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Determinants of Willingness to Adopt Alley Cropping among Smallholder Farmers in Maryland, USA

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ABSTRACT

Smallholder farmers face increasing challenges from climate variability, highlighting the need for sustainable farming practices that improve agricultural resilience. Climate-resilient alley cropping (CRAC), which combines trees (fruit/nuts) with annual or seasonal crops, offers potential environmental and economic benefits. However, limited studies have examined willingness to adopt CRAC in Maryland, particularly the role of extension demonstrations in encouraging its adoption. This study examined factors associated with farmers' willingness to share and apply knowledge gained from CRAC field-day demonstrations in Maryland, USA. Data were collected through a voluntary, self-administered survey of 93 participants attending field days at on-farm and community demonstration sites in Somerset, Wicomico, Caroline, and Baltimore counties. Binary logistic regression was used to analyze the data, with 54 complete responses included in the regression analysis. The results showed that participants who were highly satisfied with the field day had significantly greater odds of expressing the highest level of willingness to share knowledge (OR = 16.13, $p < 0.01$) and apply the knowledge gained (OR = 6.87, $p < 0.05$). Demographic information was not a statistically significant predictor in either adjusted model. Although the small, event-based sample and reliance on self-reported intentions limit the generalizability of the findings, the results also suggest that participant satisfaction is an important consideration in extension-based learning. Likewise, agricultural extension programs should emphasize practical demonstrations, relevant educational content, and continued technical assistance.

INTRODUCTION

Extreme weather conditions such as warming temperatures, irregular rainfall patterns, long periods of drought, flooding, and storms are reducing crop yields and making food supplies less stable (IPCC, 2019). Agricultural activities are particularly sensitive to such changes because local weather conditions determine crop growth, soil health, and water availability. Higher temperatures can speed up crop growth but often reduce final yields. Unpredictable precipitation can bring droughts or flooding, and warmer conditions often increase the spread of pests and diseases (Mahato, 2014). Recent studies have also shown that increasing heat has already started to lower crop yields in many regions, with more serious impacts when temperature thresholds for crops are exceeded (Tran *et al.*, 2025). Climate-resilient agriculture refers to farming practices that help maintain stable farm production, strengthen the capacity to overcome changing climate conditions, and minimize greenhouse gas emissions while improving carbon storage in soil (FAO, 2014). In the United States, such extreme events are becoming a serious concern for agricultural productivity and rural economies, affecting not just farmers and landowners but also everyone who depends directly and indirectly on the food system and livelihood (EPA, 2024). To address the growing challenges of extreme weather, a practical and effective strategy that can help adapt, recover, and grow is needed. By deliberately incorporating trees into agricultural

commodities, agroforestry provides a sustainable land-use approach that supports healthier soils, more effective water management, and greater biological diversity (McRae, 2024). The long-term success of agroforestry systems depends on careful design and management that promote beneficial interactions between trees and crops (Xu *et al.*, 2019). Among various agroforestry practices, alley cropping has gained attention for its ability to improve soil health, increase carbon sequestration, reduce environmental degradation, and enhance farm productivity. Climate-resilient alley cropping (CRAC), particularly fruit- and nut-based systems, can offer opportunities to increase both environmental and economic sustainability while supporting long-term agricultural resilience (Smith *et al.*, 2013).

While there is numerous evidence supporting the benefits of alley cropping practices, relatively few small-scale and minority farmers have adopted this practice (Gurung *et al.*, 2026). Lack of technical knowledge, uncertainty regarding economic returns, and limited access to information often constrain adoption decisions. Agricultural extension programs play an important role in addressing these challenges by connecting research-based knowledge with practical farm management. Educational, practical, and facilitative services such as training, field visits, workshops, and farmer-to-farmer learning provide opportunities for producers to observe practices, gain technical knowledge, and evaluate potential benefits before adoption (FAO,

