

Village-Based Advisors and Regenerative Agriculture Adoption among Smallholder Farmers in Kitui County, Kenya

Juddy Musyoki¹, Dr. Grace Mutia, PhD², Shadrack Kasonzo³, Dr. Juddy Wambua, PhD¹,

¹*Department Agriculture Environmental, Water and Natural Resources
South Eastern Kenya University,*

²*Department of Hydrology and Aquatic Sciences
South Eastern Kenya University*

³*Cereal Growers Association*

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I. INTRODUCTION

Agriculture remains central to food security, employment, and rural livelihoods across Sub-Saharan Africa, where smallholder farmers constitute a substantial proportion of agricultural producers. However, the productivity and sustainability of smallholder farming systems are increasingly threatened by climate variability, recurrent droughts, declining soil fertility, land degradation, biodiversity loss, and increasing pressure on natural resources. These challenges are particularly acute in arid and semi-arid lands (ASALs), where dependence on rain-fed agriculture exposes households to substantial production risks. In such environments, improving agricultural resilience requires approaches that address not only immediate production constraints but also the long-term health and productive capacity of soils and agroecosystems. Consequently, increasing attention has been directed towards agricultural practices that restore ecological functions while maintaining or improving farm productivity and livelihood resilience.

Regenerative agriculture has emerged as an increasingly prominent approach within this broader transition towards sustainable and resilient food systems. Although there is no universally agreed definition of regenerative agriculture, the concept generally emphasizes the restoration of soil health, biodiversity, water regulation, and ecosystem functions through context-specific combinations of practices. Common practices include intercropping, agroforestry, minimum or reduced soil disturbance, mulching, composting, cover cropping, crop diversification, and integrated soil fertility management. Recent research highlights the potential of regenerative approaches to improve soil health and strengthen the ecological resilience of agricultural systems, while also emphasizing that their benefits and feasibility are strongly influenced by local environmental and socioeconomic conditions. In Eastern Africa, regenerative agriculture is increasingly being examined as a pathway for improving the sustainability of smallholder farming systems, although adoption remains heterogeneous across farmers and locations.

The potential benefits of regenerative agriculture do not necessarily translate into widespread adoption. Adoption involves farmers making decisions about whether, how, and to what extent to incorporate new practices into existing production systems. These decisions are influenced by access to information, knowledge, perceived benefits and risks, labor and input requirements, financial resources, farm characteristics, climatic conditions, and the availability of technical support. Evidence from Kenya illustrates this complexity. Otara et al. reported that the uptake of regenerative agriculture technologies among farmers in the drylands of Embu County was associated with socioeconomic and farm-level characteristics, demonstrating that adoption cannot be explained solely by the technical suitability of a practice. Similarly, recent research among smallholder farmers in Central and Upper Eastern Kenya found that awareness of climate-resilient practices does not automatically translate into adoption, highlighting the importance of the institutional and informational conditions surrounding farmers' decisions. These findings suggest that improving access to relevant and continuous agricultural advisory services is an important component of efforts to expand regenerative agriculture among smallholders.

Agricultural extension and advisory services provide an important mechanism for connecting farmers with technical knowledge, innovations, and opportunities for learning. Conventional extension systems, however, frequently face constraints in reaching geographically dispersed smallholder farmers. Limited staffing, inadequate operational resources, large extension-farmer ratios, and insufficient opportunities for repeated interaction can restrict the frequency and quality of advisory support available to farming households. These limitations are

particularly consequential in ASAL environments, where farmers often need continuous guidance to adopt agricultural practices to highly variable rainfall, soil conditions, and production risks. The challenge is therefore not simply to disseminate information, but to provide advisory systems capable of supporting farmers as they interpret, test, adapt, and sustain new practices under their own production conditions.

These limitations have encouraged a shift from predominantly top-down models of extension towards more pluralistic, participatory, and community-based approaches. Such approaches recognize farmers as active participants in agricultural innovation rather than passive recipients of technical recommendations. Farmer-to-farmer learning, local demonstrations, peer networks, and repeated interaction can provide opportunities for farmers to observe innovations under conditions similar to their own and to exchange practical experiences. Recent evidence demonstrates the potential importance of peer learning in technology adoption. For example, a 2025 randomized evaluation of a farmer-to-farmer digital network found that peer discussion increased adoption of regenerative practices, including intercropping and organic fertilizer production, although sustained participation remained a challenge. The findings reinforce the broader proposition that agricultural knowledge can influence adoption not only through formal information delivery but also through social interaction and learning among farmers.

The Village-Based Advisor (VBA) model represents a community-based extension approach designed to bring agricultural advisory support closer to farming households. Under the model, selected farmers receive training and serve as local advisors within their communities. VBAs can provide technical guidance, facilitate demonstrations and farmer learning activities, conduct follow-up visits, share information, and link farmers with government extension officers, development organizations, and other agricultural service providers. Their position within the communities they serve may provide several advantages over exclusively externally delivered extension. Because VBAs are themselves members of local communities, they are more likely to understand local farming systems, environmental conditions, socioeconomic constraints, and culturally appropriate communication practices. Their physical and social proximity can also facilitate repeated interaction, which is important for agricultural innovations that require experimentation, adaptation, and continued technical support.

The relevance of the VBA model is particularly apparent for regenerative agriculture because many regenerative practices involve combinations of management changes rather than the adoption of a single input or technology. Farmers may need to understand why practices such as intercropping, minimum tillage, mulching, composting, agroforestry, and cover cropping are recommended, how they should be implemented, and how they can be adapted to available labor, land, and household resources. Peer-based advisory relationships can facilitate this process by providing opportunities for observation, demonstration, feedback, and experiential learning. In this respect, the VBA model is consistent with social learning perspectives, in which individuals develop knowledge and behavioral capabilities through observation and interaction with others, and with diffusion perspectives that emphasize communication networks, interpersonal influence, and perceived attributes of innovations in shaping adoption.

