Determinants of Adoption and Performance of Greenhouse Technology among Smallholder Tomato Farmers in North Rift Region, Kenya

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Abstract: **One of the most widely grown vegetables in Kenya is tomato, which is grown mainly for domestic consumption and sales at local markets. It is also an important cash crop for small-scale growers with potential for increasing incomes in rural areas, improving standards of living and creating employment opportunities. Greenhouse technology is one of the methods which can be used to increase tomato yield and by extension income for the farmer. Despite the importance, farmers in North Rift region hardly adopt this technology and further few studies if any have been done to establish the reason for low adoption of greenhouse technology. Therefore, this study aimed at analyzing the factors influencing the adoption of greenhouse technology among smallholder tomato farmers in North Rift region. Specific objectives were to determine the factors influencing the adoption and performance of greenhouse technology among smallholder tomato farmers in North Rift region. The target population were all smallholder tomato farmers in North Rift region. A survey research design was used in the study. Purposive, proportionate, multistage, simple random and systematic sampling techniques were used to select 384 respondents for the study. Data was collected by use of structured questionnaires and analyzed using STATA V12. Descriptive and inferential statistics were used in data analyses. Both probit and bivariate probit models were estimated to achieve the objectives of the study. Results indicated that social factors such as age, gender, education level and farm experience affected adoption of greenhouse technology among smallholder tomato farmers in North Rift region (p – value 0.0000 < 0.05). The study also indicated that economic factors such as farm income, farm size, and land tenure determined adoption of greenhouse technology among smallholder tomato farmers in North Rift region (p – value 0.0000 < 0.05). The study also revealed that institutional factors such as access to credit, availability of extension service and frequency of extension visits determined adoption of Greenhouse technology among smallholder tomato farmers in North Rift region (p – value 0.0000 < 0.05). It is recommended that the government should empower farmers through training, introduction of cost sharing programs and increase access to extension and credit services so as to enable them commercialize tomato production and hence increase adoption of greenhouse technology and thus improve their livelihoods.**

Key Words: **North Rift region, Kenya, Smallholder Farmer, Greenhouse**

I. INTRODUCTION

Agriculture is a leading sector in the Kenyan economy, contributing 24 percent directly and 27 percent indirectly to the Gross Domestic Product (GDP) (Government of Kenya, 2012). Horticulture is among the leading contributors to the national economy accounting for 33 percent of agriculture's contribution to the Kenyan economy (GoK, 2010). The horticulture industry is also the leading foreign exchange earner after tea. In 2012, Kenya exported 350,474,113 kg of horticulture produce valued at Kenya Shillings 71.6 billion (MOA, 2012). In the same year, the country earned Kenya Shillings 153 billion from the domestic market worth of horticultural produce. The sub-sector has continued to grow at an annual rate of 15–20 percent over the last decade (GoK, 2012).

The main country's horticultural crops include fruits, flowers and vegetables. Among the sub-sectors of the horticulture industry, the vegetable industry holds the future of the Kenyan horticulture industry due to the high local demand for vegetables with 80 percent of produce consumed locally (HCDA, 2009). Tomato (*Lycopersionesculentum*mill.) is one of the leading vegetable crops worldwide, under production .The crop is used fresh for green salad, for cooking and provides raw material for manufacturing of tomato paste and juice. There is an increasing demand for tomato as fresh crop among consumers. Tomato ranks next to potato in production, but as canning crops, it takes the first rank among the vegetables, Tomato originated in tropical America, probably in Mexico or Peru where a variety of wild cherry tomato was brought into cultivation. The rich agricultural resources of Kenya enable this large country to have a variety of agricultural products, of which horticultural crops (fruits and vegetables) rank high. Though horticultural production as commercial pattern of life is relatively recent, it had been practiced since long time.

Thus the increase in tomato production and imports as a proxy for increased consumption of this commodity urged for the production of tomato in new areas. One of the most widely grown vegetables in the Kenya is tomato, which is grown mainly for home use and local markets (Musyoki*et al*., 2005).

