land ownership	0.0391	0.0949	0.413	0.680	1.036
Land size	-0.1451	0.0277	-5.244	0.000***	1.052
Constant	0.345	0.0065	2.232	0.526	

Source: Own analysis (2020) *significance at 10%, ** significance at 5%, *** significance at 1%

From the results, gender of the farmer had a positive coefficient and was significant at 5% level. This implies that being a male farmer in indigenous chicken production would lead to an increase in poultry production. Being a male farmer in poultry production would increase poultry production by 19.69%. This is possibly due to the ability of male farmers to easily access credits by using land titles as collateral. In addition, male farmers engage less in domestic chores allowing them adequate time to engage in poultry production.

The coefficient of off-farm employment was 0.3694, indicating that 1% increase in off-farm income led to an increase in poultry production by 0.37%. This is possibly because income generated from off-farm activities increases the working capital at farm level thus enabling farmers to timely procure inputs and adopt modern production innovations leading to higher yields and returns.

Besides, use of improved poultry feeds had a significant influence on production with a positive coefficient of 0.2819. This result signifies those farmers who embraced commercial feeds and quality homemade rations recorded higher levels of production compared to their counterparts failed to compliment scavenging poultry birds. In regards to adoption of improved poultry breeds the coefficient was positive (0.2519) and differed significantly at 5 percent level of probability. The result shows that farmers who embraced modern breeds recorded higher levels of poultry production.

Flock size had a positive coefficient that was significant at 1% level. A 1% increase in flock size increased poultry production by 0.0143%. farmers with large flocks were more likely to generate higher returns from indigenous chicken than their counterparts with small flocks.

The coefficient of land size was negative and significant at 1% level. This implies that 1% increase in land size reduced IC production by 0.1451%. This is possibly because farmers with large chunks of land engaged in mixed farming and apportioned their time and resources in the production of different enterprises. This reduced their potential to achieve production efficiency in poultry production since much concentration could have been allocated on other enterprises other than indigenous chicken.

Contact with extension agents was significant at 10% level of probability with a positive relation to poultry production. This indicates that farmers who had more access to extension contacts had higher poultry production compared to their counterparts with few extension contacts. An increase in extension visit would increase indigenous chicken production by 0.944%. This is because extension educates farmers on good production practices such as disease control measures, modern innovations and market information. Through these knowledge farmers are able to ensure reduced bird mortality, maintains good health for the indigenous chickens leading to increased high-quality products that command better market prices hence more returns.

4.7 Market participation among indigenous chicken farmers

4.7.1 Rate of market participation

Results depicted in Table 4.12 displays a summary of the proportion of indigenous chicken marketed among respondents. The proportion was achieved as the ratio of the value of chicken sold to the total value of chicken kept by the farmer in a period of one year. The results in Table 4.12 revealed an average chicken sale of 38.3% among indigenous poultry farmers in Tigania West. This explains that by mitigating the effects of constraints encountered in poultry markets, smallholder farmers in the study area would increase indigenous chicken sales by more than 60%.

Table 4. 12: The results of descriptive analysis of farmer participation in indigenous chicken markets

Chicken sales category	Frequency	Percentage	Cum. Percentage
0 to 0.25	85	23.7	23.7
0.25 to 0.50	192	53.5	77.2
0.50 to 0.75	67	18.7	95.8
0.75 to 1	15	4.2	100.0
Mean sales		0.383	
Min		0.0051	
Max		0.977	
Standard deviation		0.186	

The standard deviation of chicken sales was 0.186 implying that on ordinarily, the deviation of chicken sales from the mean was 18.6% while the proportion of sales ranged from 0.51% to 99.7%. This explains that inefficiencies existed in poultry markets leading to huge disparity in poultry sales. In addition, 77.2% of the respondents had chicken sales below 50% denoting that if sales increased, about 77.2% of the smallholder indigenous poultry farmers in Tigania West would manage to market more than 50% of their indigenous poultry flocks.

In regard to egg sales, the descriptive analysis was computed as a ratio of the value of eggs sold to the total value of eggs produced by respondents annually. Results in Table 4.13 indicates that on average farmers marketed 47.71% of eggs produced. This elucidates that by reducing marketing challenges encountered in the sale of eggs, respondents would increase sales by more than 50%. Further, the results show that 68.3% of the farmers' market less than 50% of their eggs. This indicates that enhanced market efficiency in the study area would enable majority of the respondents to efficiently market more than half of their indigenous eggs. On average, farmers were 26.67% more likely to achieve the average rate of marketing indigenous eggs whereas sales ranged from 3.63% to 77%.

Table 4. 13: Descriptive analysis of indigenous egg sales

Indigenous egg sales	Frequency	Percentage	Cum. Percentage
0 to 0.25	95	26.5	26.5
0.25 to 0.50	150	41.8	68.3
0.50 to 0.75	75	20.8	89.1
0.75 to 1	39	10.9	100
Mean sales		0.4771	
Minimum		0.0363	
Maximum		0.77	
Standard deviation		0.2667	

4.7.2 Factors influencing market participation of indigenous chicken

The results highlighted in Table 4.14 show characteristics that influence smallholder farmers' participation in indigenous poultry markets. To achieve the third objective, Heckman two stage selection model was employed in the analysis where the first stage is a probit model with a binary categorical variable.

The model was fitted with 16 variables out of which 8 were significant. Age, household size, average price and volume of quantity produced were significant at 1% level. Years of education, market distance and extension contact were significant at 5% while number of years in poultry farming was significant at 10% level. The chi square statistic was significant at 1% level. This clarifies that all the significant marginal effects displayed in the model were not equal to zero and that the model demonstrated a high illustrative power. The variables in the model assumed positive and negative signs. All the directions of the variables were as predicted apart from age which assumed negative signs contrary to the predicted positive effects.