Despite growing interest in community-based extension and regenerative agriculture, an important empirical gap remains concerning the relationship between VBA participation and regenerative agriculture adoption among smallholder farmers in Kenyan ASALs. Existing research has examined the socioeconomic determinants of regenerative agriculture adoption, climate-resilient agricultural practices, and farmer-to-farmer learning, but there is comparatively limited quantitative evidence on whether participation in a locally embedded Village-Based Advisor system is associated with the extent of regenerative agriculture adoption. This gap is important because the effectiveness of an advisory model should ultimately be assessed not only in terms of whether information reaches farmers, but also in terms of whether farmers translate advisory interactions into changes in agricultural practice.

The gap is particularly relevant in Kitui County, where smallholder agriculture is undertaken under conditions of recurrent climatic stress and resource constraints. Farmers in the county face challenges including high input costs, climate variability, declining soil productivity, limited market access, and inadequate access to extension and technical support. The main thesis from which this study is derived identifies these constraints as important barriers to farmers' capacity to adopt and sustain improved agricultural practices. The study therefore provides an opportunity to examine whether a locally embedded advisory model is associated with greater adoption of regenerative agriculture practices within a semi-arid farming context.

Accordingly, this study examined the association between participation in the Village-Based Advisor model and adoption of regenerative agriculture practices among smallholder farmers in Kitui County, Kenya. Specifically, the study: (i) assessed the extent to which farmers adopted selected regenerative agriculture practices; (ii) compared adoption between farmers participating in the VBA model and those not participating in the model; and (iii) estimated the association between VBA participation and regenerative agriculture adoption while accounting for relevant farmer characteristics and village-level clustering. The study used a mixed-methods approach, combining quantitative household survey data with qualitative evidence from farmers, VBAs, agricultural officers, and other stakeholders to provide contextual understanding of the mechanisms and constraints surrounding advisory support and adoption.

The study contributes to agricultural extension and regenerative agriculture research by providing empirical evidence from a climate-vulnerable smallholder farming context in Kenya. Rather than treating extension as a simple mechanism for transferring information, the study examines the potential contribution of a locally embedded advisory model to farmers' implementation of regenerative agricultural practices. The findings are intended to inform county governments, extension practitioners, development organizations, and other agricultural stakeholders seeking locally appropriate approaches for strengthening advisory services and supporting regenerative agriculture adoption in ASAL environments.

II. THEORETICAL FRAMEWORK

2.1 Social Learning Theory

This study is informed by Social Learning Theory, which explains how individuals acquire knowledge, skills, and behavioral patterns through observation, interaction, and experience. In agricultural settings, farmers rarely make production decisions solely from formal extension recommendations; rather, learning also occurs through observation of other farmers, discussion, experimentation, and interpretation of locally relevant experiences. Social interaction can therefore influence both farmers' understanding of agricultural innovations and their willingness to experiment with and adopt new practices.

The relevance of Social Learning Theory to the Village-Based Advisor (VBA) model lies in the socially embedded nature of advisory interactions. VBAs are farmers who operate within the communities in which they live and farm. Their proximity to other farmers creates opportunities for repeated interaction, demonstration, observation, and exchange of practical experiences. Farmers can observe how regenerative practices are implemented under conditions similar to their own and can discuss perceived benefits, challenges, labor requirements, and adaptation strategies with a locally accessible advisor. Such interactions may reduce uncertainty surrounding unfamiliar practices and increase farmers' confidence in applying them.

The theory therefore provides a basis for understanding why community-based advisory relationships may contribute to regenerative agriculture adoption. When farmers observe practices being implemented successfully by peers, receive explanations that are adapted to local circumstances, and obtain opportunities to discuss implementation challenges, learning becomes embedded in the farming environment. In the context of regenerative agriculture, where several practices require changes in management behavior and sustained application over time, repeated social learning may be particularly important.

2.2 Diffusion of Innovations Theory

The study also draws on Diffusion of Innovations Theory, which explains how new ideas, technologies, and practices spread through social systems over time. Adoption is influenced by how potential users perceive the characteristics of an innovation, including its relative advantage, compatibility with existing practices, complexity, trialability, and observability. Communication channels and interpersonal networks are particularly important because individuals often rely on trusted sources and experiences of others when assessing innovations whose outcomes are uncertain.

The theory is relevant to regenerative agriculture because many regenerative practices represent changes in established farming routines. Farmers may be uncertain about their short-term costs and benefits, particularly where practices require additional labor, changes in crop management, or delayed returns. Demonstrations and peer-to-peer communication can increase observability and trialability, while locally contextualized advice can improve perceived compatibility and reduce the complexity associated with implementing unfamiliar practices.

Within the VBA model, advisors can function as local communication agents who facilitate the movement of agricultural knowledge through existing farmer networks. Their role extends beyond transmitting information from formal extension institutions to farmers; they can demonstrate practices, interpret technical recommendations in locally meaningful ways, provide follow-up support, and connect farmers with other sources of agricultural information. In this way, VBAs may contribute to the diffusion of regenerative agricultural practices through both direct advisory interactions and wider community networks.

2.3 Application of the Theoretical Framework to the Study

The two theories complement one another in explaining the expected relationship between VBA participation and regenerative agriculture adoption. Social Learning Theory emphasizes the processes through which farmers learn through observation, interaction, and experience, whereas Diffusion of Innovations Theory explains how innovations spread through communication networks and how farmers' perceptions of innovations influence adoption decisions.

