ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 23 No. 10 November 2023 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2023; 23(10): 24759-24782 https://doi.org/10.18697/ajfand.125.23400

FACTORS INFLUENCING THE ADOPTION OF CLIMATE SMART AGRICULTURE PRACTICES AMONG SMALLHOLDER FARMERS IN KAKAMEGA COUNTY, KENYA

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ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 23 No. 10
November 2023
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Most of Kenya's population's livelihoods and agri-food systems rely on rain-fed agriculture making them vulnerable to climate change. The adverse effects of climate change on agricultural production have necessitated the promotion of Climate-Smart Agriculture (CSA) technologies. Climate-Smart Agriculture (CSA) technologies help guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security by increasing farmers' resilience to climate change. This study sought to ascertain the current state of CSA practices among Kakamega County's smallholder farmers to identify the main drivers of CSA adoption. Stratified sampling was used to select six sub-counties to represent the county's various agroecological zones and regions for the research sample. A combination of purposive and snowball sampling was used to select 428 smallholder CSA farmers of which 182 were adopters while 246 were dis-adopters. Primary data were collected using interview guides developed through the Kobo Collect Application. Microsoft Excel and Statistical Package for Social Sciences (SPSS) statistical packages were used to process and analyze the data. This study established that CSA technologies in Kakamega are mainly promoted by international development partners, non-governmental organizations and research organizations. In addition, the most adopted CSA technologies were agroforestry, composting, and soil and water conservation structures, while push-pull technology, conservation agriculture, and vermiculture were the least adopted. This study, further, established that smallholder farmers' level of education, membership to a farmers' group, interaction with extension officers and farming experience influenced adoption of CSA technologies. Other factors are those that increase household productive resources, such as land ownership, household income, and access to agricultural credit. The results of this study suggest that those who promote CSA technologies, policymakers, extension service providers, and other stakeholders should take smallholder farmers' socioeconomic and bio-physical factors into account when doing so.

Key words: Climate-smart agriculture, CSA practices, CSA adoption, CSA dis-adoption, smallholder farmers

https://doi.org/10.18697/ajfand.125.23400

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INTRODUCTION

Climate Smart Agriculture (CSA) has been described as a method of combining various sustainable methods to address a specific community's climate challenges [1]. While sustainable agriculture focuses on producing crops and livestock with minimal environmental impact, CSA is an approach that aims to assist those who manage agricultural systems in responding effectively to climate change. The triple wins of CSA are the sustainable increase in productivity and income, adaptation to climate change, and reduction in greenhouse gas (GHG) emissions [2]. Thus, CSA practices can be defined as agricultural practices that consider both resilience and adaptation to climate change.

The farming community employs CSA practices in a variety of ways. The first method of implementing CSA is through smart farming. Smart farming is a farming management concept that employs modern technology to increase both the quantity and quality of agricultural products [3]. Thus, smart farming employs available information and communication technologies (ICTs) to boost agricultural productivity, reduce production costs, and reduce GHG emissions. The use of drones, robots, sensors, and other smart devices in agricultural production, processing, transportation, and marketing are examples of smart farming practices.

Other significant CSA interventions have been implemented to increase smallholder farmers' resilience and adaptation to climate change. Agroforestry, the integration of trees with crop and livestock production, is one of these. Available reports indicate that agroforestry helps to keep soil organic matter and biological activity at levels that are suitable for soil fertility and at the same time reduce surface runoff and soil erosion [4]. This reduces water, soil nutrients, and soil organic matter loss. Other common CSA practices include Integrated Soil Fertility Management (ISFM), Push Pull Technology (PPT), Integrated Sustainable Land Management (ISLM), conservation agriculture (CA), water harvesting, crop insurance, and soil and water conservation (SWC) structures. ISLM and ISFM aim to manage natural and planted forests responsibly to increase the benefits derived from forests and forest ecosystems in lands containing forest areas such as forests and woodlands [5]. Conservation Agriculture (CA) is practised when the three principles of zero or minimal tillage, crop rotation or crop association, and permanent crop cover are observed in farmland. CA is primarily meant to minimize soil disturbance and thus reduce the cost of fuel, labour and inorganic fertilizer expenses [6]. Soil and water conservation structures, on their part, help to control soil erosion and reduce surface runoff while water harvesting facilities help to provide irrigation water during dry periods [7].

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ISSN 1684 5374

Smallholder farmers in Kakamega County implement CSA practices through various projects. The Kenya Climate Smart Agriculture Project (KCSAP) is one of the major projects working with smallholder farmers within the county. This World Bank-funded project, implemented by the County Government of Kakamega, works with smallholder farmers in three sub-counties and six wards across the county. Previously, the county government and her partners worked on several projects. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is one of the most important CSA partners in Kakamega County. GIZ has rehabilitated over 166,000 hectares in three counties, Kakamega, Siaya, and Bungoma, through CSA interventions such as CA, agroforestry, composting, and the implementation of soil conservation structures through their Soil Protection and Rehabilitation of Degraded Soil for Food Security Project [8]. The ISLM/ISFM project, implemented by KALRO Alupe and other partners in the counties of Nandi, Kakamega, and Vihiga, is another major CSA project that has operated in Kakamega County. This project used a micro-catchment approach to increase the incomes of smallholder farmers in the Kakamega forest by implementing sustainable land and forest management technologies [9]. These projects, among others, indicate the role that has been played by development partners in promoting CSA practices in the county.