It is also an important cash crop for small-scale growers with potential for increasing incomes in rural areas, improving standards of living and creating employment opportunities (Ssejjemba, 2008). The value of tomatoes produced in Kenya in 2007 was Kenya Shillings 14 billion (Odame*et al*., 2008). Between 2005 and 2007, the area under tomato reduced from 20,743 ha to 18,926 ha, a 9 percent reduction, but in the same period, the total volume produced increased by about 5percent from 542,940 Metric tons to 567,573 Metric tonnes (Odame*et al*., 2008). The increase in production is attributed to the extensive adoption of high yielding varieties and other modern technologies by farmers. Since majority of farmers own less than four acres of land in Kenya (GoK, 2000), tomato farming will remain an important sub-sector to many farmers, because it is practical on small scale.

Benefits of Greenhouse Technology

Greenhouse technology has numerous advantages such as throughout the year four to five crops can be grown in a greenhouse due to the availability of required plant environmental conditions, the productivity of the crop is increased considerably, superior quality produce can be obtained as they are grown under suitably controlled environment, gadgets for efficient use of various inputs like water, fertilizers, seeds and plant protection chemicals can be well maintained in a greenhouse (Wikipedia,2012).

Previous Studies on Adoption

There exist vast literatures on factors that determine agricultural technology adoption. According to Loevinsohnet *et al.,* (2013), farmers' decisions about whether and how to adopt new technology are conditioned by the dynamic interaction between characteristics of the technology itself and the array of conditions and circumstances. Diffusion itself results from a series of individual decisions to begin using the new technology, decisions which are often the result of a comparison of the uncertain benefits of the new invention with the uncertain costs of adopting it (Hall and Khan, 2002). An understanding of the factors influencing this choice is essential both for economists studying the determinants of growth and for the generators and disseminators of such technologies (Hall and Khan, 2002).

Traditionally, economic analysis of technology adoption has sought to explain adoption behavior in relation to personal characteristics and endowments, imperfect information, risk, uncertainty, institutional constraints, input availability, and infrastructure (Feder *et al.,* 1985; Koppel 1994; Foster & Rosenzweig 1996; Kohli & Singh1997; Rogers, 2003 and Uaiene, 2009). A more recent strand of literature has included social networks and learning in the categories of factors determining adoption of technology (Uaiene, 2009). Some studies classify these factors into different categories. For example, Akudugu*et al*., (2012) grouped the determinant of agricultural technology adoption into three categories namely; economic, social and institutional factors. Kebede Journal of Economics and Sustainable Development www.iiste.orgISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)Vol.6, No.5, 2015210 *et al.,* (1990) as cited by Lavison (2013) broadly categorized the factors that influence adoption of technologies into Social, Economic and physical categories, McNamara, Wetzstein and Douce (1991) categorized the factors into, farmer characteristics, farm structure, institutional characteristics and managerial structure, Nowak (1987) grouped them into informational, economic and ecological, while Wu and Babcock (1998) classified them under human capital, production, policy and natural resource characteristics. Although there are many categories for grouping determinants of technology adoption, there is no clear distinguishing feature between variables in each category. Categorization is done to suit the current technology being investigated, the location, and the researcher's preference, or even to suit client needs (Bonabana-Wabbi, 2002). For instance the level of education of a farmer has been classified as a human capital by some researchers while others classifies it as a household specific factor. This study will review the factors determining adoption of green house technology by categorizing them into social factors, economic factors and institutional factors. This will enable a depth review of how each factor influences adoption

According to Just and Zilberman (1983), there are various factors that influence the adoption of any technology. Just and Zilberman explains that technology may require some costs that are associated with new equipment's and investments, learning time, locating and developing markets and training labour. This view is supported by Bonabana-Wabbi (2002) adding that for farmers to adopt a technology, they must see an advantage or expect to obtain greater utility in adopting it.

