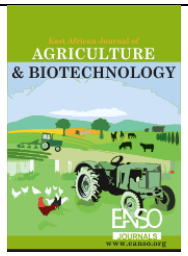


East African Journal of Agriculture and Biotechnology
eajab.eanso.org
Volume 7, Issue 1, 2024
p-ISSN: 2707-4293 | e-ISSN: 2707-4307
Title DOI: https://doi.org/10.37284/2707-4307

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Evaluating Challenges and Opportunities in Greenhouse Farming among Smallholder Vegetable Producers in Kericho County, Kenya

Millicent Otiende[1], Joseph Kipkorir Cheruiyot[1] & Jenifer Opunga[2]*

[1] University of Kabianga, P. O. Box 2030-20200, Kericho, Kenya.
[2] Department of Agriculture, Livestock and Cooperative Management, P. O. Box 50-20200, Kericho, Kenya.
* Author for Correspondence ORCID ID: https://orcid.org/0000-0002-9065-5654; Email: cheruiyotjoseph@gmail.com

Article DOI : https://doi.org/10.37284/eajab.7.1.1866

Date Published:

15 April 2024

Keywords:

Greenhouse, Challenges, Opportunities, Wilcoxon Test, Garrett Ranking.

ABSTRACT

Greenhouse technology has an important role to play in minimising adverse effects of climate variability on vegetable production. Studies indicate that greenhouse farmers face several challenges, sometimes leading to the abandonment of Greenhouses. The types and levels of severity of the challenges have not been adequately documented and acted upon on a context-specific basis, yet the demand for Greenhouse fresh produce is increasing, particularly in populated urban areas. This study identified and evaluated core challenges, available opportunities, and a concatenation of the challenges with productivity perceptions among Greenhouse farmers in Kericho County. A cross-sectional survey design drawing on data from 10% of Greenhouse farmers from each of the six Sub-counties was adopted for the study. Structured and unstructured interview schedules were administered to 59 sampled farmers and 16 Extension agents. The Henry Garret ranking method was used to analyse ranked data on challenges from farmers' views and potential opportunities from Extension agents. A one-sample Wilcoxon test was used to analyse the deviation of views from 'neutral'. Challenge due to pests and diseases was significantly higher than hypothesised median of 3 (neutral); $Z = 5.198$, $P < .01$. Cost of inputs and lack of finances for maintenance were significantly higher than neutral; $Z = 5.061$, $P < .01$ and $Z = 3.810$, $P < .01$ respectively. The top five challenges based on Garrett scores were pests & diseases, cost of inputs, maintenance costs, inadequate water, and initial costs. Top-ranked opportunities were integrated pest & disease management, farm-inputs subsidy, information on crop varieties, support from extension and capacity building in water harvesting. Concatenations existed between productivity of greenhouse units with quality of produce, ease of access to markets and profitability of greenhouses. The study recommends stakeholders' concerted effort towards utilisation of the opportunities identified to enhance sustainable Greenhouse productivity among smallholder vegetable producers.

APA CITATION

Otiende, M., Cheruiyot, J. K. & Opunga, J. (2024). Evaluating Challenges and Opportunities in Greenhouse Farming among Smallholder Vegetable Producers in Kericho County, Kenya. *East African Journal of Agriculture and Biotechnology*, *7*(1), 173-187. https://doi.org/10.37284/eajab.7.1.1866

CHICAGO CITATION

Otiende, Millicent, Joseph Kipkorir Cheruiyot and Jenifer Opunga. 2024. "Evaluating Challenges and Opportunities in Greenhouse Farming among Smallholder Vegetable Producers in Kericho County, Kenya". *East African Journal of Agriculture and Biotechnology* 7 (1), 173-187. https://doi.org/10.37284/eajab.7.1.1866.

Article DOI : https://doi.org/10.37284/eajab.7.1.1866

HARVARD CITATION

Otiende, M., Cheruiyot, J. K. & Opunga, J. (2024) "Evaluating Challenges and Opportunities in Greenhouse Farming among Smallholder Vegetable Producers in Kericho County, Kenya", *East African Journal of Agriculture and Biotechnology*, 7(1), pp. 173-187. doi: 10.37284/eajab.7.1.1866.

IEEE CITATION

M. Otiende, J. K. Cheruiyot & J. Opunga "Evaluating Challenges and Opportunities in Greenhouse Farming among Smallholder Vegetable Producers in Kericho County, Kenya", *EAJAB*, vol. 7, no. 1, pp. 173-187, Apr. 2024.

MLA CITATION

Otiende, Millicent, Joseph Kipkorir Cheruiyot & Jenifer Opunga. "Evaluating Challenges and Opportunities in Greenhouse Farming among Smallholder Vegetable Producers in Kericho County, Kenya". *East African Journal of Agriculture and Biotechnology*, Vol. 7, no. 1, Apr. 2024, pp. 173-187, doi:10.37284/eajab.6.1.1866.

INTRODUCTION

Greenhouse technology is viewed as a unique technique for providing favourable conditions for the growth of plants. This technology involves the use of structures that are covered with a transparent or translucent material to allow radiation while controlling other environmental conditions. The resultant protected system facilitates optimum growth of the plants (Farmers Trend, 2022). They protect the crops against high solar radiation and potentially destructive heavy rains (Ateka *et al.*, 2021). Greenhouse Technology (GHT) is thus associated with better yields and farm incomes. The framed or inflated structures that are used in the greenhouse technology enhance crop production through their ability to control environmental conditions such as humidity, temperature, and light (Farmers Trend, 2023). It also provides a controlled environment against the adverse effects of weather conditions such as stormy, heavy rains and strong winds. These attributes of the GHT make the technology a climate-smart agriculture technology since the greenhouses are designed to control local climatic conditions and are less land-intensive.