While development partners and donors have played a vital role in promoting CSA practices, many of these interventions have been short-lived, with most farmers abandoning these practices once donor funding ends. According to available data, most projects aimed at smallholder farmers become unsustainable after donor funding is withdrawn. According to Olang [9], several donor-funded projects in Kakamega County have failed to be sustainable following the donor agency's withdrawal. First, Olang [9] identifies two dairy cooperatives that were revived with Danish International Development Agency (DANIDA) funding but were no longer operational after DANIDA funding was withdrawn. According to him, the Western Kenya Community Driven Development and Flood Mitigation Project (WKCDD and FMP) established milk chilling plants in Tombo and Kimangeti dairies, both of which were still underutilized despite World Bank funding. Moreover, Olang [9] discovered that only 10 per cent of the 21 community cattle dips revived by the Malava Constituency Development Fund in 2007 were still operational in 2015. Finally, Send a Cow, a local non-governmental organization (NGO), gave out 16 dairy goats as support to 5 groups in Malava Sub-County, which had reduced to 25 per cent [9]. This suggests that donor-funded projects have a higher likelihood of failing to continue after the donor organizations stop providing financing.

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The fore-going notwithstanding, different smallholder farms have different resource endowments in the form of smallholder farmers' level of education, household income, labour availability, individual smallholder farmers' interest, and other farm-based characteristics such as soil characteristics, types of crop and livestock enterprises, and different farm management practices. In addition, these smallholder farmers may face challenges including a lack of credit facilities, small land holdings, limited access to necessary infrastructure, and support services such as extension, farm inputs, and markets. These challenges, coupled with the supporting CSA projects coming to an end, may result in CSA technology dis-adoption among smallholder farmers.

The main objective of this study was to create an understanding of the main drivers and barriers to the sustainable adoption of climate-smart agricultural practices. This study, therefore, sought to determine and document the current state of CSA practices among smallholder farmers in Kakamega County.

METHODOLOGY

Location of the Study

This study was undertaken in Kakamega, one of the 47 counties in Kenya (see Figure 1). The county covers an area of 3051.3 KM^{2}. and borders Trans Nzoia and Bungoma Counties to the north, Siaya and Vihiga Counties to the south, Nandi and Uasin Gishu Counties to the east, and Busia County to the west [10]. Kakamega is the fourth most populous County in Kenya, with a population of 1,867,759 persons, comprising 897,133 males and 970,406 females [11]. The county is divided into 12 sub-counties, namely Matungu, Mumias West, Mumias East, Butere, Khwisero, Navakholo, Ikolomani, Shinyalu, Lurambi, Malava, Lugari, and Likuyani. Due to the different agroecological and climate characteristics of the county, the sub-counties are grouped to form the three regions of Southern, Central, and Northern. The Southern Region covers Matungu, Mumias West, Mumias East, Butere, and Khwisero sub-counties. While the Central Region covers the sub-counties of Navakholo, Ikolomani, Shinyalu, and Lurambi, the Northern Region covers Malava, Lugari, and Ikolomani sub-counties.

https://doi.org/10.18697/ajfand.125.23400

ajfand
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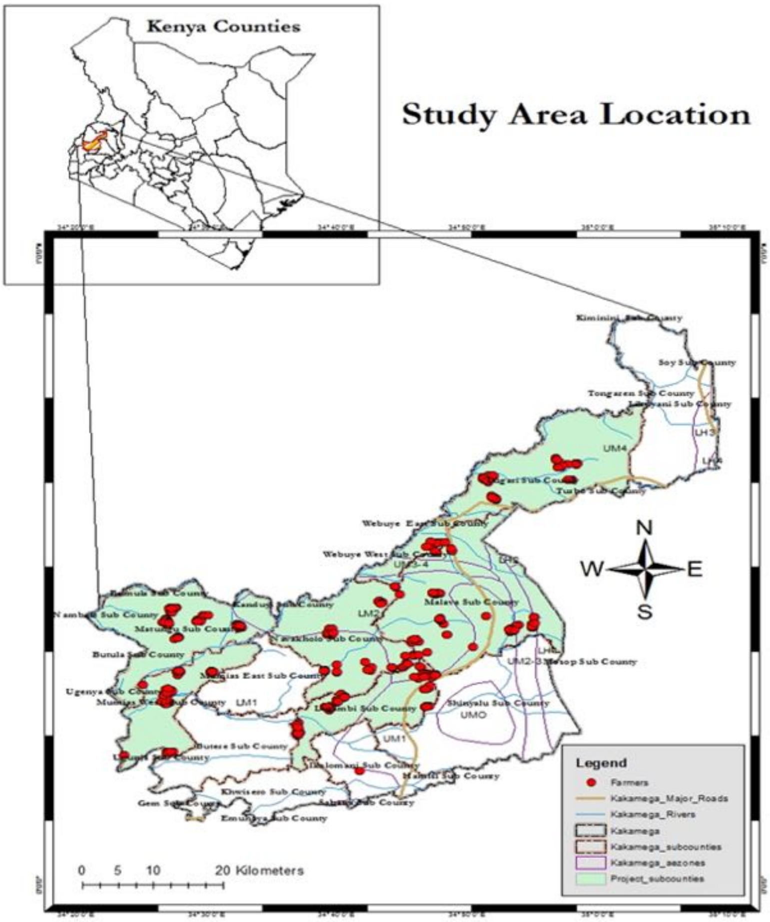

Figure 1: Study Area Map

Data Collection

Data collection focused on smallholder farmers who have received training from several CSA promotion programs. The major CSA-promoting organizations in Kakamega County had offered support on CSA practices to 68,762 smallholder farmers by December 2021. As a result, 68,762 was the study population.