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2014; Hailu *et al.*, 2025). In simple terms, extension serves as the bridge between scientific innovation and practical farming decisions. It plays an important role in transmitting knowledge, thereby promoting the wider adoption of improved farming practices. Access to training, extension, and market information has been identified as a key driver of adoption behavior (Aryal *et al.*, 2020). Successful adoption of agroforestry practices depends on understanding farmers' needs, experiences, and perceptions. Jha *et al.* (2021) emphasized that incorporating farmers' perspectives is critical for encouraging adoption. Furthermore, maximizing the benefits of agroforestry requires collaboration among researchers, farmers, policymakers, and local communities, supported by investments in research, education, and technology, as well as enabling policies (Prajapati *et al.*, 2024). Although previous studies have documented the environmental and economic benefits of agroforestry systems, relatively few studies have examined smallholder farmers' willingness to adopt climate-resilient alley cropping in Maryland. Therefore,

this study addresses the gap by assessing smallholder farmers' perceptions about their willingness to adopt climate-resilient alley cropping.

MATERIALS AND METHODS

Study Area

The study was conducted in Maryland, USA (Figure 1), where survey data were collected during extension field day programs focused on climate-resilient alley cropping (CRAC) practices. The field days, titled "Alley Cropping for Extreme Weather Variability and Higher Profitability," were held in August and September 2025 at demonstration sites in Somerset, Wicomico, Caroline, and Baltimore counties (Figure 1). These CRAC demonstration sites, established by the University of Maryland Eastern Shore (UMES) Extension, featured both on-farm and community garden demonstrations with fruit and nut trees grown alongside vegetables. The field day events were designed to showcase CRAC practices, facilitate experiential learning, and promote knowledge exchange among participants.

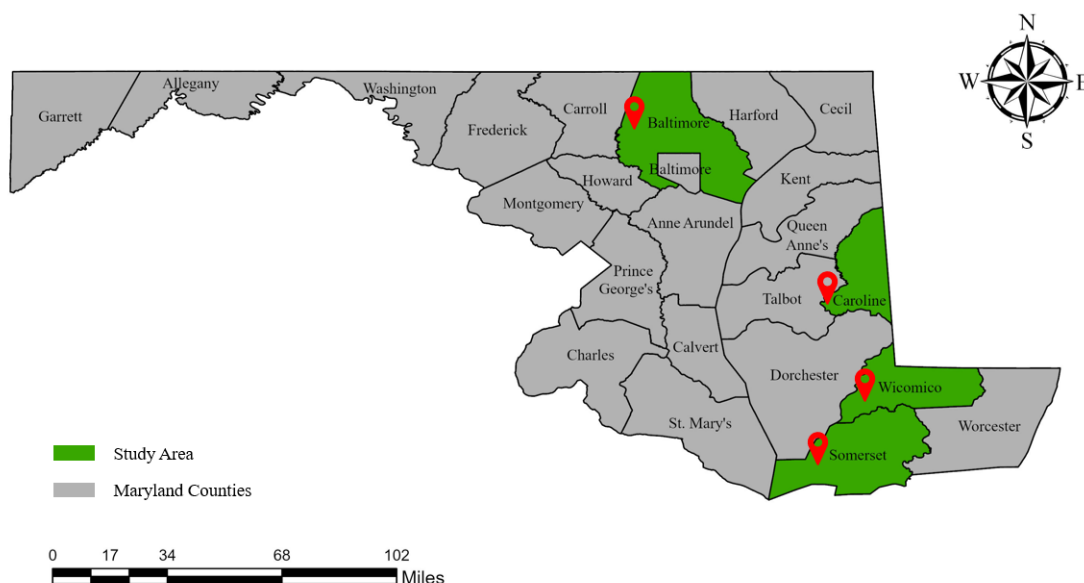


Figure 1: Map of Maryland showing counties included in the study

Data Collection

A self-administered, semi-structured survey instrument was used for data collection and was distributed to participants attending the climate-resilient field day events across all four counties of Maryland. The survey mainly consisted of closed-ended questions, including 5-point Likert-scale items and fixed-response options. It collected information on respondents' socio-demographic profile (age, gender, racial identity, level of education, and occupational status), familiarity with and perceptions of climate-resilient alley cropping, and satisfaction with the field day events. It also captured participants' self-reported willingness to share and apply the knowledge to introduce alley cropping practices. The survey was self-administered, meaning participants completed it independently without interviewer assistance. Respondents participated voluntarily and gave informed consent before receiving

the survey. Ethical approval for the study protocol was obtained from the Institutional Review Board (IRB) of the University of Maryland Eastern Shore (Protocol # 01-2026-003).

