Factors Influencing the Adoption of Greenhouse Technology among Smallholder Tomato Farmers in Nakuru County: Kenya

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Abstract: **Tomato (*Lycopersicon escutelum*) is one of the major and most popular vegetable that is grown in Kenya. It is mainly grown on small scale in the open field under both rain-fed and irrigation production systems due to declining land sizes. The country does not have an all year-round supply of tomatoes because of the rapidly changing weather conditions. However, tomato production in Kenya has taken a new course of the greenhouse technology. The introduction of the greenhouse production of tomatoes raises hopes that the popular vegetable will become available throughout the year. The introduction also heralds what could be a major shift from open pollinated farming to hybrid high yielding methods which will lead to massive improvements in tomato production, incomes and ultimately self-sufficiency in the production of tomatoes. The technology has however been proved profitable and also economically viable but the adoption in Nakuru County has however been low. Therefore, this study sought to investigate why the uptake of the technology is low in the county and also explain what has been the fundamental tool for growers and investors to do investment analyses and make decisions of which production system to adopt. The study also sought to provide up-to-date benchmark indicators for evaluating the viability and sustainability of greenhouse tomato production. In carrying out the study, targeting small holder tomato farmers, a systematic random sampling technique was used to select a sample of 40 respondents and data was collected with the help of structured questionnaires. Data analysis for both qualitative and quantitative data was conducted through Statistical Package for Social Science (SPSS). Results indicated that access to extension services, access to credit, membership to farmers' group and farm income significantly determined adoption of greenhouse technology (p – values 0.008, 0.029, 0.029 and 0.005 respectively).**

I. BACKGROUND OF THE STUDY

More than 119 million tons of tomatoes were produced during the year 2012 with the crop being grown across 9.9 million acres in over 160 countries. Total world production has increased by over 35% over the last 10 years. The biggest producer is China with 27.6 million tons followed by United States of America with 13.4 million tons. The other major growers with figures above 5.5 million tons are Turkey, India, Italy, and Egypt. The current average world yield stands at 12 tons/acre but highest yields are from European greenhouses where yields can exceed 312.3 tons/acre in a season.

In Kenya one of the most widely grown vegetable is tomato. It is mainly grown in the open field for domestic consumption and sales 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 living standards and creating employment opportunities (Ssejjemba 2008). The value of tomato produced in Kenya in 2007 was KES 14 billion (Odame *et al.,* 2009). Between 2005 and 2007 the area under tomato reduced from 20,743 ha to 18,926 ha a 9% reduction but in the same period the total volume produced increased by about 5% from 542,940 metric tons to 567,573 metric tons (Odame *et al.,* 2009). The increase in production is attributed to the extensive adoption of high yielding varieties and other modern technologies by farmers.

In Nakuru North district tomato is one of the major vegetable crops in terms of acreage (GoK 2010). The crop is largely grown in the open field and is mainly rain fed. The various tomato varieties that are grown in the district are Roma VF, Cal-J, Fortune marker, Rio-Grande, Onyx among others (GoK 2010). The average tomato yield in the district stands at 15 tons per ha (Gok 2007). This performance is however still far below the national production level of 30.7 tons per ha (GoK 2009) although it is a major crop in the district. The crop has some potential in terms of production especially if the farmers adopted the greenhouse technology.

To increase the productivity in the county, there is therefore need for adoption of improved, sustainable production technologies like the greenhouse system that are not only profitable but also responsive of the changing climatic conditions. In choosing a production system for adoption, the farmers are guided by various considerations including costs, returns and availability of information among the farmers. Greenhouse and open field tomato production systems have varying production costs and return levels which have an implication in adoption of either of the systems. Information

on the economic performance of the two systems in Nakuru north district is however quite limited and variable, this is what necessitated the study.

Problem Statement

Tomato is one of the most important commercial crops in Nakuru County that is replacing common cash crops like tea and coffee. Its production in the County has been conventionally under the open field system that is prone to adverse weather conditions. As a result there has been a remarkable decline in yields in recent years. The average tomato yields in Nakuru County is 15 tons/ha indicating that the performance is far below the expected production level of 30.7 tons/ha (GoK 2011). This decline is attributed partly to the changing climatic conditions marked by unpredictable rainfall patterns and increased tomato disease and pest incidences.

The greenhouse technology has been proved profitable and preferable to the open field system, elsewhere in the world. However, in Nakuru County, most farmers still use the open field rain fed system of tomato production. Due to inadequate information regarding the profitability of greenhouse and open field tomato production systems, farmers are unable to make informed choices which may explain in part why there is low uptake of the greenhouse tomato technology in Nakuru County.