Yamane's [12] formula was used to calculate the study sample size, lowest number of responses to maintain a 95 per cent confidence level. The formula is given as follows:

$$n = N/1 + N(e)^2$$

Where:
n is the required minimum sample size from the population under study
N is the whole population that is under study

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e is the precision or sampling error (0.05 for this study)
Thus:
n= 68,762/1+68762$(0.05)^2$
n = 397.68

The minimum sample size calculation gave a sample size of 398 respondents. A cluster sampling technique was used to select six sub-counties to represent the County's various agroecological zones and regions for the research sample. This ensured that each sub-county in each region had an equal chance of being chosen and that half of the Kakamega sub-counties would participate in the study. The stratified Random Sampling technique was used to identify CSA adopters and dis-adopters. This data collection process reached 428 respondents which was above the minimum sample size.

Primary data were collected using an online-created mobile phone questionnaire through the Kobo Collect software. Using the Toolbox form creator feature of Kobo Collect, an interview guide was created and administered to the respondents in the sampled Sub-Counties.

Data Processing
Microsoft Excel was used to download data from the Kobo Collect software. The downloaded data yielded 610 variables. The downloaded data, both for the variables and the responses, was coded, from V1 to V610 and the responses were assigned numerical values, for ease of analysis. The data were processed and analyzed using SPSS statistical software. The coded variables were subjected to Pearson's pairwise correlation to identify the variables that were associated with smallholder farmers' adoption of CSA technologies. The dependent variable, V12, represented the CSA farmer type which was either a CSA technology-adopting or a dis-adopting smallholder farmer. The smallholder CSA adopting farmers had sustainably adopted more than four CSA practices while the dis-adopters had either completely or partially abandoned most CSA practices. Variables with significant correlations at the 0.05 and 0.01 levels (2-tailed) were identified and further investigated and validated using p values. To write a report that included discussions and conclusions, the findings were eventually incorporated into interpretations based on the reviewed literature. Descriptive statistics, such as frequencies, percentages, and means were used to sum up how the relevant variables in the sample were distributed. Tables, charts, diagrams, and discussions were used to present the analysis findings. The various situations that were observed were given possible explanations using descriptive statistics.

https://doi.org/10.18697/ajfand.125.23400

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ISSN 1684 5374

RESULTS AND DISCUSSION

Adoption of CSA Practices in Kakamega County

Smallholder CSA farmers were trained in a variety of CSA technologies and implemented what they could. Close to all respondents had received training in on-farm composting (96.5 opercent), SWC (93 per cent), agroforestry (93 per cent) and CA (90.2 per cent). While agroforestry, composting, and SWC were the least abandoned, vermiculture and green housing were the most abandoned, (dis-adopted by 93.1 per cent and 85.1 per cent of the trained farmers, respectively). Other technologies with high dis-adoption rates included fallowing (73.1 per cent), water harvesting (67.6 per cent), PPT (66.8 per cent), ISLM/ISFM (66.1 per cent), and CA (46.4 per cent).

Composting may have been highly adopted because the process is not complicated for the smallholder CSA farmers and the materials are readily available at the household level. Soil and water conservation structures are permanent farm structures that conserve soil and prevent water erosion. Their permanent presence on farmlands may help to prevent abandonment. Agroforestry adoption, like SWC structures, involves the planting of perennial trees on the farm, making it difficult to abandon. The low pest infestation in farmlands may account for the high dis-adoption rate in PPT. Furthermore, desmodium seeds are expensive and out of reach for most smallholder CSA farmers. CA may be widely dis-adopted because most smallholder farmers are accustomed to intensive tillage of the land, in contrast to CA, which advocates for zero tillage on farmlands. The difficulty in weed control on CA farmlands may also have contributed to the high dis-adoption rate of the technology. The least adopted practices were water harvesting (16.8 per cent), PPT (14.4 per cent), Green housing (8.1 per cent) and vermiculture (6.9 per cent). Similar studies by Maguza-Tembo *et al.* [13] indicate that SWC was adopted more than other CSA practices.

Survey Population Demographics

Table 2 depicts the survey population demographics. The variables in this table include the gender, age, education level and marital status of the respondent. Other data collected include whether the smallholder CSA farmer was the household head, the gender of the household head (when the respondent is not the household head) and who is the main farm decision maker.

Gender of the Respondents

Relatively higher CSA adoption rates were found among male respondents than were found in female respondents. Even though women have dominated

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ISSN 1684 5374

smallholder CSA technologies, this study finds that female smallholder farmers dis-adopt at a higher rate (65.9 per cent) than their male counterparts (43.9 per cent). This could be explained by male farmers having greater access to resources, land, and decision-making than female farmers. Furthermore, it has been established that when the primary decision-maker is male, the rate of adoption is higher (46.7 per cent) than when the decision-maker is female (33.6 per cent). Similar studies found that male smallholder farmers have greater access to resources, land, and decision-making than their female counterparts [14-16]. These findings are also consistent with those of Deressa *et al.* [17], who found that male-headed households are more likely than female-headed households to adopt new agricultural technologies

