

Low Adoption of Greenhouse Technology among Small Scale Tomato Farmers in Kericho County: Socioeconomic and Institutional Perspectives

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Abstract Tomato is one of the most popular vegetables in Kericho County albeit low production and productivity due to various abiotic, biotic and managerial factors. Greenhouse production system is known for profitable and quality year-round tomato production. However, adoption of this system is low in the County. The reasons for low adoption of greenhouse tomato production among small scale farmers remain unclear. The study evaluated socio-economic and institutional factors influencing adoption of greenhouse tomato production technology among small scale tomato farmers in Kericho County. The study employed descriptive survey design. Data was collected from a sample of 135 small scale tomato farmers. Semi structured questionnaires were used to collect both quantitative and qualitative data and analysed using SPSS statistical package. The study revealed that the following socio-economic attributes: age, marital status, education, employment, and monthly income had significant ($p \leq 0.05$) positive effect on greenhouse adoption. About 51% of those practicing greenhouse productions were in the economic active age (18-40 years) associated with high level of productivity. Education and age significantly increased adoption of greenhouse tomato production. Most of the respondents (88.9%) did not have alternative source of income and therefore relied on farming as the main economic activity. Access to extension services and credit facilities did not hinder adoption of the technology. Low income from tomato sales and inadequate training negatively influenced adoption of greenhouse tomato production. The government should continually offer regular trainings and demonstrations on greenhouse management to enhance its adoption.

Keywords: Greenhouse, Technology, Adoption, Tomatoes, profitability, extension

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1. Introduction

The Horticulture subsector consisting of flowers, vegetable and fruits is an important source of income to small scale farmers, foreign exchange earner to the country and also immensely contributes to food insecurity alleviation [1]. The sub sector is dominated by small scale producers which accounts for 60% of the horticultural exports [2]. Tomato (*Solanum lycopersicum* L.), one of the vegetables is ranked second in terms of volume and value among the vegetables produced in Kenya [3]. It contributes about 20% of vegetable produce from Kenya [4]. It also generates an annual income of 137,000 USD from 410,033 tons [5]. The area under tomato production recorded an increase of 238 (220%) hectares during period of 2017 to 2020 [6]. This indicates the potential for commercialization of tomato by small-holder farmers and other value chain actors. The predominant agro-ecological zones in Kericho County are four: Upper highlands (UH),

lower highlands (LH), Upper midlands (UM) and lower midland (LM). These agro-ecological zones are conducive for both open and greenhouse tomato production. The Upper highlands (UH) and lower highlands (LH) experience low temperatures and high rainfall thus are not conducive for open tomato production. The farmers are gradually embracing greenhouse technology [6]. However, the productivity has been low and therefore to meet the high demand by the consumers, the county relies on imports from the neighbouring counties like Narok, Nakuru and Bomet.

Open field production for domestic consumption and local market sales is mainly practiced though the yields have remained low. Dependence on rain fed production systems is highly susceptible to extreme weather variability, pests, and diseases [7]. Irrigation is minimal due to seasonality of the water sources like rivers and inadequate water harvesting and conservation technologies.

Greenhouses have been used in commercial production of cut flowers in Kenya since 1990 however, the trend has

been slowly changing with farmers adopting it for production of other high value crops [8,9]. Greenhouses are mostly concentrated in the Rift Valley, Central and Western highlands of Kenya but are also slowly spreading to humid regions such as coastal and Eastern regions [8]. High yields, year-round production, market timing and reduced risks to climate change vulnerability are some of the benefits accrued from greenhouse farming. Greenhouse farming is also associated with efficient land use, a factor that is gaining increased significance in many sub-Saharan Africa countries where land is emerging as one of the most limiting production constraints [10].

Even though the government agencies, NGOs and private companies have been promoting the use of greenhouse farming among small scale farmers in Kenya and sub-Saharan African countries, the utilization is still low estimated to an average of 5% [11,12]. In effect some of the adopters have abandoned greenhouse farming after a short time [12,13] due to varying challenges.

