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**Active Participation and Adoption of Climate-Smart Agriculture Greenhouse
Technology among Smallholder Farmers in Kiambu County, Kenya**

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Abstract

Purpose: This study sought to examine the influence of active participation on the adoption of climate-smart agriculture greenhouse farming technology among smallholder farmers in Kiambu County. Climate Change has exacerbated food insecurity and malnutrition, despite the implementation of participatory development approaches aimed at ending hunger by 2030. One of communication's main roles is to facilitate people's participation in sustainable development since there can be no participation without communication. The study was guided by the Participatory Communication Theory (PCT) and Unified Theory of Acceptance and Use of Technology (UTAUT).

Methodology: The study was conducted using a mixed-method research design, with data collected through questionnaires, in-depth interviews, and focus group discussions. Quantitative data were collected from 387 smallholder farmers in Kiambu County, Kenya, while qualitative data were obtained from 50 key informants through in-depth interviews and focus group discussions. Quantitative data were analysed using descriptive and inferential statistics, while qualitative data were analysed using emerging themes as narratives.

Findings: Active participation among stakeholders influenced the adoption of climate-smart agriculture greenhouse technology with key attributes being planning phase (sig. =.003) and assessment phase (sig. =.031). The study found that more than 90% of farmers agreed that they must actively participate in all the four phases of active participation during uptake of climate-smart greenhouse farming.

Unique Contribution to Theory, Practice and Policy: The study recommends that all stakeholders should be actively involved in the entire process of adopting greenhouse farming from the diagnosis, planning, implementation and assessment phases for farmers to encounter high productivity when solving food crisis and malnutrition.

Keywords: *Communication, Farm Households, Agricultural Extension Services, Agricultural Technology, Technological Innovation*

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INTRODUCTION

Food insecurity and malnutrition are global challenges linked to a rapidly changing climate, including global warming and precipitation variability and extremes (Mirzabaev et al., 2022). Globally, over 700 million people face hunger crisis and 2 billion are micronutrient-deficient (FAO, IFAD & WFP as cited in Lulanga & Khayeka, 2022). Development agents have made deliberate efforts, including the introduction of climate-smart agriculture technologies and practices, to end all forms of hunger by 2030 as envisioned in the second Sustainable Development Goal (SDG). To share information, knowledge, trust, and commitment in development projects, people must actively participate in the decision-making process. Participatory communication can effectively influence the practice of greenhouse farming because adoption is guided by access to adequate technologies built through active involvement of various stakeholders (Muriithi et al., 2021).

Participatory communication approaches facilitate the sharing of opinions, ideas and experiences on greenhouse farming among individual farmers or farmers' groups. Therefore, integrating communication into participatory development is critical because there can be no participation without communication (Singhal, 2001). Participation in development projects is key to ownership and successful policy implementation (Maina et al. 2020), thus improving farmers' livelihoods.

Participation involves farmers and other stakeholders in adopting greenhouse farming technology to increase productivity and address food insecurity and malnutrition. Unlike passive participation where individuals are considered to be participating merely by showing up at meetings, active participation entails the inclusion of farmers in the entire development process of their development from the design and planning through to the implementation and assessment of innovative agricultural technologies (Melkote & Singhal, 2021).

Two-way communication is transversal and can only be effective when applied consistently from the beginning of the development project to the monitoring and evaluation to facilitate meaningful development (Melkote & Singhal, 2021). This provides the added value needed to make all four phases of active participation more effective and sustainable for farmers (Mefalopolous, as cited in Anani-Bossman & Blankson, 2023), because participatory communication is a social process aimed at achieving a common understanding and consensus among all stakeholders. Active interaction between the facilitator and the farmer enables the transfer of new and beneficial greenhouse farming information and technical knowledge from the facilitator to the farmer, thereby influencing the adoption of greenhouses. The farmers get to learn about these climate-smart farming practices like humidity control, drip irrigation, pest management with experts from the facilitators (agricultural extension officers, media or internet sources), besides just receiving a structural kit.

Development agents should restructure the learning process from mere distribution of greenhouses to farmers to involving them to get their buy-in. Farmers should be enabled to gain a better understanding of smart greenhouse technology (Bseiso et al., as cited in Bashir et al., 2024). The successful adoption of greenhouse farming in Africa can be attributed to participatory farming which has enabled farmers to engage, learn and share farming tips amongst themselves, for instance in Malawi, Zambia, Eastern and Southern Africa resulting in the successful replacement of maize with early-maturing, drought and disease-resistant crops like cassava (Ariom et al., 2022). In Nigeria, extension agents have been empowered through

access to information, leading to engagement in climate-smart actions such as planting early maturing crop types (Chukwuone & Amaechina, 2021).

To achieve cooperation among all stakeholders participating in a project, clear goals and objectives must be established through open and participatory communication, ensuring that all voices are heard. Working together allows effective decisions to be made and implemented (Melkote & Singhal, 2021). Active participation between farmers and facilitators should be reflected during the decision-making process throughout the development cycle from the diagnosis, planning, implementation to the assessment phase (Servaes & Servaes, 2021). The use of a participatory communication approach to create awareness on innovative farming techniques should be integrated to ensure effective stakeholder involvement and sustainability (Pawera et al., 2024).

In some cases, weak links between farmers and research advisory services (Getahun, as cited in Eshtie & Chanie, 2024) and the non-involvement of smallholder farmers during the decision-making of the intended development (Krell, 2020) limit the farmers' voice in the decision-making process during the adoption of greenhouse farming.