From the study, it is argued that without a significant difference in outcomes between two options and in the returns from alternative and conventional practices, it is less likely that farmers, especially small-scale farmers will adopt a new practice. Since adoption of a practice is guided by the utility expected from it, the effort put into adopting is reflective of its anticipated utility. Moreover, there is no standard way of classifying factors influencing adoption and classification cannot be uniform (Bonabana-Wabbi, 2002). This is because the factors influencing adoption may be a complex set of interactions and factors like the institution (administration), the potential/targeted adopter (the farmer) or the general setting in which the technology is introduced act either as barriers or enhancers of adoption. Several factors have been found to influence adoption. A study by Bonabana-Wabbi (2002) used multivariate Logit analysis to identify factors and their relative importance in explaining adoption of eight Integrated Pest Management (IPM) agricultural technologies in Kumi District, Eastern Uganda. The study results indicated that size of household labour force had negative influence on Celosia adoption but positive influence on growing improved cowpea and groundnut varieties. For the gender variable, the study indicated that males were more likely to adopt Celosia than females while experience positively influenced timely

planting of cowpeas. The study argued that, farmers with accumulated farming experience may have acquired encouraging returns from the practice and thus continue with it anticipating continued benefits. Farm size and level of education did not show any Significance with IPM adoption. Although the study analyzed quite a number of factors, access to market, infrastructure, gender and land tenure were left out in the study.

Nchinda *et al.,* (2010) used Tobit regression method as the main analytical tool in a study of factors influencing adoption and intensity of yam seedling technology in Cameroon. Farm size was not a significant determinant of adoption in their study. However, hired labour and membership to farmers' organizations positively and significantly influenced the adoption and intensity of yam minisett technology in areas covered. They also showed that age had significant influence with farmers less than forty one years of age being found to positively influence yam adoption and its intensity.

Another study by Adeogun *et al.*,(2009), aimed at estimating and explaining the parameters of the adoption process of Hybrid Clarias "Heteroclarias" by fish farmers in Lagos State Nigeria, showed age, farming experience and farm size to be statistically significant in explaining hybrid catfish adoption. However their Logit model results showed that education, contact with extension agents, access to seed and market distance were significant variables that influence fish farmers hybrid catfish adoption and use decisions. In a study by Engindeniz (2007) on comparative economic analysis between contract-based and non-contracted farmers, a binary Logit model was estimated to determine the factors which make farmers prefer to grow tomato on contract-based. Some of the independent variables of the regression included age of farmers, education level, and tomato growing experience, market conditions and cooperative membership of farmers. The results pointed out that important factors affecting the profitability of tomato growing were market conditions and cooperative membership of farmers.

The study concluded that contract-based agriculture can put farmers in a position to achieve greater access to credit, inputs (in particular, new technologies) and the market, relative to their peers who are not operating under contractual arrangements. Jans and Fernandez-Cornejo (2001) in a study on the economics of tomato organic growing in the United States used the Probit model to determine factors influencing adoption. Their findings were that education level; contract farming and crop price were significant and positively influenced adoption. The price was very significant and the researchers attributed this to the fact that adoption was significantly related to price premiums. In the same study, farm size was found to be negatively significant while age and off-farm employment were not significant.

Oyekale and Idjesa (2009) showed that education, access to credit, access to farm inputs and farming experience significantly and positively influenced adoption of improved maize seeds in the River State Nigeria. The study argued that, access to credit permits farmers to invest in a new technology or acquire related inputs such as, labour and fertilizer.

In the same study, absence of visits from extension services highly influenced the adoption negatively. On the contrary, contacts and access to extension services had positive and significant influence on adoption and intensity of technology according to a similar study of adoption of improved maize seeds in Tanzania (Nkonya *et al*., 1997). In a nut shell, adoption of a technology may be dependent on a number of factors which are dynamic both in terms of geographic setting and in time (Bonabana–Wabbi, 2002). In this study, the binary Logit regression will be adopted since the model is mathematically simpler in estimation than the Probit model and the effects of the independent variables area analyzed for each outcome as opposed to ordered Probit model where only one coefficient is estimated for all the outcomes (Aldrich and Nelson, 1984). 3.8:A greenhouse requires higher capital to establish, run and maintain for it to serve its intended purpose efficiently, Clifton (2004). There is also need to source for the right materials for particular greenhouse. In Kenya, the major hindrance towards the success of greenhouse projects is the lack of appropriate materials. According to the Ministry of Agriculture annual report (2011) on adoption of greenhouse technology, lack of materials for the same was highlighted as a major problem. According to sigh (2009), greenhouse materials availability is the starting point of a successful venture. In Kenya majority of persons resolve the problems of lack of raw materials by using available ones like low quality polythene papers, nets, irrigation systems, Loam soils among other obstacles.

