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TECHNOLOGICAL AND SOCIOECONOMIC FACTORS INFLUENCING ADOPTION OF GREENHOUSE FARMING AMONG SMALL SCALE TOMATO FARMERS IN SOTIK SUB COUNTY, KENYA

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ABSTRACT----------
Greenhouse farming may cushion small scale vegetable farmers against economic losses during harsh environmental conditions, however, the technology has not been embraced by many farmers. The purpose of this study, therefore, was to determine the factors that influence the adoption of greenhouse technology among small-scale tomato farmers in Sotik Sub-County. The study used an ex-post-facto research design a target population of 200 small-scale greenhouse farmers and a sample size of 133 farmers was selected using stratified random sampling. Data was collected using questionnaires and analyzed using SPSS version 26 software. The results revealed that among the social factors studied age and education levels recorded a significant positive correlation with the adoption of greenhouse technology though gender had an insignificant but positive correlation with greenhouse adoption. Economic factors such as cost of materials, inputs, sources of income, access to credit and farm income levels indicated a positive and significant relationship with greenhouse adoption. The technological factors including perception on the technology itself, technical know-how and perceived cost of technology showed a positive significant relationship with the adoption of greenhouse technology. The study concluded that the studied factors had statistically significant influence on adoption of greenhouse farming small scale tomato farmers. The study recommends that comprehensive training and capacity-building programs be established to enhance farmers' technological know-how and practical skills in greenhouse farming and the agricultural extension officers should provide tailored, farm-specific advice and solutions that address the unique needs and challenges of individual farmers.

KEY WORDS: *Small Scale Farmers, Greenhouse, Adoption, Tomato----------*

INTRODUCTION

Kenya is one of Sub-Saharan Africa's leading tomato producer (Ochilo *et al.,* 2019) being cultivated in regions between 1150 and 1800 meters above sea level (Mwangi & Karioki, 2015). Tomatoes are one of the most commonly grown crop, ranking second in volume and value after potatoes (Mitra & Yunus, 2018). The crop is extensively cultivated, accounting for about 7% of horticultural and 14% of vegetable production (Mwangi *et al.,* 2015). Production is primarily in open fields for domestic consumption and local market sales. This crop helps to generate income and trade, alleviate poverty, and create jobs, especially for rural populations (Singh et al., 2017). However, tomato production is facing the challenge of low productivity despite this primary contribution to economies in the rural region (Geoffrey et al., 2014), introduction of new varieties and advanced technologies such as greenhouses farming.

The production from greenhouse farming constitutes 5% of total production, while open-field production is 95% of overall tomato production (FAO 2017). Open field production mostly weather dependent is faced by myriad challenges including pests, diseases and climate variability. Temperature fluctuations and poor rainfall patterns and distribution predisposes the crop to vagaries of pests and diseases consequently reducing the yield and quality of tomatoes, increases prices and cost of production. Greenhouse technology presents a viable solution to these challenges by offering a controlled environment for crop production and also extending the growing season (Alvarado et al., 2020).

Greenhouse provide a number of benefits that contribute to global food supply, economic development and environmental sustainability. Greenhouses protect crops from adverse weather conditions, pests, and diseases,

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enabling year-round cultivation and higher yields (Messelink et al., 2021; Līcīte et al., 2022). They offer opportunities for precision agriculture, allowing farmers to optimize resource utilization and minimize waste (Cheuk et al., 2003). Furthermore, greenhouses minimize pesticide use, promote high water use efficiency (Stanghellini, 2014), control land degradation and maximize land use. Greenhouses enhance the quality and ensures consistency and availability of fresh produce, ensuring food security and meeting consumer demands (Grinberga-Zalite & Zvirbule et al.,2022). Despite the benefits of greenhouses, the rate of adoption of this technology among small scale tomato farmers remains relatively low. Many studies have highlighted various factors influencing the adoption of agricultural technologies. Variables like financial constraints, technological know-how, access to credit, farmers' income levels, education, and land ownership have been found to be significant barriers to the adoption of technologies. Despite these insights, there is a lack of comprehensive research specifically examining the factors influencing the adoption of greenhouse technology among small-scale farmers in Bomet County. Most existing studies focus on broader regions or different agricultural technologies, leaving a gap in localized understanding and context-specific challenges.

The purpose of this study, therefore, was to determine the factors that influence the adoption of greenhouse technology among small-scale tomato farmers in Sotik Sub-County, Bomet County.

Statement of the Problem

The agricultural sector in Kenya is a critical component of the country's economy, providing employment and sustenance to a larger portion of the population. Within this sector, small-scale farming is predominantly significant in regions like Sotik Sub County despite significant potential for productivity and income generation by small-scale tomato farmers in this area. There are numerous challenges, including erratic weather patterns, pest infections, and limited access to modern farming technologies. Greenhouse technology presents a viable solution to these challenges by offering a controlled environment for crop production, potentially leading to increased yields and improved quality of production. However, the adoption of greenhouse technology among tomato farmers in the Sotik Sub-County remains relatively low.