Although Greenhouse technology has an important role to play in minimising these adverse effects of climate variability on fresh vegetable production, reports suggest that smallholder farmers are faced with many challenges in its utilisation. Limited resources to invest in greenhouse technology is one such challenge; the adaptive capacity of the farmers is another (Muriithi *et al*., 2021). Studies conducted by Ateka *et al.* (2021) revealed that the adaptive capacity of the farmers may be aided by their education levels, farm income, access to credits, and access to markets. However, some of the challenges associated with Greenhouse technology (GHT) are technical in nature; for example, under cool temperature conditions, as expected in Kericho county, humidity levels within the greenhouse may rise and lead to fungal infections, as opined by Sanzua *et al*. (2018). The authors identified some challenges in GHT that included low productivity, a lack of technical know-how among the smallholder farmers and a lack of water resources. These were the major challenges that faced greenhouse farming in the coastal region of Kenya, as reported by Sanzua *et al*. (2018). The coastal region, nonetheless, has different contextual conditions from those that prevail in highland areas such as Kericho County, Kenya.

Kenya is prone to high variations in temperature and rainfall, making consistent crop production difficult. Resorting to greenhouse farming as a form of protected farming technology system has its challenges that need to be addressed. The challenges in GH farming include a lack of experience among small-scale farmers, high cost of inputs, water scarcity and incidences of pests and diseases (Agri Farming, 2022). The ample sunlight and relatively cool temperatures in most parts of Kenya, with some areas having fertile soils and plenty of water, indicate that GH farming can be successfully conducted in many regions of the country (Agri Farming, 2022).

Statement of the Problem

Whereas the Greenhouse technology provides for protected farming of high-value vegetables, it is currently faced with challenges at levels of

Article DOI : https://doi.org/10.37284/eajab.7.1.1866

severity that have not been adequately documented and acted upon. The high-value vegetables suitable for greenhouse farming include leafy vegetables, cucumbers, tomatoes, and capsicums. Tomatoes are widely grown in many parts of Kenya and are the second most important horticultural vegetable in the country, after potatoes, in terms of volume and value (Ateka *et al.,* 2021). The high-value vegetables can be produced intensively in protected environments with reduced need for land, water, and agrochemicals and with increased efficiency in the use of resources. These crops have the potential to improve the livelihoods of many resource-poor households, but their production in the protected environments offered by greenhouses is faced with some challenges. The challenges associated with the application of greenhouse technology (GHT) have been broadly documented but have not been adequately studied and addressed in many high-potential areas in Kenya. Previous studies in Kenya were mostly conducted in hot humid environments (Sanzua *et al*., 2018; Wachira, 2012). The current study was conducted to provide valuable insights in a different context; in the cold humid environments of Kericho County. The challenges associated with protected farming technologies, if addressed, have the potential to improve on the exploitation of ready markets for fresh produce in increasingly populated urban areas. The demand for fresh vegetable produce continues to increase with the increasing urban population, and yet some of the challenges faced by the fresh produce farmers have not been adequately understood and addressed by stakeholders in the sub-sector. Reports galore about greenhouse units that have been abandoned by smallholder farmers, but the reasons for the abandonment appear to vary from one context to another (Sanzua *et al.,* 2018; Wayua *et al*., 2020; Opanda, 2021). It is logical to document the challenges and opportunities for GH farming within a set of specific socio-economic and environmental contexts in the interest of GH vegetable production.

Purpose

This study was conducted to evaluate the challenges and opportunities in Greenhouse farming among smallholder vegetable producers in Kericho County, Kenya. The study was guided by the following specific objectives:

- To identify the core challenges faced by smallholder greenhouse farmers
- To evaluate the severity of the Greenhouse technology challenges from the perspective of smallholder farmers
- Examine the opportunities available to address the challenges faced by smallholder greenhouse farms and
- Investigate a concatenation, if any, between the challenges of greenhouse farming and the productivity perceptions of the smallholder farmers.

METHODOLOGY

Location of Study

This study was carried out in Kericho County of the Rift Valley region. The county was deemed appropriate for this study as it experiences a temperate climate due to its high elevation, with an average altitude of 2002 metres above sea level (County Government of Kericho, 2018). The high altitude contributes to its cool and temperate climate. Previous studies on greenhouse technology have mostly concentrated on hot humid environments such as the coastal region and central Rift. Kericho county lies between longitude 35º 02’ and 35º 40’ East and between the equator and longitude 0 23’ South. The county receives a well distributed annual rainfall of between 1400 and 2,125mm with temperature ranges of between 10ºC to 29ºC (County Government of Kericho, 2013).

Study Design

A cross-sectional descriptive survey design was adopted to gather data from representative greenhouse technology users in Kericho County. Greenhouse technology is a relatively new

Article DOI : https://doi.org/10.37284/eajab.7.1.1866

technology in the county. The county has six Sub-counties, and all six participated in the study. A sample of 10% of all the greenhouse farmers within a Sub County was randomly selected from an inventory of Greenhouse farmers that was provided by the Department of Agriculture and Livestock Production in Kericho County. In this descriptive study the 10% sample-size from the target population was deemed sufficient for the study as explained by Mugenda and Mugenda (2011). In the process of sampling, a total of 59 farmers were selected for interviews. An interview schedule with structured and unstructured questions was utilised to collect demographic data, greenhouse crop types and farmers' views and opinions in regard to the challenges in greenhouse farming. Data were collected on the perceived benefits of GH technology, perceived yield ratings, quality of produce and profitability. Agricultural extension agents from the county department of agriculture who were involved in the promotion of greenhouse technology were interviewed for their opinions in regard to the opportunities available to address the farmers' challenges. The interviews used structured scales so as to yield quantitative data. All the 16 agents involved were interviewed. The interviews were conducted by enumerators who had been exposed to the interview schedules and trained on the basics of conducting an interview with the aim of soliciting honest responses from the interviewees. The interviewers were trained to ensure they asked questions in the same way to all the interviewees.

Data Analysis

The data collected on the views and opinions regarding GHT challenges were measured on a ranking scale (1-5). To establish the core challenges faced by the GHT Farmers, all the challenges that had been gathered through an earlier exploratory survey were presented to the interviewees for ranking on a scale of 1 (not experienced) to 5 (very severe). The presence of the challenges was analysed by descriptive statistics, frequencies, medians and means. The Data for each of the challenges were further subjected to a one-sample Wilcoxon signed rank test. The observed medians were tested against a theoretical median of 3. The median of 3 is based on a null hypothesis that the challenge is not severe, and most respondents were expected to report a near neutral severity.