Farmers' Age

The average age of the Smallholder CSA farmer was 50.3 years with 13.3 percent of respondents being under the age of 35. As shown in Table 2, the rate of Climate-smart agriculture technology adoption increased with age, peaking in the 56-65 age group. At the same time, the study found that the adoption rate for people aged 66 and up had decreased. This may be associated with the decreased energy for productive activities, retirement from income sources and shifting to other income-generating activities. Other studies have found similar results, indicating that older farmers are more familiar with beneficial technologies and can thus easily adopt them [17]. These findings, however, contradict those of Waaswa *et al.* [18] and Bryan *et al.* [19] who found no effect of age on climate change adaptation through agricultural technology adoption. The low levels of adoption of CSA technologies among respondents below 35 years may be linked to the lack of productive resources such as land and capital among most young people [18]. Other studies by Tiamiyu *et al.* [20] Moges *et al.* [21] and Abdulai *et al.* [22] have, however, shown that younger farmers are more willing to adopt new CSA technologies than older farmers. According to these studies, older farmers have shorter planning horizons and are more hesitant to invest in technologies that take a long time to reap benefits.

Highest level of education completed by the household head

Most household heads (70.8 per cent) had completed at least primary school, and 34.8 per cent had completed at least secondary school. Only a few household heads (9.3 per cent) had completed tertiary education. The highest level of education completed by the household head was found to have an inverse relationship with the adoption/dis-adoption rates. From Table 3, respondents whose household heads had completed tertiary education had higher rates of technology adoption (65 per cent) as compared to those whose household heads had not completed primary school (30.4 per cent). These results indicate that the respondents with higher education adopted CSA technologies more than the ones with lower education levels. It is possible that education improves understanding of training instructions and increases access to necessary information. Yirga and Hassan [23], found similar results, arguing that education provides a better understanding of ideas, and thus households with higher levels of education adopt CSA technologies more than households with lower levels of education. Other studies by Messer and Townsley [24], show that an educated farmer makes the best use of scarce resources and composts a large portion of their waste. These findings, however, contradict those of Bryan *et al.* [19], who found no significant effect of the household head's level of education on climate change adaptation measures.

Support from NGOs

Table 3 presents the smallholder CSA farmers receiving support from CSA promoting NGOs. Only slightly over one-third (35.3 per cent) of the respondents received assistance from the CSA-promoting NGOs. This assistance was in form of climate information, extension information, and training. Such incentives allowed smallholder farmers to obtain inputs such as desmodium seeds and irrigation equipment that are otherwise out of reach for most smallholder farmers due to their prohibitive cost. Without donor support, these farmers are not able to receive these incentives and thus, they dis-adopt. Higher technology adoption rates (53.6 per cent) were found in respondents who were supported by NGOs as compared to those who were not supported by NGOs (36.5 per cent). This view is supported by Tanti *et al.* [25] who opine that NGOs and other supporting organizations support farmers in various ways including training and follow-up SMSs thus increasing adoption rates. Other studies by Vincent and Balasubramani [26] indicate that NGOs support the testing and scaling up of CSA technologies by providing extension advisory services through such models as participatory approaches and climate field schools. Given the role of NGOs in promoting CSA technologies, coming to an end of CSA projects that are supported by NGOs leads to the dis-adoption of the practices [27]. For sustainable adoption of CSA technologies, the selection of participants in the donor and NGO-funded CSA initiatives should, therefore, be data-driven gauging from the individual farmer's biophysical and socio-economic characteristics.

Access to information and communications technology devices

Information and Communications Technology devices increase smallholder farmers' access to agricultural information, resulting in better farming practices. According to the findings of this study, as presented in Table 3, radios are the most

https://doi.org/10.18697/ajfand.125.23400

accessible ICT devices (90.7 percent of respondents), followed by basic mobile phones at 51.9 per cent. Less than half of the respondents (43.7 per cent) had access to televisions. Smartphones and tablets, as well as computers, were only accessible to 20.1 per cent and 1.6 per cent of respondents, respectively. These results indicate that radios are the most common ICT devices in the area, and they play a major role in agricultural information dissemination. The respondents who had ownership of smart devices and televisions had the highest CSA adoption rates (50 per cent and 49.2 per cent respectively) while the ones who did not own any ICT device had the lowest adoption rate (40 per cent). These results indicate that ownership of ICT devices influences the adoption of CSA technologies in the study area.

Studies conducted on the role of ICT devices in agricultural technology adoption indicate that they assist farmers to stay updated with recent information including weather information and better ways of agricultural production to improve quality and productivity [30]. According to Fosu-Mensah *et al.* [31], ICTs facilitate agricultural growth through the improvement of market activities, the exchange of information, and networking with other global players. As noted by Fosu-Mensah *et al.* [31], however, poor internet connectivity, insufficient power supply and lack of basic ICT skills among rural farmers hinder the successful reaping of the fruits of ICT application in rural agricultural activities.

Interaction with Agricultural Officers

Extension plays an important role in promoting CSA practices. As shown in Table 3, this study investigated the interactions between respondents and agricultural officers. Respondents who had their most recent interaction with agricultural officers within the previous year had higher CSA adoption rates (47.1 per cent) as compared to those who interacted with agricultural officers for more than five years (16.7 per cent). It could be argued that frequent contact with agricultural officers allows farmers to gain access to agricultural information and modern farming technologies required for CSA technology adoption. Furthermore, frequent contact with agricultural officers indicates increased access to government services such as subsidized farm inputs, grants, and other farmer support systems. These findings are consistent with those of Danso *et al.* [39], who reported that farmers with access to extension services were more willing to participate in CSA technologies because the extension services raised farmers' awareness of the benefits. Other studies by Roncoli *et al.* [40] found that access to extension service providers not only helps farmers with technical training but also with group formation and institutional mechanisms that allow for better distribution of government aid and services.

