# Agricultural Extension Services and Adoption of Climate-Smart Agricultural Practices among Small-Scale Farmers in Bureti Sub-County, Kericho County, Kenya

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## ABSTRACT

Climate change continues to threaten agricultural productivity and the livelihoods of small-scale farmers in Kenya, necessitating the adoption of Climate-Smart Agricultural Practices (CSAPs). Agricultural extension services play a critical role in disseminating information, improving farmers' technical knowledge, and promoting the adoption of innovative farming practices. However, evidence on the effect of extension services on CSAP adoption at the sub-county level remains limited. This study examined the effect of agricultural extension services on the adoption of Climate-Smart Agricultural Practices among small-scale farmers in Bureti Sub-County, Kericho County, Kenya. The study employed a descriptive cross-sectional mixed-methods research design guided by Rogers' Diffusion of Innovations Theory. Quantitative data were collected from 344 small-scale farmers using structured interviews, complemented by questionnaires administered to agricultural extension officers and qualitative information obtained through key informant interviews and focus group discussions. Quantitative data were analyzed using descriptive statistics, Chi-square tests, and binary logistic regression at a 5% level of significance, while qualitative data were analyzed thematically. The findings established that access to agricultural extension services had a statistically significant effect on the adoption of Climate-Smart Agricultural Practices. Farmers who received frequent extension visits, participated in agricultural training, and accessed demonstration activities were more likely to adopt climate-smart technologies than those with limited extension contact. Binary logistic regression further identified agricultural extension services as the strongest predictor of CSAP adoption. The study concludes that strengthening agricultural extension systems is essential for accelerating climate change adaptation among small-scale farmers. It recommends increased investment in extension personnel, farmer field schools, digital advisory platforms, and continuous farmer training to enhance the adoption of climate-smart agricultural practices and improve agricultural resilience.

**Keywords:** Agricultural Extension Services, Climate-Smart Agriculture, Adoption, Small-Scale Farmers, Climate Change, Kenya

## INTRODUCTION

Agriculture remains one of the most climate-sensitive sectors globally, with small-scale farmers experiencing the greatest impacts of climate variability due to their dependence on rain-fed production systems. Rising temperatures, erratic rainfall, prolonged droughts, floods, and increased pest and disease outbreaks continue to reduce agricultural productivity and threaten food security, particularly in developing countries. Climate-Smart Agriculture (CSA) has emerged as an important approach for improving agricultural productivity while strengthening farmers' resilience to climate change and promoting environmental sustainability.

Climate-Smart Agricultural Practices (CSAPs), including conservation agriculture, agroforestry, crop diversification, water harvesting, improved seed varieties, and efficient soil fertility management, have demonstrated considerable potential for enhancing resilience among small-scale farmers. Despite these benefits, adoption remains uneven across many developing countries because of institutional, financial, and informational barriers. Among these factors, agricultural extension services have consistently been recognized as a major pathway through which farmers access knowledge, technical skills, and innovations required for successful implementation of climate-smart technologies.

In Kenya, agriculture contributes substantially to employment, household income, and national economic growth. However, climate variability continues to undermine agricultural production, particularly among smallholder farmers who rely heavily on rainfall. Government agencies and development partners have promoted Climate-Smart Agricultural Practices through extension programs, yet adoption remains below expected levels due to inadequate extension coverage, limited technical support, and financial constraints.

Bureti Sub-County in Kericho County is characterized by predominantly small-scale farming systems where maize, tea, vegetables, and other crops form the main sources of livelihood. Farmers in the area increasingly experience unpredictable rainfall patterns, prolonged dry spells, declining soil fertility, and emerging crop pests associated with climate change. Although several climate-smart technologies have been introduced, the effect of agricultural extension services on their adoption has not been adequately documented.