Data to address the second and third objectives of the study were subjected to the Henry Garrett ranking method. The Henry Garrett ranking method follows six steps. The first step involves the study participants ranking the potential challenges according to their severity, from the first or most severe to the last or least severe. The second step is to convert the participants' ranks into percent positions by the formula:

$$\text{Percentage score} = 100(\text{Rij} - 0.5)/_{Nj}$$

Where Rij = the rank of the i^{th} challenge by j^{th} individual and Nj = Number of challenges ranked by j^{th} individual

In the third step, the calculated percent position is converted into Garrett scores using Garrett's conversion table. The Garrett score is calculated by multiplying the Number of participants in the particular rank by the corresponding Garrett conversion table value. In the 4^{th} step, the scores for each challenge are summed up to obtain a total value for each challenge. The 5^{th}step is to divide the total value for each challenge by the total Number of participants in the study to obtain an average value. The 6^{th} and final step is to arrange the average values in order from the highest to the lowest and rank them accordingly, with the highest value being ranked as the most severe challenge (Dhanavandan, 2016). For the analysis of the opportunities, similar steps as used for the challenges were followed but replacing severity with the importance of an opportunity. The most important potential opportunity, as judged by the interviewee, was ranked first, and the least potential ranked last; the rest of the steps were worked out as for the challenges.

To accomplish the fourth objective of investigating concatenation between the challenges and productivity performance, the ordinal data on the challenges, measured on a

Article DOI : https://doi.org/10.37284/eajab.7.1.1866

scale of 1 to 5, were tested for correlations with the participants' perceived benefits, yields, quality and profitability by running Kendall's tau-b analysis and Somers'd. Kendall's tau-b was suitable for the ranked data as a non-parametric measure of association, even in situations where samples appear small or where there are many ties in the ranks (Lund Research Ltd., 2018). Since Kendall's tau-b is non-directional, a Somer's d test was further carried out to establish the association when the perceived productivity is treated as a dependent variable (Lund Research Ltd, 2018). The perceived benefits, yields, quality, and profitability were measured on a ranking scale from one to ten. The average score for the outcomes was treated as an indicator of productivity. The correlation analysis was run on SPSS version 27 for Windows to investigate the concatenation between the challenges and the productivity indicators of greenhouse farming as perceived by the participants in the study.

RESULTS AND DISCUSSION

Socio-Demographics

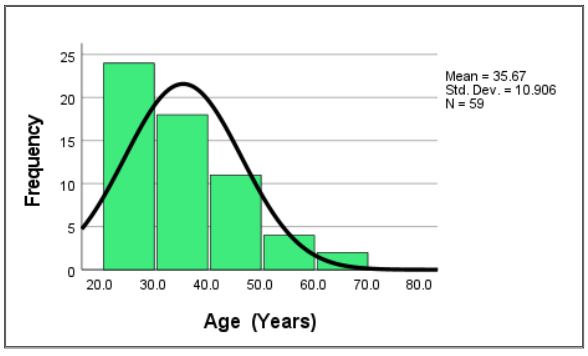
The Sampled households were dominated by youth aged between 18 and 30 years (40.7%), while those over 60 years were least represented, as illustrated in *Table 1*. Males formed 55.9% of the respondents, with 44.1% being female respondents. A Majority were educated to Secondary School level (54.2%), 3.4% possessed primary level education, while 42.4% had attained tertiary level education. The median education level for females was significantly lower than for males (P = .017). Education levels have implications in regard to the acquisition of technical information.

Table 1: Socio-demographics of the sample (N = 59)

Socio-demographic		Frequency	Percent
Age	18-30	24	40.7
	31-40	18	30.5
	41-50	11	18.6
	51-60	4	6.8
	Over 60	2	3.4
Gender	Male	33	55.9
	Female	26	44.1
Education	Primary	2	3.4
	Secondary	32	54.2
	College/University	25	42.4

The age distribution of the respondents was slightly skewed (*skewness* = 0.956) but showed a normal univariate distribution with a mean of about 36 years (*Figure 1*). This means that a majority of the respondents were in the youth category. This distribution indicates that greenhouse vegetable production was probably dominated by youths.

Figure 1: Age distribution of the respondents



Challenges in Greenhouse Farming

A previous exploratory survey that used questionnaires for a preliminary survey, as suggested by Kumar (2011), identified a number of challenges associated with GH farming. The Challenges identified included the prevalence of pests & diseases, high cost of farm inputs, poor access to information, poor access to extension services, lack of finances for maintenance of greenhouse farming system, lack of markets for farm produce and inadequate water for the protected GH farming. The challenges identified

Article DOI : https://doi.org/10.37284/eajab.7.1.1866

through the preliminary survey were subjected to further investigations in this study. The interviewees were asked to rate the challenges on a scale of 1 (Never experienced) to a scale of 5 (Very often experienced) in order to test the prevalence of the challenges among the GH farmers. The results are as summarised in *Table 2*.

Table 2: Prevalence of challenges (%) and their mean scores based on respondents' Experiences (N = 59)

Challenges	1 Never	2Very Rarely	3 Rarely	4 Often	5 Very often	Mean
Pests and Diseases	0	6.8	27.1	44.1	22.0	3.81
High cost of inputs	1.7	8.5	18.6	39.0	32.2	3.92
Poor Access to Information	10.2	33.9	22	25.4	8.5	2.88
Poor Access to Extension	16.9	30.5	25.4	18.6	8.5	2.71
Lack of maintenance finances	8.5	3.4	22	37.3	28.8	3.75
Lack of Markets	23.7	27.1	32.2	13.6	3.4	2.42
Inadequate Water	13.6	25.4	15.3	20.3	25.4	3.19

The data collected were further subjected to a one-sample Wilcoxon sign rank test against a pre-determined median of 3. A median value of 3 represented a situation that was interpreted to mean the challenge is rarely experienced. The median value of 3 meant that a majority of the greenhouse farmers had not experienced the challenge. However, a median that was significantly higher than 3 from the sampled population will imply that the constraint was widespread. On the contrary, a median that was significantly lower than 3 would imply that the challenge was negligible. This analytical approach was used in order to assess the severity of the challenges among the smallholder farmers in the study location. The One-Sample Wilcoxon signed rank test against the pre-determined value of 3 was run on SPSS version 27, and the results are indicated in *Table 3*.