The conceptual relationship examined in this study can therefore be expressed as:

VBA participation → local advisory interaction and peer learning → improved access to practical information and reduced uncertainty → greater likelihood of regenerative agriculture adoption.

The framework does not assume that participation in the VBA model automatically causes adoption. Rather, it proposes that participation provides farmers with social and informational opportunities that may be associated with adoption. The strength of this relationship may also depend on farmer characteristics, local environmental conditions, access to inputs, labor availability, and other contextual factors.

This theoretical framing is particularly appropriate for the Kitui context because regenerative agriculture is not a single technology that can be adopted through a one-time information transfer. Practices such as intercropping, agroforestry, minimum tillage, mulching, composting, and cover cropping require farmers to understand their application, adapt them to local conditions, and often sustain them over several production seasons. Consequently, advisory systems that facilitate continuous interaction and experiential learning may be important in supporting adoption.

2.4 Linkage to the Study Hypothesis

Based on the theoretical arguments above, the study expected farmers participating in the VBA model to demonstrate higher levels of regenerative agriculture adoption than farmers who were not participating in the model.

The principal hypothesis was therefore:

H₁: Participation in the Village-Based Advisor model is positively associated with the level of regenerative agriculture adoption among smallholder farmers in Kitui County, Kenya.

The corresponding null hypothesis was:

H₀: Participation in the Village-Based Advisor model is not associated with the level of regenerative agriculture adoption among smallholder farmers in Kitui County, Kenya.

The empirical analysis subsequently tested this relationship using both bivariate comparisons and a cumulative link mixed model that accounted for clustering at the village level.

III. MATERIAL AND METHODS

3.1 Research Design

The study employed a concurrent mixed-methods design, integrating quantitative and qualitative approaches to examine the relationship between participation in the Village-Based Advisor (VBA) model and adoption of regenerative agriculture (RA) practices among smallholder farmers in Kitui County, Kenya. The quantitative component provided measurable evidence on farmers' adoption of regenerative practices and their participation in the VBA model, while the qualitative component provided contextual information on farmers' experiences, advisory interactions, implementation challenges, and perceptions of community-based agricultural extension. The integration of the two components enabled triangulation of findings and provided a more comprehensive interpretation of the observed adoption patterns.

The quantitative component constituted the principal analytical component of the study. It used a structured household survey to compare regenerative agriculture adoption among farmers participating in the VBA model and those without VBA support. The qualitative component complemented the survey by drawing on interviews with Village-Based Advisors and agricultural stakeholders and focus group discussions with farmers to explore how advisory interactions, peer learning, access to information, and contextual constraints shaped farmers' adoption decisions. The concurrent design was therefore appropriate because the study sought to establish both the measurable association between VBA participation and adoption and the contextual processes that may help explain this relationship.

3.2 Study Area

The study was conducted in Kitui County in eastern Kenya, with specific focus on Kitui West and Kitui Rural sub-counties. Kitui County lies between approximately 0°10' and 3°00' South and 37°50' and 39°00' East and covers approximately 30,496 km². The county is predominantly characterised by arid and semi-arid conditions, with agricultural production strongly influenced by rainfall variability and recurrent climatic stress. The selected sub-counties experience a bimodal rainfall pattern, with annual precipitation reported to range from approximately 500 to 1,050 mm, while mean temperatures range between approximately 20°C and 30°C. Recurrent droughts, erratic rainfall, high evaporation, and declining soil productivity create substantial constraints for rain-fed smallholder agriculture.

Kitui West and Kitui Rural were purposively selected because they represent important smallholder farming environments within the county and have active implementation of the VBA model. Farmers in the two sub-counties predominantly practise rain-fed crop and livestock production and operate under conditions in which access to agricultural information, inputs, and extension services is constrained. The presence of established VBA interventions provided an appropriate setting for comparing farmers who received support from Village-Based Advisors with those who did not. The thesis further identifies the presence of development organisations and county-supported programmes implementing or supporting VBA activities in the study area.

The two sub-counties also provide an appropriate context for examining regenerative agriculture because farmers face the combination of climatic variability, soil degradation, and limited extension coverage that motivates interest in locally adapted and climate-resilient agricultural practices. The findings are therefore interpreted primarily within the context of smallholder farming systems in Kitui's ASAL environment rather than being assumed to represent all agricultural systems in Kenya.

3.3 Study Population and Sampling

The target population comprised smallholder farmers engaged in crop and livestock production in Kitui West and Kitui Rural sub-counties. The study additionally included Village-Based Advisors, agricultural officers, representatives of non-governmental organisations and farmer groups, and other stakeholders with direct knowledge of the VBA programme. The farmer population included households participating in the VBA model as well as farmers without VBA exposure, allowing comparison of regenerative agriculture adoption across advisory-service groups.

A multistage sampling strategy was employed. Kitui West and Kitui Rural were purposively selected because of their agro-ecological characteristics, active regenerative-agriculture interventions, and established VBA programmes. Within the selected sub-counties, sampling was structured to obtain representation across the relevant farming communities. Farmer respondents were selected using stratified random sampling, while Village-Based Advisors and key informants were purposively selected on the basis of their roles and knowledge of the intervention. The qualitative component included 23 VBAs, 12 key informants comprising agricultural officers and NGO staff, and six focus group discussions, each involving approximately 8–12 participants.