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ISSN 1684 5374

Smallholder CSA Farmers' Farming Experience

Different respondents in this study had varying levels of farming experience. As shown in Figure 2 below, CSA adoption rate among the respondents increased with years of farming experience. This could be explained by lessons learned by the smallholder farmers in their activities and their gradual shift from traditional to modern agricultural technologies that meet their current needs. These findings are in agreement with those of Fosu-Mensah *et al.* [32], who reported that farming experience increased the likelihood of CSA technology adoption because farmers have a wealth of knowledge and information on climatic changes and the best crop management practices to implement. Other studies, such as those conducted by Israr *et al.* [33], support this viewpoint by demonstrating that farmers with more farming experience are more knowledgeable about weather patterns and their implications for crop production, resulting in a high rate of adoption. From the foregoing, it could be argued that more experienced farmers have a better chance of selecting the right technologies and thus making informed farming decisions. Farmers with less farming experience, on the other hand, may be unsure about the best technologies for their farms, resulting in higher rates of dis-adoption.

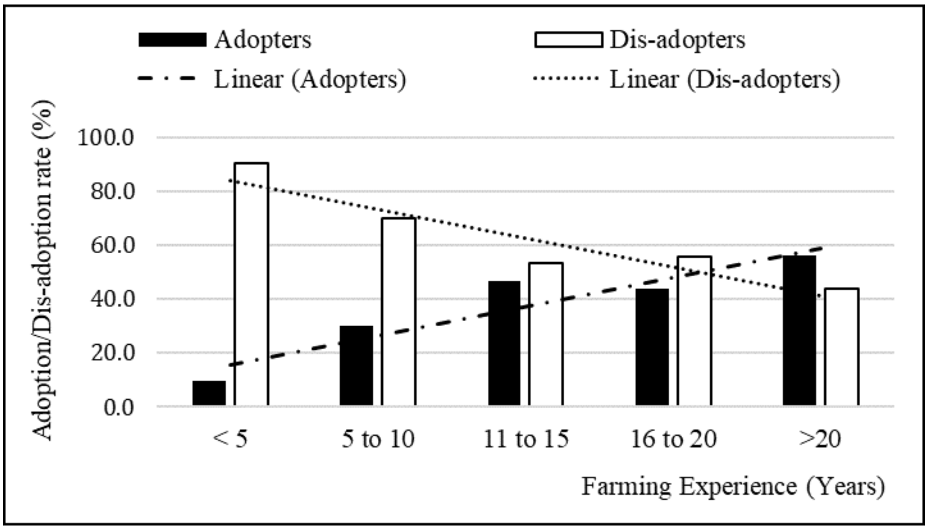

Figure 2: Farming Experience and CSA Adoption Rate

CSA Farmer Categorization

Smallholder CSA farmers are organized to facilitate training, demonstrations, and capacity building, as shown in Table 4. On the one hand, lead farmers are typically group leaders who provide a demonstration plot for group members to learn about various CSA technologies. Follower farmers, on the other hand, are mostly other group members who learn from the demonstration plot in the hopes of implementing the technologies learned on their farms. This study found that lead

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ISSN 1684 5374

farmers had higher CSA adoption rates (81 per cent) while follower farmers had lower CSA adoption rates (33.8 per cent). Similar findings by Maguza-Tembo *et al.* [13] indicate that being a lead farmer increases the probability of adopting CSA practices, implying that the farmer category may influence CSA technology adoption. In addition, lead farmers may be given demonstration materials and other types of assistance on behalf of their groups, incentivizing them to adopt more than regular group members. This view is supported by Kadzamira *et al.* [34] who report that the lead farmer is the main contact for CSA promotion, they are given materials and they train other farmers in their locality.

Average Land Size

It has been established that the respondents with larger farm sizes adopted CSAs more than farmers with smaller land sizes. From Table 4, the average land size in the study area was 1.88 acres with a standard deviation of 1.39. The results of the study, further, indicate that respondents with farm sizes between three and four acres had higher CSA technology adoption rates (66.7 per cent) than those with land sizes less than or equal to one acre (33.9 per cent). This finding implies that land size is an important factor to consider when promoting the adoption of CSA technologies. Smallholder farmers with larger land holdings may have more space to experiment with new technologies than farmers with smaller land holdings. However, smallholder farmers with very large land holdings may have already committed their land to other enterprises and are unwilling to adopt the new CSA practices. These findings are consistent with those of Fosu-Mensah *et al.* [32] who found that smallholder farmers with small land sizes are less likely to adopt CSA technologies due to the high fixed costs and the uncertainty associated with such technologies. Regarding the smallholder farmers with very large farmlands, these findings, agree with those of Maguza-Tembo *et al.* [13] who argue that an increase in land ownership entails an introduction of additional costs to the farmer which they may fail to cover given their resource base and thus low adoption rates.