This contributes to poor yields from greenhouses that directly lead to food insecurity. Through the establishment of KARI miniaturized greenhouse the government aimed at making it easier for farmers to acquire raw materials that would be pivotal in increasing the overall output of the greenhouses.

Bhat (2002) indicated that usage of raw materials like heating systems, temperature sensors, chemicals among others have been minimal due to the all-time competition in the industry. According to Taft (2011), every raw material in a greenhouse is a fundamental success tool and thus there is need to be well organized financially and technically. The Kenya government through Kenya rain water Association and Kari have been supporting farmers who approach them with raw materials like water reservoirs, pipes seeds among other key raw- materials. The move is aimed at spearheading the success in the adoption and running of the greenhouses and eventual enhancement of food security .

Scope and Limitation of the Study

The study only covered North Rift region. This was mainly due to limitation of resources in terms of time and funds

required in undertaking the study on a larger scale. The study also targeted small-scale tomato farmers in the area. The key issues in this study are social, economic and institutional characteristics of smallholder tomato farmers. A structured questionnaire was used to collect data. Due to such factors as illiteracy the respondents might distort the information; and to deal with this problem training and close supervision of the enumerators was done to improve on the quality and reliability of data that was collected.

II. MATERIALS AND METHODS

This study was based on Diffusion of Innovation theory proposed and popularized by Rogers (1985).The study was undertaken in the North Rift region that comprises of six counties namely: Uasin Gishu, Trans Nzoia, Turkana, West Pokot Elgeyo Marakwet and Nandi. However, for this study Uasin Gishu and Nandi counties were selected. This was because they are the main agricultural hubs in the region.

Uasin Gishu is a highland plateau situated at an altitude of between 1,500 metres above sea level, around Kipkaren, and 2,700 metres above sea level around Timboroa (District Annual Report, 2010). It receives rainfall of approximately 960 mm/year, which is evenly distributed. This rainfall is bimodal with the two peaks coming in March and September. The wettest areas are Ainabkoi, Kapseret and Kesses divisions. Turbo, Moiben and Soy divisions receive relatively lower amounts of rainfall as compared to Ainabkoi, Kapseret and Kesses divisions (GOK, 2010).

Temperatures range from a minimum of 8.8^0C to a maximum of 26.1^0C. The average temperature is 18^0C during the wet season and a maximum of 26.1^0C during the dry season. February is the hottest month, while June is the coolest month (Region Annual Report, 2010).

North Rift region is basically an agricultural region, producing more than a third of the total wheat production in the Country (GOK, 2010). Second to wheat production is maize which is planted both as a food and cash crop. Agriculture thus forms the main driving force for industrialization in the Region. Most of the industries in Eldoret town, headquarters of North Rift region, are agro-based industries, which utilize the raw materials from the agriculture sector. The main crops that are produced in small farm sector include: maize, beans, wheat, vegetables, pyrethrum and dairy crops.

The main livestock enterprises in the region are dairy cattle, pigs, goats, sheep, poultry and bee-keeping. The main products include milk, beef, mutton, eggs, wool, honey and pork. All these products are capable of promoting industrialization in the region.

Nandi County borders Kakamega County to the North West and has an area of 883.5 Km^2. It lies at an altitude ranging between 1330 metres and 2005 metres above sea level. It has a cool and moderately wet climate. It receives an average annual rainfall between 1200 mm per annum. Most parts of the County experience mean temperatures of between 18 and 22 degrees centigrade during the rainy seasons of July and August while higher temperatures averaging 23 degrees centigrade are recorded during the drier months of December.