II. LITERATURE REVIEW

Tomato (*Lycopersicon esculentum)* is a juicy berry of the nightshade family (*Solanaceae*). It originated from America and got introduced into East Africa early in 1900. It grows well in warm conditions of 20-27^0 C day temperatures and 15-17^0 C night temperatures (Musyoki *et al.,* 2005). Tomato prefers deep, well drained, sandy loam soils (Mungai *et al.*, 2005). In Kenya, the major producing areas include Mwea, Nakuru, Meru, Nyeri and Taita Taveta (Ssejjemba 2008).

Tomato is grown in Kenya as a commercial and important vegetable crop. In 2007, the value of the tomatoes produced in Kenya was KSh. 14 billion (Odame *et al.,* 2009). It is an important crop in Kenya with a potential for increasing incomes in rural areas, improving living standards, and creating employment for women and youth (Ssejjemba 2008).

Tomatoes can also be a source of foreign exchange (Atiya 2006) and for countries whose agricultural substantially contributes to the GDP there is need for diversifying sources of foreign earnings through increase of exports which can be achieved by adoption of high production technology and processing systems in the tomato sub sector. Furthermore, the quantity of the tomatoes consumed including both fresh and processed is large making tomatoes to be a source of income, food security and improved health standards to farmers (Yoshihiko 1993).

The tomato subsector worldwide is amongst the fast-evolving subsectors (Odame *et al.,* 2008). Some of the factors leading to this evolvement are increasing population, decreasing land sizes and changing climatic conditions. As a result, various production technologies have been developed to ensure adequate tomato supply, good quality and the achievement of various farmers' objectives. One such technology is the growing of tomatoes in greenhouses instead of the open field system.

It takes a shorter period of 2 months for greenhouse produced tomatoes to mature, while it takes a minimum of 3 months for open field tomatoes to mature (Makunike 2007). The national average yields are 30.7 tons per hectare (GoK, 2007). One greenhouse plant has a potential of giving up to 15 kgs at first harvest going up to 60 kgs by the time it has completed its full cycle, at one year (Makunike, 2007). Farmers can get 10 times more yield with greenhouse production system than with open field open pollinated varieties (Seminis Kenya 2007).

2.1 Factors influencing technology adoption:

According to Just and Zilberman (1983) there were various factors that influence the adoption of any technology. Just and Zilberman (Ibid) explain that technology may require some costs that are associated with new equipment and investments, learning time, locating and developing markets and training labor. 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 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 the new practice since adoption of a practice is guided by the utility expected from it, the effort put into adopting. It is reflective of this anticipated utility. Moreover, she contends that 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 these 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 the size of household labor force had negative influence on *celosia* adoption but positive influence on growing improved cowpea and groundnut varieties. For gender variable, the study indicated that males were more likely to adopt *celosia* than females while experience positively influenced timely planting of cowpeas.

Nchinda *et al.,* (2010) used Tobit regression model 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 in their study. However, hired labor and membership to farmers organizations positively and significantly influenced the adoption and intensity yam mini set technology in the areas covered. They also showed that age had influence with farmers less than 41 years of age being found to positively influence yam adoption and its intensity.

Another study aimed at estimating and explaining the parameters of the adoption process of hybrid clarias "heteroclarias" by fish farmers in Lagos state Nigeria, Adeogun *et al.,* (2008) 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 D fish farmers in hybrid catfish adoption and use decisions.

Jane and Fernandez-Comejo (2001) in a study on the economics of tomato economic growing in the United States used the Probit model to determine factors influencing adoption. Their findings were that educational level, contract farming, and crop price were significant and positively influenced the adoption. The study 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.

2.2 Conceptual Framework:

A farmer will decide on whether to use the open field or the greenhouse tomato production system given the farmers socio- economic characteristics such as gender, age education, income, farm size, land tenure, and experience in tomato growing among other factors. Institutional factors will also influence the choice of tomato production system by the farmer. Some of the institutional factors include credit extension, access to markets, and infrastructure and group participation among others.

After choosing either the open field or the greenhouse production systems (assumed to have different production levels) given a farmer's socio-economic characteristics and institutional factors, the farmer will have different returns and costs from each choice, hence different profitability levels. A rational farmer seeking to maximize profits will choose a production system with higher profit. The system that gives the highest profitability, results to higher farm incomes.