Previous studies have highlighted various factors influencing the adoption of agricultural technologies. Variables like financial constraints, technological know-how, access to credit, farmers' income levels, education, and land ownership have been found to be significant barriers to the adoption of technologies. Despite these insights, there is a lack of comprehensive research specifically examining the factors influencing the adoption of greenhouse technology among small-scale farmers in the Sotik Sub-County. Most existing studies focus on broader regions or different agricultural technologies, leaving a gap in localized understanding and context-specific challenges.

This research aims to fill this gap by generating data for the purpose of analysis and dissemination. The study will also seek to provide insights that may inform policymakers, agricultural extension services, and other stakeholders in their efforts to enhance the uptake of greenhouse technologies, thereby improving the productivity and livelihoods of small-scale farmers in the region.

Research Hypothesis

$H_0$1 There is no statistically significant influence of social factors on the adoption of greenhouse technology by small-scale tomato farmers in Sotik Sub-County.

$H_0$2 There is no statistically significant influence of technological factors on the adoption of greenhouse technology among small-scale tomato farmers in the Sotik Sub-County.

LITERATURE REVIEW

Theoretical Review

This study was based on Rogers' diffusion and adoption of technology theory, which was advanced in 2003. The theory explains diffusion as a process through which members of a specific audience can gradually embrace a new idea, technology, or concept. Innovations in this context are seen as unique ideas or activities. The theory explores how new ideas and technology are communicated, evaluated, implemented, and reviewed before being adopted. Adoption is viewed as a human, social, and economic process. Key elements of the adoption process include innovation, diffusion, motivation, and adoption (Rogers, 2007).

The adoption process occurs in stages. In the first stage, there are the Innovators, who are individuals who adopt immediately after obtaining general knowledge about the innovation. This category makes up 2.5% of the total population. The second stage comprises early adopters, who adopt through local leaders and make up 13.5% of the

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total population. The third stage is the early majority, who make individual decisions to adopt and don't rely on local leaders; they represent 34% of the population. The fourth stage is the late majority, who adopt after observing relatives and neighbors adopting the technology, making up 34% of the total population. The last stage is the laggards, who are the last to adopt and make up 16% of the total population (Miller, 2015).

Empirical Review

Social factors influencing adoption of greenhouse technology

Social factors play a pivotal role in the adoption of new agricultural technologies, including greenhouse farming. These factors encompass various elements of the social environment that influence individual and collective behaviors, attitudes, and decisions. Serebrennikov, Thorne, Kallas, and McCarthy (2020) established that social factors such as access to markets have a significant influence on the adoption of emerging agricultural technologies. The availability of a ready market for farm produce gives farmers assurance that there will be a profitable market for their produce before they invest in new technology. In addition, market access ensures that the surplus produce generated through the adoption of agricultural technologies finds buyers easily, thus reducing the risk of post-harvest losses.

In assessing factors influencing the adoption of sustainable farming practices in Europe, Serebrennikov *et al.,* (2020) indicated that modern industrial farming practices in Europe had caused widespread degradation of agricultural land across the continent. Thus, there was a need to adopt different emerging farm management strategies to reduce the impact of environmental degradation. The study was a systematic review of literature, and 23 peer-reviewed scholarly articles extracted from Google Scholar covered the period between 2003 and 2019. The study established a positive significant correlation between economic attitudes, sources of information, and the adoption of agricultural technology. The study also established that farmers' age and education level could systematically influence technology adoption.

In developing countries, education is not universal to all. Access to education would improve awareness and understanding of agricultural technologies. In assessing the determinants of farmers' perception of investing in water and soil conservation technologies in the western highlands of Ethiopia, Moges, and Taye (2017) revealed that the use of agricultural technology is positively linked to a higher level of education. Male-headed households have greater access to technology and information than women. Men-headed households were more involved in considering the adoption of modern agricultural innovations than women. The study also established that Land size and ownership had a positive impact on the belief that farmers are investing in emerging farming technology. Through size, the latest developments may be tested in small areas of the ground. Household size is a proxy for available labor that allows farmers to use labor-intensive technologies.

Sarker, Galdos, Challinor, and Hossain (2021) conducted a study on farming system typology for the adoption of new technology in Bangladesh. The study was based on individual farmhouse characteristics, farming practices, and farm structure. The study used cluster analysis and principal component analysis to establish farm typologies. The findings revealed a significant influence of factors such as farming experience, age of the farmer, household income, access to markets, the proportion of hired labor, land ownership savings, income from off-farm activities, and adoption of new agricultural technologies. Further, the study found differences among farmers based on livelihood orientation and resource endowment. These categories were well-resourced farmers, resource-constrained farmers, moderately resourced households, and severely resourced households.