Lack of participation among farmers and facilitators hampers the adoption of greenhouse farming. For instance, little involvement between farmers in North Wollo Zone, Ethiopia and communication workers, agricultural extension workers and development agents to shape programmes affected adoption (Eshetie & Chanie, 2024). Kenyan farmers continue to reap low agricultural productivity due to low uptake of climate-smart agriculture (Waaswa et al., 2021). In Nyandarua County, for instance, the practice failed due to a lack of information among smallholder farmers (Muriithi et al. 2021). In Kisii County, the practice failed because greenhouse farming was introduced to farmers without prior training (Wayua et al. 2020). However, in Kiambu County where this study was conducted, active participation facilitate successful uptake, although, a lot of effort still needs to be incorporated to achieve more success.

Sources of greenhouse information among them; KALRO, Tegemeo Institute, and JKUAT, have outreach programs aimed at imparting climate-smart knowledge and best farming practices to farmers. Farmers' participation in the decision-making process is very important because it fosters knowledge and information sharing, develops trust, dedication, and the proper mindset for development (Eshetie & Chanie, 2024). Participatory communication has influenced the successful adoption of greenhouse technology.

Agricultural extension utilises one-on-one interaction because farmers prefer interpersonal communication, particularly face-to-face interaction (Jullandhry 2020). Agricultural extension officers (AEOs) have facilitated the communication of essential adaptive agricultural information. Kathula (2023) argues that extension services should be enhanced through timely recruitment, regular training of agents and proper coordination. Active participation can be enhanced through agricultural extension, where facilitators impart farming knowledge to farmers.

Kiambu County was chosen among the other 46 counties in Kenya specifically because of its high food production ability and endowment of rich agricultural resources mainly through the high concentration of greenhouses despite the diminishing land sizes in the county and its peri-urban setting. Kiambu County is also regarded as a breadbasket due to its proximity to major outlets in Nairobi, Kajiado, Machakos, Muranga, Nyandarua and Nakuru counties (CIDP,

2023). During the COVID-19 pandemic, Kiambu County supplied food groceries to Nairobi residents and environs when the government imposed a lockdown and cessation of movements, subsequently cutting food supply to the Nairobi residents. (TMG, 2020).

In the past, the Kenyan government, through the Ministry of Agriculture has used agricultural extension officers to pass information to farmers (Munyua 2000). Currently, the ratio of extension officer to farmer is 1:2000 at the national level and 1:3000 at Kiambu County which is very low according to the World Bank recommendation of 1:200-500 (Eshetie & Chanie, 2024).

Statement of the Problem

There have been deliberate communication efforts to actively involve farmers in climate-smart agriculture greenhouse farming however, the uptake of this agricultural innovation to solve food crisis, is still low in Kenya. This has resulted in low productivity and losses by farmers due to minimal interaction between the farmer and the facilitator. Studies cite low extension programmes, poor linkages between farmers and inadequate research advisory services (Munyua, 2000; Eshetie & Chanie, 2024). Ultimately, the farmer's voice is muffled during the decision-making process of their agricultural development (Kathula, 2023), hence low productivity.

In some cases, adoption of climate-smart greenhouse farming has failed due to lack of involvement of smallholder farmers during the decision-making of the intended development (Krell, 2020). For instance, the strategies used by agricultural researchers in Ethiopia failed because it utilised top-down communication where they controlled agricultural research, planned and executed approaches without involving the farmers (Kassa & Degnet, 2004, cited in Eshetie & Chanie, 2024). Deekor (2019) also observed that the participation of rural women farmers was limited by socio-cultural practices and poor information flow in Rivers State, Nigeria. In the long run, farmers lose out owing to non-involvement in the decision-making process. In Kenya, KALRO, Tegemeo Institute, and JKUAT have established outreach programs that impart agricultural knowledge and best farming practices to farmers.

The agricultural information in Kenya is outdated, poorly packaged and disseminated thus limiting farmers' participation (Kathula, 2023). Yet, participation is crucial in the decision-making process because it fosters knowledge and information sharing, develops trust, dedication, and the proper mindset for development (Eshetie & Chanie, 2024).

Low adoption of greenhouse technologies is also affected by low extension programme both at national and county levels. The government, through the Ministry of Agriculture has made efforts to engage with farmers (Munyua, 2000), but the limited number of agricultural extension officers affects active engagement in greenhouse farming. Currently, the ratio of extension officer to farmer is 1:2000 at the national level and 1:2000 at the county level which is very low as per the World Bank recommendation of 1:200-500 (Eshetie & Chanie, 2024).

Maina et al. (2020) opined that stakeholder participation in development projects is key to ownership and successful policy implementation, thus improving the lives of the community members. Adoption of greenhouse technology has been successful where participatory communication has been utilised. Akhtar and Jullandhry (2020) pointed out that farmers prefer interpersonal communication, particularly face-to-face interaction. The disproportionate extension-to-farmer ratio in Kiambu (1:3000) creates a communication bottleneck that prevents the 'active participation' during the design, planning, implementation and assessment phases

required for complex greenhouse technology adoption. Therefore, this study sought to examine the influence of active participation as a participatory communication principle on the adoption of climate-smart agriculture greenhouse farming technology among smallholder farmers in Kiambu County.