Table 4. 14: The results of first stage probit model results on factors influencing market participation

Variables	Coefficient	Std. Error	p>/z/
Age (Years)	-.025	.006	.000***
Gender (0=female, 1=Male)	.098	.091	.323
Education (Years)	.041	.063	.023**
Experience (Years)	.016	.006	.052*
Household size (Number)	.078	.026	.001***
IC income (, 000 Ksh)	1.8186E-7	2.8789E-7	.527
Off farm income (, 000 Ksh)	-7.3557-7	5.0232E-7	.143
Land size (Ha)	-.332	.319	.298
IC credit quantity (, 000 Ksh)	8.281E-7	4.3704E-7	.850
Market distance (KMs)	-.015	.011	.009**
Training distance (KMs)	.895	0.81	.523
Extension contacts (Number of visits)	.267	.098	.005**
Group membership (Number of groups)	.060	.207	.735
Average price (Ksh)	.002	.001	.001***
Flock size (Number of birds)	.001	.002	.546
Volume of poultry products (Quantity)	.546	.035	.000***

*significance at 10%, ** significance at 5% and *** significance at 1%

The results show that age of the farmers had a negative effect on market participation and was significant at 1% level of probability. This implies that as farmers advance in age, their willingness to participate in indigenous poultry markets diminishes, that is, a unit increase in age of the household head impacts the decision to participate negatively. A possible explanation is that older household heads are risk averse and choose to engage buyers at farm level unlike younger household heads who may be willing to explore various markets.

Education had a positive marginal effect and significant at 5% level. This signifies that household heads with more years of schooling were more likely to participate in indigenous poultry markets. This is because highly educated farmers have better and more market opportunities owing to their informed communication skills. The marginal effect of education level was 0.041 implying that a unit increase in education by one year among the household head would increase the probability to participate by 4.1%.

In regard to the number of years a farmer had engaged in indigenous poultry production, the marginal effect was positive and significant. A possible explanation is that more experienced farmers were more likely to involve in market activities since they hand firsthand information on market trends. In addition, experienced farmers understood the responsiveness of market forces and had the ability to endure market fluctuations. The marginal effect was 0.016 meaning that a unit increase in experience, would increase the probability of entering indigenous poultry markets by 1.6%. The size of the household portrayed a positive relation with market participation at 1% level. The direct connection shows that large households had a greater potential to participate in markets compared to small households. This is possibly due to that members of large households desired to maximize returns from poultry sales to sustain their livelihoods. A unit increase in household size would increase the possibility to participate in poultry markets by 7.8%.

Household heads located closer to the markets had higher possibilities to participate in markets compared to their colleagues located far from the markets. This elucidates that market proximity encouraged farmers to sell more poultry products because of marketing costs. The marginal effect was negative and significant at 1% level. This denotes that a unit increase in market distance reduced the possibility of participation, while a unit decrease in market distance increased the willingness to engage in markets by 1.5%. Increased access to extension agents improved the likelihood of farmers to market poultry products. Extension agents inform farmers on prevailing market trends and educate them on ways to mitigate the effects of market fluctuations and uncertainties. Farmers with increased access to extension services are more likely to engage in poultry markets with an extra visit increasing the probability by 26.7%.

Besides, price influenced market participation positively and was significant at 1% level. This infers that markets that offer lucrative prices attract more participants compared to markets that offer lower prices, that is, better prices influence the decision to participate in indigenous poultry markets positively. This is because higher prices would increase the value of poultry products thus increased returns. Further, the availability of price information prior to selling reduces transaction costs and thus increases the quantity sold. This informed market participation based on whether households would meet their overhead and transaction costs.

In regard to poultry products produced annually, the marginal effect was positive and significant at 1% level. This implies that a unit increase in the yield of poultry products would increase the possibility of smallholder farmers to participate in indigenous poultry markets by 0.546%. Increased yield resulted from improved production efficiency thus enabling smallholder farmers engage in various markets in different nodes. This was ascribed to reduced costs thus enabling farmers derive the benefits of economies of scale.

4.7.3 Factors influencing intensity of market participation among smallholders

The results of the second stage OLS regression model on factors affecting the intensity of market participation are presented in Table 4.15. The intensity of market participation was measured as a proportion of the marketed poultry products against the total value of poultry products produced per annum. The marginal effect of the Inverse Mills Ration (IMR) was positive and significant at 5% level. The IMR being significant shows that the data set was not biased in selection thus Heckman two-step was the most appropriate model due to its ability to handle selection problem. This upholds the assumption of Heckman two stage model regarding correlation of the error term of selection and outcome equations. This consistency entwined with the notion that an accurate IMR was generated eliminates partiality in interpretation. From the results, extension contacts and volume of poultry products produced were significant at 1% level. Education and quantity of credit on IC were significant at 5% level while group membership was significant at 10% level.