Sennuga, Fadiji, and Thaddeus (2020) examined factors influencing the adoption of improved agricultural technologies among smallholder farmers in Nigeria. The study adopted a descriptive research design. A sample of 200 farmers and 100 farmers from two communities in Kaduna State were selected using purposive and simple random sampling methods. Primary data was qualitatively used in in-depth interviews, focus group discussions, and a structured interview guide, while secondary data was obtained from the Kaduna Agricultural Development office. The findings revealed that the farmer’s age, gender, and level of education had a significant positive influence on the adoption of agricultural technology in Kaduna State. Therefore, the study recommended that the state implement policies that support adopting improved farming technologies. Notably, the study relied on qualitative techniques, and thus, there is a need for further studies using mixed research methods.

Mugambi (2020), while investigating the factors influencing the adoption of greenhouse technology in farming by small-scale farmers in Central Imenti, established that the level of adoption of greenhouse farming in the county was very low at 42 percent when compared to other counties. The study established that economic factors that address the

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cost of greenhouse technology adoption, such as the farmers' income levels, cost of engaging technical experts support, and availability of essential resources such as labor, land, and water, had a significant influence on the adoption of greenhouse farming. The study adopted a descriptive research design targeting 380 farmers. Data was obtained using both qualitative and quantitative techniques. However, the study adopted a descriptive research design that does not quantify the extent to which the examined variables explain the variation in greenhouse adoption.

Technological factors influencing adoption of greenhouse technology

Rizzo *et al.,* (2024) conducted a systematic literature review to identify key factors in farmers' adoption of sustainable agricultural innovations in Italy. This study identified, analyzed, and summarized 44 studies published between 2010 and 2023. The study established that specific technological factors influenced the agricultural innovation process in addition to individual farmer characteristics and other social-demographic factors. The study further established that the adoption of sustainable agricultural innovations was determined by environmental values. For instance, when comparing conventional and organic farming, organic farmers tend to have a greater concern for environmental conservation, and, therefore, they are less likely to take into account financial gains. On the contrary, a high degree of innovation aversion, complexity of the innovation, and low perception of the control of innovation were found to be the core barriers to innovation adoption.

Dissanayake *et al.,* (2022) carried out a systematic review of the literature on factors affecting the adoption of technology in the agricultural sector in Sri Lanka. The reviewed literature was compiled from different sources for a period of 50 years. The factors influencing the adoption of agricultural technology were classified into three categories; the first involved technology-related factors, such as availability, affordability, observability, complexity, and compatibility. The second one was institutional factors such as the availability of credit facilities, farm inputs, ready markets, and access to extension services. The third category involved factors related to individual user characteristics such as age, gender, income, farm size, and prior experience. The reviewed studies established that technological factors had the most significant influence on the adoption of agricultural technology in Sri Lanka.

Forkuor, Amponsah, Oteng-Darko, and Osei (2022), in their paper on safeguarding food security through large-scale adoption of agricultural production technologies such as greenhouses in Ghana, indicated that the climate change impacts and predominance of open-field rain-fed agricultural systems were posing a significant risk to food security in Africa and therefore the need to adapt to clean production technologies to increase productivity in an environmentally sustainable way. However, through examination of data obtained through consultation with business communities, stakeholders in research, policymakers, and institutional strategic plans and policy documents, the study revealed that the greatest challenge to technological adoption was the unsustainability of the existing greenhouse designs, low technical expertise, and high installation and utility charges. The study recommended establishing and enhancing the capacity of the local fabrication industry and extension services.