Land Tenure System

As shown in Table 5, a significant number (93.7 per cent) of the respondents owned land. Those who did not own land farmed on leased farmland or on farms to which they had been granted rights but did not own. All (100 per cent) of those who leased farmland dis-adopted CSA technologies. This could be attributed to leased lands' lack of ownership and decision-making ability. Furthermore, lands are leased for shorter periods, such as one year, preventing lessees from investing in such technologies. Secure land tenure may encourage farmers to make long-term investments in their lands, such as Agroforestry and SWCs practices. These findings are consistent with many studies that find that land ownership influences

https://doi.org/10.18697/ajfand.125.23400

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the adoption of CSA practices [35, 36]. According to Bryan *et al.* [19], smallholder farmers with land ownership have the incentive to invest in their farms while those with leasing farmlands record lower profits thus negatively influencing their adoption of CSAs.

Group Membership

Table 6 depicts smallholder CSA farmers involvement in groups, their participation and leadership. Almost all (96.3 per cent) of the respondents were members of agricultural groups. Climate-smart agriculture technology adoption rates were higher (43.9 per cent) among respondents in groups than among those who were not (6.3 per cent). In addition, active group members had higher (48 per cent) CSA adoption rates as compared to passive group members (35.6 per cent). These results indicate the importance of the farmers' group in the adoption of CSA technologies. Group members may be more easily reached with agricultural information than non-members. It is also possible that group members exchanged ideas and opportunities more than non-members thus the higher rates of adoption. It is also possible that Active group members could gain access to agricultural extension officers, group loan products, and CSA technology capacity building through groups, among other benefits. Previous studies have found that farmer groups and organizations are used as a proxy for farmer-to-farmer information sharing, access to extension service packages, farm inputs acquisition and group marketing of produce thus improving their profits [37]. Kassie *et al.* [38] argue that groups are a form of social capital, and that group membership facilitates the exchange of information, enables farmers to access inputs on time, and helps them overcome credit constraints and shocks, thus positively influencing CSA technology adoption.

Level of Monthly Income

It has been established that respondents from higher-income households were better CSA technology adopters than those from lower-income households. From Table 7, the average household monthly income was KES. 7,354.47 (US$ 66.19). with a Standard Deviation of 958.76. The results also indicate that the respondents from households earning between KES 10,000 and 20,000 per month had a relatively higher adoption rate (54.7 per cent) and a relatively lower dis-adoption rate (45.3 per cent). Respondents from households earning less than KES 5,000 per month, on the other hand, had relatively higher dis-adoption rates (68 per cent) and relatively lower adoption rates (32 per cent). These findings are like those of Tiamiyu [18] who found that adoption of CSA practices was significantly higher among smallholder farmers with higher incomes than those with lower incomes. These findings imply that household income is an important factor in the adoption

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of CSA technologies. It could be said that higher incomes encourage households to adopt CSA technologies because they could obtain necessary farm inputs and pay for requisite labour.

Access to Agricultural Credit

Access to agricultural credit is an important consideration when farming profitably. According to the findings of this study, more than half (58.9 per cent) of the respondents did not have access to agricultural credit. The low access to agricultural credit could be attributed to the high interest rates on loans and the lack of collateral by most smallholder farmers. As shown in Table 7, there were higher CSA adoption rates (48.9 per cent) among the respondents who had access to agricultural credit as compared to those who did not (38.1 per cent). These findings are similar to those of Bryan *et al.* [17], who found that the availability of credit increased the adoption of several CSA practices including soil conservation, adoption of different crop varieties, agroforestry, and irrigation.

Identification of Drivers of CSA Adoption - Correlation Analysis

This study sought to identify the factors that influence the adoption of CSA practices in Kakamega County. Pearson correlation coefficients were used to identify the factors associated with farmers adoption of CSA practices. It is, however, acknowledged that association does not imply causation. Table 8 shows the variables that were found to have a significant correlation at the 0.05 and 0.01 levels (2-tailed). P values were used to measure the significance of the variables. From these findings, farmer category (lead farmer and follower farmer), marital status, years of experience in farming, sex of the farmer, household head level of education and the main group activity were found to be the main factors driving adoption of CSA practices in Kakamega County.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study identified the major Climate Smart Agriculture (CSA)practices in Kakamega County. It was found that conservation agriculture (CA), fallowing, vermiculture, greenhouse, push-pull technology (PPT), soil and water conservation (SWC) structures, Composting, agroforestry, integrated sustainable land management (ISLM), integrated soil fertility management (ISFM), and water harvesting are the main CSA technologies promoted and adopted by majority of smallholder farmers in Kakamega County. Composting, soil and water conservation (SWC) structures and agroforestry were the most sustainably adopted technologies while vermiculture, greenhouse, fallowing and water harvesting are the most dis-adopted CSA technologies. Composting may be simple

https://doi.org/10.18697/ajfand.125.23400

for smallholder CSA farmers because the materials needed to create one are readily available at the household level. Soil and water conservation structures are permanent farm structures that conserve soil and prevent water erosion. Their permanent presence on farmlands may help to prevent abandonment. Agroforestry adoption, like soil and water conservation (SWC) structures, involves the planting of perennial trees on the farm, making it difficult to abandon. The low pest infestation in farmlands may contribute to the high dis-adoption rate in push-pull technology (PPT). Furthermore, desmodium seeds are expensive and out of reach for most smallholder farmers. Conservation agriculture may be widely dis-adopted because most smallholder farmers are accustomed to intensive tillage of the land, in contrast to conservation agriculture, which advocates for zero tillage on farmlands. The difficulty in weed control on conservation agriculture farmlands may also contribute to its high dis-adoption rate among smallholder farmers.