III. STUDY AREA

The study was carried out in Nakuru County specifically in Nakuru sub County. The sub County occupies an estimated area of 647 km^2 has an estimated human population of 20,200 farm families with average farm size (small scale) being 10, 000 m^2 while the average large scale being 4.5 km^2 (GoK 2007). The County's Agro-ecological zones include: Upper Highland-1 (UH1), Lower Highlands-2 (LH2), Lower Highlands-3 (LH3), Upper Midland-3 (UM3) AND Upper Midland-4 (UH4) and has an average rainfall of between 1,800 and 2000 mm/annum with the wettest season being during April and May. The temperature ranges from minimum of 12^0 C to 26^0 C. It lies at an altitude of between 1.700 and 2, 500 m above sea level. The main food crops and vegetables that are grown include tomatoes, peas, citrus, peaches, apples, cabbages, strawberries, asparagus, and leeks. There are several economic activities in other sectors other than agriculture. The county has 146 industrial plants and over 5200 informal sector enterprises. Tourism industry is also amongst the leading foreign exchange earners in the County. The conventional tomato production system in the district is the open field. The greenhouse system is a recent system of growing tomatoes in the district.

IV. MATERIALS AND METHODS

The study used the survey design inclusive of both qualitative and quantitative methods. The design incorporated the use of observation, interviews and well-structured questionnaire as methods of collecting data. The study used simple random sampling technique to select respondents for the study. Simple random sampling was advantageous as it ensured an unbiased representative sample.

The sample frame consisted of all the small scale tomato farmers in Nakuru sub County. Simple random sampling technique will be used to select respondents from Bahati and Dunduri areas. Out of the 20,200 farm families Bahati has a total of 9000 farm families hence out of 40 respondents only 17 will come from there and 23 from Dunduri giving a total of 40 respondents. Simple random sampling will ensure an unbiased representative sample**.**

The target population included small scale tomato farmers in Nakuru sub County, that is, a farmer with a farm size of not more than 10,000m^2, the unit of research being the farm household. Structured questionnaires were used to source information from farmers. This was supplemented with interviews and observations. The use of the structured questionnaires ensured that data that was obtained was free from bias.

Primary and secondary data were used. Primary data was gathered from respondents by use of structured interview schedule. Discussions through informal surveys were also held with relevant informants. Information from informal surveys was necessary for developing and improving the structured interview schedules. Secondary data was used to supplement the primary data and it was collected from past studies on adoption of tomatoes and also from books, and journals. A review of various government department reports like the Ministry of Agriculture was done. Other sources included various publications by the government, non-governmental organizations and research organizations.

Descriptive statistics was used to summarize and describe the sample. The inferential statistics were also used to generalize

the study from the sample to the whole county. Data was also analyzed through Statistical Package for Social Science (SPSS) software.

The raw data was transformed into computer usable form. Data processing involved four stages. Firstly, editing of data was done to detect errors and omissions and corrections were made where possible. Secondly, coding was done with categories which were established for each response and master code was prepared for the rest of information in the questionnaire. Thirdly, codes were transferred from the serialized questionnaires. Lastly, data was input into SPSS software for analysis.

Binary Logit Regression model:

The study was based on cumulative logistic probability functions. The model was estimated using the iterative maximum likelihood estimation procedure. This estimation procedure yields unbiased efficient and consistent parameter estimates (Aldrich and Nelson 1984). The model will be expressed as:

$$Z_{i(0,1)} = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_n X_{in} + \varepsilon$$

Where $Z_{i(0,1)=}$ The dependent variable constrained to take the values 0 and 1

β_s = were the coefficients of the coefficients in the model

X_s = were a set of explanatory variables and ε is the error term

In deciding whether to adopt greenhouse production system or retain open field system, the model identified factors influencing adoption and those which do not and was specified as:

$$Z_{(0,1)} = \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon$$

Where adoption was denoted by 1 and non-adoption was denoted by 0. B_0 is a constant, $\beta_{1\ldots n}$ were parameters to be estimated and X_{is} were vector of explanatory variables which included:

X_1 = Gender of household head (Gender); X_2= Age of the household head (Age); X_3 = Education level (Educ); X_4 = Income (income); X_5 = Farm size (Farmsize); $X_{6=}$ Access to credit facilities (credit); X_7 = Extension service (Extensvce); X_8 = Group membership (Grupmemb)

The empirical model for analyzing the factors affecting adoption became:

$$Y_{(0,1)} = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Educ + \beta_4 Income + \beta_5 Farmsize + \beta_6 Credit + \beta_7 Extensvce + \beta_8 Grupmemb$$

V. RESULTS AND DISCUSSIONS

This chapter presents results and discussions for the project. It summarizes descriptive analysis on the socio-economic characteristics of the small scale tomato growers in Nakuru County and gives results on Binary Logistic model for the factors influencing the adoption of greenhouse technology among smallholder tomato farmers in Nakuru County.