Table 4. 15: Results of the second stage OLS regression model on factors influencing the intensity of market participation

Variable	Coefficient	P>/t/
Gender (0=female,1=male)	-778.954	.691
Household size (Number)	-82.580	.872
Age (Years)	24.562	.829
Education (Years)	3765.555	.004**
IC income (,000 Kes)	0.002435	.641
Off farm income (,000 Kes)	0.001595	.870
Experience (Years)	53.003	.669
Land size (Ha)	16.107	.998
Group membership (Number of groups)	6824.207	.080*
Extension contacts (Number of visits)	3223.998	.000***
IC credit quantity (,000 Kes)	0.021	.020**
Market distance (KMs)	-256.356	.286
Volume of poultry products (Quantity)	436.157	.000***
IMR	2240.5	0.023**
Prob>F=0.000, R2=0.392		

***, ** and * indicate significance at 1%, 5% and 10% levels of significance

In regard to years of schooling among household heads, the marginal effect was positive. This infers that farmers with higher education achievements recorded more sales compared to their counterparts with few years in formal education. Increased literacy levels enable farmers to timely acquire price information before sales. This empowers farmers to make informed market choices thus the ability to maximize returns. The positive regression parameter implies that an extra year spent in education increased poultry sales by Kes 3765 among smallholder farmers. A possible explanation is that educated farmers have

knowledge and skills to embrace value addition techniques on poultry products which command higher market prices.

Being a member of organized groups was significant and positively influenced the intensity of market participation at 10% level. Group membership permits collective marketing and reduces transaction costs in the transportation of poultry products. It also increases access to information such as production techniques, available markets and expands farmers' bargaining power. By farmers engaging in one more social group, market intensity among smallholder poultry farmers increased sales by about Kes 6824.

Number of extension contacts had a positive impact on the intensity of market participation and significant at 1% level. Extension informs on the trends of both input and output markets thus educates famers on markets that offer better prices. In addition, extension equips farmers with the ability to predict market uncertainties resulting from the forces of demand and supply. Increased number of extension visits, increases the value of marketed poultry products by Kes 3224.

Access to formal credits related positively with the intensity of market participation and significant at 5% level. Access to credit enables producers to increase the quantity of inputs and other productive assets acquired such as fertilizer, seed and ploughs. This increases poultry production and the marketable surplus among respondents. The regression parameter implies that an increase in financial credit by Kes 1000, the value of marketed products would increase by Kes 21 per unit.

The volume of quantity produced influenced intensity of participation positively and was significant at 1% level. Increased output enabled farmers enter in different markets at low costs due to benefits of economies of scale. This implies that increasing the quantity produced, market participation improved thus more marketable surplus. Quantity produced is critical for semi-commercial farmers who need to first meet home consumption and only sell the surplus. The marginal effect explains that 1% increase in quantity would increase the value of marketed output by Kes 437 per unit.

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Socioeconomic and institutional factors affecting technology adoption

Section 4.5.2 shows results of the binary logistics regression model. The model was applied to examine factors that influence adoption of technology among smallholder indigenous poultry farmers. Four technology aspects were considered namely; improved poultry breeds (breeding), improved poultry housing structures (slated floor/deep litter), disease control (vaccination) measures and use of improved feeds (homemade rations/commercial feeds). The technology parameters were independently regressed against twelve (12) selected factors which signified varying degree of significance.

From the results, age had a negative relation with adoption of improved breeds. The coefficient (-0.075) was significant at 1 percent level of probability implying that as the respondents advanced in age, the use of improved breeds in indigenous poultry production diminished. A reasonable explanation is that aged farmers are less likely to adopt technologies in indigenous poultry farming compared to young farmers. In addition, the results clarify that adopters of technologies that involved better breeds among respondents were younger than non-adopters. This shows that majority of young farmers in the study area were well-informed thus understood the importance of technology investment in agricultural production. This result coincided with the findings of Salifu and Salifu (2015) and Folefack, Tsafack and Kamajou (2018). However, the results negated the results of Miassi and Dossa (2018) who reported a positive relationship between age and adoption. The researchers reasoned that aged producers were more likely to embrace modern techniques in agriculture since they acquire knowledge and experience that makes them receptive to innovations.

Household size had a positive affiliation with technology adoption. The coefficient positively connected to use of improved poultry breeds. The coefficient was positive 0.406 and differed significantly at 1 percent level denoting that a unit increase in household size increased embrace of improved breeds by 40.6 percent. This clarifies that as household

expands, the likelihood of adopting technologies in the study area increased. A plausible explanation is that every member is a potential source of labour thus enabled cost saving in the farm. In addition, this shows that smallholders in large families had a greater potential to adopt improved breeds compared to their counterparts with small families. The result was in line with Salau *et al*. (2017) but differed with Derbe, Yehuala and Agitew (2018) who found a negative relation between family size and technology adoption. The researcher argued that among smallholders, it is impossible to separate family and farm resources thus hindering decisions to improve productivity through modern innovations.

The significant connection of experience and technology adoption was an interesting result. Experience showed a positive relation on adoption of improved breeds and use of improved feeds in indigenous poultry production at 1 percent level. This implies that one more year in indigenous poultry production would increase use of improved breeds and feeds in the study area by 6.1percent and 6.7 percent respectively. Mwangi *et al*. (2020) debated that experience equips farmers with necessary knowledge, skills and understanding enabling smallholders gain management aptitudes which are essential in achieving a profitable enterprise. A possible explanation is that more experienced farmers have higher chances of embracing technologies. These results were similar to those of Bhagyamma and Bhat (2019) and Ullah *et al.* (2018). However, the results differed with the studies of Folefack *et al*. (2018) and Laosutsan, Shivakoti and Soni (2019) who reported that more experienced farmers are less likely to embrace technologies.