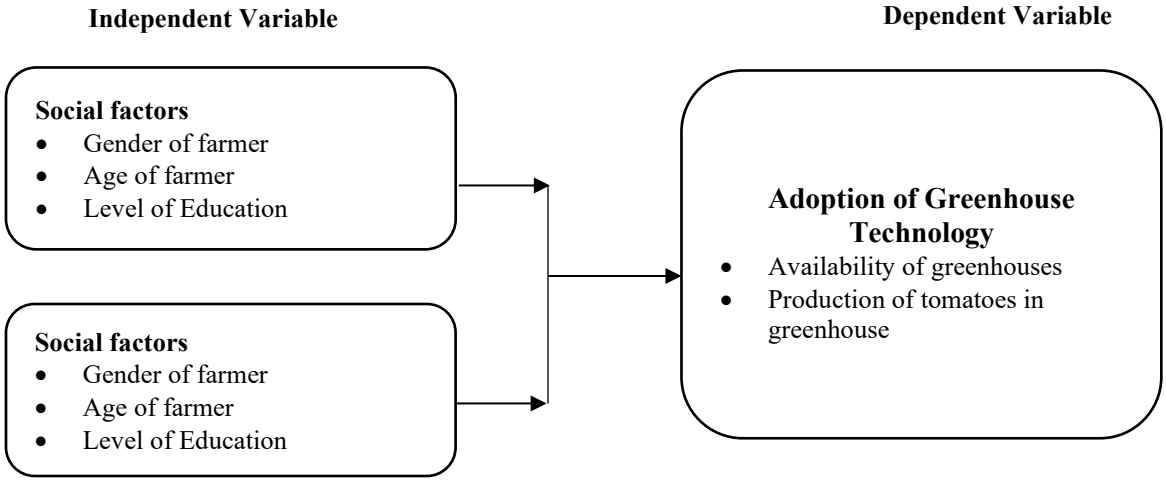
A study carried out on technical efficiency in Tomato production among small-scale farmers in Kirinyaga County, Mwangi, Ndirangu, and Isaboke (2020) established that farmers in the county were inefficient, with technical efficacy at an average of 39.5% being more efficient with greenhouse tomato production than the open field systems. They found a significant relationship between the availability of extension services, market information, availability of information on effective production systems, household size, and technical efficiency. The study found that even though firm size was significant, it had an inverse relationship with technical efficacy; the study adopted a cross-sectional research design and relied on primary data obtained using structured questionnaires from 384 respondents randomly selected from the six Sub-Counties in Kirinyaga County. However, the study adopted a cross-sectional research design using structured questionnaires, and the proposed study will adopt mixed research methods

Conceptual Framework

In *Figure 1*, The independent variables are social factors and technological factors while the dependent variable is the adoption of greenhouse technology, which measured the presence of a greenhouse structure and the production of tomatoes in the greenhouse.

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Figure 1: Conceptual Framework



MATERIALS AND METHODS

Research Design

The study employed an ex-post-facto research design, deemed appropriate as the interactions between the variables had already occurred naturally, allowing the researcher to simply observe the outcomes of these interactions between the independent and dependent variables. The study targeted two populations: the first comprised 133 small-scale greenhouse farmers, while the second included 10 extension officers who served as key informants. A sample size of 133 farmers was determined using Yamane's (1967) sample determination formula. Data was collected using a questionnaire and a focus group discussion guide. Qualitative data was analyzed thematically, while quantitative data was analyzed using descriptive statistics. The majority of the greenhouse farmers were male, making up at least 58%, with an average age of 35-45 years and an educational background of a diploma. Most farmers had adopted greenhouse technology with three to five years of farming experience and were involved in off-farm occupations. Similarly, most extension officers in Sotik Sub-County were male, aged 45-55 years, held a diploma as their highest education level, and had worked in the region for an average of six to 10 years.

DATA ANALYSIS AND PRESENTATION

Influence of social factors on adoption of greenhouse technology among farmers

The first objective of the study was to evaluate the influence of social factors on the adoption of greenhouse technology. For this objective, farmers were requested to indicate the extent to which their social factors influence their decision to adopt greenhouse technology. A five-point Likert scale with weights ranging from 5=strongly agree, 4=agree, 3= neutral, 2=disagree, and 1=strongly disagree was used to assess the respondents' feedback. The data was summarized using frequencies and percentages. The results are displayed in Table 1.

Table 1: Frequency, and percentages of social factors for farmers

Statement on Social factors (Farmers)	SA 5	A 4	N 3	D 2	SD 1
The gender of the farmer significantly influences the decision to adopt greenhouse farming	12(9)	55(41.4)	37(27.8)	24(18)	5(3.8)
Farmers with formal education are better able to access and understand information about greenhouse farming, thus are more likely to adopt it.	9(6.8)	53(39.8)	55(41.4)	16(12)	0
Farmers with higher educational levels are more open to adopting greenhouse farming	9(6.8)	53(39.8)	55(41.4)	16(12)	0
Older farmers with more farming experience are less likely to adopt greenhouse technology	9(6.8)	82(61.7)	40(30.1)	2(1.5)	0
Younger farmers are more likely to adopt greenhouse farming compared to older farmers	35(26.3)	62(46.6)	32(24.1)	2(1.5)	2(1.5)

Source: Field Data (2024)

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Table 1 reveals that majority of the respondents (41.4+9=50.4%) agreed and strongly agreed that their gender significantly influences their decision to adopt greenhouse farming. This finding concurs to that of Sarker, *et. al.,* (2021) who established that women have lower levels and slower rates of adoption of various agricultural technologies than men. The findings also revealed that majority of the respondents (39.8+6.8=46.6%) agreed and strongly agreed that farmers with formal education were more likely to access and understand information about greenhouse farming which could make them easily adopt the technology. This finding was unique to the study. Further, the study found that majority of the respondents (39.8+6.8=46.6%) agreed and strongly agreed that farmers with higher educational levels were more open to adopting greenhouse farming. This finding agree with Tuitoek *et al.,* (2019).