Table 3: Wilcoxon sign rank test results on the observed median for each challenge

Variable	Statistic, *Z*	Median	*P* value
Pests and Diseases	5.198	4	< .001
High cost of inputs	5.061	4	< .001
Poor Access to Information	-0.758	3	Not significant
Poor access to extension services	-1.763	3	Not significant
Lack of Finance for maintenance	3.810	4	< .001
Lack of produce markets	-3.410	2	.001
Inadequate water for irrigation	1.151	3	Not significant

Pests and Diseases

The observed median in regard to the prevalence of pests and diseases as a challenge in GH farming was significantly higher than the hypothesised median of 3 (Z = 5.198, P<.001). This suggests that many of the interviewees often experienced pest and disease challenges in their greenhouses. The descriptive data indicated that 44.1% often experienced pests and disease outbreaks in their greenhouses, 22% very often. About 6.8% reported that they rarely experienced it, and 27.1% very rarely experienced the menace. None of the respondents indicated that they had never experienced pest and disease outbreaks (*Table 2*). This finding is in agreement with other findings elsewhere (Wayua *et al.*, 2020; Opanda, 2021). Ghani *et al.* (2018) explain that the spread of pests and diseases is largely attributed to the prevailing indoor micro-climate within the greenhouse, a factor that is largely influenced by the prevailing external environment.

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

High Cost of Inputs

The interviewees rated the high cost of inputs above the hypothesised median of 3. On a scale of 1 to 5, the observed median was 4; a large proportion of 39% indicated that they often experienced the high cost of inputs challenges; only 1.7% indicated that they never experienced the challenge (*Table 2*). The observed median was significantly higher than the hypothesised median of 3 (Z = 5.061, P<.001), suggesting that the challenge was widespread among the greenhouse farmers. The costs of farm inputs such as seeds, fertilisers, pesticides have been cited elsewhere as a major hindrance to the adoption of greenhouse technology (Wayua *et al*., 2020). A similar finding was reported by Smitha *et al.* (2016), who observed that non-availability and the cost of inputs for greenhouse production were major constraints faced by the farmers.

Lack of Finances for Maintenance/ Sustenance of Greenhouse Technology

The lack of finances for the maintenance of greenhouse-protected farming was a widespread challenge, judging from the significantly higher median than 3 (Z = 3.810, P<.001). The observed median of 4 implies that a majority of the respondents were of the view that a lack of finances for the sustenance of greenhouse technology was often experienced. This robust Wilcoxon signed rank test corroborates what is observed in the frequency distributions where a majority of 37.3% was of the view that lack of finances for the maintenance of the greenhouse technology was often experienced in their farms (*Table 3*). Wayua *et al*. (2020) found that the high cost of establishing and maintaining greenhouses by smallholder tomato farmers affected their productivity. Some farmers cut costs by utilising local materials, but, unfortunately end up compromising on the effectiveness of the technology (Wayua *et al*., 2020). It has been observed that the high capital outlay requirements for the technology hinder their adoption among smallholder financially constrained farmers (Mburu *et al*., 2015). Such constraints suggest a need for accessible credit facilities. The current observation indicates that the smallholders are unable to access finances for the maintenance of their GH farming activities (Smitha *et al*., 2016). The authors further observed that the non-availability of credit in time hampered GH-based farming among smallholders. A review of gray literature based on data from within the county of Kericho indicates that credit constraints, though sometimes reported as non-severe (Otiende *et al*., 2024), may suggest a need for accessible credit facilities so as to address cases of smallholder farmers in dire need of the facilities.

Lack of Markets for Fresh Greenhouse Produce

The markets for fresh produce from the greenhouses appear not to be a significant challenge to the farmers (P > .05). A majority of the farmers reported that they rarely experienced a lack of markets. 27.1% very rarely experienced it, and 23.7% had never experienced it at all. A few of the respondents, however, experienced a lack of market often (13.6%) and very often (3.4%), as illustrated in *Table 2*. A Wilcoxon signed rank test of the observed median against the hypothesised median of 3 revealed that the observed median was significantly lower than the hypothesised (Z=-3.410, P = .001). This observation suggests that the challenge of a lack of fresh produce markets was not severe, though experienced by a few farmers. A Previous study elsewhere suggests that there was under-pricing of greenhouse tomatoes in the market (Sanzua *et al*., 2018). Some smallholder greenhouse tomato farmers reportedly could not find a ready market for their greenhouse tomatoes. Lack of market was ranked the fifth most important challenge in a study conducted in Kisii, Kenya (Wayua *et al*., 2020). Elsewhere, Smitha *et al*. (2016) reported that there was a lack of reasonable prices for the greenhouse produce. The current finding suggests the contrary that market-related constraints were rare. This variation in market-related constraints suggests that the challenges, where they occur, may be localised.