Study Objective

To establish the influence of active participation on the adoption of climate-smart agriculture greenhouse technology among smallholder farmers in Kiambu County, Kenya

Research Question

What is the influence of active participation on the adoption of climate-smart agriculture greenhouse technology among smallholder farmers in Kiambu County, Kenya?

Theoretical Framework

Participatory Communication Theory

Participatory communication approach is a dynamic, interactive and transformative process of dialogue between people, groups and institutions that enables people, both individually and collectively, to realize their full potential and be engaged in their welfare (Singhal, 2001). It is the exchange of information between the parties involved in the development process through dialogue to achieve mutual understanding (common understanding) and consensus for the decision-making process (Aminah, as cited in Guuru & Adede, 2022)

Long before participation was purposefully advocated for development, people had formed collectivities to farm (Singhal, 2001). Participatory communication transcends the usual exchange of communicating messages to building deep trust, sharing knowledge and experiences, identifying and investigating problems, needs and opportunities and finally about defining priorities and solutions (Ibuot et al., 2021). This theory emerged out of the need to seek a new approach to sustainable development that involves active participation at the centre of development.

According to Thomas and Mefalopulos, as cited in Guuru & Adede, (2022), this theory encourages trust and openness in an organization thus ensuring free flow of information. This model is a process that allows communication for social change and provides a communication framework that is characterised by community participation, language, and cultural relevance, creation of local content, using appropriate technology, network and convergence (Melkote & Singhal, 2021).

Participatory approach is intended to make communication common through sharing meanings, perceptions, worldviews or knowledge in a community. It opposes the unilateral approach to communication which limits the role of participation and involvement by community members in development.

Freirean dialogic communication emphasizes interpersonal and group dialogue in a community setting and hence has found more application in the practice of community development, participation and transformation (Singhal, 2001). Individual farmers come together and form community organisations such as farmer groups and Saccos where they participate in joint message construction and seek joint solutions to challenges that they face as they go about their agricultural activities through their daily interactions. Unlike other forms of communication that dwell on mere exchange of information, participatory communication is more deep,

exploratory, engaging and focuses on generation of new knowledge aimed at addressing situations that need to be improved (Melkote & Singhal, 2021). The concept has been fully integrated in sustainable development since the 1990s and has contributed toward discourse on ideal meaning of participation. This theory is pegged on four principles: active participation, dialogic pedagogy, socio-cultural identity and empowerment (Melkote & Singhal, 2021).

Active participation of community members should be reflected during the decision-making process throughout the development cycle right from diagnosis, planning, intervention or experimentation and assessment (Servaes & Servaes, 2021). The use of a participatory communication approach to create awareness on innovative farming techniques should be integrated into participatory approaches to ensure effective stakeholder involvement and sustainability (Pawera et al., 2024).

Participatory communication is simply a process of joint message construction within a group of community members with an aim of improving their existential situation and change of the social structure in development (Mody, as cited in, Phan, 2019). As farmers participate in farmers schools and agricultural shows they learn to express themselves. They also agitate for sound policies and reforms in the agriculture sector. Daily interaction among farmers improves their social well-being since participatory paradigm utilises culture-specific and people-centred holistic development approaches.

The Unified Theory of Acceptance and Use of Technology (UTAUT)

This theory was developed by Venkatesh et al. in 2003 to explain user intentions for using technology and subsequent usage behaviour. It was created by reviewing, integrating and mapping constructs from eight leading theories and models: The Innovation Diffusion Theory (IDT), the Motivational Model (MM), The Technology Acceptance Model (TAM), the Model of Personal Computer Utilization (MPCU), the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB), a combined Theory of Planned Behaviour/Technology Acceptance Model (C-TPB-TAM) and the Social Cognitive Theory (SCT).

Technology acceptance theories and models study the method of understanding and accepting new technologies, their usage and their influence. Some factors such as usefulness, ease of use, complexity, and social influence can affect the users' decision against the use of technology. Similarly, the adoption of agricultural technologies in Africa can be enhanced by educating farmers in technology dissemination and climate change adaptation (Nyoni et al., 2024).

UTAUT has been widely used in innovation diffusion and technology adoption research. It has been utilised in various disciplines in academia, agriculture among others. It has helped clarify factors that influence how successfully new technology is adopted. Its validity, stability and viability in the adoption of technology in a variety of circumstances have all been proven by researchers. Technology acceptance theories and models study the method of understanding and accepting new technologies, their usage and their influence. The evolution of technology acceptance theories and models has been initiated since the beginning of the 20th century. This evolution took place in different theoretical perspectives, such as cognitive, affective, motivational, behavioural intentions and the reactions of individuals.

Performance expectancy, effort expectancy, social influence and facilitating conditions are the four main components of this theory and are direct predictors of technological behaviour intention and ultimately, behaviour Venkatesh et al., cited in (Momani, 2020). It also states that the core constructs is moderated by gender, age, experience, and voluntariness of use.

These constructs influenced this study in the sense that the perceived usefulness of the performance expectancy applies to this study in the manner in which farmers adopt greenhouse farming technology knowing that they stand to benefit from the practice and thus the motivation. The perceived ease of use in the effort expectancy of the greenhouse farming technology is relevant to this study in the sense that farmers become innovative as constructing their greenhouses using available resources such as wooden structures and plastic vinyl as easily as possible.

Performance expectancy is the degree to which an individual expects that utilising new technology would enable them to improve gains in job performance. Perceived usefulness (PU), extrinsic motivation, job fit, relative advantage and outcome expectations are the main components of performance expectancy. PU is the extent to which an individual believes that using a specific system will improve their job performance. Extrinsic motivation is the perception that users will want to perform an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself. Job fit describes the manner in which the system's capabilities enhance user's job performance.