This study therefore examined the effect of agricultural extension services on the adoption of Climate-Smart Agricultural Practices among small-scale farmers in Bureti Sub-County, Kericho County. The findings provide evidence to support agricultural extension policy, strengthen climate adaptation strategies, and improve the design of farmer-centered extension programs that promote sustainable agricultural development.

## LITERATURE REVIEW

Agricultural extension services are widely recognized as one of the most effective mechanisms for promoting the adoption of agricultural innovations. Within the context of Climate-Smart Agriculture (CSA), extension services facilitate knowledge transfer, enhance farmers' technical capacity, improve access to climate information, and strengthen farmers' confidence in implementing climate adaptation technologies. Rogers' Diffusion of Innovations Theory posits that innovations are more readily adopted when individuals have access to information, opportunities for experimentation, and observable benefits within their social systems (Rogers, 2003; Ma & Rahut, 2024)

### Theoretical Perspective

Rogers' Diffusion of Innovations Theory provides a useful framework for understanding how Climate-Smart Agricultural Practices (CSAPs) spread among small-scale farmers. The theory emphasizes that adoption is influenced by five key attributes: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003).

In agricultural systems, farmers are more likely to adopt CSAPs when they perceive tangible benefits such as increased productivity and resilience. Trialability and observability are particularly important, as farmers often rely on demonstration plots and peer learning before adopting new practices. Agricultural extension services play a crucial role in facilitating these processes by enhancing knowledge and reducing uncertainty. Recent studies in Kenya confirm that frequent extension visits and improved access to advisory services significantly enhance learning and adoption of climate-smart technologies (Wageningen University, 2024)

### Climate-Smart Agricultural Practices and Their Relevance

Climate-Smart Agricultural Practices (CSAPs) encompass a range of technologies and approaches aimed at improving productivity, enhancing resilience, and promoting environmental sustainability. These practices include conservation agriculture, agroforestry, crop diversification, water harvesting, improved seed varieties, and integrated soil fertility management.

Recent empirical studies demonstrate that CSAPs significantly improve farmers' adaptive capacity under climate variability. For example, adoption of climate-smart practices has been shown to enhance productivity, reduce soil erosion, and improve livelihood diversification among smallholder farmers in Kenya (Waaswa et al., 2024) .Similarly, studies in Kenya indicate that CSAP adoption contributes to improved resilience and food security outcomes (Kenduiwa et al., 2024). Despite these benefits, adoption remains uneven due to barriers such as limited access to information, financial constraints, and weak institutional support systems. These constraints continue to limit the scaling of climate-smart technologies among small-scale farmers.

**Role of Agricultural Extension Services in Technology Adoption**

Agricultural extension services serve as a critical link between research institutions and farmers by providing information, training, and technical support. Extension approaches such as farmer field schools, demonstration farms, and advisory visits enhance farmers' knowledge and capacity to adopt new technologies.

Recent evidence shows that access to agricultural information and extension services has a statistically significant effect on the adoption of CSAPs. In Kenya, access to climate-related information and extension services has been found to positively correlate with increased adoption of climate-smart practices among smallholder farmers (Ajwang et al., 2024)

Furthermore, extension contact frequency, training participation, and knowledge acquisition have been identified as key determinants of adoption and intensity of use of climate-smart technologies (Wageningen University, 2024). These findings highlight the importance of strengthening extension systems to enhance farmer learning and innovation uptake.

However, extension services in many developing countries, including Kenya, face challenges such as limited funding, inadequate staffing, and low coverage, which constrain their effectiveness.

**Socio-Economic Determinants of CSAP Adoption**

The adoption of Climate-Smart Agricultural Practices is influenced by various socio-economic factors, including education level, household income, farm size, and access to credit. Educated farmers are more likely to adopt new technologies due to their ability to access and interpret information effectively.