Farm size had a negative (-0.265) coefficient that differed significantly at 1 percent level of probability. This explain that smallholder farmers with large chunks of land were less likely to embrace use of improved poultry breeds compared to their compatriots with small farms. This is possibly due to the fact that farmers with large farms engaged in diversification which is an aspect aimed that reducing the risk of losses. This shows that land fragmentation among individual farmers would discourage uptake of emerging innovations. In addition, respondents with large farms may have leased part of their farms due to resource limitations. Additionally, since indigenous poultry birds are scavengers, large pieces of land would help sustain their feeds with technologies improving their wellbeing. Further, smallholders may have limited management aptitude to govern large

farms which has been explained by Mathiu *et al.* (2021) and Ambetsa *et al*. (2020) as a major source of inefficiency in agriculture. The result was in line with Laosutsan *et al*. (2019) but negated the findings by Bhagyamma and Bhat (2019), Ntshangase *et al*. (2018). These researchers explained that farmers with large pieces of land were associated with the possibility to adopt existing technologies.

Adoption of technology among smallholder farmers in the study was directly and significantly dependent on the level of income derived from indigenous poultry farming. The connection displayed a positive connection with use of improved feeds and improved housing structures. This implies that farmers with high income were able to timely procure modern poultry structures and engage in bulk purchase of improved poultry feeds thus benefiting from the economies of scale. Further, it is assumed that farmers with high income could use their supplementary returns to invest in expansion of poultry production unlike those with low income who have limited capital. Wealthier poultry farmers can procure technologies that improve agricultural practices thus enhancing productivity and ensuring food security. This argument coincided with that of Tefera, Lagat and Bett (2014).

Contact with extension agents signified a positive and significant relationship with adoption of improved feeds, improved housing structures, disease control and improved feeds. This implies that farmers with more extension contacts were more likely to adopt indigenous poultry production technologies compared to their counterparts who had little or no contact with experts. From the results, an extra contact with extension experts increased the used of improved breeds, better housing structures and disease control measures by more than a hundred percent while the use of improved breeds increased by 99.1 percent. The plausible explanation is that increased accessibility in extension and training educated farmers on emerging production innovations and their benefits Ullah *et al*. (2018). In addition, extension demonstrates efficient use of technologies thus equipping farmers the expertise necessary in increasing productivity. The result is consistent with the studies of Mmbando and Baiyegunhi (2016), Danso-Abboam *et al*. (2017) and Ingabire *et al*. (2018) who reported direct affiliations of extension training and adoption of modern innovations.

In regard to level of education, the relation was negative with respect to the poultry house structure, disease control and use of improved feeds. This implies that an extra level of education earned by the household head, technology adoption in regard to structure, disease control and use of feeds reduced by a factor of 0.129,0.095 and 0.085 respectively. A plausible explanation is that educated farmers concentrated more on research with limited time allocated for farm management. The negative affiliation between education and technology adoption was contrary to prior anticipations and were in line with the findings of Ntshangase *et al*. (2018) but negated the findings of Ambetsa *et al*. (2020) who explained that education enhances skills and ability of farmers to better utilize market information.

Land tenure was significantly affiliated to technology adoption and differed significantly at 1 percent level of probability. The coefficient was positive implying that by farmers having land possession, the uptake of improved indigenous poultry breeds increased by more than a hundred percent. A possible explanation is that land tenure gives farmers the guarantee to invest and embrace modern innovations that promote productivity and production. In addition, possession of a title deed enabled farmers to easily acquire financial credits thus enabling smallholders to timely purchase necessary inputs. These results were in agreement with the findings of Salau *et al*. (2017) and Ingabire *et al*. (2018) but disagreed with a study by Folefack *et al*. (2018) who reported a negative connection of land ownership and technology adoption.

5.1.2 The Stochastic Cobb Douglas input-output relationship

Table 4.10 displays results of the input output relationship derived from the Cobb Douglas production function. The parameter coefficients of all inputs in the production function were positive with the exception if labour employed. The coefficients of amount of credit used in indigenous poultry, feed quantity and frequency of vaccination were significant. Further, land under indigenous poultry production and labour employed were found to have insignificant coefficients.

From the results of the study, a unit increase in amount of credit apportioned in poultry production would increase yield by a factor of 0.298. This explicates that more credits apportioned for indigenous poultry production enables smallholder farmers increase

output. A reasonable justification is that credit empowers farmers giving them a competitive advantage to timely acquire technologies and production resources as explained by Narcisse (2017). Application of vaccines influenced production and was significant at 1 percent level of probability. This implies by increasing the frequency of vaccination, poultry output would increase by a factor of 0.358. A reasonable justification is that vaccination plays a vital role in controlling acute diseases that increases mortality rates for birds in the farm. Therefore, continued application of vaccines to indigenous poultry improved the probability of increasing production a result that was in agreement with a study by Ogolla (2016). The quantity of feeds used in indigenous poultry production were significant at 5 percent level of probability. The results explained that by increasing feeds by one kilogram, poultry yield would increase by 37.6 percent. A possible explanation is that improved feeds had the necessary nutrient composition thus tremendously increased poultry output thus deriving more benefits from economies of scale. This enabled farmer to increase output per unit of input at least cost. This can also be interpreted as that a unit increase in feed quantity improves the possibility of smallholders' increase production thus enhanced farm incomes as explained by Tabe and Molua (2017) and Dessale (2019).

5.1.3 Influence of selected factors on indigenous poultry productivity

Table 4.11 shows the results of the selected factors that influence indigenous poultry productivity in Meru County. The results derived from one step Cobb Douglas production function reported that six (6) factors significantly influenced indigenous poultry production levels. These factors were namely; Gender of the respondent, off farm income, technology adoption, access to extension services, flock size and land size.