Data Analysis

A total of 93 responses were collected in person during the field-day events. The completed questionnaires were first reviewed for completeness and consistency before data entry into Microsoft Excel. Responses were then numerically coded (e.g., Likert-scale responses assigned values from 1 to 5). Of the 93 survey responses, only 54 were included in the regression analysis after records with missing values were removed to ensure accurate and reliable statistical results. In this study, two binary logistic regression analyses were conducted, each with a distinct behavioral outcome as the dependent variable.

Table 1: On-farm and community demonstration sites for survey data collection during field day events

Demonstration Sites	County	Row crops	Alley crops
On farm	Caroline	Fig	Asparagus, Bell peppers, Eggplants
	Somerset	Fig, Persimmon	Bell peppers, Tomato
		Pecan	Bell peppers, Eggplants, Cantaloupe, Squash
Community		Fig	Bell peppers, Eggplants, Okra, Squash, Tomato
	Wicomico	Chestnut	Bell peppers, Squash, Tomato
	Baltimore	Spinach	Pawpaw, Fig, Persimmon

The first model examined respondents' willingness to share, and the second measured their willingness to apply the knowledge they gained from the field day events. All dependent variables were coded as binary outcomes, with 1 indicating the highest level of willingness, and all other responses were coded as 0 to distinguish the highest level of willingness from all lower levels. This approach allowed the analysis to focus specifically on factors associated with the strongest and most definitive willingness, rather than combining full commitment with moderate or partial willingness.

Model specifications

Demographic characteristics

Age was coded as 1 for respondents younger than 35 years. All other participants, aged 35-45, 45-55, and 55+ years, were grouped and coded as 0 to serve as the reference group. Gender was coded as 1 for male respondents, with female respondents serving as the reference group. Respondents reported their race as White, Black or African American, or Asian. For analysis, White respondents were coded as 1, and all others were grouped as the reference category (0). Education was coded as 1 for respondents holding a graduate degree (master's or doctoral). Those without a graduate degree (bachelor's, associate, high school, middle school, or elementary education) were coded as 0 and served as the reference group. Occupation was coded as 1 for respondents whose primary occupation was farming, including farmers, beginning farmers, and entrepreneurs. All other respondents, including agricultural professionals, educators, students, and those in other non-farm occupations, were coded as 0 for the reference group.

Field-Day related factors

These variables were included to examine whether participants' field day experiences and perceived knowledge gains influenced their willingness. Two variables represented participants' field-day experience: overall satisfaction with the event and the level of knowledge gained. Responses indicating high satisfaction were coded as 1, representing the group with the strongest positive experience and a greater likelihood of translating that experience into behavioral outcomes. All remaining responses (satisfied, moderately satisfied,

and not at all satisfied) were grouped as the reference group. Similarly, post-event knowledge gain was coded as 1 for respondents who reported that their knowledge had increased significantly after the event, indicating a substantial improvement in understanding. Those who indicated increased, moderately increased, slight, or no changes were grouped as the reference group.

Data analysis was conducted in the following stages

- Data were coded and prepared for analysis. Responses were screened for completeness, and observations with missing values in key variables were removed using listwise deletion.
- Descriptive statistics and binary logistic regression were conducted on the complete-case sample ($N = 54$) to examine factors influencing farmers' willingness to share and apply knowledge to introduce climate-resilient alley cropping. Model results were interpreted using odds ratios.

Missing Values

The dataset contained a small number of missing responses across several key variables. In a few cases, respondents did not answer questions about adopting or expanding alley cropping on the farm without financial support. Responses marked "prefer not to answer" were also removed because they did not provide meaningful information for analysis. Ensuring accuracy and reliability was a key consideration in the study design; only complete cases ($N=54$) were included. Missing data can reduce statistical power and introduce bias in parameter estimates if not properly handled. Therefore, a complete-case (listwise deletion) approach was used to exclude observations with missing values. Listwise deletion is appropriate when the proportion of missing data is small, and missingness is assumed to be random. More advanced imputation methods were not applied in this study. Simple approaches, such as mean substitution, were avoided because they can underestimate variability and distort relationships among variables (Zhong *et al.*, 2018).