Similarly, the study found that majority of the respondents (61.7+6.8=68.5%) agreed and strongly agreed that older farmers with more farming experience were less likely to adopt greenhouse technology. This finding agree with Serebrennikov, *et al.,* (2020) who observed that a middle category of smallholder farmers aged between 40 and 50 years were better adopters of irrigation technology compared to the youth and the elderly Finally, the study found that majority of the respondents (46.6+26.3=72.9%) agreed and strongly agreed that younger farmers are more likely to adopt greenhouse farming compared to older farmers. This finding agree with Sarker, *et. al.,* (2021). In addition, the extension officers were asked to indicate the extent to which the various social factors influenced small-scale farmers' decision to adopt greenhouse technologies. The data was analyzed using frequencies, and percentages. The results are displayed in Table 2

Table 2: Frequency, and percentages of social factors for agricultural extension officers

Statement on Social Factors	SA 5	A 4	N 3	D 2	SD 1
The gender of the farmer significantly influences the decision to adopt greenhouse farming	0	0	1(10)	6(60)	3(30)
Farmers with formal education are better able to access and understand information about greenhouse farming, thus are more likely to adopt it.	5(50)	4(40)	1(10)	0	0
Farmers with higher educational levels are more open to adopting greenhouse farming	0	4(40)	3(30)	0	0
Older farmers with more farming experience are less likely to adopt greenhouse technology	0	9(90)	1(10)	0	0
Younger farmers are more likely to adopt greenhouse farming compared to older farmers	8(80)	2(20)	0	0	0

Source: Field Data (2024)

Table 2 shows that the majority (60%) of the extension officers disagreed that gender of the farmer significantly influences their decision to adopt greenhouse technology. This finding is in agreement with Sarker, *et. al.,* (2021) who found a significant relationship between gender and adoption of agricultural technology. The findings also revealed that majority of the extension officers (40+50=90%) agreed and strongly agreed that farmers with formal education were more likely to access and understand information about greenhouse farming which could make them easily adopt the technology. This finding was unique to the study.

Further, the study found that majority of the extension officers (40%) agreed that farmers with higher educational levels were more open to adopting greenhouse farming. This finding is in agreement with Tuitoek *et al.,* (2019). that established a significant relationship between level of education and adoption of technology. The study also found that majority of the extension officers (90%) agreed that older farmers with more farming experience were less likely to adopt greenhouse technology. This finding agree with Serebrennikov, *et al.,* (2020) who observed that a middle category of smallholder farmers aged between 40 and 50 years were better adopters of irrigation technology compared to the youth and the elderly. Finally, the study found that majority of the extension officers (20+80=100%) agreed and strongly agreed that younger farmers are more likely to adopt greenhouse farming compared to older farmers. This finding is in agreement with Sarker, *et. al.,* (2021)

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Results of a Focus Group Discussion

The researcher gathered more information on the factors that influence the adoption of greenhouse technology among small-scale tomato farmers through focus group discussions involving Nyumba Kumi members from each ward. From the discussions, most respondents revealed that access to credit, expected returns, cost of inputs, and land size had a significant influence on the adoption of modern farming technologies, such as greenhouse farming. Some Nyumba Kumi members shared their thoughts on the influence of social factors on the adoption of greenhouse technology. The responses are captured as follows;

On Age. respondent one said: "I think younger farmers are more open to adopting greenhouse technology because they are more willing to try new things and take risks. They also tend to be more educated and have better access to information about modern farming techniques."

Respondent two said: "Older farmers may be less inclined to adopt greenhouse technology because they are set in their traditional ways. They have been farming the same way for many years and might be skeptical about new methods."

Respondent Three said: "Age plays a key role in terms of physical ability as greenhouse farming can be labor-intensive, and younger farmers find it easier to manage the physical demands compared to older farmers."

On gender, Respondent One said: "In our community, farming is often considered men's work, especially when making major decisions like investing in greenhouse technology. However, women also play a crucial role and could influence the adoption if they are empowered and given access to resources."

Respondent Two said: "Gender norms can be a barrier. Women might face challenges in adopting greenhouse technology due to limited access to land ownership and financial resources, which are typically controlled by men."

Respondent Three said: "There's also a perception that greenhouse farming requires technical skills, which are often attributed more to men. We need to address these stereotypes and encourage women to participate more actively."

On Education; Respondent One said, "Education is a significant factor. Farmers with higher education levels are more likely to understand the benefits and technical aspects of greenhouse farming. They can easily access and interpret information on how to implement and maintain greenhouses."