Gender of the respondents had a positive affiliation to indigenous poultry productivity. The coefficient was positive (0.1969) and differed significantly at 5 percent level of probability. This justifies that as gender of the respondents' increases from female to male, poultry productivity increased by 19.69 percent. A possible justification is that male farmers were more likely to adopt modern innovations in poultry production as compared to female farmers. In addition, the poultry enterprise offers better returns which enables men to meet

other family needs such as school fees, health and construction. The results coincided with the findings of Salau *et al*. (2017) and Ingabire *et al*. (2018) but drew a discrepancy with the results of a study by Ntshangase, Muroyiwa and Sibanda (2018) who reported that gender had a negative influence on productivity among smallholder producers.

Interestingly, the coefficient of off farm income was positive and significant at 5 percent level of probability. This implies that farmers who earned more income from non-farm activities were more productive in indigenous poultry than those who had no income from non-farm activities. These results upheld those of Wabomba (2015), Shettima, Amaza, and Iheanacho (2015), Abate, Dessie and Mekie (2019). The explication of this impression is that off farm employment empowered poultry farmers to timely procure inputs by ensuring a consistent flow of income and eliminating financial constraints (Ambrose, Lokina, & Hepelwa, 2018). Conversely, Ndirangu *et al* (2018) explained that off farm employment had a negative influence on levels of productivity. The researchers claimed that the involvement of farmers in off farm occupations reduced the time and resources devoted to the farm operations hence low productivity.

Further, the results reported that adoption of improved feeds was positively connected with indigenous poultry productivity at 1 percent level of significance. The results clarify that by farmers using high quality feeds would increase poultry production by 28.19 percent. Additionally, embrace of improved breeds was positively related to production of indigenous chicken at 5 percent level of probability. That is, by farmers introducing improved breeds in the production of indigenous chicken would increase production by 25.19 percent. A reasonable justification is that appropriate adoption of technology (improved poultry breeds and feeds) enables smallholder farmers to produce more with a given level of resources. Besides, farmers are able to produce same quantity of output with few resources. The findings were consistent with the results of Ntabakirabose (2017) who observed that producers who use modern innovations had higher levels of productivity.

Land size had a negative and significant coefficient at 1 percent level of probability. This explains that farmers who had allocated small portions of land for poultry production recorded high output levels compared to their counterparts who had huge land sizes. This

was attributed to the involvement of hired labor which offers high productivity and the desires of farmers with small farms to maximize production since they may have foregone other crops with poultry production. The result agreed with the finding of Folorunso and Adenuga (2013) and Dessale (2019) but negated the results presented by Chepng'etich *et al*. (2015) who found a direct relationship between land size and production efficiency. The researcher reasoned that as the farm size increases, the of farmer's managerial ability increases leading to reduced production efficacy given the level of technology.

The flock size among respondents was directly affiliated with indigenous poultry productivity and significantly different at 1 percent level. This elucidates that farmers who had huge stocks of indigenous poultry were more productive compared to their counterparts with fewer birds. This is justifiable by that huge flocks increased the availability of poultry products and given the market demand for poultry products farmers were able to achieve better prices hence high income. Further, a huge flock demanded that farmers purchase inputs such as feeds, vaccines and other essentials in bulk hence low factor costs thus benefiting from the economies of scale. These results were consistent with the findings of Dessale (2019), Mohamed *et al* (2018). On the contrary, the result disagreed with Mohamed *et al* (2018) who expounded that a huge flock size increased the costs involved in poultry management thus lowering farm productivity.

In regard to contact with extension agents, the coefficient was positive and differed significantly at 10 percent level. This implies that as access to extension increases, indigenous poultry production among smallholder farmers in the study area improved. These results coincided with the findings of Dessale, (2019) who found that extension and training in agriculture had a positive and significant impact on technical knowledge which equips farmers with technical skills and practical knowledge in adoption of improved technologies hence increasing yield. Further, increased contact with extension agents showed that the level of productivity among smallholder farmers in the study area increased. This result agreed with Ndirangu *et al*. (2018) who concluded that with increased extension services farmers had better knowledge in agricultural production.

5.1.4 Factors affecting participation in indigenous poultry markets

The results of the study reveal the factors that influence the probability of market participation among smallholder indigenous poultry farmers in Tigania west. The model was fitted with 16 factors out of which 8 were found to significantly influence market participation as discussed below.

Age of the household head was significant and negatively related to market participation. This implies that as age of the household head increases, they are less likely to decide on participating in indigenous poultry markets. This could be attributed to the notion that older households head tends to be risk averse, than younger household heads. This clarified that the aged population found it difficult to sell their products to markets relatively due to long distances to the nearest markets. Further, these people did not have means of transportation to move poultry products to markets hence opted to wait for buyers at village level or farm unlike younger household heads who may travel to towns to sell their commodity (Lynette, 2016). Additionally, aged household heads have limited access to market information; whereas younger household heads could sell a relatively large portion of their product through a better access to price information (Moono, 2015). The result was similar to an argument by Ayieko, Bett and Kabuage (2015) who reported a negative relationship between age and market participation of indigenous poultry producers in Makueni County.

The level of education for the household head positively influenced the decision to participate in indigenous poultry markets at 5 percent level of significance. This signifies that respondents with high education achievements had a higher probability to engage in indigenous poultry markets than their counterparts who had low education. This is probably due to increased ability to solicit information and acquire connections beyond their rural areas. In addition, educated farmers have an understanding with communities due to better communication skills thus the ability to create a good rapport. These aspects lower the fixed transaction costs. In addition, literate farmers have a higher uptake of recommended agricultural practices due to better understanding thereby increasing marketable output. These contradicts earlier results by Moono (2015) but concurs with Mirembe (2018).