Poor Access to Information and Extension Services

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

Poor access to information and access to extension services both posted a median that did not differ significantly from 3 (P > .05). This observation signifies that those who had experienced poor access to information and extension services were nearly equal to those who rarely or never experienced the challenge. A look at the frequencies reported reveals that 33.9% very rarely experienced a lack of information challenge, but 25.4% reported that they often experienced poor access to information (*Table 2*). Lack of information on the right structures, management of the greenhouse, post-harvest handling, grading and other marketing aspects have been reported elsewhere by Wayua *et al.* (2020). The lack of extension support for greenhouse farmers was also reported by Sanzua *et al.* (2018) in a study conducted in the coastal region of Kenya. Some farmers were reportedly learning from other farmers. Some of the farmers even used trial and error methods to solve their greenhouse management challenges (Sanzua *et al.*, 2018). As noted by Opanda (2021), specialised knowledge is often required for greenhouse technology; a lack of extension support thus is expected to present challenges where extension services are lacking or inadequate. Muriithi *et al.* (2021) observed that GHT requires adequate expertise, indicating a need for technical information to initiate and sustain the GHT system. The lack of scientific information on greenhouse farming was identified as a major challenge among smallholders (Wayua *et al.*, 2020). The lack of relevant information was ranked the fourth most important challenge in their study. Muriithi *et al.* (2021) similarly pointed out that lack of information was a major constraint in the utilisation of greenhouse technology as a measure to mitigate climate variability. Elsewhere in other crops, crop productivity in coffee has been linked to technical information inputs (Cheruiyot, 2022); emphasising the significance of the information inputs on the overall farm productivity.

Inadequate Water for Irrigation in Greenhouse

An equal proportion of interviewees were captured as very rarely experiencing inadequate water challenges, with another similar proportion experiencing the challenge very often (*Table 3*). The overall observed median was not significantly different from the expected midpoint of 3 (P>.05). The high frequency of those who reported that they experienced the challenge of inadequate water very often indicates that the challenge, though not widespread, may manifest itself severely when and wherever it occurs. Greenhouse technology is credited with the ability to save water. The technology improves water use productivity compared to that of open fields. Low adoption of greenhouse technology has, however, been previously attributed to low water quality and quantity (Sanzua *et al.*, 2018).

Severity of the Greenhouse Farming Challenges

The interviewees had been asked to rank ten challenges, seven of which had featured prominently in an earlier preliminary survey. Another three that were mentioned by a few respondents were included: lack of greenhouse suppliers, initial capital, and high transport costs. The ten challenges were randomly listed, and the participants were asked to rank them from 1 (the most severe) to 10 (the least severe) without a repeat of any rank. The Henry Garrett ranking method was then used to convert the participants' rank positions into Garret scores. The rank positions of the interviewees are captured in *Table 4.*

The frequencies of each rank position were converted into rank scores by multiplying the frequencies per rank position by a corresponding Garret table value. The results are shown in *Table 5*.

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

Table 4: Rank frequencies per challenge from the interviewees' responses

Rank/Challenges	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Pests and diseases	15	10	8	7	4	3	3	3	2	4
High cost of inputs	10	6	8	8	8	5	6	5	3	0
Poor access to information	4	1	4	4	4	6	9	16	3	8
Poor Access to Extension	2	4	1	2	5	7	12	7	14	5
Lack of suppliers	4	6	8	3	12	10	8	4	1	3
High maintenance costs	3	12	13	7	9	4	3	5	3	0
Lack of produce markets	3	4	3	3	11	6	2	7	13	7
Lack of initial capital	12	8	4	5	7	6	3	2	5	7
Inadequate Water	8	10	7	7	3	8	6	6	2	2
High transport costs	1	3	3	6	4	3	6	10	9	14

The total and average Garrett scores were worked out for each of the greenhouse challenges by summing up the scores for each rank for all the 10 positions for every listed challenge and dividing by the Number of respondents to obtain the total Garrett scores and average scores respectively (*Table 6*). The average Garret score for each constraint or challenge in greenhouse farming was used to rank the ten challenges from 1 (the most severe) to 10 (the least severe). The results obtained from the Garret ranking Matrix analysis based on the data from the 59 greenhouse farmers show that Pests and diseases were the most severe constraint faced by the producers, with an average Garret Score of 60.3% (*Table 6*). This observation implies that the outbreaks of pests and diseases were the most important constraints among GH producers. The observation is consistent with the earlier observation in this study, where 44.1% of the interviewees indicated that they often experienced pest and disease challenges (*Table 2*).

The second most important constraint based on the Garrett scores is the high cost of farm inputs, with an average Garrett score of 57.4. Closely related to this is the high maintenance costs for the greenhouse system (Average Garret score of 57.1). The fourth most important constraint was inadequate water for irrigation (average score of 56.1). The least important challenge was the high cost of transport, as detailed in *Figure 2*

The current findings are in agreement with the findings by Wayua *et al.* (2020), who ranked pests and diseases as a leading challenge for greenhouse farming in Kisii County, Kenya. Opanda (2021) similarly cited pests and crop diseases as major factors in failed greenhouses among smallholder farmers. Elsewhere, Sanzua *et al.* (2018) observed that diseases were an important challenge to Greenhouse farmers in the coastal region of Kenya. Irregular watering and poor crop nutrition resulted in disorders in the greenhouse crops. Pests such as *Tuta absoluta*, American bollworms and Nematodes were reported in their study. These convergences in the findings lead to a proposition that pests and diseases are indeed a nuisance to smallholder GHT users.

A study conducted by Wayua *et al.* (2020) ranked the high cost of farm inputs as the third most important challenge after pests and diseases and inadequate water supply. Gatahi (2020) argues that the high cost of inputs and the prevalence of pests and diseases were major challenges to GH farming worldwide. This pattern appears to be in tandem with the current finding where the top four challenges as ranked by the smallholders are pests and diseases, high cost of inputs, high maintenance costs and inadequate water.