The main drivers of climate smart agriculture adoption as identified by this study include being a member of a farmers' group, being a group leader and possibly a lead farmer. This may be occasioned by the access to training and productive resources thus higher climate smart agriculture adoption rates. The gender of the farmer was also a major driver with higher adoption rates found among male farmers than female farmers. This may be associated with access to productive resources, decision making and access to education and training. Other major drivers include land ownership, household income and access to agricultural credit. This increases the household productive resources and thus higher CSA adoption rates. Finally, support from CSA promoting NGOs and education level played a major role in the adoption of CSA technologies. Climate-smart agriculture technologies in Kakamega are mainly promoted by development partners and, therefore, access to NGO support goes a long way to increase CSA adoption.

ACKNOWLEDGEMENTS
This work was supported by the World Bank research grant through the Kenya Climate-Smart Agriculture Project (KCSAP). The authors, further, appreciate the anonymous reviewers for their constructive comments.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 23 No. 10
November 2023
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Adoption of Various Field CSA Technologies by Smallholder CSA Farmers

Variable	Frequencies		Farmer Type (No.)		No Attempt	CSA Adoption Rate (%)	
CSA Practice	**Respondents Trained (No)**	**Proportion (%)**	**Adopters**	**Dis-adopters**		**Adopters**	**Dis-adopters**
Composting	413	96.5	351	56	6	85.0	13.6
SWC	398	93.0	309	75	14	77.6	18.8
Agroforestry	398	93.0	376	16	6	94.5	4.0
CA	386	90.2	190	179	17	49.2	46.4
PPT	313	73.1	45	209	59	14.4	66.8
Water Harvesting	244	57.0	41	165	38	16.8	67.6
Vermiculture	160	37.4	11	149	0	6.9	93.1
Green housing	135	31.5	11	110	14	8.1	81.5
ISLM/ISFM	127	29.7	43	84	0	33.9	66.1
Fallowing	119	27.8	32	87	0	26.9	73.1

Table 2: Survey Population Demographics

Variable Sample Size	Frequencies		Farmer Type (no.)		Adoption Rate (%)	
	Respondents	**Proportion (%)**	**Adopters**	**Dis-adopters**	**Adoption**	**Dis-adoption**
Sample Size	428	100	182	246	42.5	57.5
The gender of the respondents						
Male	164	38.3	92	72	56.1	43.9
Female	264	61.7	90	174	34.1	65.9
Farmer's Age (in Years)						
Average Age	50.3					
≤ 35	57	13.3	11	46	19.3	80.7
36 – 45	106	24.8	47	59	44.3	55.7
46 – 55	115	26.9	52	63	45.2	54.8
56 – 65	87	20.3	45	42	51.7	48.3
≥66	63	14.7	27	36	42.9	57.1
Highest level of education completed						
Completed Tertiary	40	9.3	26	14	65.0	35.0
Completed Secondary	109	25.5	60	49	55.0	45.0
Completed Primary	154	36.0	58	96	37.7	62.3
Not Completed Primary	125	29.2	38	87	30.4	69.6
Marital Status						
Married	354	82.7	168	186	47.5	52.5
Widowed	61	14.3	12	49	19.7	80.3
Single	13	3.0	2	11	15.4	84.6
Household Head						
No	174	40.7	66	108	37.9	62.1
Yes	254	59.3	116	138	45.7	54.3
Gender of Main Farm Decision Maker						
Male	291	68.0	136	155	46.7	53.3
Female	137	32.0	46	91	33.6	66.4

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ISSN 1684 5374

Table 3: Support from NGOs, Ownership of ICT Devices and Interaction with Extension Officers

Ownership of ICT Devices	Frequencies		Adopters/Dis-adopters (No.)		Adoption/Dis-adoption Rate (%)	
ICT Device	Respondents	Proportion (%)	Adopters	Dis-adopters	Adopters	Dis-adopters
Receipt of Support from CSA promoting NGOs						
Yes	151	35.3	81	70	53.6	46.4
No	277	64.7	101	176	36.5	63.5
Ownership of ICT Devices						
Radio	388	90.7	163	225	42.0	58.0
Television	187	43.7	92	95	49.2	50.8
Basic Mobile Phone	222	51.9	99	123	44.6	55.4
Smart Devices	86	20.1	43	43	50.0	50.0
Computer	7	1.6	3	4	42.9	57.1
None	5	1.2	2	3	40.0	60.0
Last interaction with extension officers (years)						
<1	274	64.0	129	145	47.1	52.9
1 – 2	87	20.3	36	51	41.4	58.6
2 – 5	55	12.9	15	40	27.3	72.7
>5	12	2.8	2	10	16.7	83.3

Table 4: Farmer Category and Farm Sizes

Variable	Frequencies		Farmer type (No)		Adoption rate (%)	
	Respondents (no)	Proportion %)	Adopters	Dis-adopters	Adopters	Dis-adopters
Farmer Category						
Follower Farmer	349	81.5	118	231	33.8	66.2
Lead Farmer	79	18.5	64	15	81.0	19.0
Total Land Size (Acres)						
≤1	168	39.3	57	111	33.9	66.1
1.1-2	134	31.3	55	79	41.0	59.0
2.1-3	84	19.6	44	40	52.4	47.6
3.1-4	21	4.9	14	7	66.7	33.3
> 4	21	4.9	12	9	57.1	42.9
$\bar{X}$ = 1.88 σ = 1.39						