Effort Expectancy is the degree of ease associated with the use of new technology. Perceived ease of use (PEOU), complexity, and ease of use (EOU) are the key pillars of Effort Expectancy. PEOU is the extent to which a user thinks that using a particular system would be free of effort. EOU is the degree to which an innovation is perceived as being difficult to use and Complexity refers to the degree to which an innovation is perceived as relatively difficult to understand. Effort Expectancy is the degree of ease associated with the use of new technology in this case, climate-smart greenhouses. Perceived ease of use (PEOU), complexity, and ease of use (EOU) are the key pillars of Effort Expectancy. The perceived ease of use of greenhouse technology is the extent to which farmers think that using the technology would be free of effort. Ease of use is the degree to which an innovation (greenhouse technology) is perceived as being difficult to use and Complexity refers to the degree to which an innovation (greenhouse technology) is perceived as relatively difficult to understand. Thus, the more the farmers participate in the "Design Phase" of the greenhouse adoption, the more the practice becomes "Easier to Use" (Effort Expectancy) because it was built according to their local constraints.

The facilitating conditions being one of UTAUT's components are direct predictors of technological behaviour intention. The Job fit describes the manner in which the system's capabilities enhance the user's job performance, Venkatesh et al., cited in (Momani, 2020). It refers to the degree to which the farmers and agricultural extension officers (AEOs) believe that the necessary infrastructure exists to facilitate successful adoption of greenhouse farming technology. Farming environments often depend on favourable infrastructural support (irrigation, access to inputs, seeds, fertilizers), institutional support (government policies and extension services), technical knowledge and training, access to ICT services (smart phones and internet for digital farming tools), access to credit and subsidies as enablers for easier adoption and usage of greenhouse farming technology. These facilitating conditions subsequently motivate farmers to voluntarily adopt and use climate-smart innovations like improved seeds or drip irrigation in greenhouses.

Conceptual Framework

The independent variable is represented by active participation. The attributes of active participation include: diagnosis, planning, implementation and assessment phases. This principle is drawn from the participatory communication theory. The dependent variable is represented by adoption of climate-smart agriculture greenhouse technology. This refers to the duration of greenhouse farming by Kiambu smallholder farmers, the type of greenhouse and the size of the greenhouse constructed. This variable is drawn from the Unified Theory of Acceptance and Use of Technology (UTAUT). One of the constructs of UTAUT is performance expectancy which predicts technological behaviour intention. This construct is the degree to which an individual (farmer) expects that utilising new technology (greenhouse) would enable them to improve gains in job performance (productivity). Another construct is Effort Expectancy which is the degree of ease associated with using new technology.

The moderating variable in this study is represented by the socioeconomic factors which include; age, gender, education and income. Some of these factors are drawn from the Unified Theory of Acceptance and Use of Technology (UTAUT). The moderating variables under the UTAUT model include gender, age, experience and voluntary use. The principle of the Participatory Communication Theory and constructs of the Unified Theory of Acceptance and Use of Technology (UTAUT) identify and operationalise the variables. They were used to propose relationships that formed a context for interpreting and explaining the study findings. The Scholarly views on each of these variables were explored and discussed. They are represented in the conceptual framework (Figure 1).

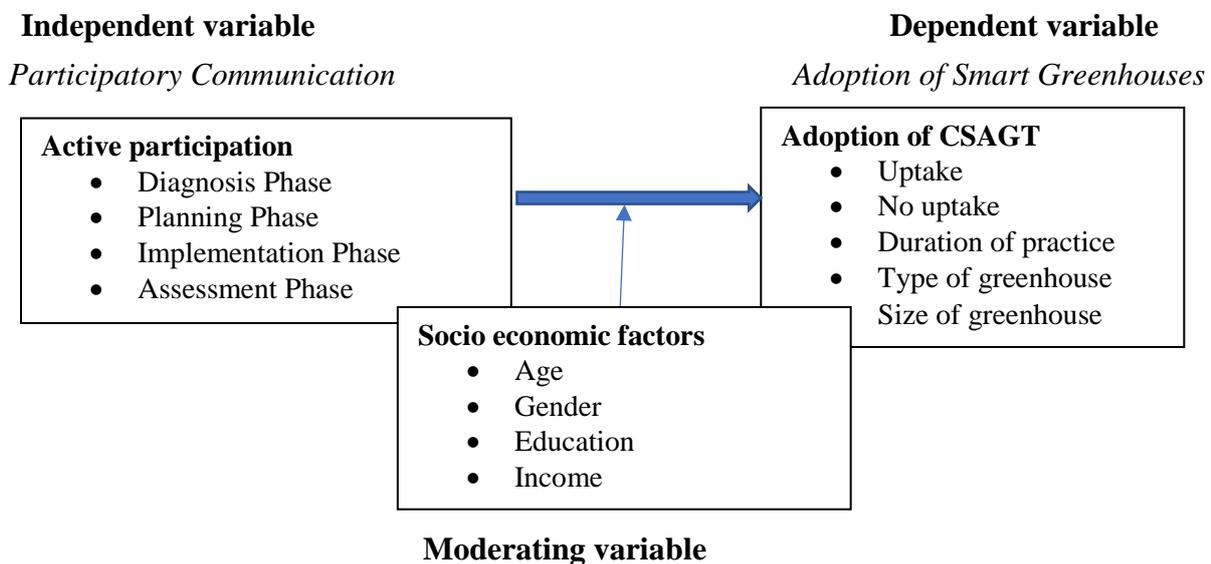


Figure 1: Conceptual Framework

METHODOLOGY

Study Design

The study applied a mixed-methods research design. Quantitative data was collected using questionnaires and analysed using descriptive statistics (mean, mode, median, cross tabulations and percentages) and inferential statistics (correlation coefficient, regression analysis and ANOVA). Qualitative data was collected using in-depth interviews and focus group

discussions and analysed using emerging themes as narratives. Triangulation of quantitative and qualitative data was carried out.