Recent studies indicate that socio-economic capacity, particularly access to financial resources and markets, plays a significant role in determining adoption decisions. Farmers with better access to credit and higher income levels are more likely to invest in climate-smart technologies. Additionally, behavioural factors such as risk preferences and attitudes toward innovation have been shown to influence adoption decisions (Tabe-Ojong et al., 2024)

**Farmers' Perception of Climate Change and Risk**

Farmers' perception of climate change is an important factor influencing their adoption of adaptation strategies. Farmers who perceive climate variability as a serious threat are more likely to adopt practices that enhance resilience.

However, recent research suggests that perception alone is insufficient to drive adoption without access to institutional support such as extension services and financial resources. Studies show that while farmers may have high awareness of climate risks, adoption of CSAPs depends largely on access to information and support systems (Ma & Rahut, 2024).

**Empirical Review and Research Gap**

Empirical studies across Sub-Saharan Africa consistently highlight the importance of agricultural extension services in promoting the adoption of climate-smart technologies. Evidence from Kenya shows that institutional factors, including access to extension services and information, significantly influence adoption decisions (Kipkemoid, 2024) .

However, most studies have focused on national or regional levels, with limited attention to localized contexts such as sub-counties. In addition, few studies have integrated extension services, socio-economic factors, and farmers' risk perception using mixed-methods approaches.

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Specifically, in Bureti Sub-County, Kericho County, there is limited empirical evidence documenting how agricultural extension services influence the adoption of Climate-Smart Agricultural Practices among small-scale farmers. This study therefore addresses this gap by providing context-specific evidence to inform policy and practice.

## MATERIALS AND METHODS

### Study Area

The study was conducted in Bureti Sub-County, Kericho County, Kenya, an area characterized by predominantly small-scale farming systems. The major agricultural enterprises include maize, tea, vegetables, dairy farming, and horticultural production. Agriculture in the area depends largely on rainfall, making farmers highly vulnerable to climate variability and climate-related production risks.

### Research Design

The study employed a descriptive cross-sectional mixed-methods research design. Quantitative methods were used to establish the relationship between agricultural extension services and adoption of Climate-Smart Agricultural Practices, while qualitative approaches provided deeper insights into farmers' experiences regarding extension service delivery and climate adaptation.

### Study Population and Sampling

The study targeted small-scale farmers in Bureti Sub-County, agricultural extension officers, and selected local leaders. Quantitative data were obtained from 344 small-scale farmers, while additional information was collected from 10 agricultural extension officers, 30 key informants, and four focus group discussions to triangulate the findings.

### Data Collection

Data were collected using structured interviews administered to farmers, questionnaires for agricultural extension officers, key informant interviews, and focus group discussion guides. Information collected included farmers' frequency of extension contact, participation in agricultural training programmes, access to demonstration farms, advisory services, and adoption of Climate-Smart Agricultural Practices.

### Data Analysis

Quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies and percentages, were employed to summarize respondents' socio-economic characteristics and their access to agricultural extension services. A Chi-square test of independence was subsequently conducted to examine the bivariate association between access to agricultural extension services and the adoption of Climate-Smart Agricultural Practices (CSAPs). The test results were reported using the Chi-square statistic ($\chi^2$), degrees of freedom ($df$), and exact ($p$)-values.

To determine the predictive relationship between agricultural extension service access and CSAP adoption while controlling for potential socio-economic and behavioral confounding factors, a binary logistic regression model was estimated at a 5% significance level ($\alpha = 0.05$). The binary logistic regression model was specified as follows:

$$\operatorname{logit}(P)=\ln\left(\frac{P}{1-P}\right)=\beta_0+\beta_1X_1+\beta_2X_2+\dots+\beta_kX_k$$

Where:

- ($P$) denotes the probability that a farmer adopts CSAPs, where ($1=\text{Adopted}$) and ($0=\text{Non-adopted}$).