Age of the Respondents: The age of the farmers was collected to determine whether or not age influences adoption greenhouse technology. According to the analysis most of the farmers were above 50 years of age with 31.7%. The others were between 20 to 29 years with 15.0%, 30 to 39 years 25% and 40 to 49 years with 28.3% of the whole sample. The main reasons given for older people being less likely to adopt new technologies is that they are less receptive to new ideas and are less willing to take risks. Regression results indicated that age was insignificant.

*Gender of the Respondents***:** The results show that 38.3% of the tomato growers were males while 61.7% were females. The gender of the farmers was not significant according to the analysis. This is because tomato production is considered as an activity that is done by women and most of the men would not engage in farming which they consider unproductive.

Education level: According to the study 25 % farmers never attended school, 31.7% only got to the primary level, 35.0% up to secondary level and 8.3% had gotten up to tertiary level which indicated that most farmers were not educated to the level of having minimum skills in farming. Education was not significant in the study because the less educated people only depended on the indigenous modes of cultivation and use of poor varieties which led to poor yields in tomato production.

Income Level: The income of the farmers was considered as the income that farmers got per month from agricultural production. According to the study most farmers of the farmers got income less than 5000 Ksh with a percentage of 38.3%, the rest were those with between 5000 Ksh to 10000 Ksh with 28.3% and those with above 10000 Ksh were 33.3% of the whole sample. Most farmers do engage in agricultural production mainly for commercial purposes. Income was significant according to the study.

Experience: The experience of the farmers was taken to determine whether those farmers with more experience were more likely to adopt greenhouse technology or not. Experience was expected to positively affect the rate of adoption but according to the analysis it was insignificant. The experience of the farmers was taken as the number of years the farmer had been farming. Most of the farmers experience ranged from 11 to 20 years with 36.7%, 33.3% had an experience of above 20 years while 30% were those whose experience ranged from 1 to 10 years.

Table 4.1 Socio-Economic Characteristics of the Tomato Growers

		FREQUENCY	PERCENT
AGE	20-29	9	15.0
	30-39	15	25.0
	40-49	17	28.3
	Above 50	19	31.7

GENDER	Male	23	38.3
	Female	37	61.7
EDUCATION LEVEL	None	15	25
	Primary	19	31.7
	Secondary	21	35.0
	College/University	5	8.3
INCOME LEVEL	1-4999	23	38.3
	5000-10,000	17	28.3
	10,000 +	20	33.3
Farming Experience	1-10	18	30.0
	10-20	22	36.7
	Above 20	20	33.3
Extension Service	Yes	34	56.7
	No	26	43.3
Size of Land	1	51	85.0
	2	5	8.3
	3	4	6.7
Group Membership	Yes	42	70
	No	18	30
Credit Access	Yes	38	63.3
	No	22	36.7

Source: Research Data, 2019

Extension Service: The extension service was collected to determine whether or not farmers' access to extension services influenced the rate of adoption. The extension contact was taken as whether or not a farmer had access to extension services concerning farming and the answer was either yes or no. Those who gave yes as the answer were 56.7% and those who gave No as the answer were 43.3% of the total sample. This indicated that most of the farmers had an access to extension services. According to the analysis Extension contact was significant.

Size of the land: Size of land was expected to affect the rate of adoption but after the analysis the size of the land was not significant and did not affect adoption. The size of the farm was considered as the number of acres of land that a farmer cultivated. Most of the farmers had landless less than 3 acres with 85.0%, 8.3% had land size between 3 to 5 acres and 6.7% had land size above 5 acres. This indicated that majority of farmers are still under small scale production.

Group Membership: The data concerning membership to farmer's organizations was collected to determine whether membership to farmer's organizations affected the rate of adoption. Membership to farmers' organization was whether or not a farmer is a member to a farmers group aimed at providing them with farming skills and new enterprises which are suitable in the area. Those who said they belonged to a farmers' organization were 70.0% and the others were 30.0% who did not belong to any farmer organization. According to analysis, Membership to farmers' organization was significant.

Access to Credit: According to analysis most of the farmers had an access to credit with 63.3% and the rest of the farmers were 36.7% who had no access to credit. Credit was significant according to the study.