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

Table 5: Calculated percent position and their corresponding Garrett table values

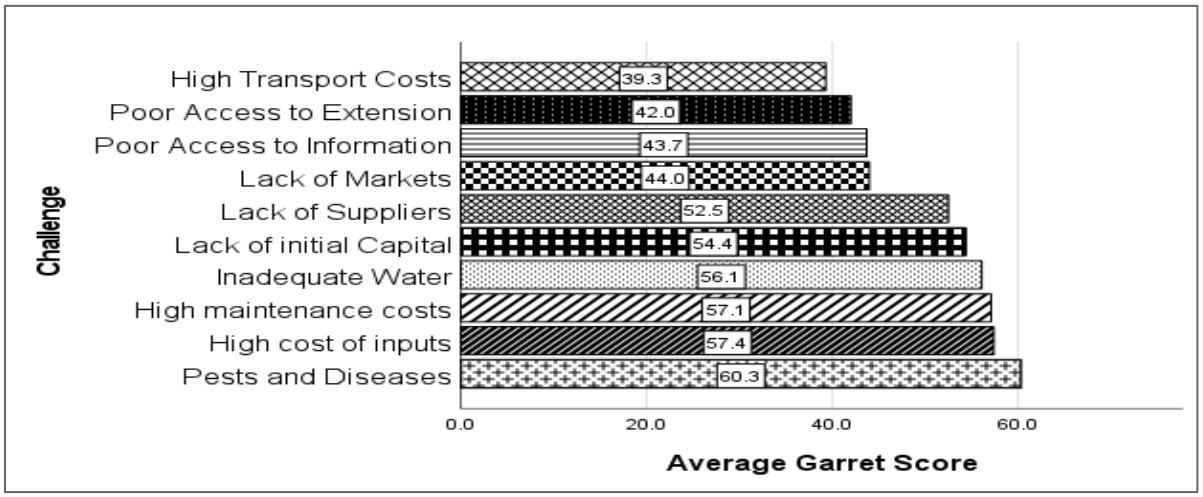
Respondents' Ranks	Percent position = 100*(Rij-0.5)/Nj	Calculated % position	Table Value	Respondents' Ranks	Percent position = 100*(Rij-0.5)/Nj	Calculated % position	Table Value
1st	100*(1-0.05)/10	5	82	6th	100*(6-0.5)/10	55	48
2nd	100*(2-0.5)/10	15	70	7th	100*(7-0.5)/10	65	42
3rd	100*(3-0.5)/10	25	63	8th	100*(8-0.5)/10	75	37
4th	100*(4-0.5)/10	35	58	9th	100*(9-0.5)/10	85	29
5th	100*(5-0.5)/10	45	52	10th	100*(10-0.5)/10	95	18

Table 6: Calculated total and average garret scores per challenge from observed rank frequencies

Position/Challenge	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total	Average	Rank
Pests and Diseases	1230	700	504	406	208	144	126	111	58	72	3559	60.3	I
High cost of inputs	820	420	504	464	416	240	252	185	87	0	3388	57.4	II
Poor access to information	328	70	252	232	208	288	378	592	87	144	2579	43.7	VIII
Poor Access to Extension	164	280	63	116	260	336	504	259	406	90	2478	42.0	IX
Lack of suppliers	328	420	504	174	624	480	336	148	29	54	3097	52.5	VI
High maintenance costs	246	840	819	406	468	192	126	185	87	0	3369	57.1	III
Lack of produce markets	246	280	189	174	572	288	84	259	377	126	2595	44.0	VII
Lack of initial capital	984	560	252	290	364	288	126	74	145	126	3209	54.4	V
Inadequate Water	656	700	441	406	156	384	252	222	58	36	3311	56.1	IV
High transport costs	82	210	189	348	208	144	252	370	261	252	2316	39.3	X

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

Figure 2: Severity of the Greenhouse Farming Challenges Based on Garret scores



Opportunities to Address the Greenhouse Challenges

Agricultural extension agents were asked to identify and rank potential opportunities available to address the challenges identified by farmers in the area. There were ten identified potential opportunities to address the challenges identified by farmers during the exploratory survey. The respondent-ranked potential opportunities were subjected to Henry Garrett's ranking method to prioritise the opportunities available to the farmers. The ranked potential opportunities are indicated in *Figure 3***.** The observed pattern (*Figure 3*) suggests that an integrated approach to pest and disease management is viewed as a priority opportunity to exploit. As observed by one interviewee; "farmers sometimes experience enormous challenges due to infestation of diseases and pests", suggesting an urgent need for an integrated approach to address the menace. In the view of another responded, "soil-borne diseases are particularly a major challenge to greenhouse farmers". These observations are consistent with the reports obtained from the farmer-interviewees that pests and diseases were the most severe challenges in the GH farms.

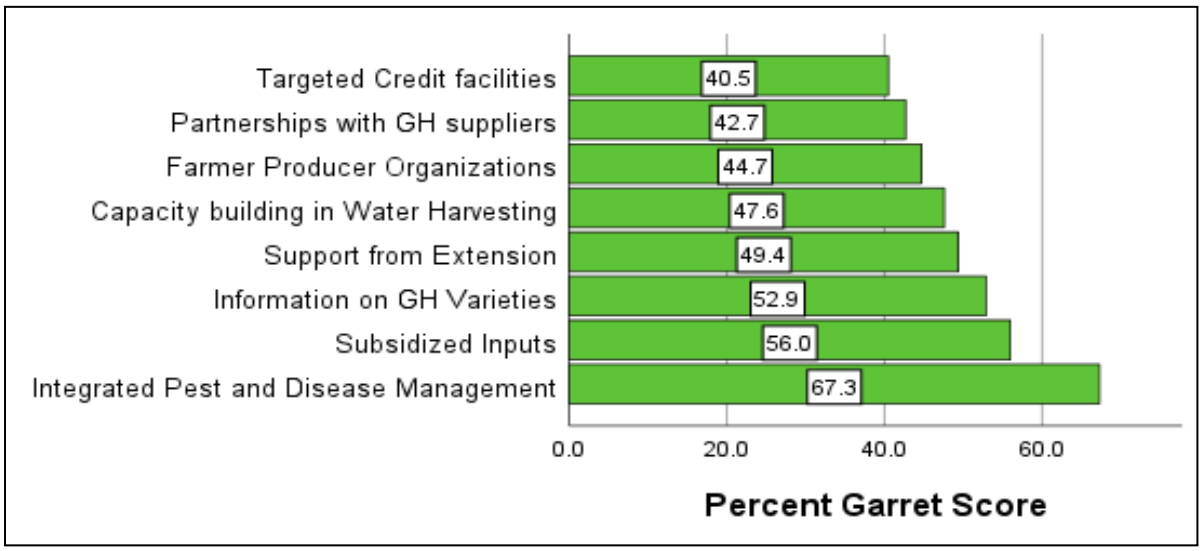
The second most important opportunity was taking advantage of the governments' policy on subsidised inputs. This, again is in tandem with the farmers' second most important challenge of a high cost of inputs and high GHT maintenance costs. The agricultural extension agents ranked leveraging information available on the appropriate crop varieties for GH production systems as the third most important opportunity. This suggests that, in the opinions of the extension agents, the farmers were not exploiting this opportunity. In the words of one interviewee, "a profitable venture like greenhouse technology requires adequate capacity-building for the farmers to fully benefit". The farmers on the other hand had ranked poor access to information as the 8th most important challenge; this discordance may imply a lack of awareness amongst the smallholder farmers that they can access the information by linking up with extension agents and other information sources. The other opportunities in the order of their priority as ranked by the extension agents were; support from extension, capacity-building in water harvesting, leveraging on producer organisations, partnerships with GH suppliers and targeted credit facilities (*Figure 3*).