- ($\beta_0$) represents the intercept parameter.
- ($\beta_1,\dots,\beta_k$) represent the estimated regression coefficients expressed in log-odds units.
- ($X_1$) represents access to agricultural extension services, operationalized in terms of the frequency of extension visits, participation in agricultural training, and access to demonstration plots.
- ($X_2,\dots,X_k$) represent the socio-economic control variables, including education level, household income, farm size, credit access, and climate risk perception.

Model adequacy and predictive performance were assessed using the Hosmer-Lemeshow goodness-of-fit test, Cox & Snell ($R^2$), Nagelkerke ($R^2$), and overall classification accuracy. Qualitative information obtained through key informant interviews and focus group discussions was analyzed thematically. The qualitative findings were used to complement the quantitative results and provide contextual explanations for the observed relationships between agricultural extension services and CSAP adoption.

# RESULTS

**Respondents' Access to Agricultural Extension Services**

The study assessed access to agricultural extension services using indicators including frequency of extension contact, participation in farmer training programmes, attendance at demonstration plots, access to climate-smart agricultural information, and overall satisfaction with extension support. The results showed that farmers with regular interaction with extension personnel demonstrated substantially higher adoption of Climate-Smart Agricultural Practices (CSAPs) than farmers with limited or no extension contact. These findings suggest that extension services remain a critical source of technical knowledge and practical skills required for climate adaptation.

Training programmes and field demonstrations were particularly effective in increasing farmers' confidence to implement climate-smart technologies. Farmers who participated in organized training sessions reported better understanding of conservation agriculture, agroforestry, water harvesting, improved seed varieties, and integrated soil fertility management than those without training opportunities. Qualitative findings further revealed that demonstration farms enabled farmers to observe the benefits of climate-smart technologies before adoption, thereby reducing uncertainty and perceived risks.

**Relationship Between Agricultural Extension Services and CSAP Adoption**

A Chi-square test of independence was conducted to determine whether a statistically significant association existed between access to agricultural extension services and the adoption of CSAPs. The cross-tabulation results indicated that farmers with more frequent extension contact exhibited higher rates of CSAP adoption than farmers with limited or no extension contact.

The Chi-square analysis revealed a statistically significant association between agricultural extension service access and CSAP adoption, ($\chi^2(1, N=344)=18.42$), ($p<0.001$), with a Cramer's ($V$) of 0.231. The magnitude of Cramer's ($V$) indicates a positive association of moderate strength between extension service access and CSAP adoption.

Since the observed ($p$)-value was less than the predetermined significance level of ($\alpha=0.05$), the null hypothesis of no association between agricultural extension service access and CSAP adoption was rejected. The findings therefore indicate that extension service access was significantly associated with farmers' adoption of climate-smart agricultural practices. Specifically, farmers who received regular extension visits, participated in field-based training, and had access to demonstration plots were more likely to adopt CSAPs than those who experienced limited or no contact with agricultural extension services**4.3 Binary Logistic Regression Analysis**

A binary logistic regression analysis was conducted to assess the extent to which access to agricultural extension services predicted CSAP adoption after controlling for selected socio-economic factors. The dependent variable was CSAP adoption, coded as (1) for adopters and (0) for non-adopters. The explanatory variables included extension service access, education level, farm size, credit access, and climate risk perception.

Table 1: Logistic Regression Predicting CSAP Adoption

| **Variable** | **Coefficient ((\beta))** | **Std. Error** | **Wald (\chi^2)** | **(p)-value** | **Odds Ratio (OR)** | **95% C.I. for OR** |
|---|---|---|---|---|---|---|
| Extension Services Access ((X_1)) | 0.762 | 0.215 | 12.56 | < 0.001 | 2.143 | [1.406, 3.267] |
| Education Level | 0.312 | 0.141 | 4.89 | 0.027 | 1.366 | [1.036, 1.802] |
| Farm Size | 0.184 | 0.102 | 3.25 | 0.071 | 1.202 | [0.984, 1.468] |
| Credit Access | 0.421 | 0.198 | 4.52 | 0.033 | 1.523 | [1.033, 2.246] |
| Climate Risk Perception | 0.389 | 0.175 | 4.94 | 0.026 | 1.476 | [1.047, 2.080] |
| Constant | -1.105 | 0.342 | 10.42 | 0.001 | 0.331 | — |