In regard to experience in poultry markets, results portrayed a positive relation with the resolution to participate in poultry markets. This implies that an additional year of marketing poultry products increased the possibility to engage in indigenous poultry sales in the study area. A reasonable explanation is that more years of experience gives producers an advantage in dealing with market activities thus increasing their bargaining power. Further, these enables farmers to possess the ability to predict market fluctuations. Additionally, experience enables smallholder farmers understand market dynamics which helps them improve decisions on the quantity of farm produce to be sold. In line with this finding, Lifeyo (2017) reported that farmers' increased years of experience resulted in an increase in the amount of agricultural output supplied in Malawi markets. In addition, Abeykoon, Weerahewa and Silva (2013) noted that increased years of experience enables producers make informed decisions and efficiently establish trading networks.

Household size expressed a positive relationship with participation in indigenous poultry markets and was significant at 1 percent level. This infers that as the size of the household increases by one member, the chances of participating in indigenous poultry markets in Meru County increased by 7.8 percent. The plausible description is that since poultry production is labour intensive, large households would provide adequate labour required in poultry production. The result was in line with Lynette (2016) but drew a discrepancy with the study of Boniphace, Fengying and Chen (2014).

Proximity from the farm to the nearest market was significant at 5 percent level and negatively influenced market participation. This implies that increase in distance from farm to market by one-kilometer reduced market participation by 1.7 percent.

This is probably because households closer to markets have better information access, reduced transport costs and shorter walking time. Therefore, farmers further away from market places will be less willing to engage in poultry marketing unlike their counterparts nearer the markets. The finding agreed with the studies of Gebremedhin *et al*. (2015) and Sebatta *et al*. (2014) but differed with Moono (2015.

Contact with extension agents showed a positive relationship with market participation. This implies that farmers who received extension were more likely to engage in indigenous

poultry markets compared to their colleagues who had no extension contact. These results explain that by farmers accessing extension services the possibility of participating in markets increased by 26.7 percent. A possible justification is that extension educate farmers on modern innovations that increase productivity. Further, extension provides information regarding both input and output markets thus enabling farmers access important facilities such as technologies and veterinary services. The results concurred with previous studies of Apind *et al*. (2015) and Gebremedhin *et al*. (2015).

Products price influenced market participation positively at 1 percent level of significance. Price is an important element deciding whether to enter the market because producers will only enter a market at a particular threshold when they are able to cover the transaction costs Apind *et al*. (2015). The results show that a unit increase in demand price increased the possibility of market participation by about 2 percent. This result is in line with economic theory that price influences supply and demand. Mirembe (2018) argued that the unit price acts as an incentive by significantly increasing the percentage of products sold in both rural and peri-urban areas of Kenya. On the contrary, Moono (2015) proved that price had a vital influence on the level of farmers' participation in agricultural markets.

The volume of poultry product sold positively influenced the possibility of farmers participating in poultry markets at 1 percent level of significance. This clarifies that by increasing quantity of poultry products marketed, the willingness to participate increased by 54.6 percent. This is possible given that increased output marketed increased the farmers bargaining. In addition, more output enabled farmers to solicit information regarding more outlets in search of better prices. The result was in agreement with the argument presented by Mathiu *et al.* (2021) that market diversification enabled farmers to attain product prices that resonates with the quantities available in the markets.

5.1.5 Factors affecting the value of indigenous poultry sales

Group membership positively influenced level of poultry sales. The results of this study shows that respondents who belonged to at least one farmer group were more likely to increase poultry sales unlike nonmembers. By a farmer being a member of social groups, their sales increased by KES 6825. The possible reason for this is that working in groups

brings with it advantages such as easy access to extension services, information sharing, bargaining power to access veterinary services and better prices for inputs and outputs. The effect of all these is to produce surplus and increase quantity of indigenous chicken that is sold. Ayieko *et al*. (2015) and Sebatta *et al*. (2014) had similar results while results presented by Apind, *et al*. (2015) found a negative significant relationship between group membership and intensity of market participation.

The level of education had a positive and significant effect on the level of indigenous poultry sales. An increase in the level of formal education among respondents increased poultry sales by about KES 3765.56. This is probably due to better understanding of technologies used in production. Further, education improves the skills of producers in interpretation of market information thus farmers are able to predict market linkages and fluctuations in prices. The results concurred with Boniphace, Fengying and Chen (2014). Group membership positively influenced level of poultry sales. The results of this study shows that group members were more likely to increase poultry sales unlike nonmembers. Members of social groups increased their sales by KES 6825. The possible reason for this is that working in groups brings with it advantages such as easy access to extension services, information sharing, bargaining power to access veterinary services and better prices for inputs and outputs. The effect of all these is to produce surplus and increase quantity of indigenous chicken that is sold. Ayieko *et al*. (2015) and Sebatta *et al*. (2014) had similar results. On the other hand, Apind, *et al*. (2015) found a negative significant relationship between group membership and intensity of extent market participation.

The availability of extension services and contact with agent in regards to market information was significant and positively influenced indigenous poultry sales. The level of sales would increase by KES 3224 if the availability of extension services and the frequent of extension contacts are improved. This was attributed to use of modern marketing techniques and the ability of farmers to understand market information. The results were in concurred with Altalb and Felipek (2016).