Ateka *et al.*, [10] noted that human and financial capital would enhance absorption of protected farming technologies among small scale farmers. Awareness creation of a new technology was identified by Mallya [14] to positively influence greenhouse farming technology among farmers in Kinondoni district in Dar-es-salaam region. However, insufficient supply of experts, limited agricultural knowledge on greenhouse management limited the ability to use the greenhouse effectively in the same region. A study by Dwasi *et al.*, [15] opined that access to financial capital, technical skills, availability of market and technology characteristics influenced greenhouse farming among small scale horticulture farmers in Gem Sub County and further recommended that credit facilities and farmers capital should be increased and extension services be made accessible to farmers. Tuitoek *et al.*, [16] found that access to extension, credit facilities, farm income and membership to farmers group significantly influenced adoption of greenhouse technology among small scale tomato farmers in Nakuru County. However, lack of awareness of technology, age, gender, family size had no significant effect on greenhouse technology adoption.

Greenhouse technology can be an adaptation tool to mitigate the effects of climate change due to modification of microclimatic conditions in the growing area. Greenhouse protects crops against harsh climatic conditions. Study by Tanti *et al.*, [17] on the role of institutional factors in climate smart technology adoption in Agriculture in Eastern Indian state showed that government extension service, farmer field school participation and perception of climate shock played a crucial role in adoption of new technology. Interaction among institutions through networking and partnership, public-private collaboration of institutions, capacity building to local communities through training, demonstrations, and peer interactions could enhance CSA adoptions [18,19]. The interaction between extension workers and farmers creates a long-term communication network that enhances farmers' technical knowledge regarding adoption of new technologies. Studies on adoption of climate smart technologies among the resource-poor smallholder farmers in developing countries have indicated that one of the biggest constraints, apart

from financial and technical support, is the lack of awareness and knowledge about CSA [20,21,22]. It is evident from the literature that factors influencing adoption of a new technology may vary with regions under the study though some factors may cut across all the regions. In Kericho County, there is low uptake of greenhouse technology among small scale tomato farmers in spite of the favourable climatic conditions for this production system. The study therefore aimed at evaluating the socio-economic and institutional perspectives of small-scale tomato farmers on low adoption of greenhouse technology.

2. Methodology

Study Site

Kericho County is one of the 14 Counties in the Rift Valley region. It lies between longitude 35° 02' and 35° 40' East and between the equator and latitude 0 23' South. The county receives relief rainfall, with moderate temperatures of 17°C and low evaporation rates. The temperature ranges between 29°C and 10 °C. The rainfall pattern is such that the central part of the county, where tea is grown, receives the highest rainfall of about 2125 mm annually while the lower parts of Soin and parts of Kipkelion receive the least amount of rainfall of 1400 mm [23]. The County experiences two rainy seasons: the long rainy season occurs between April and June whereas the short rainy season occurs between October and December every year. The driest season is mostly from January to February. The county is divided into four topographical zones, namely, Upper Highland (UH), Lower Highland (LH), Upper Midland (UM) and Lower Midland zones (LM). The county is composed of six sub counties, namely: Ainamoi, Belgut, Bureti, Kipkelion East, Kipkelion West and Soin-Sigowet. These are further subdivided into 85 locations that are further sub-divided into 209 sub-locations. It covers an area of 2,479 sq. km. The main economic activity is agriculture including tea, dairy, coffee, and poultry. Horticulture subsector represented by flowers, fruits and vegetables such as tomatoes and medicinal and Aromatic Plants (MAPS) are also important in the County [23].

Scope

The study only covered small-scale tomato farmers in the six Sub Counties in Kericho County namely: Ainamoi, Belgut, Bureti, Kipkelion East, Kipkelion West and Soin-Sigowet. The factors examined in the study are socio-economic and institutional characteristics of small-scale tomato farmers.

Research Design and Sampling

A descriptive survey research design was used in the study. The study targeted 204 small scale tomato farmers in Kericho County. A list of small-scale tomato farmers in the county was obtained from the County Directorate of Agriculture. The study was done in the whole county because of the small number of tomato farmers in the county. The agricultural extension officers and other key informants were also interviewed. The sample size was calculated by the formula outlined by Yamane, [24]. A sample size of 135 farmers was selected from the Sub Counties. Simple random sampling was chosen as it

ensured an unbiased representative sample. The data was collected between May 2021 and January 2022. Both quantitative and qualitative data were collected from the study area using structured questionnaire. Data was first coded then entered the excel sheet and analysed using SPSS version 25. Descriptive statistics mean and frequencies were generated and the results presented in tables. Chi square test was used to determine the factors that significantly ($P \leq 0.05$) influenced greenhouse adoption among the small scale tomato farmers in the study area.