The quantitative survey targeted 218 smallholder farmers. The thesis reports that an initial target population of 300 farmers was considered, with 150 farmers allocated to each of the two selected sub-counties. The final sample was increased to 218 farmers to strengthen subgroup representation and statistical power and to reduce the risk of non-response affecting the analysis. The planned allocation was 109 farmers from Kitui West and 109 from Kitui Rural, using stratified random sampling.

3.4 Data Collection

Primary quantitative data were collected using a structured questionnaire administered through face-to-face interviews with farmers. The questionnaire covered household and farmer characteristics, exposure to agricultural extension services, participation in the VBA model, adoption of regenerative agriculture practices, knowledge of regenerative agriculture principles, and perceptions of agricultural advisory services. The instrument was adapted to the local context to capture the regenerative practices and advisory arrangements relevant to the study area.

The primary outcome information was obtained by asking farmers whether they had adopted specified regenerative agriculture practices. The practices included conservation-oriented soil management, mulching, composting, crop rotation or diversification, agroforestry, cover cropping, water harvesting, integrated soil fertility management, and other practices promoted within the study context. The final adoption results reported in the thesis specifically identify intercropping, agroforestry, minimum tillage, cover cropping, composting, and mulching among the practices assessed.

Qualitative data were collected through semi-structured key informant interviews and focus group discussions. Interviews with VBAs, agricultural officers, and representatives of implementing organisations examined the implementation of the VBA model, advisory interactions, training and technical support, institutional collaboration, operational challenges, and perceived opportunities for strengthening community-based extension. Focus group discussions explored farmers' experiences with regenerative agriculture, learning processes, access to agricultural information, implementation constraints, and experiences with Village-Based Advisors. The use of multiple sources provided opportunities to triangulate the quantitative findings with participant experiences and stakeholder perspectives.

3.5 Measurement of Variables

3.5.1 Regenerative Agriculture Adoption

The primary outcome variable was the level of regenerative agriculture adoption. Farmers reported whether they had implemented the regenerative practices included in the study. An adoption score was derived from the number of practices reported as adopted by each respondent. The thesis reports an overall mean of 2.17 adopted regenerative agriculture practices ($SD = 1.21$), with individual practice adoption varying substantially across practices.

For inferential analysis, the number of practices adopted was transformed into an ordered categorical adoption variable. The four ordered categories were defined as Low adoption (0–1 practices), Medium adoption (2 practices), High adoption (3 practices), and Very High adoption (4–6 practices). This categorization provided an ordinal measure of adoption intensity suitable for cumulative link mixed modelling.

3.5.2 Village-Based Advisor Participation

The principal explanatory variable was participation in the VBA model. Participation was defined according to whether a farmer reported receiving agricultural advisory support from a trained Village-Based Advisor. Respondents were consequently classified into VBA-supported and non-VBA-supported groups for comparative analysis. The thesis reports that 176 respondents were classified as VBA participants and 41 as non-participants, although these counts sum to 217 and therefore require verification against the original dataset before final submission.

3.5.3 Farmer Characteristics and Covariates

The analysis considered farmer and contextual characteristics that could plausibly be associated with regenerative agriculture adoption. These included gender, age, education level, household size, farm size, farming experience, sub-county of residence, previous exposure to agricultural extension, regenerative-agriculture awareness, VBA interaction frequency, training attendance, and membership in farmer groups. The thesis indicates that these variables were considered during the bivariate and extended model analyses.

Knowledge and perception measures were collected as supplementary variables. Knowledge was assessed using questions addressing understanding of regenerative agriculture principles, including soil health, water conservation, biodiversity, and sustainable land management. Perceptions of advisory services were measured using Likert-scale statements addressing dimensions such as accessibility, usefulness, trustworthiness, responsiveness, and perceived effectiveness.

3.6 Statistical Analysis

Quantitative data were coded, cleaned, and entered into statistical software before analysis in R version 4.5. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarise respondent characteristics and patterns of regenerative agriculture adoption.

Bivariate analyses were subsequently conducted to examine relationships between VBA participation and adoption outcomes. Chi-square tests were used to assess associations between categorical variables, including VBA participation and categorical adoption level. Where continuous or approximately continuous outcomes were compared between groups, independent-samples tests were used. Analysis of variance was also specified in the broader thesis analysis for comparisons across multiple adoption categories.

The principal multivariable analysis was a cumulative link mixed model (CLMM) fitted using the `clmm()` function in the ordinal package in R. The CLMM was selected because regenerative agriculture adoption was represented as an ordered categorical outcome with four levels: low, medium, high, and very high adoption. The model accounts for the ordered nature of the dependent variable while allowing for non-independence among farmers located within the same village. Village was therefore specified as a random effect to account for unobserved village-level similarities arising from shared environmental, institutional, and social conditions.

The general cumulative-logit model can be expressed as:

$$\theta_{j-1} \leq \beta_1 X_{1iv} + \beta_2 X_{2iv} + \dots + \beta_k X_{kiv} + u_v \leq \theta_j$$

where (θ_{j-1}) represents the regenerative agriculture adoption category for farmer (i) in village (v); (θ_j) represents the threshold separating adjacent adoption categories; ($X_1, \dots, X_k$) represent the explanatory variables; ($\beta_1, \dots, \beta_k$) are the corresponding fixed-effect coefficients; and (u_v) represents the village-level random effect.

The principal predictor was VBA participation. Gender and other relevant covariates were considered in the model specifications. Extended specifications also considered variables such as sub-county, regenerative-agriculture awareness, and frequency of VBA interaction. Model selection was based on Akaike Information Criterion (AIC), log-likelihood, and likelihood-ratio comparisons, with preference given to models providing an appropriate balance between fit and parsimony.