Logistic Regression: The value from the Hosmer and Lemeshow Chi-square test was significant, which indicates that the binary logit model fitted the data while Omnibus tests of model of coefficients at 95% level of significance indicated that all predictions jointly predicted the dependent variable well. The classification table also showed good prediction performance of 93.3% (Table 4.2).

The binary logistic model was used to do the analysis with nine independent variables (age, gender, education level, farm income, and experience, and extension contact, size of land and group membership). The variables were significant were extension contact (0.008), credit access (0.029), farm income (0.005) and group membership (0.029).

Extension service was significant and the coefficient (β) was positive which shows a positive relationship between extension contact and the likelihood to adopt greenhouse technology in tomato production. The positive value of the coefficient indicates that with access to extension service it's more likely for the farmer to adopt the technology.

Membership to a farmers' organization was significant and had a positive relationship between group membership and the likelihood to adopt greenhouse technology in tomato production. The positive value of the coefficient indicates that when a farmer belongs to a farmers' organization the more likely to adopt greenhouse technology in production of tomatoes.

Credit access in terms of Kenya shillings of credit received was significant at 95% level of significance and positively associated with the adoption of greenhouse technology. The positive sign of the coefficient shows that as access to credit increases for the household, the probability to adopt greenhouse technology in tomato farming increases. The possible justification for this is the fact that, access to credit compensates for insufficient household income, thereby providing the required initial capital required greenhouse tomato production. Access to credit permits farmers to invest in a new technology or acquire related inputs.

The level of both on-farm and off-farm income in Kenya shillings for the household head was significant at 95% significance level and positively associated with the adoption of the greenhouse technology in tomato production. The positive sign of the coefficient shows that as the income level of the household head increases, the probability to adopt increases. With a higher level of income, there is a tendency

to adopt greenhouse technology which requires a substantial amount of money especially for initial investment.

Table 4.2: Classification Table[a]

Observed			Predicted		
			Adoption		Percentage Correct
			adopted	not adopted	
	adoption	Adopted	20	2	90.9
		not adopted	2	36	94.7
Overall Percentage					93.3

Source : Research Data, 2019

Results of logit regression are presented in table 4.3.

Table 4.3: Results of Logit Regression

	B	S.E.	Wald	Df	Sig.	Exp(B)
Gender	-.629	1.037	.369	1	.544	.533
Age	.905	.576	2.470	1	.116	2.471
Education	.321	.549	.343	1	.558	1.379
Farm size	.143	.975	.022	1	.883	1.154
Farming experience	-1.084	.683	2.522	1	.112	.338
Extension	3.694	1.390	7.059	1	.008	40.189
Credit access	2.591	1.184	4.789	1	.029	13.338
Group member	2.914	1.331	4.794	1	.029	.054
Farm income	2.180	.771	8.005	1	.005	8.848
Constant	-7.651	3.618	4.472	1	.034	.000

Source : Research Data, 2019

According to regression analysis, social factors; age, gender, and education level were insignificant. Hence, it can be concluded that these social factors do not affect the adoption of greenhouse technology among smallholder farmers in Nakuru North District. These findings are consistent with prior study by Jane and Fernandez-Comejo (2001). Similarly, farm size and farming experience did not determine adoption of greenhouse tomato production technology. However, Extension services, Credit access, Group membership and Farm income were significant at 0.05 level of significance and concluded that these factors affects adoption of greenhouse technology as shown in table 4.3

VI. CONCLUSIONS

The study was carried out in Nakuru North District, Nakuru County. The data analyzed was collected from 40 respondents using purposive and multistage random sampling techniques. The data obtained was analyzed using SPSS software version 20 and the results showed that 4 factors namely: access to credit, group membership, farm income and access to extension service affected the adoption of greenhouse technology in tomato production in the District.

The study showed that most of the farmers were not informed concerning new technologies. It also showed that most people involved in farming were elderly and own small pieces of land. Moreover, most of the farmers were female despite the fact that majority of the farm land are owned by men, the families were also found to have less than four individuals who can fully participate in agricultural production. Most of the youths did not engage in agricultural production despite the issue of unemployment.

RECOMMENDATIONS

Since extension was significant to the adoption of greenhouse technology in tomato production in Nakuru North district, there is need to enhance more extension services to ensure that more farmers access the service and this would lead to adoption of new technologies and even greenhouse technology in tomato production.

Farmers should also be encouraged to join farmers' organizations by highlighting to them the benefits accrued from such organizations and the government should also offer financial support to such organizations to motivate farmers.

Research institutions should be involved in doing research concerning other factors affecting greenhouse tomato technology adoption and come up with solutions to enhance its adoption to increase productivity.

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