The region is divided into four administrative districts namely Nandi East, Nandi South, Nandi Central and Nandi North (GoK, 2009). The area is agriculturally productive. The economy is agriculturally based with most farmers being engaged mainly in tea, maize, sugarcane and dairy farming. The County is cosmopolitan and thus is inhabited by people across the country. It has good soils enabling it to practice subsistence crop farming. It also practices livestock farming. The area is made up of four sub counties namely Mosop, Emgwen, Tindiret and Aldai. This region was chosen by the researcher because it is an area suitable for agricultural production mainly livestock and crop production (GoK, 2010).

The research design that was used in this study is a survey research design; this is because it allows the researcher to examine the effect of the naturally occurring influence of the independent variable on the dependent variable. Green house tomato producing households were used as units of analysis because it is in the households that major decisions relating to production are made. These decisions have a bearing on the extent of involvement in tomato production and also how to produce.

This study was based on both primary and secondary data. Primary data was obtained from the households information on age (in years), gender(male or female),education level (either, primary, secondary or tertiary level), farmer experience(in years), income (in KSh), farm size (in acres), land tenure(either freehold, communal or leased) access to credit (in KSh)and access to extension services and frequency of extension visits in North Rift region.

Secondary data was used where historical information was required. Secondary data was obtained from statistical abstracts, national and county development plans and Ministry of Agriculture reports. The study targeted all the smallholder tomato farmers in the two selected counties 43,155 in Nandi county and 64,233 in Uasin Gishu county in North Rift region. The sample frame was all smallholder tomato farmers in North Rift region. A sample of 384 farmers was selected from the sub counties using multistage sampling and systematic sampling technique

Purposive, proportionate, multistage, simple random and systematic sampling techniques were used to select 384 respondents for the study. A structured questionnaire was used to collect data from identified farmers. Both quantitative and qualitative data were collected from the study area. Pilot test of the data collection tool was done in Aldai Sub County to ensure reliability of the research instrument. Data was analyzed using a combination of descriptive statistics and inferential statistics.

Descriptive statistics was used to summarize and describe the sample. The technique was useful in analyzing all the quantitative data. In this case, cross tabulation, frequency tables and general statistics such as means, standard deviations of certain variables was worked out.

Inferential statistics such as correlation and regression analysis was used as to ensure efficient inferences were made to the larger population. Inferential statistics enabled the researcher to infer sample results to the general population. In this study logit model was used.

The study employed the Bivariate Probit model with the assumptions that greenhouse technology adoption and performance are two distinct variables. The Bivariate Probit model was formulated by Cragg(1971); the model assumes that farming household heads make two sequential decisions with respect to adoption and management which determines performance. The first analysis determines whether to adopt or not. This decision of adopting is influenced by social, economic and institutional factors. The second Bivariate concerns the income received from greenhouse technology adoption. Data was analyzed using STATA 12 a very versatile statistical software and is very useful in giving in depth examination of data.

III. RESULTS AND DISCUSSIONS

3.1 Descriptive Statistics: The descriptive statistics are presented in the following section.

Table 3.1 Descriptive Statistics

Variable	Observation	Mean	Std Dev	Minimum	Maximum
Adoption	384	0.4099	0.4925	0	1
Age	384	35.9817	7.9319	20	70
Gender	384	0.5807	0.4940	0	1
Education Level	384	3.1875	0.7271	1	4
Farmer experience	384	4.3541	3.0542	0.5	20
Income from tomato farming	384	447668.5	426157.6	20000	556000
Farm size	384	5.9035	3.6225	0.2	23
Land tenure	384	1.3072	0.6578	1	3
Credit access	384	0.3932	0.4891	0	1
Extension access	384	0.6771	0.4682	0	1
Frequency of extension	384	2.2001	2.5248	0	12

3.1.1 Age Distribution of tomato farmers:

Results in Table 3.1 showed that the average age of the 384 respondents was found to be 36 years old with the respondents' age ranging from a minimum of 20 years and maximum of 70 years. This shows that most of them were within the most active age in terms of farm activities. The study hypothesized that age may influence adoption either negatively or positively. The first scenario was by assuming that, the young are less risk averse and thus more willing to take up a tomato production system that is more profitable (hence more risky) than the aged(Abdulai and Huffman, 2005). Therefore, age in that case was hypothesized would negatively influence adoption. However, age of farmer can influence technology adoption in any direction depending on his/her position in the life cycle, education level and experience. Younger farmers are more likely to be interested in adopting new technologies if they are not constrained by limited cash resources, while older farmers are less likely to be able to use new technologies if they require extra physical labour and/or older farmers may be less interested because they have less need for extra income Tiamiyu *et al.*, (2009).