*Model diagnostics: Hosmer-Lemeshow test (\chi^2(8)=6.14), (p=0.632); Cox & Snell (R^2=0.187); Nagelkerke (R^2=0.254); overall classification accuracy = 74.1%.*

The regression results indicate that access to agricultural extension services was a statistically significant positive predictor of CSAP adoption. Extension service access had a regression coefficient of (\beta=0.762), with a Wald statistic of 12.56 and (p<0.001). The corresponding odds ratio was (OR=2.143), with a 95% confidence interval of [1.406, 3.267]. Thus, holding the other variables in the model constant, farmers with regular access to agricultural extension services had 2.143 times higher odds of adopting CSAPs than farmers with limited extension support.

Education level also demonstrated a statistically significant positive relationship with CSAP adoption ((\beta=0.312), (p=0.027), (OR=1.366), 95% CI [1.036, 1.802]). This indicates that higher educational attainment was associated with increased odds of adopting climate-smart agricultural practices.

Farm size had a positive coefficient ((\beta=0.184)) and an odds ratio of 1.202; however, its relationship with CSAP adoption was not statistically significant at the 5% level ((p=0.071)). The 95% confidence interval for the odds ratio was [0.984, 1.468], which includes 1.0, further indicating the absence of statistically significant evidence of an independent association at the specified significance level.

Credit access was positively and significantly associated with CSAP adoption ((\beta=0.421), (p=0.033), (OR=1.523), 95% CI [1.033, 2.246]). Similarly, climate risk perception was a statistically significant positive predictor of adoption ((\beta=0.389), (p=0.026), (OR=1.476), 95% CI [1.047, 2.080]). These findings suggest that access to financial resources and greater perception of climate-related risks were associated with increased likelihood of adopting CSAPs.

The model diagnostics indicated an adequate fit between the observed and predicted outcomes. The Hosmer-Lemeshow goodness-of-fit test was not statistically significant, (\chi^2(8)=6.14), (p=0.632), suggesting no statistically significant evidence of poor model fit. The Cox & Snell (R^2) was 0.187, while the Nagelkerke (R^2) was 0.254. The model correctly classified 74.1% of the cases, indicating a classification accuracy of 74.1%.

Overall, the findings demonstrate that agricultural extension service access remained the strongest positive predictor of CSAP adoption within the estimated model. The results further show that education level, credit access, and climate risk perception contributed significantly to explaining variation in adoption, whereas farm size did not attain statistical significance at the 5% level.

# DISCUSSION AND CONCLUSION

## Discussion

The empirical findings demonstrate a statistically significant relationship between access to agricultural extension services and the adoption of Climate-Smart Agricultural Practices (CSAPs) among small-scale farmers in Bureti Sub-County. Both the bivariate and multivariate analyses provide evidence that farmers who had greater access to extension services were more likely to adopt CSAPs. The Chi-square analysis established a significant association between extension service access and adoption, (\chi^2(1, N=344)=18.42), (p<0.001), while the logistic regression analysis showed that extension service access was a significant positive predictor of adoption ((OR=2.143), (p<0.001)).

These findings are consistent with the propositions of Rogers' Diffusion of Innovations Theory, particularly the roles of trialability and observability in facilitating technology adoption. Agricultural extension services can enhance these attributes by providing farmers with practical demonstrations, field-based training, and opportunities to observe the performance of climate-smart technologies under local farming conditions. Such interactions may reduce uncertainty regarding the applicability, costs, and expected benefits of new agricultural practices, thereby increasing farmers' willingness to experiment with and adopt them.