Respondent Two said: "Those with lower levels of Education might find it challenging to adopt greenhouse technology because they may not fully understand how it works or the potential benefits. They might need more hands-on training and support."

Respondent Three said: "We have seen that when extension services provide training and demonstrations, even less educated farmers show interest and begin to adopt greenhouse technology. It's about making the information accessible and understandable."

Hypothesis testing

Hypothesis one: There is no statistically significant influence of social factors on the adoption of greenhouse technology by small-scale tomato farmers in the Sotik Sub-County.

A chi-square test was performed to evaluate the statistical significance of the results in Tables 1 and 2 and the findings are presented in Table 3.

Table 3: Chi-square results of influence of Social factors

Tested Variable	Degrees of freedom (*df*)	χ^2	Significance (P value)	Correlation Coefficient (V)	Strength of association
Gender	1	0.782	NS	0.077	Negligible
Age	3	28.668	0.000	0.464	Relatively strong
Education	2	22.438	0.000	0.411	Relatively strong

Source: Field Data, (2024)

A Chi-square analysis revealed a significant ($P < .05$) relationship between age and the adoption of the technology. There was a relatively strong correlation between the age of the farmer and adoption, with a V-coefficient of 0.464, as

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indicated in Table 4.5. It showed a relatively strong correlation with a V-coefficient of 0.411. There was no significant ($p = 0.065 > 0.05$) association between gender and the adoption of greenhouse technology. The observed data findings indicate that age has a positive correlation with the decision to adopt greenhouse technology. There were proportionately more youthful adopters compared to older people.

This study has a similar outcome to that reported by Serebrennikov, *et al.,* (2020) who observed that a middle category of smallholder farmers aged between 40 and 50 years were better adopters of irrigation technology compared to the youth and the elderly. Gender of household head similarly had an influence in the adoption of irrigation technology; males were better adopters. A Similar trend was also reported by Sarker, *et. al.,* (2021) who opined that women have lower levels and slower rates of adoption of various agricultural technologies than men. The study elucidated that female farmers are primarily agricultural workers and they rarely participate in decision making, networking, and training due to social restrictions. Our results were, however, contrary to the findings of Tuitoek *et al.,* (2019) in a study on the factors influencing the adoption of greenhouse technology among smallholder tomato farmers in Nakuru County, where greenhouse tomato production was dominated by females in the study area.

Influence of Technological Factors on adoption of Greenhouse Technology

The second objective of the study was to evaluate the influence of technological factors on the adoption of greenhouse technology. For this objective, farmers were requested to indicate the extent to which technological factors influenced their decision to adopt greenhouse technology. A five-point Likert scale with weights ranging from 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly disagree was used to assess the respondents' feedback. The data was summarized using frequencies and percentages. The results are displayed in Table 4

Table 4: Frequency, and percentages of technological factors for farmers

Statement on Technological Factors	SA 5	A 4	N 3	D 2	SD 1
Having adequate knowledge about greenhouse technology significantly influences its adoption among small-scale farmers	42(31.6)	63(47.4)	23(17.3)	4(3)	1(0.8)
The perception that greenhouse technology is too complex discourages small-scale farmers from adopting it	10(7.5)	70(52.6)	42(31.6)	9(6.8)	2(1.5)
Access to ongoing technological support and guidance encourages small-scale farmers to adopt greenhouse farming	7(5.3)	68(51.1)	35(26.3)	11(8.3)	12(9.)
Farmers are more likely to adopt greenhouse technology if they perceive it as easy to use and manage	12(9.0)	52(39.1)	35(26.3)	30(22.6)	4(3)
Participation in training sessions and workshops on greenhouse technology positively influences its adoption by small-scale farmers	21(15.8)	81(60.9)	16(12)	6(4.5)	9(6.8)

Source: Field Data (2024)

Table 4 shows that an overwhelming majority (31.6+47.4=79%) of the small-scale farmers agreed and strongly agreed that having adequate knowledge about greenhouse technology significantly influences their decision to adopt to greenhouse technology. This finding was supported by Dissanayake *et al.* (2022) who similarly reported that adequate knowledge on greenhouse micro-climate management influenced adoption of greenhouse technology.

Most respondents (52.6+7.5=60.1%) of the small-scale farmers agreed and strongly agreed that their perception that greenhouse technology was too complex discouraged them from making a decision to adopt the technology. This finding were similar to those of Sarker*, et. al.,* (2021).

Further, the study found that the majority (51.1+5.3= (56.4%) of the small-scale farmers agreed and strongly agreed that access to ongoing technological support and guidance encouraged their decision to adopt greenhouse technology. This finding agrees with Mwangi *et al., (*2020).