The amount of credit borrowed by the smallholder indigenous poultry farmers was positive and significantly influenced poultry sales. The parameter shows that if credit borrowed is

increased by Kes 1000, poultry sales increases by 21 percent. The possible explanation is that credit empowers farmers and enables them to timely procure improved inputs and modern technologies that boost the quality of output. In addition, credit availability enables farmers adopt various marketing techniques thus broadening their markets. Further, credit increases the resources available to transport more farm products hence increased proceeds. The results concurred with Ohen, Etuk and Onoja (2013) and Ayieko *et al.* (2015).

The quantity of poultry products demanded in the study area was significant and positively increased poultry sales. The results show that a unit increase in quantity demanded increased poultry sales by Kes 436.157 a result that coincided with the findings of Mirembe (2018). A possible explanation for this is that the more the demand for poultry products always assured a continued supply of local chicken to the market as explained by Kindeya (2015); Mirembe (2018) and Moono (2015).

5.2 Conclusions

This section gives a conclusion based on the research questions, specific objectives and results of the study. The first objective was to assess effects of selected socio-economic and institutional factors on adoption of improved production technologies among smallholder indigenous chicken farmers. Results revealed that out of the twelve (12) selected factors, eight (8) factors had a significant effect on adoption of technologies. The effects were either positive or negative. These factors were age, experience, household size, extension services, farm size, land size, education and indigenous chicken income. From the results provision of extension services had the highest coefficients on adoption. This implies that increased contact with extension experts increased the likelihood of farmers embracing modern production technologies.

The second objective was to evaluate the effect of selected socio-economic and institutional factors on production among smallholder indigenous chicken farmers. Results revealed that improved feeds, vaccination and financial credits were the most limiting factors in poultry production. The Cobb Douglas results reported that increased land holdings by farmers negatively affects poultry production. This implies that farmers with small parcels of land were more productive compared to their counterparts with large chunks of land.

Further, factors such as Gender, extension access and size of the flock had a positive impact on production. Technology uptake and engagement in off farm employment were the most outstanding characteristics that increased indigenous poultry production in Tigania West.

The third objective entailed an assessment of the effect of selected socio-economic and institutional factors on extent of market participation among smallholder indigenous chicken farmers. The Heckman two-stage model presented results showing that increased age and distance to the market reduce the willingness of farmers to participate in indigenous poultry markets. Other factors such as level of education, household size, experience, demand price and quantity of output positively improved farmers' participation with extension access been the most notable variable. From the Heckman OLS, the number of years spent while schooling and number of extension visits were the most important in determining the extent of participation among smallholder farmers.

5.3 Recommendations

The findings suggested that land tenure improved the probability of technology adoption among smallholder indigenous chicken farmers. Thus, there is a need for the ministry of land and the county government to develop mechanism that ensure guaranteed land tenure through provision of title deeds to the smallholder farmers. This will strengthen the farmers' bargaining power while they seek financial credits to expand their enterprises thus enabling them to invest more resources and time leading to increased yields. Besides, visits by extension agents presented significant changes in technology adoption among respondents. This shows that there is a need for policy makers and other participants to develop friendly extension programs that educate farmers on modern production innovations. The study also recommends that farmers need to express extension demand by engaging in meaningful activities such as being members of social groups which promote training efficacy.

Based on the findings, the study recommends that, increased engagement of farmers in nonfarm employments will increase farmers' income. This will increase the ability of smallholders to timely procure modern production technologies that are efficient in poultry production. Besides, male-headed households dominated in indigenous poultry production,

thus developing policy interventions that support more female-headed households' participation in poultry farming will be appropriate in enhancing gender parity. There is a need for farmers to constantly increase their poultry flocks to ensure guaranteed yield increase hence more output thus benefiting from the economies of scale.

Based on the results, the study recommends that, increased extension and trainings will enhance farmers' skills on indigenous poultry production. This will also promote farmers' knowledge on the various worthwhile techniques that ultimately contribute to reducing production costs among smallholders in rural areas. Results revealed that age advancement reduces market participation among smallholder farmers. The study therefore recommends that policy makers and other stakeholders need to develop incentives that attract the youth in indigenous poultry production. This will make use of their diversified energies given their risk-taking attributes. The average demand price was found to affect the willingness of farmers to participate in markets. Thus, interventions by the Ministry of Agriculture through Agriculture, Food and Fisheries (AFFA) should formulate policies that protect farmers from exploitation.

The use of improved breeds and quality feeds in poultry production was found to increase productivity among smallholder farmers. The study therefore recommends that there is a need for the County government to enhance extension services among the young and experienced farmers who expressed significant willingness in the adoption of this technologies. The study also recommends that farmers should continue using high quality homemade rations, commercial feed supplements and embrace use of improved indigenous breeds that are resistant to perennial diseases. This will ensure that the birds are provided with adequate nutrition thus increased productivity and enable farmers achieve optimal levels due to reduced bird mortality rates.

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APPENDICES

Appendix 1: Interview schedule

TECHNOLOGY ADOPTION, PRODUCTION AND MARKET PARTICIPATION AMONG SMALLHOLDER INDIGENOUS CHICKEN FARMERS IN TIGANIA WEST SUB-COUNTY, MERU COUNTY

Introduction

This questionnaire aims to collect data on technology adoption, production and market participation among smallholder indigenous chicken farmers in Tigania West-Sub County, Meru County. The information provided herein will be treated with the utmost confidentiality.