The study population was climate-smart greenhouse technology smallholder farmers in Kiambu County. The sample size for quantitative research was 387 smallholder farmers and 50 key informants for qualitative research. The sample size was determined using Fischer *et al* (1991) formula.

Where;

$$n = Z^2 \cdot p \cdot q/d^2$$

n = sample size (if the target population is > 10,000).

z = the value at the chosen confidence interval (1.96 for a confidence interval of 95%)

p = estimated population with attributes of interest where infinite p = 0.5,

q = 1-p, and

d = degree of accuracy set; 0.05 confidence level corresponding to 1.96.

Sampling

A multistage sampling technique was used for quantitative research (Creswell & Creswell, 2022) and purposive sampling was used to sample qualitative respondents for qualitative research. Before carrying out the main study, the researcher did a pilot test by administering questionnaires to 20 smallholder farmers in Lari and Ruiru Sub-Counties in Kiambu County to test the validity and reliability of the research instruments. The researcher collected 387 questionnaires representing 80% response rate, which was sufficient and acceptable, and thus used for data analysis. The in-depth interviews were done with 26 key interview informants and 24 respondents for focus group discussions that comprised of between 6-8 respondents per group.

RESULTS AND DISCUSSION

Active Participation among Stakeholders

The study established that active participation influenced adoption of greenhouse adoption among smallholder farmers in Kiambu County. Active participation comprises of: diagnosis, planning, implementation and assessment phases. Participatory communication aims at ensuring farmers' involvement throughout the entire development process. Thus, people-centered communication strategies are key when disseminating smart greenhouse farming (Bessette 2021). In this study, farmers were assessed on their level of participation in seeking greenhouse information based on the attributes of active participation namely: The first meeting to learn about greenhouse farming (diagnosis phase); the planning of the construction of a greenhouse (planning phase); the actual construction of a greenhouse (implementation phase) and lastly, checking the progress of greenhouse farming (assessment phase). To achieve this, Likert scale questions were posed on farmers where where: 5 =Strongly agree, 4 = Agree, 3 =Neutral, 2 = Disagree, 1= Strongly Disagree.

Table 1: Active Participation and Adoption of Climate-Smart Greenhouse Farming

Active participation phases	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Non response	Total
A farmer must interact with his/her source of information during the first meeting to learn about greenhouse farming (diagnosis)	2%	1%	5%	43%	49%	1%	100%
A farmer must interact with his/her source of information during the planning of the construction of a greenhouse (planning)	1%	1%	3%	45%	48%	1%	100%
A farmer must frequently interact with his/her source of information during the actual construction of a greenhouse (implementation)	1%	1%	5%	44%	48%	1%	100%
A farmer must frequently interact with his/her source of information when checking the progress of greenhouse farming (assessment)	1%	1%	6%	49%	42%	1%	100%

The findings showed that cumulatively, farmers agreed that they must interact with their sources of information during: diagnosis phase (92%), planning phase (93%), implementation phase (92%) and assessment phase (91%). This finding concurs with (Mathe, as cited in Tokede & Traverso, 2020) that involving stakeholders in development increases the likelihood of acceptance. This interaction occurs daily through social media platforms, weekly through fellow farmers or quarterly through farmers field schools or training centres.

One pioneer farmer said:

Farmer 4

I came to learn about greenhouse farming through an extension programme undertaken by the Food and Agriculture Organisation (FAO). They used to visit different farms in our area teaching us best farming practices. From that interactive learning experience, I can now access the information through the Television, social media, demonstration farms in JKUAT and KALRO.

During the planning phase of active participation, 93% of farmers affirmed that it was imperative to interact with their sources of information to facilitate adoption of smart greenhouse farming. One key informant agricultural extension officer revealed that:

AEO 1

I interact with farmers on a weekly basis, they come to my model farm. We sit down and agree on the type of greenhouse and crops to plant. I teach them the type of seeds and the need to know the soil type in their farms. Because when you plant some seeds during the sunny seasons you will encounter losses; some you plant during the rainy season yet they have low maturity. If a farmer wants to construct the greenhouse they come to me directly and get the preferred design.

During the implementation phase of active participation, it was established that 92% of the farmers affirmed that they must frequently interact with their sources of information during the adoption of greenhouse farming. This finding agrees with (Melkote & Singhal, 2021) that participatory communication in the form of training on crop farming techniques during the implementation stage, was deemed beneficial to farmers.

One key informant agronomist said:

Agron 1

After purchase, we install and train them (farmers) how to operate and maintain the greenhouse. Training is done every month for six months depending on the crop in the greenhouse.

Lastly, during the assessment phase of active participation, 91% of the farmers affirmed that they must interact with their sources of information during the adoption of greenhouse farming. During this phase, success or failure of project is observed. Communication experts will then be able to evaluate the progress of the project and propose new techniques if need be.