The logistic regression results further demonstrate that the relationship between extension service access and CSAP adoption remained significant after controlling for education level, farm size, credit access, and climate risk perception. Farmers with regular access to extension services had 2.143 times higher odds of adopting CSAPs than those with limited extension support. This finding suggests that extension services constitute an important institutional mechanism for translating technical information and climate-related knowledge into practical farm-level decisions.

Nevertheless, the cross-sectional nature of the study warrants caution in interpreting the observed relationships as causal effects. Although the regression results demonstrate a strong predictive association, they do not establish that extension service access directly caused the observed differences in CSAP adoption. Other unobserved characteristics of farmers or farming households may also influence both their access to extension services and their propensity to adopt climate-smart practices.

The significance of education level, credit access, and climate risk perception provides additional evidence that CSAP adoption is influenced by a combination of informational, economic, and behavioral factors. Education may improve farmers' ability to understand and process technical information, while access to credit may enhance their capacity to meet the initial financial requirements associated with adopting new agricultural technologies and practices. Similarly, greater perception of climate risks may increase farmers' motivation to implement practices intended to reduce vulnerability to climatic variability and associated production risks.

The findings confirm observations by Hu et al. (2026) and Biswas et al. (2026), who highlighted the importance of participatory learning in facilitating agricultural technology adoption. They also correspond with the local findings of Mwikamba et al. (2024) and Mburu et al. (2024), which emphasize the importance of continuous and structured advisory support in promoting adoption within rain-fed agricultural systems. Taken together, the evidence suggests that extension approaches based on sustained farmer engagement, practical training, demonstrations, and participatory learning are more likely to support CSAP adoption than approaches relying primarily on passive dissemination of information.

Overall, the findings underscore the central role of agricultural extension systems in supporting the transition from awareness of climate-smart agriculture to actual implementation at farm level. Strengthening the frequency, quality, and practical orientation of extension interactions may therefore contribute to greater uptake of CSAPs among small-scale farmers. However, extension interventions should be complemented by measures that address other adoption constraints, particularly access to credit, educational needs, and farmers' perceptions of climate-related risks.

### Conclusion

This study investigated the effect of agricultural extension services on the adoption of Climate-Smart Agricultural Practices (CSAPs) among small-scale farmers in Bureti Sub-County, Kericho County, Kenya. The findings demonstrate that agricultural extension services are a significant determinant of CSAP adoption. Farmers who had regular contact with extension officers, participated in agricultural training programmes, attended demonstration plots, and received continuous technical support were significantly more likely to adopt climate-smart agricultural practices than those with limited extension access. The binary logistic regression analysis identified agricultural extension services as the strongest predictor of adoption, underscoring the importance of effective extension systems in facilitating climate change adaptation among smallholder farmers.

The findings support Rogers' Diffusion of Innovations Theory by demonstrating that timely access to information, practical demonstrations, and continuous technical guidance enhance farmers' willingness and ability to adopt agricultural innovations. Strengthening extension systems will therefore be critical for improving agricultural productivity, building climate resilience, and supporting sustainable rural livelihoods in Kenya and similar smallholder farming systems.

### Practical Implications

The study provides important implications for policymakers, county governments, agricultural extension agencies, and development partners. Investment in well-resourced extension systems, continuous farmer training, Farmer Field Schools, demonstration farms, and digital advisory platforms can substantially increase the adoption of Climate-Smart Agricultural Practices. Integrating extension services with accessible credit facilities and climate adaptation programmes would further enhance farmers' capacity to implement recommended technologies.

### Study Limitations and Future Research

The study was conducted in Bureti Sub-County, and the findings therefore reflect the local socio-economic and institutional context. Future studies should validate these findings in other agro-ecological zones using longitudinal research designs to assess sustained adoption of Climate-Smart Agricultural Practices over time. Additional research should also examine the effectiveness of digital extension services, compare public and private extension models, and investigate gender and youth differences in access to agricultural advisory services.

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