QUESTIONNAIRE NO: ____

GENERAL INFORMATION

Enumerator:	Ward
Location	Sub-location

SECTION A: SOCIO-ECONOMIC INFORMATION: This section will record information on socio-demographic information of smallholder indigenous chicken farmers

A1 Household head gender	1=male 2=female
A2 Household size	
A3Household head age in years	
A4 Household head education level	1= primary 2=secondary 3=college 4= university
A5. Household head occupation	1= farming 2= business 3=employment
A6. Household income per year in KES	
A7**.** The off-farm income per year in KES	
A8. Sources of off-farm income	1= self-employment 2= salaried jobs 3= pension 4=wages 5 others specify…….
A9**.** No. of years spent in chicken farming	

SECTION B. PRODUCTION OF IC

0)Do you practice poultry production on your farm? Yes () No () 1)

a) What is the size of your land?.....

b) What is the size of land under chicken production?.....

2) If yes, what is the size of your flock in numbers? indicate in the table below

Improved indigenous chicken	
Indigenous chicken	
Exotic chicken	

3) Indicate the number of chickens under the following categories

Young chicks< 8 years	Growers 8-20 Weeks	Hens >20 weeks	Cocks >20weeks

4) Do you participate in any social group? Yes () NO ()

If yes, what type of group are you engaged in? (1= farmers group, 2=common interest group 3=women group, 4= others specify……)

5) What are the main activities your group is engaged in? (1= IC production, 2= IC marketing 3= dairy farming 4= crop farming 5= others specify……)

6) What is the source of information in regard to IC production? (1= Radio, 2= Television, 3= Extension services 4= Neighbours 5= others specify…….)

7) How would you rate the accessibility of information source mentioned in quiz 7 above? 1 = Highly accessible 2 = Less accessible 3 = Not accessible

8) What is the source of your farm labour? (1= Hired, 2= family labour 3= both 4= others specify……)

9) How much labour is used in IC…….?

10) Have you been trained on poultry production in the last one year? Yes () No

11) If yes, how many times have you been trained?.....

12) What is the distance from your home to the training point?.....

13) Do you have any source of off-farm income? Yes () No ()

14) If yes, indicate the source of off-farm income in the table below?

Formal employment	
Wages	
Remittances	
Business	
Others specify……	

15) Did you access any form of credit for the last one year? Yes () No ()

   i. If yes, from which institution did you access the credit? (1= merry go round, 2= farmers group, 3= Sacco 4= NGO, 5= commercial banks 6= others specify……

   ii. If No, why did you not get the credit? ……

   iii. How much of the credit did you access? ……

   iv. How much was used for IC? ……..

SECTION C: TECHNOLOGY ADOPTION IN IC

16) How do you manage your indigenous chicken flock? (1= free-range 2= semiconfined, 3= intensive systems 4= others specify……)

17) Are you aware of improved indigenous chicken? Yes () No ()

18) Have you adopted any of the following improved production technologies? Yes () NO ()

19) If Yes, please tick the technology adopted below and use the ranking provided to indicate the level of adoption

Technology adoption KEY 1= Very good 2= Good 3= Average 4= Poor		Rank
Improved breeds	Pure breeds	
	Pure breeds and Crosses	
	Crosses	
	Native	
Housing	Spacing	
	Feeders and drinkers	
	Laying nests	
	Ventilation	
Disease Control	Vaccination against NCD	
	Vaccination fowl pox and typhoid	
	Deworming	
	Pests and predators' control	
Feeding	Free-range without supplementation	
	Free-range with supplementation (raw feeds)	
	Semi-intensive with home-made ration	
	Commercial feeds	

20) Have you been trained in feed formulation and supplementation? Yes () No ()

If yes, which feeds do you use for supplementation? (1= on-farm formulated feeds, 2= commercial feeds, 3= kitchen- leftovers, 4= others specify…….....)

Feed	Quantity used
On-farm formulated feeds	
Commercial feeds	
Kitchen leftovers	
Others	

21) How many times do you give a supplement to your chicken per day?

Which chicken category above do you supplement……?

22) Have you been trained in housing structure standards? Yes () No ()

If yes, do your housing structures have good ventilation? Yes () No ()

23) Do you keep the housing facilities clean before stocking? Yes () No () If yes, how frequent do you clean your housing facilities? (1= regular basis, 2= before introducing new stock, 3= never clean 4= others specify…....)

24) Have you been trained in disease control? Yes () No ()

If yes, do you follow the recommended vaccination schedule? Yes () No ()

25) Name the major diseases in order of priority that you have vaccinated……

……..

SECTION D. MARKETING OF IC

26) Do you sell your indigenous chicken? Yes () No ()

27) Have you sold IC in the last one year? Yes () No ()

At what price have you sold your IC in the last one year?

Type	No. sold	Prices
Cocks		
Hen		
Chicks		
Growers		

28) How do you sell your IC? (1= live 2= dressed carcasses)

29) Where do you sell your chicken? Indicate in the table below:

	Chicks	Growers	Hen	Cocks
Farm gate				

Local market				
Hotel				
Butchery				
Urban market				
Others specify				

30) Do you have a contract for selling your IC? Yes () No () If yes, do you face any constraints in selling your IC?

31) If yes above, please specify…….

32) If dressed, do you usually consider age and weight while selling?

Yes () No ()

If yes, fill in the table below

	Pullets	Cockerels	Hen	Cock
Age				
Weight				

33) How many eggs do you collect in a week? .....

34) Do you usually sell eggs? Yes () No ()

If yes, in which form do you sell your eggs? (1= Tray 2= per egg) 35) How many eggs did you sell in the last one year?

Number of eggs sold	Unit of measure
	1 = Tray 2 = physical counts 3 = others

36) Do you sell mature chicken? Yes ()

If yes, how do you sell the mature chicken? (1= kilograms 2= per chicken 3= others Specify(……)

37) How many mature chickens did you sell in the last one year? …….

38) How much money did you get from the selling of IC in the last one year?.....