Farmer 8

I have always depended on Amiran agronomists to get greenhouse information even after introducing me to the practice 15 years ago. Our interaction is fairly good. I have no time to watch TV.

On the other hand, the facilitators such as agronomists guide farmers on greenhouse farming during the entire phases of participation as one agronomist revealed:

Agron 3:

We call or visit our smallholder farmers in Kikuyu and Thika Sub Counties and make follow ups for 6 weeks. We interact with them (farmers) at all levels of participation. We discuss and advise farmers on sources of water, drilling or pumping, preference of the type of greenhouse and also teach them the benefits of using organic manure.

Active participation is also demonstrated in farmers' training centres where they offer information in form of advisories as facilitators engage farmers daily, weekly, monthly, quarterly or annually. A trainer at Waruhiu Agricultural Training centre confirmed that:

ATC 1

Farmers walk in and out of Waruhiu ATC having been equipped with the needed information. We also monitor their progress regularly because we already have their contacts in our visitors' book. The normal training programme, runs for 2 to 3 days, every month. Additionally, we organise a two-day annual farmers' field day in March usually on a Friday and Saturday. During such interactions, we advice farmers on the right seedlings for their greenhouses from nursery to harvest.

In the process, during the training sessions at the farmers training centers and Institutes, farmers are guided on what to do as far as greenhouse farming is concerned at all levels of participation from inception of greenhouse adoption to productivity through SMSes and toll-free calls. Interpersonal communication underscores the aspect of participatory communication as agricultural extension services offer sound technical advices to farmers (Kathula, 2023).

Adoption of Climate-Smart Agriculture Greenhouse Technology

The knowledge gap on greenhouse farming has created the need for a comprehensive and context-appropriate decision to guide farmers through the preparation, planting, nurturing and harvesting of greenhouse productions (Bseiso et al., as cited in Bashir et al., 2024). In this study, the adoption of greenhouses is represented by the duration of practicing greenhouse farming, the size of greenhouse, and type of greenhouse. The study found that 257 (66.5%) of farmers owned greenhouses, 59 (15.2%) used to own but abandoned due to various reasons 71 (18.3%) who did not own greenhouses were willing to start practicing this type of farming.

Among the factors that motivate farmers into adopting greenhouse farming include: the desire to reduce the effects of climate change (67%) of the farmers, the need to improve nutrition in their families (58%), the need to make their families food secure (56%), the need to remain abreast with modern food production methods (48%). In some instances, where farmers stated they had abandoned greenhouses, 59(15.2%) of the farmers stated the lack of information on greenhouse farming, 18(4.7%) stated lack of information on food security, 59(15.2%) stated high costs of managing and operating the greenhouses and 37(9.6%) stated high costs of constructing greenhouses. However, they indicated that they resume the practice.

These findings corroborate Sanzua et al. (2018); Wayua et al. (2020) that low productivity, lack of technical knowledge of greenhouse crop production, lack of information on appropriate structures and high initial costs for establishing and operating the greenhouses hamper the adoption of greenhouse farming technology. With increased technical support, greenhouse farming can be a more viable economic booster, especially in urban and non-traditional agricultural areas. Therefore, adaptation of CSA depends on the potentialities of technology, its performance at the field level, and acceptance by farmers (Bhattacharyya et al., 2020). The greater the availability of technical support, the more farmers tend to adopt green agricultural production technology (Kexiao et al., 2022).

Collinearity Test for the Dependent Variable

A correlation test was conducted to determine the results. The data was ordinal and as such Spearman's rho rank correlation statistics were employed and generated using the SPSS computer program. The test was conducted at a ninety-five (95%) confidence level where the significance was set at 0.05.

Table 2: Collinearity Test for the Dependent Variable

	Type of greenhouse owned	Duration practiced greenhouse farming	Size of your greenhouse
Type of greenhouse owned	1.000	.567**	.614**
Duration practiced greenhouse farming	.567**	1.000	.615**
Size of your greenhouse	.614**	.615**	1.000
Average farm size	.086	.180**	.417**
Income from greenhouse farming	.507**	.541**	.485**

There was a strong positive correlation between the duration of practice, type and size of greenhouse. The findings showed that a majority of the respondent farmers, 219 (56.6%) practiced greenhouse farming between 1-5 years and 95(24.5%) practiced between 6-10 years. These findings imply that the practice of greenhouse farming has taken shape for some time now and is being gradually embraced. Kiambu County has distributed greenhouses to farmers' groups (CIDP, 2023) although ownership of greenhouses has majorly been individually based thus the farmer-to-farmer interaction between farmers serves as a source of agricultural information to solve their food security needs for subsistence and economic purposes. There is a high likelihood that farmers' experience in greenhouse farming influences their adoption as (Wayua et al., 2020) argue that the number of years of operation significantly influences the functionality of the greenhouses.

In some instances, land ownership influenced the type, size and duration of the greenhouses to be constructed. 155(40.1%) of farmers owned 1/4 of an acre and 153(39.5%) own an eighth of an acre, 40(10.3%), 40(10.3%) owned half an acre and 14(3.6%) each owned an acre piece of land. These findings imply that due to land subdivisions and the rise of commercial residential activities, land sizes have diminished. However, farmers are practicing smart farming for subsistence and economic purposes. In Kiambu County, land ownership is 95% private, 0.01% communal, and approximately 5% public. 85% of landowners have title deeds to their land (MoALFC, 2021). The population growth and the cultural practice of land inheritance subdivision have decreased average farm sizes in Kiambu County (ASDSP II, 2021). This has compelled smallholder farmers to adapt to the reality of climate change by embracing smart agricultural farming technologies such as greenhouse farming. Climate change in the county is coupled with the unpredictability of the timing and amount of rainfall received.