The observed data indicating a prominence of integrated pest and disease management as an opportunity that is yet to be fully exploited by greenhouse users is in tandem with a study conducted in Ghana. The study conducted by Forkuor *et al.* (2022) observed that 80% of their respondents had experienced a negative impact of pests and diseases on the productivity of their greenhouses. Their study recommended research to generate local solutions to the problems of pests and diseases. Capacity-building of smallholder farmers on sustainable agriculture (Warner *et al.*,

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

2020) with minimal usage of inorganic chemicals may be a priority to exploit, as suggested by the current findings. Aznar-Sanchez *et al.* (2020) point out that pest and disease control within greenhouse facilities is part of global research trends on greenhouse technology. De Witte *et al.* (2023) proposed that such new knowledge should relate to specific local social and spatial environments.

Figure 3: Ranked Potential Opportunities Based on Garrett Scores



The second most prioritised opportunity on farm inputs subsidy probably was attributed to the current government interventions to mitigate against the high cost of inputs. Wachira (2012) pointed out that maintenance cost was a major obstacle to the uptake of greenhouse technology, suggesting that an input subsidy program may improve the uptake of the technology. In regard to crop varieties, the extension agents' views suggest that the farmers had insufficient information on greenhouse-suited varieties. Smitha *et al.* (2016) similarly observed that a lack of knowledge about the varieties/crops that were suited to greenhouse cultivation constrained GH productivity. The current finding is consistent with that view.

Perceived Productivity and Associated Challenges

The perceived yield levels were used as an indicator of the productivity of the greenhouses. The farmers had been asked to self-evaluate their yields on a scale of 1 to 10. This indicator was highly negatively correlated to lack of markets (τ_b = -0.353, P< .001). This observation indicates that the respondents who reported high yields from their greenhouses tended to report that they had no problem with the markets. However, higher yields were associated with views on lack of access to extension services (τ_b = 0.288, P< .001). This is an interesting observation that suggests that higher produce from the greenhouses demanded higher extension services. It implies that the farmers who enjoy higher greenhouse produce had unmet demands for extension services. The perceived yield levels were highly correlated to the perceived benefits of GH technology (τ_b = 0.344, P<.01). Interestingly, there were relatively strong links between the self-reported yields with the reported quality of the produce (τ_b=0.402, P<.01) and the profitability (τ_b = .384, P< .01) of the greenhouse farming (*Table 7*). There was a concatenation between productivity (as measured by yields), quality of fresh produce, ease of access to the markets and profitability of the GH technology. The other factors were not correlated with productivity (P> .05). This observation implies that any factor that adversely affected yields also affected the quality of the produce and access to markets. The observed data is logical given that factors such as pests and diseases that affect both yields and quality ultimately affect the

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

marketability of the produce. The overall effect is that the profitability of GH farming is affected.

Table 7: Respondents Self-evaluated yield levels and associated attributes

Variable	τ_b	*P* value	Somers' *d*	*P* value
Poor Access to Extension	.288	< .001	.304	.003
Lack of markets	-.353	< .001	-.378	< .001
Perceived benefits of GHT	.344	< .001	.353	< .001
Self-evaluated Quality of produce	.402	< .001	.406	< .001
Self-evaluated profitability of GH farming	.384	< .001	.387	< .001

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that Greenhouse technology adopters in Kericho County experience some challenges that vary in severity from one farmer to another. The challenge of pests and diseases and the high cost of farm inputs are the dominant and severe challenges among smallholder farmers practising the protected greenhouse farming in Kericho County. Moderately strong concatenations exist between the productivity of greenhouse production units, the quality of fresh produce harvested, ease of access to markets and the profitability of the greenhouse farming enterprise. It is recommended that an in-depth study be carried out in future to characterise the pests and diseases that present challenges to smallholder greenhouse technology users and to develop appropriate integrated control measures. This study is of importance to the farmers' advisory service in formulating strategies to mitigate the adverse effects of the challenges identified amongst the smallholder farmers. The Henry Garrett average scores were a good indicator of the severity of the challenges experienced by the smallholder Greenhouse technology users.The severity with which some of the challenges have been associated is a useful indicator of what the priority interventions ought to be.

ACKNOWLEDGEMENT

We acknowledge the tremendous efforts made by the County Department of Agriculture, Livestock and Cooperative Management, led by Ms. Edna Tonui, in spearheading the mobilization of stakeholders for the study. The Agriculture Sector Development Support Program, led by Mr. Bernard Too, deserves special recognition for taking the lead in facilitating the training of interviewers. Special thanks also go to the Sub-county Agricultural Officers for their active participation in the field survey and to the lead interviewers: Phillip Sotin (Ainamoi Sub-county), Reuben Chirchir (Soin-Sigowet), and Gilbert Langat of the Kenya Plant Health Inspectorate Service (KEPHIS). We extend our gratitude to all of you.