Descriptive Statistics

To better understand the analytical sample, summary statistics were computed for all variables in the regression

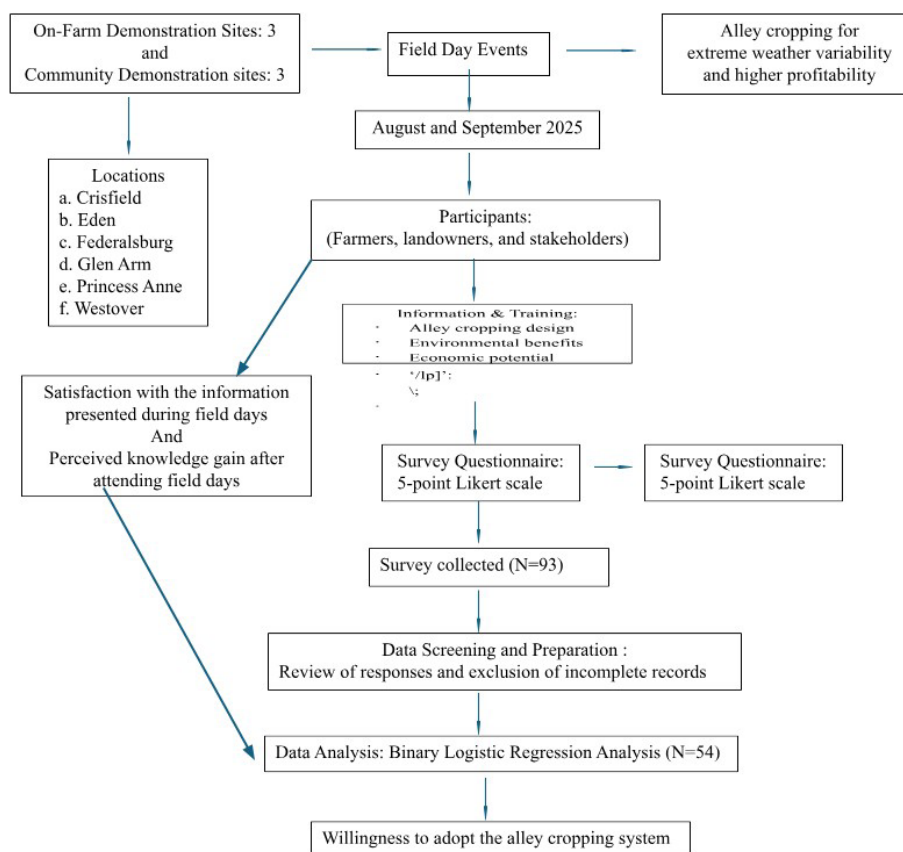


Figure 2: An analytical framework for survey data analysis to assess participants' willingness to adopt climate-resilient alley cropping

model. The analysis focused on respondents' socio-demographic background (age, gender, racial identity, educational attainment, and occupation), their familiarity with alley cropping, and key factors hypothesized to influence their willingness to adopt or expand climate-resilient alley cropping. The dataset was summarized using measures of frequency, proportion, central tendency, and standard deviation.

Measurement of variables

The study developed two logistic regression models that used the same set of independent variables but differed in the outcome variable examined.

- **Dependent variable:** The dependent variable in this study measured respondents' willingness to share the acquired knowledge with family members, relatives, friends, and their networks, and to apply the acquired knowledge to introduce and improve the climate resilience of alley cropping for fruits, vegetables, herbs, and shrubs/bushes.

- **Independent variables (explanatory or predictor):** As shown in Tables 4 and 5, these variables included socio-demographics and field-day-related factors (age, racial identity, educational attainment, occupation, and satisfaction with the information presented and knowledge level after attending), which were expected to influence respondents' willingness to adopt alley cropping. All variables were coded as binary indicators,

with 1 representing the category of interest and 0 the reference group.

Variance Inflation Factor (VIF)

The presence of multicollinearity among the predictor variables was detected by VIF, which ranged from 1.367 to 1.638 and fell well within acceptable limits. No evidence of multicollinearity was found in the model (Sarma *et al.*, 2022; Kamau *et al.*, 2024).