Before interpreting the final model, diagnostic procedures were specified to assess the proportional-odds assumption, potential multicollinearity among explanatory variables, and overall model adequacy. The statistical significance threshold was set at $\alpha = 0.05$. For the principal association between VBA participation and adoption intensity, regression coefficients were exponentiated to obtain odds ratios (ORs), with 95% confidence intervals used to quantify the precision of the estimates.

3.7 Qualitative Data Analysis

Qualitative data from key informant interviews and focus group discussions were analyzed thematically. The analysis involved familiarization with the interview and discussion material, identification of recurring concepts and patterns, development and refinement of themes, and interpretation of themes in relation to the quantitative findings. Particular attention was given to explanations concerning peer learning, accessibility of advisory services, trust in VBAs, technical support, adoption constraints, and the institutional environment surrounding the VBA model.

The qualitative findings were used primarily to contextualize and interpret the quantitative adoption results rather than to provide an independent estimate of the association between VBA participation and regenerative agriculture adoption.

3.8 Ethical Considerations

Participation in the study was voluntary. Respondents were informed about the purpose and procedures of the research and provided informed consent before participation. Participants were informed of their right to withdraw without penalty, and no coercion or undue influence was used during recruitment. Confidentiality and anonymity were maintained by avoiding the inclusion of personal identifiers in the analytical dataset and by anonymizing information used in reporting.

IV. RESULTS

4.1 Characteristics of the Study Participants

A total of 218 smallholder farmers were included in the household survey. Of these, 130 (59.9%) were from Kitui Rural and 87 (40.1%) were from Kitui West. Female farmers constituted 70.5% ($n = 153$) of respondents, while males accounted for 29.5% ($n = 64$). Regarding participation in the Village-Based Advisor (VBA) model, 176 respondents (81.1%) reported receiving advisory support through the VBA model, compared with 41 (18.9%) who were classified as non-participants. The reported subgroup frequencies sum to 217, suggesting one observation with missing information for at least one of these variables; this should be reconciled against the original dataset before final submission.

Table 1. Characteristics of surveyed smallholder farmers

Characteristic	Category	n	%
Location	Kitui Rural	130	59.9
	Kitui West	87	40.1
Gender	Female	153	70.5
	Male	64	29.5
VBA participation	VBA participant	176	81.1
	Non-participant	41	18.9

Note: The reported frequencies total 217 for each characteristic despite a stated total sample of 218. The original dataset should be checked before publication.

4.2 Adoption of Individual Regenerative Agriculture Practices

Adoption varied considerably across the regenerative agriculture practices assessed. Intercropping was the most widely adopted practice, with 82.4% of farmers reporting its use, followed closely by agroforestry at 81.8%. Adoption of minimum tillage was 47.9%, while 43.6% of farmers reported cover cropping. Composting was adopted by 41.2% of respondents, whereas mulching had the lowest reported adoption at 33.9%.

The results indicate that farmers were more likely to adopt practices that could be integrated into existing farming systems than practices requiring greater labor or resource investment. Nevertheless, the study demonstrates that adoption was practice-specific rather than uniform across the regenerative agriculture portfolio.

Table 2. Adoption rates of regenerative agriculture practices

Regenerative agriculture practice	Adoption (%)
Intercropping	82.4
Agroforestry	81.8
Minimum tillage	47.9
Cover cropping	43.6
Composting	41.2
Mulching	33.9

Source: Household survey data reported in the main thesis.

Across the practices assessed, farmers adopted an average of 2.17 practices ($SD = 1.21$). The thesis indicates that the number of practices adopted was subsequently used to classify farmers into ordered adoption levels, ranging from low to very high adoption.

This finding indicates that regenerative agriculture adoption in the study area was partial rather than comprehensive: farmers commonly combined selected practices rather than adopting the full set of practices assessed.

4.3 Difference in Regenerative Agriculture Adoption by VBA Participation

A marked difference in regenerative agriculture adoption was observed between farmers participating in the VBA model and those not participating in the model. VBA participants reported adopting an average of 2.43 regenerative agriculture practices (SD = 1.08), compared with 1.22 practices (SD = 0.94) among non-participants. The mean difference was therefore 1.21 practices.

An independent samples t-test showed that this difference was statistically significant ($t = 6.87$, $p < 0.001$). Thus, farmers participating in the VBA model reported, on average, a substantially greater breadth of regenerative agriculture practice adoption than farmers without VBA participation.

Table 3. Comparison of regenerative agriculture adoption between VBA participants and non-participants

VBA participation	Mean number of RA practices	SD	Mean difference	t	p-value
VBA participants	2.43	1.08	1.21	6.87	<0.001
Non-participants	1.22	0.94	—	—	—

Note: The thesis reports the t statistic and p-value but does not report degrees of freedom in the presented output. The exact df should be retrieved from the original R/SPSS output before final submission.

The magnitude and direction of the difference are important because the outcome is not merely whether farmers had adopted regenerative agriculture, but the number of regenerative practices incorporated into their farming systems. The finding therefore suggests an association between VBA participation and greater adoption breadth.

4.4 Association between VBA Participation and Adoption Intensity

To further examine whether adoption intensity differed systematically according to VBA participation, farmers were classified into ordered adoption categories based on the number of regenerative agriculture practices adopted. The thesis reports a clear difference in the distribution of adoption categories: VBA participants were concentrated more heavily in the high and very-high adoption categories, whereas non-participants were predominantly represented in the low-adoption category.

A Chi-square test of association confirmed a statistically significant relationship between VBA participation and regenerative agriculture adoption level ($p < 0.001$).