REFERENCES

Agri Farming (2022, November 25). *Greenhouse farming in Kenya: How to start, crops, construction cost, profits, and subsidy*. https://www.agrifarming.in/greenhouse-farming-in-kenya-

Ateka, J. M., Mbeche, R. M., & Muendo, K. M. (2021). Determinants of protected tomato production technologies among smallholder peri-urban producers in Kiambu County, Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, *122*(1), 43– 52. https://doi.org/10.17170/kobra-202102113203

Aznar-Sánchez, J. A., Velasco-Muñoz, J. F., López-Felices, B., & Román-Sánchez, I. M. (2020). An analysis of global research trends on greenhouse technology: Towards a sustainable agriculture. *International Journal of Environmental Research and Public Health*, *17*(2), 664. https://doi.org/10.3390/ijerph17020664

Cheruiyot, J. K. (2022). Farmers' information inputs and their sway on coffee productivity

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

in the west of Rift, Kenya. *Journal of Applied Life Sciences International*, 1– 14. https://doi.org/10.9734/jalsi/2022/v25i230282

County Government of Kericho (2018). Kericho County Integrated Development Plan 2018 - 2022. Republic of Kenya.

County Government of Kericho (2013). Strategic Plan 2014-2017. Republic of Kenya.

De Witte, R., Janssen, D., Sayadi Gmada, S., & García-García, C. (2023). Best practices for training in Sustainable Greenhouse Horticulture. *Sustainability*, *15*(7), 5816. https://doi.org/10.3390/su15075816

Dhanavandan, S. (2016). Application of Garret Ranking Technique: Practical Approach. *International Journal of Library and Information Studies*, *6* (3), 135-140. http://www.ijlis.org/

FarmersTrend. (2022, July 3). *Read on: Pros and cons before investing in greenhouse farming*. Farmers Trend. https://farmerstrend.co.ke/trending/read-pros-cons-investing-greenhouse-farming/

Farmers Trend. (2023, May 21). *The advantages and disadvantages of greenhouse farming in Kenya*. Farmers Trend. https://farmerstrend.co.ke/trending/diseases/the-advantages-and-disadvantages-of-greenhouse-farming-in-kenya/

Forkuor, G., Amponsah, W., Oteng-Darko, P., & Osei, G. (2022). Safeguarding food security through large-scale adoption of agricultural production technologies: The case of greenhouse farming in Ghana. *Cleaner Engineering and Technology*, *6*, 100384. https://doi.org/10.1016/j.clet.2021.100384

Gatahi, D. M. (2020). Challenges and opportunities in tomato production chain and sustainability standards. *International Journal of Horticultural Sciences and Technology* 7(3), 235-262.http://doi.org/10.22059/ijst.20

Ghani, S., Bakochristou, F., ElBialy, E. M., Gamaledin, S. M., Rashwan, M. M., Abdelhalim, A. M., & Ismail, S. M. (2019). Design challenges of agricultural greenhouses in hot and arid environments – A Review. *Engineering in Agriculture, Environment and Food*, *12*(1), 48–70. https://doi.org/10.1016/j.eaef.2018.09.004

Kumar, E.R. (2011). *Research Methodology*, 3rd Ed. SAGE Publications LTD., London.

Lund Research Ltd. (2018). Kendall's tau-B using SPSS statistics. Kendalls tau-b using SPSS Statistics- A How-To Statistical Guide by Laerd Statistics. https://statistics.laerd.com/spss-tutorials/kendalls-tau-b-using-spss-statistics.php

Mburu, K. B., Biu, J. K., &Njagi, J. M. (2015). Climate change adaptation strategies by small-scale farmers in Yatta District, Kenya. *African Journal of Environmental Science and Technology*, *9*(9), 712–722. https://doi.org/10.5897/ajest2015.1926

Mugenda, O.M., & Mugenda, A.G. (2011). *Research Methods: Quantitative & Qualitative Approaches*. Acts Press, Nairobi.

Muriithi, I., Wambua, B. N., &Omoke, K. J. (2021). Constraints and Opportunities for Greenhouse Farming Technology as an Adaptation Strategy to Climate Variability by Smallholder Farmers of Nyandarua County of Kenya. *East African Journal of Science, Technology and Innovation*, *2*(Special), 1–13.

Opanda, S. (2021, June 5). Why greenhouses failed Kenyan farmers. International Policy Digest. https://intpolicydigest.org/why-greenhouses-failed-kenyan-farmers/

Otiende, M., Kere, G., Opunga, J., & Langat, G. (2024). *Adoption of Greenhouse Technology among small scale Tomato Farmers in Kericho County: Socio-economic and Institutional perspectives* [submitted for publication]. Department of Agricultural Biosystems, Economics & Horticulture, University of Kabianga, Kenya.

Article DOI : https://doi.org/10.37284/eajab.7.1.1811

Sanzua, L. J., Saha, H. M., &Mwafaida, J. (2018). Status of greenhouse farming in the coastal humid climatic region of Kenya. *Universal Journal of Agricultural Research, 6*(5), 165–172. https://doi.org/10.13189/ujar.2018.060504

Smitha, S., Parvathy, A., Misha Madhavan, M., & Diksha, P. (2016). Constraints faced by Farmers in Adopting Greenhouse Technology (GT) in Anand District of Gujarat. *International Journal of Agriculture Sciences*, *8*(62), 3510–3511.

Wachira, J. M. (2012). Comparative Analysis of Greenhouse versus Open-Field Small-Scale Tomato Production in Nakuru-North District, Kenya (thesis). Egerton University, Njoro, Kenya.

Warner, L. A., Lamm, A. J., White, S. A., Fisher, P. R., & Beattie, P. N. (2020). A new perspective on adoption: Delivering water conservation extension programming to nursery and greenhouse growers. *Journal of Agricultural Education*, *61*(1), 172–189. https://doi.org/10.5032/jae.2020.01172

Wayua, F. O., Ochieng, V., Kirigua, V., &Lusike, W. (2020). Challenges in greenhouse crop production by Smallholder Farmers in Kisii County, Kenya. *African Journal of Agricultural Research*, *16*(10), 1411–1419. https://doi.org/10.5897/ajar2020.15086