3.1.2 Gender:

Table 3.1 also shows the gender distribution of sampled respondents. The results showed that 58 percent were male and 42 percent were female. This scenario gives the indication that male dominated the sampled population and hence made most of the tomato farming decisions in North Rift region. Gender of the household may have varied effects on use of a technology; there are certain agricultural technologies or enterprises that are predominantly taken by a certain gender on the basis of their profitability.

3.1.3 Education level:

Respondents visited were also asked on their level of education. Table 4.3 showed that the majority of the respondents had attained secondary education. This is an indication that most respondents who practiced tomato farming were educated to ordinary level. Abdulai and Huffman (2005) observed that, it was expected that more educated farmers would use acquired skills and adopt the more profitable production system.

3.1.4 Farmer Experience:

Table 3.1 gives a descriptive summary of all concerned variables results indicated that majority of the respondents interviewed had an experience of 4 years. This is an indication that most farmers who were practicing tomato farming were new entrants to farming. This was measured by the number of years of farming. Experienced farmers are assumed to have tried out a number of profitable technologies. It was hypothesized to have a positive coefficient

3.1.5 Income from tomato production:

Information on income sources was sought since income is an important determinant in technology choice (Mose, 2013). The farmers' crop and livestock income throughout the year on average were found to be KSh. 326739. The maximum income from tomato production was found to be 556,000 with a minimum of 20,000. This showed that the farmers mainly depended on income from the tomato farming.

3.1.6 Farm Size:

Table 3.1 also gives results on the distribution of land size among the respondents. Results showed that majority of the visited respondents had 6 acres of land (average land size 5.904). This is an indication that majority of tomato farmers in north rift were small scale farmers. Farm size can influence and in turn be influenced by other factors influencing adoption. The effect of farm size has been variously found to be positive since it affects adoption costs, risk perceptions, human capital, credit constraints, labour requirements, tenure arrangements and more (Bonabana-Wabbi, 2002). A substantial farm may also be good collateral for credit, which is much needed to adopt a profitable technology. On the other hand, farm size may have negative influence on adoption of a technology. Especially, where adoption of land-saving technologies, seems to be the only alternative to increased agricultural production (Bonabana-Wabbi, 2002)

3.1.7 Land Tenure:

Table 3.1 also gives results on land tenure distribution. Result indicated that on average majority of the respondents were private land owners. This means that they had the potential of utilizing their land for long-term projects and also had title deeds to access funds from financial institutions. Where the land tenure system is of the leasing type, profit may be lower and thus negatively influence adoption.

3.1.8 Access to Credit:

Respondents were also asked on their credit access. Results in table 4.3 indicated that majority of the respondents in the tomato farming industry in north Rift did not access credit. Facts from the data indicated that only 39.3% of the respondents interviewed went for credit to run their operations. Just as argued in the case of income, households with access to credit may have the capital required for adopting the higher profit production system. The variable which was expressed as amount of credit was hypothesized to have a positive coefficient.

3.1.9 Access to Extension Services:

Results on extension services showed that majority of the respondents visited (67.7%) received extension services in North Rift region. This means that extension activities were very available in the region. This has been reflected by number of extension contacts either through farm visits made or training sessions received during the preceding one year production season. Most studies analyzing this variable in the context of agricultural technology show its strong positive influence on adoption (Bonabana-Wabbi, 2002). Contact with extension is expected to provide information not only on a technology but also its profitability.

3.1.10 Frequency of Extension Visits:

The results on frequency of extension visits showed that on average, the farmers in North Rift region were visited two times in a year by the extension personnel. This frequency is low given that the farmers require continuous information throughout the year for them to effectively implement what they are advised to do. This finding is in line with Kipkemei (2014).