The study findings showed that 268 (69.3%) of farmers owned wooden greenhouses, 18 (4.7%) owned metallic greenhouses, 29 (7.5%) owned both wooden and metallic greenhouses. These findings imply that despite the prevailing food insecurity, farmers were determined to solve their food crisis through local solutions facilitated by information available to them for instance, the locally available materials that eventually yielded high productivity. Pronti et al., (2024) observe that African farmers are the world's most productive and inventive agriculturalists thus their inventiveness should be supported by educational and technical assistance. This in part is highlighted in the definition of participatory communication which is a dynamic, interactional, and transformative process of dialogue between farmers, both individually and collectively, to realise their high productivity and address food insecurity

(Singhal, 2001). Most wooden greenhouses are owned by individual farmers, most probably because of their economic advantage and practicability.

In terms of the size of greenhouses, the findings also showed that 165(42.6%) operated greenhouses on an 8 by 15m, 119(30.7%) operated 8 by 30m greenhouses, 21(5.4%) operated an 15 by 30m greenhouses, 7(1.8%) 24 by 30m greenhouses. These findings imply that with the diminishing land sizes in Kiambu County, smallholder farmers are becoming innovative by venturing into greenhouse farming due to the rising trend of urban farming. Wayua et al., (2020) established that greenhouses owned by individuals had a significantly higher probability of being functional, than those owned by groups and institutions. It proposed the need to enhance adoption of greenhouses to achieve food security by training smallholder farmers on greenhouse crop production and linking them to appropriate sources of funding.

Correlation Analysis

Correlation techniques were used to generate Spearman's Rank Correlation Coefficients. The study showed that there was a positive correlation between the interaction of facilitators and farmers during all the four phases and the adoption of greenhouse farming. For instance, there was statistical significance during the first meeting and the duration of greenhouse farming ($r=0.232$, Sig. <0.05), the planning phase and duration of greenhouse farming ($r=0.214$, Sig. <0.05), the implementation phase and duration of greenhouse farming ($r=0.177$, Sig. <0.05) and the assessment phase and the duration of greenhouse farming ($r=0.117$, Sig. <0.05). The correlation analysis between active participation and adoption of greenhouse farming is shown in Table 3 below.

Table 3: Correlation Analysis between Active Participation and Adoption of Greenhouse Farming

Communication level	Spearman's rho	Duration of greenhouse farming	Type of greenhouse adopted	Size of greenhouse adopted
A farmer must interact with their source of information during the first meeting to learn about greenhouse farming	Correlation Coefficient Sig. (2-tailed)	.232** .000	.188** .000	.159** .002
A farmer must interact with their source of information during the planning of the construction of a greenhouse	Correlation Coefficient Sig. (2-tailed)	.214** .000	.178** .000	.153** .003
A farmer must frequently interact with their source of information during the actual construction of a greenhouse	Correlation Coefficient Sig. (2-tailed)	.177** .001	.163** .001	.112* .029
A farmer must frequently interact with his/her source of information when monitoring the progress of greenhouse farming	Correlation Coefficient Sig. (2-tailed)	.117* .022	.120* .019	0.082 .111

The correlation analysis between active participation and adoption of greenhouse farming points to the fact that for successful adoption of smart greenhouse farming technology, farmers

must interact with their source of information during the diagnosis, planning, implementation and assessment of greenhouse farming. This finding concurs with (Singhal, 2001) that all participation is communication-driven. It also corroborates (Melkote & Singhal, 2021) that active participation of stakeholders in the development process is critical for genuine development which involves all stakeholders in the decision making from the onset stage of diagnosis, planning, implementation and assessment phases of any development project. Correlation analysis was also done to examine the influence of active participation and moderating variables using Spearman's Rank Correlation Coefficient that was used to draw conclusions shown in the Table 4 below:

Table 4: Correlation between Active Participation with Moderating Variables

		Level of education	Knowledge of greenhouse farming	Age	Gender
Active participation during diagnosis phase	Correlation Coefficient	0.091	.203**	.630**	.638**
	Sig. (2-tailed)	0.075	0.000	0.000	0.000
Active participation during planning phase	Correlation Coefficient	0.102*	.195**	.617**	.621**
	Sig. (2-tailed)	0.047	0.000	0.000	0.000
Active participation during implementation phase	Correlation Coefficient	0.055	.212**	.604**	.593**
	Sig. (2-tailed)	0.284	0.000	0.000	0.000
Active participation during assessment phase	Correlation Coefficient	0.083	.148**	.514**	.503**
	Sig. (2-tailed)	0.106	0.004	0.000	0.000

Table 4 shows that there was a significant correlation between the active participation sub-constructs and socio-economic factors (moderating variable) for instance, the planning phase and moderating variables: education ($r=0.102$, Sig. <0.05), knowledge of greenhouse ($r=0.195$, Sig. <0.05), age ($r=0.617$, Sig. <0.05) and gender ($r=0.621$, Sig. <0.05).

Regression Analysis

Regression analysis was conducted to determine the extent to which active participation influenced the adoption of climate-smart agriculture greenhouse technology and which attributes were the more significant factors. It was also used to determine how the independent variables influenced the dependent variable collectively.