Majority (39.1+9.0=48.1%) of the small-scale farmers agreed and strongly agreed that they were more likely to adopt greenhouse technology if they perceive it as easy to use and manage. This finding agrees with Sarker*, et. al.,* (2021),

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Finally, an overwhelming majority (60.9+15.8=76.7%) of the small-scale farmers agreed and strongly agreed that participation in training sessions and workshops on greenhouse technology positively influences their decision to adopt greenhouse technology. This finding agrees with Teye and Quarshie (2022) who found that access to information through training influenced the adoption of greenhouse technology.

In addition, the extension officers were asked to be asked to indicate the extent to which the various technological factors influenced the decision of small-scale farmers to adopt greenhouse technologies. The data was analyzed using frequencies, means, and standard deviation. The results are displayed in Table 5

Table 5 Frequency, and percentages of the influence of technological factors for agricultural extension officers

Statement on technological factors	SA 5	A 4	N 3	D 2	SD 1
Having adequate knowledge about greenhouse technology significantly influences its adoption among small-scale farmers	8(80)	1(10)	1(10)	0	0
The perception that greenhouse technology is too complex discourages small-scale farmers from adopting it	6(60)	3(30)	1(10)	0	0
Access to ongoing technological support and guidance encourages small-scale farmers to adopt greenhouse farming	0	3(30)	2(20)	3(30)	2(20)
Farmers are more likely to adopt greenhouse technology if they perceive it as easy to use and manage	2(20)	2(20)	4(40)	2(20)	0
Participation in training sessions and workshops on greenhouse technology positively influences its adoption by small-scale farmers	6(60)	3(30)	1(10)	0	0

Source: Field Data (2024)

Table 5 shows that an overwhelming majority (10+80=90%) of the extension officers agreed and strongly agreed that having adequate knowledge about greenhouse technology significantly influences their decision to adopt to greenhouse technology. This finding agrees with This finding was supported by Dissanayake *et al.* (2022) who similarly reported that adequate knowledge on greenhouse micro-climate management influenced adoption of greenhouse technology.

Majority (30+60=90%) of the extension officers agreed and strongly agreed that their perception that greenhouse technology was too complex discouraged them from making a decision to adopt the technology. This finding were similar to those of Sarker, *et. al.,* (2021).

Further, the study found that that a slight majority (30%) of the extension officers agreed that access to ongoing technological support and guidance encouraged their decision to adopt greenhouse technology. This finding agrees with Mwangi *et al.,* (2020).

Majority (20+20=40%) of the extension officers agreed and strongly agreed that they were more likely to adopt greenhouse technology if they perceive it as easy to use and manage. This finding agrees with This finding agrees with Sarker, *et. al.,* (2021),

Finally, an overwhelming majority (30+60=90%) of the small-scale farmers agreed and strongly agreed that participation in training sessions and workshops on greenhouse technology positively influences their decision to adopt greenhouse technology. This finding agrees with Teye and Quarshie (2022) who found that access to information through training influenced the adoption of greenhouse technology.

Focus Group Discussion

The researcher obtained further information on technological factors influencing the adoption of greenhouse technology among small-scale tomato farmers from the focus group discussion involving Nyumba Kumi members from each ward. From the discussions held, most respondents revealed that farmer perception, technological knowledge, and access to technological support greatly influenced the adoption of modern farming technologies such

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as greenhouse farming. A sample of the participants from the focus group discussion involving the Nyumba Kumi members had this to say;

Response 1: "Many farmers perceive greenhouse technology as too complicated and expensive. They think it's only for large-scale or wealthy farmers, discouraging small-scale farmers from even considering it."

Response 2: "There is also a perception that greenhouse farming is risky. Farmers worry about potential failures and losing their investment, which makes them hesitant to adopt new technology."

Response 3: "Those with some level of education or training are more likely to adopt greenhouse technology. They can grasp the technical aspects better and are more open to trying new methods."

Response 4: "Many farmers are willing to try greenhouse farming if they can access reliable support and resources. Knowing there are experts available to guide them makes a big difference."

Response 5: "In areas where extension services are active and supportive, we see higher adoption rates of greenhouse technology. Continuous support and follow-up visits from agricultural officers are essential."

Hypothesis Testing

Hypothesis Three: *There is no statistically significant influence of technological factors on the adoption of greenhouse technology among small-scale tomato farmers in the Sotik sub-county.*

To determine whether the results obtained on the influence of technological factors on the adoption of greenhouse technology were statistically significant, the data was further subjected to a chi-square test. The results are displayed in Table 6

Table 6: Chi-square test results of the influence of technological factors

Tested Variable	Degrees of freedom (df)	χ^2	Significance (P value)	Correlation Coefficient (V)	Strength of association
Farmers' perception	4	31.266	0.000	0.485	Relatively strong
Technological knowledge	4	33.532	0.000	0.502	Relatively strong
Cost of access to technological support	4	38.625	0.000	0.539	Relatively strong
Median for the 3 factors	4	16.034	0.003	0.347	Moderate