3. Results and Discussion

Socio-Economic Characteristics of Tomato Farmers and their effects on adoption of greenhouse technology

Age
Age had a significant effect on adoption of the greenhouse technology (Table 2). Most of those practicing greenhouse production were in the age group of 41-50 years (34.1%), followed by 31-40 years (25.9%). Youth aged 18-35 years constituted 25.2%, and those aged over 60 years were the least at 1.5% as shown in Table 1. A larger proportion of 51.1% were aged between 18 and 40, indicating that most of the respondents were youths and others in the middle age which is an economically active age associated with high level of productivity and personal growth [25]. In this study, the 41-50 years of age had better education capacity to understand the principles and management of protected horticulture. They are also able to invest more capital and energy to ensure the success of any income generating technologies [25]. The older farmers fear taking risks which may result to low uptake of new technologies. Previous studies report that older farmers are quick adopters due to their farming experience and ability to evaluate strengths and weakness of a new technology [26]. The findings of this study where youthful farmers were better adopters of greenhouse tomato production is supported by studies conducted by Dwasi *et al.* [15] and Mugambi *et al.* [25].

Gender

Greenhouse tomato production was dominated by males at 68.9% compared to females. Mugambi *et al.*, [25] and Mallya, [14] reported similar findings. Culturally males are the key decision makers on choice of enterprise to engage in especially among the community where the study was conducted. Males also own most of the family assets like land and capital that are required for adoption of any technology. The findings are in agreement with the results of Aduwo *et al.*, [27] who found that women have lower levels and slower rates of adoption of various agricultural technologies than men. Tanti *et al.*, [17] explained that female farmers are primarily agricultural workers, and they rarely participate in decision making, networking, and training due to social restrictions.

Marital Status

The marital status of the respondents significantly influenced the adoption of greenhouse technology. The married people had higher adoption rate than the singles. This assures continuous supply of food to the family [14]. The married people can pool resources including financial and human that can enable them to engage in new agricultural technologies. Married farmers also have

divergent agricultural contacts that include extension agents and agro-dealers than the single or widowed farmers who rely on other farmers for agricultural information [28]. The results were consistent with Negussie, [29] and Fikire & Asefa, [30] findings however, no significant difference was observed by Wambui [25].

Education Level

Education level was found to have a significant effect on greenhouse adoption (Table 2). Level of education increases the ability to obtain process and use information relevant to the adoption of a new technology [31,32]. Those with secondary school certificate were the majority (53.3%) of greenhouse tomato farmers followed by those with certificate/diploma (21.5%) levels. Those with informal and University education were at 1.5% and 8.1% respectively (Table 1). Most of the respondents therefore had technical skills, experience and knowledge that could enable them to understand the importance of adopting new technologies. Higher education level is expected to influence farmers' attitudes, making them more open, judicious, and able to analyse the benefits of the new technology.

Farm Size

A Majority of the respondents (34.8%) had over 1acre of land. Large land size allows expansion and diversification of profitable technologies or enterprises. Etim and Etim [33] pointed out that large land size allows farmers to test technologies on a section of their enormous area without fear of endangering their families' food security. Positive relationship between farm size and adoption of agricultural technology has been reported in many studies [25,34]. However in our findings farm size had no significant effect on adoption of greenhouse technology in the study area (Table 2).

Average Labour Cost

The study revealed that 61.4% of the respondents spent less on labour of which 57% spent less than Ksh. 5000 and 4.4% spent none. 30.4% of the respondents spent between Ksh. 5000-10000 and the rest spent up to Ksh 20,000. Study shows that most of the respondents depended on family labour and little was required to supplement the labour requirements.

Household Size

77% of the respondents had a household size of 3-8 persons while 14.8% had a household size of 1-2 persons. Few respondents had more than 8 persons. Household size is simply used as a measure of labour availability for farmers with large families [34]. Large family size have more labour resources and also reduces the need for hiring labour to do agricultural activities and this can be evidenced by low average labour cost of less than Ksh 5000 recorded by the respondents (Table 1). Large family size is positively associated with the adoption of more technologies [35]. Conversely, family size also negatively affects adoption because more family members within the household may weaken their economic status and in turn decreases adoption [36]. However, in our study household size had no significant effect on greenhouse adoption.

Alternative Source of Income

Information on income sources was sought in view of the fact that income is an important determinant in technology choice. Alternative income source was found to have a significant effect on greenhouse technology

(Table 2). Most of the respondents (88.9%) did not have alternative source of income and therefore relied on farming as the main economic activity and this might have contributed to the low adoption of the greenhouse technology. Alternative income sources may contribute positively to technology adoption through the financing of the agricultural inputs [37]. Household income is a good measure of farm capital and therefore showed a strong correlation with adoption of technology for agricultural intensification [26]. He further noted that a unit increase in household income would increase the likelihood of greenhouse adoption by 0.6%.