Table 5: Land and Title Deed Ownership

Variable		Frequencies		Adoption rate (%)	
Land Tenure		Respondents (no)	Proportion (%)	Adopters	Dis-adopters
Type of land ownership	Owned	401	93.7	42.9	57.1
	Leased	5	1.2	0.0	100.0
	Rights to farm	22	5.1	45.5	54.5
Title Deed Held	Yes	173	40.4	42.2	56.1
	No	255	59.6	42.7	57.3

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Table 6: Group membership, involvement, and Leadership

Variables	Frequencies		Farmer type (No)		Adoption rate (%)	
Group Membership	Respondents (no)	Proportion (%)	Adopters	Dis-adopters	Adopters	Dis-adopters
Membership to Group						
Yes	412	96.3	181	231	43.9	56.1
No	16	3.7	1	15	6.2	93.8
Type of group						
Agricultural	400	97.1	181	219	45.3	54.8
Non-agricultural	12	2.9	1	11	8.3	91.7
Level of Involvement in Group Activities						
Active Member	277	67.2	133	144	48.0	52.0
Passive member	135	32.8	48	87	35.6	66.4
Group Leadership Position						
Chairman	49	11.9	34	15	69.4	30.6
Vice Chairman	10	2.4	4	6	40.0	60.0
Secretary	32	7.8	17	15	53.1	46.9
Treasurer	22	5.3	13	9	59.1	40.9
Other Position	50	12.1	26	24	52.0	48.0
No position	249	60.4	87	162	34.9	65.1

Table 7: Level of monthly income and Access to agricultural Credit

Variable	Frequencies		Farmer Type		Adoption rate (%)	
	Respondents (no)	Proportion (%)	Adopters	Dis-adopters	Adopters	Dis-adopters
Monthly Household Income (KES)						
≤5,000	194	45.3	62	132	32.0	68.0
5,001- 10,000	133	31.1	64	69	48.1	51.9
10,000 - 20,000	86	20.1	47	39	54.7	45.3
>20,000	15	3.5	8	7	53.3	46.7
$\bar{X}$ = 7,354.47 σ = 958.76						
Do you have access to Agricultural Credit?						
Yes	176	41.1	86	90	48.9	51.1
No	252	58.9	96	156	38.1	61.9

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Table 8: Variable Significance (P Values)

Variable Code	Variable	Correlation	P-Values	Variable Code	Variable	Correlation	P-Values
V17	Radio & TV	-.096*	0.047	V103	Group membership	.145**	0.003
V25	Computer	-.098*	0.043	V68	Solar Radio owned	-.148**	0.002
V44	ISLM/ISFM Trained	-.098*	0.043	V121	Ext. officer interaction	.152**	0.002
V48	CSA Organization	.099*	0.041	V18	Barazas	-.155**	0.001
V144	G/House abandoned	.099*	0.040	V29	Bicycle owned	-.159**	0.001
V50	Year Trained	.106*	0.029	V58	Land Size	-.161**	0.001
V133	Farming	-.106*	0.028	V41	Agroforestry Trained	-.162**	0.001
V130	Access to agric. credit?	.107*	0.027	V28	W/Barrow owned	-.163**	0.001
V38	SWC Trained	-.107*	0.027	V34	NGO Support?	.166**	0.001
V135	Other HH Activities	-.107*	0.026	V164	Agroforestry practised	-.166**	0.001
V143	ISLM/ISFM abandoned	.108*	0.026	V115	The Main Group activity is Farming	-.170**	0.000
V120	Agric credit	-.110*	0.023	V146	Vermiculture abandoned	.174**	0.000
V107	Left Group	.111*	0.022	V129	HH Monthly income	-.183**	0.000
V43	G/House Trained	-.112*	0.020	V141	PPT Abandoned	.193**	0.000
V169	Fallowing Practised	.115*	0.018	V10	Education	-.193**	0.000
V77	G/Nuts grown	-.115*	0.018	V168	Vermiculture Practised	-.197**	0.000
V40	PPT Trained	-.116*	0.016	V4	Sex	.216**	0.000
V22	TV Owned	-.119*	0.014	V49	Farming Experience	.216**	0.000
V47	Mulching Trained	-.119*	0.014	V6	Marital	.217**	0.000
V104	Reason not in a group	.120*	0.013	V140	SWC Abandoned	.235**	0.000
V76	Soybean grown	-.122*	0.011	V145	Composting Abandoned	.250**	0.000
V5	Age	-.124*	0.010	V167	W/Harvesting Practised	-.276**	0.000
V112	Position held	.125**	0.010	V163	Composting practised	-.304**	0.000
V134	Sch. Fees	-.125**	0.010	V139	W/Harvesting abandoned	.322**	0.000
V8	Decision Maker	.128**	0.008	V162	PPT Practised	-.327**	0.000
V75	Cassava grown	-.129**	0.008	V136	Abandoned CSA Practices?	-.341**	0.000
V80	Fruit Trees Grown	-.137**	0.004	V161	SWC Practised	-.344**	0.000
V119	Agric Trainings	-.139**	0.004	V51	Farmer Category	.370**	0.000
V37	CA Trained	-.141**	0.004	V138	CA Abandoned	.429**	0.000
V165	ISLM/ISFM Practised	-.143**	0.003	V160	CA Practised	-.549**	0.000

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
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November 2023
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
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