Source: Field Data (2024)

The farmers' perception regarding the possible influence of the nature of technology on the adoption of the Greenhouse technology was tested for association with the adoption using the Chi-square method. Perceptions of the technical knowledge and the cost of the technology were similarly tested for interdependence with greenhouse technology adoption. Questions were posed to the respondents on whether farmers' perception of Greenhouse technology influenced the adoption of the technology; the responses were ranked from 1 (not at all) to 5 (Very much). The perceptions were cross-tabulated with Greenhouse technology adoption (Adopted or not adopted) and tested for interdependence using the Chi-Square method. The results are as indicated in Table 4.11. According to the results, the farmers' perception of Greenhouse technology had a significant relationship with the adoption; $\chi 2$ (4) = 31.266, $P<$ .001, $V = 0.485$. The association was relatively strong based on the interpretation of Kothari (2017).

A similar question was posed regarding technical knowledge: whether it influenced the adoption of Greenhouse technology and the extent to which it did so. Cross tabulation analysis by the Chi-square method revealed that there was a highly significant relationship between the perceived technical knowledge of the farmer and the adoption of the technology; $\chi 2$ (4) = 33.532, $p < 0.001$, $V = .502$. This observation indicates that there was a significant interdependence between the perceived technical knowledge and the adoption of the technology. The perceived cost of access to technological support had a significant relationship with adoption (Table 4.11). The perception of the cost

of Greenhouse technology had a relatively strong association with adoption; $\chi 24) = 38.625$, $P < 0.001$, $V = 0.539$. The Cramer's V coefficient of 0.539 indicates quite a strong link between the perceived cost of access to technological support and its adoption.

When the three indicators of perception of Greenhouse technology were summarized by working out a median for each respondent and cross-tabulated with adoption, the results revealed a significant relationship between the medians with the adoption of Greenhouse technology; $\chi 2(4) = 16.034$, $P = 0.003$, V=.377. This observation indicates that the farmers' perceptions of greenhouse technology had a significant association with their decision to adopt the technology. Figure 2.1 displays the difference between adopters and not adopters of greenhouse technology.

A study by Dissanayake *et al.,* (2022) similarly reported that smallholder farmers faced big challenges in regard to greenhouse micro-climate management. The challenges of irregular watering and challenges in disease management implied that the farmers lacked sufficient technical know-how to manage the greenhouse technology. Low adoption of greenhouse technology was partly attributed to challenges in microclimate management due to inadequate technical know-how (Mwangi *et al.,* 2020). This argument is consistent with the current finding in which technical knowledge is closely associated with adoption

CONCLUSIONS

The study provides valuable insights into the factors affecting the adoption of greenhouse technology by small-scale tomato farmers in the Sotik Sub-County. After testing its hypotheses, the study led to the following conclusions. From the hypothesis that social factors have no statistically significant influence on the adoption of greenhouse technology by small-scale tomato farmers in Sotik Sub-County. The study established that all the social factors except gender had a significant relationship with the adoption of greenhouse technology by the small-scale farmers. Therefore, this hypothesis was rejected, and thus, the study concluded that gender is not a significant influencing factor, whereas the age and education levels of the farmer are significantly associated with the adoption of the technology.

The results for the second hypothesis that there is no statistically significant influence of technological factors on the adoption of greenhouse technology among small-scale tomato farmers in Sotik Sub-County, the study found that all the parameters of technological factors examined had a significant influence on the adoption of greenhouse technology. Therefore, this null hypothesis was rejected, and thus, the study concluded that the selected technological factors, perception of the technology, perceived technical know-how, and perceived cost of technology have a significant influence on the adoption of greenhouse technology by small-scale farmers.

RECOMMENDATION

Based on the findings of the study, it is recommended that the County Government through the ministry of agriculture develop targeted awareness and education programs to farmers to address cultural and generational barriers. These programs should focus on demonstrating the benefits and feasibility of greenhouse technology through practical workshops and success stories tailored to different age groups. Community leaders and influencers should be engaged to advocate for the cultural acceptance of innovative farming practices. Additionally, integrating greenhouse technology training into the local education system and adult learning programs can enhance understanding and skill levels, thereby increasing adoption rates.

On the influence of technological factors on adoption of greenhouse technology, the study recommended that the County Government carries out comprehensive training and capacity-building programs be established to enhance farmers' technological know-how and practical skills in greenhouse farming. These programs should be complemented by establishing accessible technological support centers that provide ongoing assistance and troubleshooting services for farmers. Additionally, efforts should be made to positively influence farmers' perceptions of greenhouse technology through demonstration projects, field visits, and showcasing success stories that highlight the tangible benefits and productivity gains from adopting greenhouse methods.

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