Table 1. Socio-economic characteristics of sampled small scale tomato farmers

Factor		Frequency	Percentage (%)
Age	18-30	34	25.2
	31-40	35	25.9
	41-50	46	34.1
	51-60	18	13.3
	over 60	2	1.5
Gender	Female	42	31.1
	Male	93	68.9
Marital status	Single	21	15.6
	Married	114	84.4
Education level	Informal	2	1.5
	Primary	21	15.6
	Secondary	72	53.3
	Cert/ Dipl.	29	21.5
	University	11	8.1
Alternative source of income	No	120	88.9
	Yes	15	11.1
Household size	1-2	20	14.8
	3-5	55	40.7
	6-8	49	36.3
	More than 8	11	8.1
Monthly income	Less than 5000	35	25.9
	5001-10000	47	34.8
	10001-20000	37	27.4
	Over 20000	16	11.9
Average labour cost	None	6	4.4
	Less than 5000	77	57.0
	5000-10000	41	30.4
	10000-15000	7	5.2
	15000-20000	4	3.0
Farming experience	Less than 1 year	16	11.9
	Over 1-3 years	32	23.7
	Over 3- 5 Years	32	23.7
	Over 5 years	55	40.7

Monthly Income from Sale of Tomatoes

Thirty four (34.8%) percent of the respondents earned between Ksh 5,000-10,000 per month and 25.9% earned less than Ksh 5000. Only 39.3% earned more than 10,000 per month (Table 1). Monthly income from the sale was found to be significant and influenced greenhouse adoption (Table 2). The earnings from the sale were very low and this might have discouraged many farmers from venturing in greenhouse production. The low earnings could have been contributed by inadequate training (Table 3) on greenhouse production management practices, post harvest management practices and market linkages.

Farming Experience

Thirty six (36%) percent of the respondents had farming experience of up to 3 years and 64% of the respondents had done farming for more than 3 years. Though most of the farmers had longer farming experience, the rate of adoption of tomato greenhouse farming in the study area was low. Probably farmers in the study area did not have adequate technical knowhow on greenhouse technology. Kumar *et al.*, [35] noted similar trend in adoption of some climate smart agriculture technologies such as cultural practices and irrigation management technologies. Longer farming experience implies accumulated farming knowledge and technical know-how and skills, all of which contribute to technology adoption [38].

Table 2. Influence of socio-economic attributes on adoption of greenhouse technology based on Chi square method

Variable	Df	χ^2	P value	Coefficient (V)	Description of strength of relationship
Age	4	19.781	.001*	.383	Large
Gender	1	.202	NS	.039	Negligible
Marital status	1	6.121	.013*	.214	Small
Education	4	9.485	.050*	.265	Medium
Farm size	4	3.061	NS	.151	Small
Household size	3	6.665	.083	.222	Small
Alternative source of income	1	8.637	.003*	.253	Medium
Monthly Income level	3	8.564	.036*	.252	Medium
Labour Expenditure	4	1.854	NS	.117	Small
Farming Experience	3	3.673	NS	.165	Small

Influence of Institutional Factors on Adoption of Greenhouse Technology

Extension services: The data indicated that 63.7% of the respondents had access to extension services (Table 3). Farmers contact with extension service providers provides more information on technology and its profitability. Access to extension services has the potential to reduce the risks by reducing information asymmetries' especially to resource poor farmers [39]. 36.3% of the respondents did not have access to extension services indicating that there is need for more extension service providers and also facilitation to them to enhance their mobility and/ service delivery. The interaction between extension service providers and farmers creates a long-term communication network that enhances farmers' technical knowledge regarding new technologies.

Training, field visits and field days attendance: Training was found to be significant in adoption of greenhouse technology (Table 4). Majority of the farmers had not attended trainings over the last one year (Table 3) and probably lacked technical skills on management of tomatoes under greenhouse conditions. Training boosts the technological skills of the farmers motivating them to adopt a technology. It was also noted that most of the respondents (53.3%) had not attended field days and among those who had attended most of them had attended

twice (Table 3). Furthermore, majority of the farmers had not attended field visits and most (33.3%) of those who had attended field visits had done it once or twice over the last one year. Frequent visits are expected to provide the farmers with continuous information to effectively implement extension messages or technologies passed to them. The low adoption of greenhouse tomato production could be attributed to inadequate extension services such as low field days and demonstration with regard to greenhouse technology. Low technical capacity coupled with poor performance of greenhouse tomato production is key barrier for adoption of the technology in the study area. Our findings parallel those of Forkuor *et al.*, [40] who reported low adoption of greenhouse technology due to poor technological skills of farmers and extension officers. Participation in agricultural training and field visits is associated with the adoption of more improved farm practices for most crops [35].