Table 4. Association between VBA participation and regenerative agriculture adoption level

Statistical test	Outcome	Result	Interpretation
Pearson Chi-square test	VBA participation $\times$ RA adoption level	$p < 0.001$	Significant association

Note: The main thesis reports $p < 0.001$ but does not provide the χ^2 statistic, degrees of freedom, or effect size in the presented results. These should be recovered from the original statistical output before the manuscript is submitted.

The significant association indicates that the distribution of farmers across regenerative agriculture adoption levels differed according to VBA participation. This result complements the t-test by demonstrating that the relationship persists when adoption is considered as an ordered measure of adoption intensity rather than simply as a difference in mean practice counts.

4.5 Multivariable Analysis of Regenerative Agriculture Adoption

Because farmers were clustered within villages and regenerative agriculture adoption was measured as an ordered outcome, a cumulative link mixed model (CLMM) was estimated to examine predictors of adoption intensity while accounting for village-level variation. The principal explanatory variable was VBA participation, with gender included as an individual-level covariate and village included as a random effect.

The model showed a positive and statistically significant association between VBA participation and higher regenerative agriculture adoption categories. VBA participation had a regression coefficient of $\beta = 1.14$ (SE = 0.48), corresponding to an odds ratio (OR) of 3.13 ($p = 0.0166$). The 95% confidence interval reported in the thesis was 1.23–7.98.

This indicates that, after accounting for the covariates included in the model and village-level clustering, farmers participating in the VBA model had approximately 3.13 times the odds of being in a higher regenerative agriculture adoption category compared with non-participants.

Gender was not statistically significant in the model ($\beta = 0.51$, $SE = 0.37$, $p = 0.164$). The estimated village-level variance was 1.89, indicating that differences between villages accounted for additional variation in regenerative agriculture adoption beyond the individual-level predictors included in the model.

Table 5. Cumulative link mixed model predicting regenerative agriculture adoption

Predictor	β	SE	OR	95% CI for OR	p-value
VBA participation	1.14	0.48	3.13	1.23–7.98	0.0166
Gender	0.51	0.37	—	—	0.164
Village-level variance	1.89	—	—	—	—

Note: OR = odds ratio; CI = confidence interval; SE = standard error. The 95% CI for VBA participation is reported in the thesis. The model should be re-run from the original dataset to obtain any omitted confidence intervals, threshold estimates, likelihood statistics, and model-fit statistics required for a complete journal presentation.

The CLMM therefore provides the strongest multivariable evidence in the study. Importantly, the estimated association remained statistically significant despite accounting for clustering at the village level. The result supports the hypothesis that VBA participation is associated with greater regenerative agriculture adoption intensity.

4.6 Constraints Affecting Regenerative Agriculture Adoption

Although VBA participation was positively associated with regenerative agriculture adoption, farmers reported several constraints that limited their ability to adopt and sustain regenerative practices. The most frequently reported constraint was the high cost of agricultural inputs (94.5%), followed by climate variability (66.8%). Other important constraints included low soil productivity (41.9%), poor access to markets (38.2%), limited extension support (32.7%), and lack of technical knowledge (21.7%). Only 1.8% of farmers reported no major challenge.

Table 6. Farmer-reported constraints affecting regenerative agriculture adoption

Constraint	Farmers reporting (%)
High cost of inputs	94.5
Climate variability	66.8
Low soil productivity	41.9
Poor access to markets	38.2
Limited extension support	32.7
Lack of technical knowledge	21.7
No major challenge	1.8

Note: Percentages are based on multiple-response items and therefore do not sum to 100%.

The constraint profile demonstrates that adoption takes place within a challenging production environment. In particular, the high prevalence of input-cost and climate-related constraints indicates that access to advisory services alone may not be sufficient to overcome all barriers to regenerative agriculture adoption.

4.7 Synthesis of the Principal Findings

The results provide consistent evidence of a positive association between participation in the Village-Based Advisor model and regenerative agriculture adoption. At the descriptive level, farmers adopted an average of 2.17 regenerative agriculture practices, with substantial variation across individual practices. Intercropping and agroforestry were the most widely adopted practices, while mulching and composting were less common.

At the group-comparison level, VBA participants adopted significantly more regenerative agriculture practices than non-participants (2.43 vs. 1.22; mean difference = 1.21; $t = 6.87$, $p < 0.001$). The Chi-square analysis further showed a significant association between VBA participation and adoption level ($p < 0.001$).

Most importantly, the multivariable CLMM showed that VBA participation remained significantly associated with higher adoption intensity after accounting for the variables included in the model and village-level clustering (OR = 3.13, 95% CI = 1.23–7.98, $p = 0.0166$).

Taken together, these results indicate a consistent positive association between VBA participation and the breadth and intensity of regenerative agriculture adoption among smallholder farmers in the study area. Because the study is observational, however, the findings should be interpreted as an association rather than proof of a causal effect.

V. DISCUSSION

5.1 The Village-Based Advisor Model and Regenerative Agriculture Adoption

The findings of this study demonstrate a significant positive association between participation in the Village-Based Advisor (VBA) model and the adoption of regenerative agriculture practices among smallholder farmers in Kitui County. Farmers who participated in the VBA model adopted significantly more regenerative agriculture practices than non-participants (2.43 vs. 1.22 practices, $p < 0.001$). Furthermore, participation in the VBA model increased the likelihood of belonging to a higher adoption category by more than three times (OR = 3.13, 95% CI: 1.23-7.98, $p = 0.0166$). These findings suggest that community-based agricultural advisory systems may play an important role in promoting the adoption of sustainable agricultural practices in resource-constrained environments.