3.2 Inferential Statistics:

The study sought to determine the effect of social factors such as age, gender, education level and farm experience on adoption of greenhouse technology among smallholder tomato farmers in North Rift region. To achieve this objective the first hypothesis stated that social factors such as age, gender, and education level and farmer experience do not significantly influence the adoption of greenhouse technology among smallholder tomato farmers in North Rift region. The results of probit regression indicated that social factors such as age, gender, education level and farmer experience significantly influenced the adoption of greenhouse technology among smallholder tomato farmers in North Rift region (p – value $0.0000 < 0.05$). Therefore it was concluded that social factors such as age, gender, and education level and farmer experience significantly influenced the adoption of greenhouse technology among smallholder tomato farmers in North Rift region. Based on these results the first hypothesis was rejected.

The second objective was to determine the effect of economic factors such as farm income, farm size and land tenure on adoption of greenhouse technology among smallholder farmers in North Rift region. Therefore the second hypothesis stated that economic factors such as farm income, farm size and land tenure do not significantly influence adoption of greenhouse technology among smallholder tomato farmers in North Rift region. Probit regression results showed that economic factors such as farm income, farm size and land tenure significantly influenced adoption of greenhouse technology among smallholder tomato farmers in North Rift region (p – value 0.0000, 0.009 and $0.032 < 0.05$ for farm

income, farm size and land tenure respectively). Therefore it was concluded that economic factors such as farm income, farm size and land tenure significantly influenced adoption of greenhouse technology among smallholder tomato farmers in North Rift region. This led to rejection of the second hypothesis. The results revealed that farm income was one of the important determinants in technology choice (p – value 0.0000 < 0.05). This is consistent with other findings by Mose (2013) and Kipkemei(2014). A number of studies have shown that there is a positive relationship between income level and adoption. Results also indicated that farm size had positive and significant effect o adoption of greenhouse technology by farmers in North Rift region (p – 0.009 < 0.05). Similarly land tenure positively and significantly affected adoption of greenhouse technology by farmers in North Rift region (p – 0.032 < 0.05).

The study was carried to determine the effect of institutional factors such as access to credit, availability of extension service and frequency of extension visits on adoption of Greenhouse technology among smallholder tomato farmers in North Rift region. Therefore the third hypothesis stated that institutional factors such as access to credit, availability of extension service and frequency of extension visits do not significantly influence the adoption of greenhouse technology among smallholdertomato farmers in North Rift region. Results of probit regression analysis showed that institutional factors such as access to credit, access to extension service and frequency of extension visits significantly influenced the adoption of greenhouse technology among smallholdertomato farmers in North Rift region. The p – values were 0.001, 0.002 and 0.036 < 0.05 respectively. Based on these results the third hypothesis was rejected.

Table 3.2Probit Regression Results

			No. of Obs	384
			LR χ^2 (10)	526.56
			Prob > χ^2	0.0000
			Log Likelihood	1189.1499
			Pseudo R^2	0.8113
Variable	Coef	Std Err.	t- Value	P – Value
Age of Household Head	0.0856	0.1919	0.45	0.656
Gender of the Household Head	1.3280	0.2188	6.07	0.000*
Education Level of Household Head	0.0627	0.0122	5.16	0.000*
Experience in Tomato Production	0.3798	0.0623	6.10	0.000*
Farm Income	0.7826	0.0715	10.95	0.000*
Farm Size	0.1662	0.0638	2.60	0.009*
Land Tenure	0.0993	0.0426	2.15	0.032*
Access to Credit	0.1721	0.0541	3.18	0.001*
Access to Extension Service	0.0426	0.0140	3.05	0.002*
Frequency of Extension	0.0028	0.0013	2.10	0.036*
Intercept	-0.8162	0.3930	-2.08	0.038

Iteration 0: log likelihood = -1452.4289: Iteration 1: log likelihood = -1216.8245: Iteration 2: log likelihood = -1191.37: Iteration 3: log likelihood = -1189.1732: Iteration 4: log likelihood = -1189.1499:Iteration 5: log likelihood = -1189.1499(*) Significant at 5 percent

Source: Author's Computation, 2017

3.3 Bivariate Probit Regression

Results of bivariate probit are presented in table 4.6. Results of bi-probit showed that adoption of greenhouse technology had improved performance of tomatoes farmers in North Rift region (the value of /athrho was 0.002 < 0.05). The value of rho-sigma was also significant (p – value 0.003 < 0.05) indicating that adoption of greenhouse and performance were jointly related.