Regression Analysis Model Summary

Regression analysis was conducted to determine the extent to which active participation influenced the adoption of climate-smart agriculture greenhouse technology. Regression modelling was adopted to assess the influence of the four sub-constructs of active participation considered by the study on the adoption of greenhouse technology. The study first performed the regression analyses of the variables and the results are summarized in Table 5 below:

Table 5: Model Summary (Regression Model Summary)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.253 ^a	.064	.054	.668

a. *Dependent Variable: For how long have you practiced greenhouse farming?*

b. *Predictors: (Constant), First meeting, Planning of the construction, During actual construction, and Monitoring progress*

The regression analysis in Table 5 shows that the relationship between the dependent variable and all the independent variables pooled together had a model correlation coefficient = 0.253^a. The adjusted R-squared ($R^2_{Adj} = 0.064$), further indicates that the model could explain up to 6.4% variations in the adoption of greenhouse farming in Kiambu County, Kenya.

Summary of ANOVA

Hair et al., (2020) state that the appropriateness of the multiple regression model as a whole can be tested using F-test. Therefore, the study also performed an ANOVA on the independent and dependent variable and the results are summarized in Table 6 below;

Table 6: Summary of ANOVA

ANOVA ^a						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	11.420	4	2.855	6.405	.000 ^b
	Residual	166.701	374	.446		
	Total	178.121	378			

a. *Dependent Variable: For how long have you practiced greenhouse farming?*

b. *Predictors: (Constant), First meeting, Planning of the construction, During actual construction, and Monitoring progress*

The results in Table 6 indicate that there is statistical significance between the active participation and adoption of greenhouse farming among smallholder farmers in Kiambu County, Kenya. The regression model was significant, $F(4, 374) = 6.405$, $p < .000$ ^b. The ANOVA presents the goodness of fit of the model and shows an F value of 6.405, which was associated with $p < 0.05$ which signifies a statistically significant model. This result therefore confirmed that the independent variable had a significant influence on the adoption of smart greenhouse farming.

Summary of Coefficients

The SPSS computer software was used to generate the regression statistics at a 0.05 level of significance and the results are as shown in Table 7.

Table 7: Summary of Coefficients

		Coefficients ^a				
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.319	.228		1.396	.164
	First meeting	.106	.100	.112	1.052	.294
	Planning of the construction	.451	.150	.450	3.002	.003
	During actual construction	-.192	.131	-.201	-1.466	.144
	Monitoring progress	.189	.088	.200	2.160	.031

a. Dependent Variable: For how long have you practiced greenhouse farming?
b. Predictors: (Constant), First meeting, Planning of the construction, During actual construction, and Monitoring progress

The coefficients summary in Table 7 indicates “planning of the construction and monitoring progress”, as P values for predictor variables were less than 0.05 ($p < 0.05$), revealing that the model was statistically significant in the variations of the dependent variable. Both of them were therefore retained in the model. The resultant model from the coefficients was therefore as follows:

$$Y = 0.451X_2 + 0.189X_4 + \varepsilon$$

Where:

Y = Adoption of climate-smart agriculture greenhouse technology (Dependent Variable)

X_2 = interactions during the planning of the construction (Independent Variable)

X_4 = interactions during progress monitoring (Independent Variable)

ε = Error term

Interactions during the planning of the construction had a beta coefficient (weight) of 0.451, while that of progress monitoring was 0.189 implying that planning of the greenhouse construction influence more on the dependent variable when compared to progress monitoring. Therefore, the promoters of the climate-smart greenhouse technology should adopt these two practices to promote the uptake of smart greenhouses to farmers in Kiambu County, Kenya.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the results of the study, the analysis concluded that active participation occurs during the diagnosis, planning, implementation and assessment phases of greenhouse farming and this significantly influences adoption of climate-smart greenhouse farming technology among smallholder farmers in Kiambu County, Kenya. The low adoption calls for interventions to optimize stakeholder participation and enhance the adoption of climate-smart greenhouse farming. It is imperative that smallholder farmers actively interact with their sources of information during the entire process of adoption of greenhouse farming since all participation is communication-driven. Specifically, communication development strategists at the Ministry of Agriculture or the County agricultural departments and promoters of climate-smart

greenhouse technology should place more focus on the planning and the assessment phases for more favourable results. This study concurs with (Melkote & Singhal, 2021) that the Participatory Communication theory provides communication framework that is characterised by community participation.

Recommendation

The study recommends the need for stakeholders (smallholder farmers, facilitators, policy makers) to interact closely together during the diagnosis, planning, implementation and monitoring the progress of greenhouse farming. By actively participating in greenhouse farming, there is bound to be more acceptability and adoption of this climate-smart farming. Decision-makers can use the study findings as intervention measures to enhance food security in other parts of Kenya, as climate change has severely affected food production in most counties. Thus, it is time for policymakers to advocate for enhancement of extension services through resumption of recruitment of agricultural officers that had been stopped in the past. This will enhance the provision of timely agricultural extension services from the current 1 (facilitator) :3000 (farmers) in Kiambu County which is short of 1:200-500 recommended by the World Bank.

Implications and Suggestions for Further Studies

This study established that active participation influence adoption of climate-smart greenhouses and frequency occurs at different phases (diagnosis, planning, implementation and assessment). This study suggests further study to be done on the dynamics affecting active participation as one of the principles of participatory communication at different levels.

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