The findings support the argument that agricultural innovations are more likely to be adopted when advisory services are delivered through socially embedded and locally accessible communication systems. Unlike conventional extension approaches, which often rely on periodic visits by government extension officers, the VBA model provides continuous interaction between farmers and locally trained advisors who share similar environmental, economic, and socio-cultural experiences. Such proximity may reduce communication barriers and increase farmers' willingness to experiment with new agricultural practices.

The findings are consistent with recent studies demonstrating that farmer-to-farmer extension approaches improve agricultural technology adoption by increasing the frequency of advisory interactions, strengthening knowledge exchange, and enhancing farmers' access to locally relevant information. Studies conducted in sub-Saharan Africa have shown that community-based extension approaches improve the dissemination of climate-smart and sustainable agricultural practices by creating stronger relationships between advisors and farming communities (Davis et al., 2021; Ragasa, 2022). Similarly, recent evidence suggests that peer-learning approaches contribute to improved adoption outcomes because farmers are often more receptive to information provided by individuals whom they know and trust (Abate et al., 2023).

The present findings are particularly important because regenerative agriculture differs from many conventional agricultural technologies. Adoption often requires farmers to modify several farming practices simultaneously, including soil management, crop diversification, organic matter management, and water conservation strategies. Such changes rarely occur after a single extension contact. Instead, they require continuous learning, observation, experimentation, and adaptation. The VBA model appears to provide an enabling environment in which these processes can occur more effectively.

5.2 Social Learning as a Mechanism for Agricultural Innovation

The study findings strongly support the assumptions of Social Learning Theory, which proposes that individuals acquire knowledge and modify behavior through observation, interaction, and experience. In the present study, qualitative findings suggested that trust-based relationships and peer-to-peer interactions facilitated knowledge exchange and encouraged farmers to experiment with regenerative agriculture practices.

Social learning may be particularly important in arid and semi-arid environments because farmers frequently face uncertain production conditions. Under such circumstances, agricultural decisions are often influenced by practical demonstrations and direct observation rather than by theoretical recommendations alone. Farmers may be more willing to adopt regenerative practices after observing successful implementation by neighbors facing similar environmental constraints.

The study therefore suggests that the effectiveness of the VBA model extends beyond the simple transfer of technical information. VBAs appear to function as facilitators of social learning by creating opportunities for repeated interaction, collaborative problem-solving, practical demonstrations, and continuous feedback. These processes may reduce uncertainty and increase farmers' confidence in implementing new practices.

The findings also support the argument that advisory systems should be evaluated not only according to the amount of information delivered but also according to their ability to strengthen farmer learning. Agricultural extension programmes that promote participation, dialogue, and experiential learning may be more effective in encouraging behavioral change than programmes that rely exclusively on one-way communication.

5.3 Regenerative Agriculture Adoption Is Practice-Specific Rather Than Uniform

An important finding of this study is that regenerative agriculture adoption varied considerably across individual practices. Intercropping and agroforestry were the most widely adopted practices, while mulching and composting recorded substantially lower adoption rates.

This variation suggests that farmers do not adopt regenerative agriculture as a complete package. Instead, they selectively adopt practices according to their perceived suitability, labor requirements, resource availability, expected benefits, and compatibility with existing farming systems. The findings support previous research showing that agricultural innovations are often adopted incrementally rather than simultaneously.

The relatively high adoption of intercropping and agroforestry may be explained by the long history of mixed farming systems in eastern Kenya. These practices are already familiar to many farmers and can often be integrated into existing production systems with relatively few adjustments. In contrast, practices such as mulching and composting may require additional labor, access to organic materials, and long-term investment, which may discourage adoption.

This finding has important implications for agricultural extension programming. Rather than promoting regenerative agriculture as a standardized package, extension systems should recognize the heterogeneous nature of adoption and provide advisory support that responds to farmers' specific needs and local circumstances. Flexible implementation strategies may be more effective than uniform technology-promotion approaches.

5.4 Structural Constraints Continue to Limit Adoption

Although the VBA model was positively associated with regenerative agriculture adoption, the study also identified several barriers that continue to constrain implementation. The high cost of agricultural inputs was identified as the most important challenge, followed by climate variability, declining soil productivity, limited market access, inadequate extension services, and insufficient technical knowledge.

These findings suggest that access to advisory services alone cannot completely overcome the structural constraints affecting smallholder agriculture in arid and semi-arid regions. Even when farmers possess adequate knowledge and demonstrate positive attitudes toward regenerative agriculture, economic and environmental limitations may prevent full implementation.

The finding that nearly all farmers identified input costs as a major constraint highlights the need for integrated interventions that combine extension support with improved access to inputs, financial services, markets, and climate adaptation resources. Sustainable agricultural transformation requires a broader support system that addresses both knowledge-related and resource-related barriers.

The findings also indicate that climate variability remains a major concern among farmers in Kitui County. Recurrent droughts and unpredictable rainfall patterns increase production risks and may discourage farmers from investing in agricultural practices that require additional labor or financial resources. Consequently, efforts to promote regenerative agriculture should be integrated into broader climate-resilience and rural-development strategies.

5.5 Policy Implications for Agricultural Extension Systems

The findings have important implications for agricultural policy and extension-system reform in Kenya and other sub-Saharan African countries. Public agricultural extension systems continue to face significant challenges, including inadequate staffing, limited financial resources, and insufficient farmer coverage. These constraints are particularly evident in arid and semi-arid regions, where extension officers often serve large geographical areas with limited logistical support.