IV. CONCLUSIONS AND RECOMMENDATIONS

The study focused on economic analysis of factors determining adoption of greenhouse technologies and its effects on performance of the tomato farmers in North Rift region. It was established that social factors such as age, gender, and education level and farmer experience significantly influenced the adoption of greenhouse technology among smallholder tomato farmers in North Rift region

Results also revealed that economic factors such as farm income; farm size and land tenure significantly influenced the

adoption of greenhouse technology among smallholder tomato farmers in North Rift region. These findings is consistent with prior studies

The study also established that institutional factors such as access to credit and availability of extension service significantly influenced the adoption of greenhouse technology among smallholder tomato farmers in North Rift region.

The study indicated that there was significant difference in the profitability/performance of greenhouse technology and open field system in North Rift region. This provides evidence that farmers who have adopted greenhouses for tomato production were earning more revenue compared with non adoptors. This was an indication that green house technology improved production of tomato.

Table 3.3 Bivariate Probit Regression Results

			No. of Obs	384
			Wald (11) χ^2	653.26
Log Likelihood	-4031.5881		Prob > χ^2	0.0000
Variable	Coef	Std Err.	t- Value	P – Value
Age of Household Head	-0.0000113	9.99e-060	-1.13	0.258
Gender of the Household Head	0.0963947	0.0097909	9.85	0.000
Education Level of Household Head	-2.60e-0700	3.40e-0700	-0.77	0.445
Experience in Tomato Production	0.0000442	5.10e-0600	8.68	0.000
Farm Income	0.0133709	0.0005514	24.25	0.000
Farm Size	0.0102557	0.0034800	2.95	0.003
Land Tenure	-3.39e-080	3.26e-0800	-1.04	0.299
Access to credit	0.0291892	0 .0156501	1.87	0.063
Access to Extension Service	0.0425870	0.0139547	3.05	0.002
Frequency of Extension	0.0716336	0.0257259	2.78	0.006
Intercept	0.0045277	0.0048856	0.93	0.355
Age of Household Head	0.0000171	0.0000126	-1.36	0.174
Gender of the Household Head	0.1635871	0.1745945	0.94	0.349
Education Level of Household Head	0.0191316	0.0094838	2.02	0.044
Experience in Tomato Production	-0.5024092	0.1525954	-3.29	0.001
Farm Income	0.2000158	0.0532982	3.75	0.000
Farm Size	0.0607928	0.0335738	1.81	0.070
Land Tenure	1.3709160	0.0549677	24.94	0.000
Access to credit	0.0497065	0.0183818	2.700	0.007
Access to Extension Service	0.0054437	0.0416869	0.130	0.896
Frequency of Extension	0.2378698	0.1026710	2.32	0.021
Intercept	0.5284227	0.3213143	1.64	0.100
/athrho |	-0.0022294	0.0307110	-0.07	0.002
rho |	-0.0022294	0.0307108	-0.06	0.003

Source: Author's Computation, 2017

From the study findings the following recommendations were drawn;

First, it was recommended that farmers should be empowered through training. This can be done through establishing of farmer school, field days, capacity building and seminars. Farmers who have more experienced in tomato farming should be used as model farmers to encourage others.

Secondly, the Government should introduce farmer credit programs to encourage greenhouse adoption. This could be done through provision of inputs, building materials and exclusive provision of training on greenhouse technologies. Also farmers should be provided with title deeds to encourage them to invest in greenhouse technology as they can use their title deeds as collateral for acquiring loans.

It is also recommended that the Government and other stakeholders should increase access to extension visits and access to credit. This can be done by employing more extension personnel and encouraging provision of credit facilities. It is recommended that the government should empower farmers through training, introduction of farmers' education programs and increase access to extension and credit services so as to enable them commercialize tomato production and hence increase adoption of greenhouse technology and thus improve their livelihoods.

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