Credit access: Majority of the respondents (73.3%) had access to credit facilities. Credit can facilitate farm households to purchase the needed agricultural inputs and enhance their capacity to engage in long-term agricultural technologies in their farms. Credit access did not significantly influence adoption of greenhouse technology among small scale tomato farmers. However, our results were contrary to the findings of Ali *et al.*, [41], Jimi *et al.*, [42] and Nasereldin *et al.*, [43] who found that credit accessibility was beneficial and significant in adoption of new agricultural inputs.

Table 3. Access to Institutional services among the small-scale tomato farmers

Institutional Services		Frequency	Percentage (%)
Access to Extension	Yes	86	63.7
	No	49	36.3
Trained over the last 1 year	Yes	62	45.9
	No	73	54.1
Number of trainings attended within 1 year	0	68	50.4
	1	26	19.3
	2	21	15.6
	More than 2	20	14.8
	No response	17	12.6
Field visits attended	Yes	55	40.7
	No	63	46.7
	No response	17	12.6
Number of fields visits attended	0	74	54.8
	1	25	18.5
	2	20	14.8
	More than 2	16	11.9
	No response	30	22.2
Field days attended	Yes	33	24.4
	No	72	53.3
	No response	17	12.6
Number of field days attended	0	92	68.1
	1	13	9.6
	2	17	12.6
	More than 2	13	9.6
	No response	30	22.2
Access to credit facilities	Yes	99	73.3
	No	36	26.7
Group membership	Yes	54	40.0
	No	81	60

Table 4. Influence of institutional attributes on adoption of greenhouse technology based on Chi square method

Variable	Df	χ^2	P value	Coefficient (V)	Description of strength of relationship
Access to Extension	1	.002	NS	.004	Negligible
Training	1	9.935*	.002	.271	Medium
Access to Credit	1	0.728	NS	.073	Negligible
Radio/TV programs	1	2.463	NS	.135	Small
Group membership	1	3.003	NS	.149	Small

Group membership: Sixty percent (60%) of the respondents did not belong to any farmer group or organization (Table 3). Membership in a farmer's group generally raises the probability of receiving information about various technologies from members or collaborating development agencies. Many studies have reported improved performance of farmer organizations for poor smallholders in sub-Saharan Africa, including increased access to financial services, better markets and increased use of modern technology [44]. Mwanajuma *et al.*, [45] in his study found that being in a group improved women access to agricultural inputs and financial support. In groups, poor small scale farmers can benefit from the collective purchasing of inputs compared to those who don't belong to any group [46,47]. Moreover many governments and organizations also prefer to support poor farmers in groups rather than as individuals [48]. The respondents should therefore be encouraged to subscribe to a farmers' group or organization

4. Conclusion and Recommendations

Conclusion

The socio-economic factors: age, marital status, education, employment, and monthly income had significant ($P \leq 0.05$) positive relationship with greenhouse adoption among the small-scale farmers in Kericho County. Most of the farmers were in the economic active age group and possessed secondary school level of education and therefore had knowledge and skills to venture into new technologies. Majority of farmers using the technology were males the decision makers and owners of family assets like land, and determinants of type of farming and technology to be used. The monthly income from tomato sale was relatively low and this might have discouraged most farmers from adopting the technology. Among the institutional factors, training had significant ($P \leq 0.05$) positive influence on greenhouse adoption. Most of the farmers had not attended trainings, field days and demonstrations and therefore lacked technical skills to manage the microclimate in the greenhouse.

Recommendations

More sensitization on greenhouse tomato production is required for improved productivity and income. The government and relevant stakeholders should empower the farmers through regular trainings and demonstrations on

greenhouse management to optimize its profitability and therefore enhance its adoption. There is need for extension services and stakeholders to increase on-farm trials/demonstrations on improved agricultural technologies, in order to enhance farmers' awareness and adoption of technologies. Further studies on the challenges affecting greenhouse tomato farmers in the County are recommended.

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