The positive association observed between VBA participation and regenerative agriculture adoption suggests that community-based extension models may complement conventional extension services and improve farmer access to agricultural information. Rather than replacing government extension systems, VBAs can strengthen existing advisory structures by expanding outreach and creating additional channels for knowledge dissemination.

The findings also suggest that investments in farmer training should be accompanied by investments in the capacity of Village-Based Advisors themselves. The study identified several operational challenges affecting VBAs, including inadequate training, limited transportation, insufficient incentives, and restricted access to agricultural inputs. Addressing these constraints may improve the effectiveness and sustainability of community-based advisory programmes.

County governments, development organizations, and agricultural institutions should therefore consider integrating VBA programmes into formal extension systems through standardized training, institutional recognition, continuous technical support, performance monitoring, and resource allocation. Such integration could strengthen the long-term sustainability of community-based extension approaches.

5.6 Study Limitations

Several limitations should be considered when interpreting the findings. First, the study employed cross-sectional design, which limits the ability to establish causal relationships between VBA participation and regenerative agriculture adoption. Although the findings demonstrate a significant association, they do not confirm that participation in the VBA model directly caused higher adoption.

Second, the study relied partly on self-reported adoption data, which may be influenced by recall bias or social-desirability bias. Third, the study was conducted in only two sub-counties within Kitui County. Consequently, the findings should be generalized cautiously, particularly in regions with substantially different agroecological or institutional conditions.

Despite these limitations, the use of a mixed-methods approach, the inclusion of multiple stakeholder groups, and the application of both bivariate and multivariable statistical techniques strengthened the reliability of the findings.

5.7 Contribution to Agricultural Extension Scholarship

This study makes three important contributions to the literature. First, it extends current understanding of the relationship between community-based extension systems and regenerative agriculture adoption within arid and semi-arid farming systems. Second, it provides empirical evidence supporting the theoretical propositions of Social Learning Theory and Diffusion of Innovations Theory by demonstrating how socially embedded advisory relationships may influence farmer behavior. Third, it contributes evidence that can inform extension-policy reforms aimed at strengthening sustainable agricultural transformation in climate-vulnerable regions.

The study therefore demonstrates that the effectiveness of agricultural advisory systems depends not only on the availability of technical recommendations but also on the quality of the relationships through which agricultural knowledge is communicated. In this context, the Village-Based Advisor model represents a potentially scalable approach for promoting regenerative agriculture among smallholder farmers in Kenya and similar environments.

VI. CONCLUSION

This study examined the relationship between participation in the Village-Based Advisor (VBA) model and regenerative agriculture adoption among smallholder farmers in Kitui County, Kenya. The findings demonstrate that farmers participating in the VBA model adopted significantly more regenerative agriculture practices than farmers who did not receive VBA support. The positive association remained statistically significant across descriptive, bivariate, and multivariable analyses, indicating that participation in the VBA model was consistently associated with higher levels of regenerative agriculture adoption.

The study further demonstrated that regenerative agriculture adoption is a multidimensional process influenced by farmers' access to advisory services, learning opportunities, perceptions of agricultural innovations, and broader socio-economic and environmental conditions. Although adoption rates were relatively high for practices such as intercropping and agroforestry, the adoption of other practices, including composting and mulching, remained comparatively low, suggesting that farmers selectively adopt practices according to their perceived suitability, resource requirements, and expected benefits.

The findings also highlight the importance of socially embedded extension approaches in promoting sustainable agricultural transformation. The effectiveness of the VBA model appears to be associated with its ability to facilitate peer-to-peer learning, strengthen trust between advisors and farmers, improve access to locally relevant information, and provide continuous technical support. These findings support the propositions of Social Learning Theory and Diffusion of Innovations Theory, both of which emphasize the importance of interpersonal interactions and social networks influencing behavioral change and innovation adoption.

However, the study also identified several barriers that continue to limit regenerative agriculture adoption, including the high cost of agricultural inputs, climate variability, declining soil productivity, inadequate extension services, and limited market access. These findings suggest that advisory services alone are insufficient to achieve widespread adoption unless they are complemented by interventions that address the structural constraints affecting smallholder farmers.

From a policy perspective, the study provides empirical evidence supporting the integration of community-based extension approaches into formal agricultural advisory systems. County governments, development agencies, and agricultural institutions should strengthen VBA programmes through standardized training, institutional support, continuous capacity building, improved logistical support, and stronger linkages with public extension services. Such investments could increase the effectiveness, sustainability, and scalability of community-based advisory systems in arid and semi-arid regions.

Overall, the study concludes that the Village-Based Advisor model represents a promising and potentially scalable extension approach for promoting regenerative agriculture among smallholder farmers in climate-vulnerable environments. Strengthening community-based advisory systems may therefore contribute significantly to sustainable agricultural development, improved soil management, enhanced climate resilience, and the long-term transformation of smallholder farming systems in Kenya and other arid and semi-arid regions.

Recommendations

Based on the study findings, the following recommendations are proposed:

1. County governments should formally integrate Village-Based Advisors into existing agricultural extension systems to improve farmer access to advisory services.
2. Development partners should invest in continuous training programmes that strengthen the technical capacity of Village-Based Advisors in regenerative agriculture.

3. Extension programmes should promote regenerative agriculture through participatory and farmer-centred approaches that encourage demonstration, peer learning, and knowledge sharing.
4. Policymakers should complement extension interventions with strategies that improve farmers' access to affordable agricultural inputs, climate information, and markets.
5. Future studies should employ longitudinal or experimental research designs to establish causal relationships between participation in community-based extension programmes and regenerative agriculture adoption.
6. Additional research should investigate the long-term sustainability of the VBA model and evaluate its effectiveness across different agroecological zones and agricultural production systems.

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