Regression Analysis (Binary Logistic Regression Model)

Factors affecting participants' willingness were determined by using regression analysis. This method is appropriate when the outcome variable has two categories (Hosmer *et al.*, 2013). Two models were estimated to assess both the unadjusted and adjusted effects of demographic characteristics and field-day-related factors on respondents' willingness outcome.

Model 1: Bivariate (Unadjusted) Model

It was first conducted to examine the relationships between each independent (predictor/ explanatory) variable and respondents' willingness to adopt climate-resilient alley cropping practices (binary outcome). The explanatory variables included the demographic profile (age/years, gender, racial background, education, and occupation), participants' satisfaction with the field day

events, and their knowledge level after attending them. Each predictor was entered into the logistic regression model separately, without controlling for other variables. By considering each variable independently, the results reflect each factor's direct influence on willingness. This approach helps identify variables that are significantly associated with willingness at the initial stage. The results provide a baseline understanding of these relationships before adjusting for other factors in the multivariate model.

Model 2: Multivariate (Adjusted) Model

Model 2 included all independent/predictor variables simultaneously to examine their effects on participants' willingness, while controlling for other factors. This approach provides a clearer understanding of each variable's independent contribution to the willingness outcome. Model performance was evaluated using McFadden's pseudo- R^2 , the model chi-square statistic, -2 Log Likelihood, and overall classification accuracy.

By expressing willingness in log-odds terms, the model allows us to identify factors that meaningfully increase or decrease the likelihood of knowledge sharing. Similar approaches have been used in agricultural studies examining farmers' willingness and adoption behaviors (Olurinde & Agboola, 2024; Song *et al.*, 2025). The logit transformation converts this probability into a continuous scale (log-odds), allowing it to be specified as a linear relationship with explanatory variables.

The logistic regression model used in this study is written as:

$$\text{logit}(Y = 1) = \ln \ln \left(\frac{p}{1-p} \right) \quad (i)$$

where:

logit($Y=1$): predicted value of the response variable in log-odds

ln: natural logarithm

p: probability that the respondent is extremely willing to share, or apply the knowledge gained during the field days ($Y=1$)

1-p: probability that the participant is not willing ($Y=0$) odds of being willing

$\left(\frac{p}{1-p} \right)$: odds of being willing

The logistic regression model is specified as:

$$\ln \ln \left(\frac{p}{1-p} \right) = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n \quad (ii)$$

where:

0= intercept

$\beta_1 \dots \beta_n$ = estimated regression coefficients (logit coefficients)

$X_1 \dots X_n$ = independent (explanatory) variables used

The model can also be written in probability form as:

$$p_i = \frac{\exp(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}{1 + \exp(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})} \quad (iii)$$

Coefficients are estimated using maximum likelihood, and the adjusted odds ratios ($\exp(\beta_j)$) show how each

predictor changes the odds of being extremely willing relative to the reference category. Higher odds ratios above one suggest factors that meaningfully increase willingness, while values below one indicate factors that reduce it (Salam *et al.*, 2024).

The fully adjusted models presented in Tables 3, and 4 can be written as:

$$\text{logit}(P(Y = 1)) = \beta_0 + \beta_1(\text{Age}) + \beta_2(\text{Gender}) + \beta_3(\text{Race}) + \beta_4(\text{Education}) + \beta_5(\text{Occupation}) + \beta_6(\text{Satisfaction}) + \beta_7(\text{Knowledge gain}) \dots \dots \dots (iv)$$

where:

Age: Respondent aged < 35 years (1 = yes, 0 = otherwise)

Gender: Male respondents (1 = male, 0 = female)

Race: White respondents (1 = yes, 0 = otherwise)

Education: Graduate-level education (1 = yes, 0 = otherwise)

Occupation: Farmer (1 = farmer, 0 = otherwise)

Satisfaction: Highly satisfied with the field day (1 = yes, 0 = otherwise)

Post-event knowledge: Self-reported knowledge increased significantly after the event (1 = yes, 0 = otherwise)

The estimated coefficients from the logistic regression model were transformed into log-odds form. To make them more interpretable, they were converted into odds ratios (OR) by exponentiation:

$$\text{Odds Ratio (OR)} = e^{\beta_i} \quad (v)$$

For easier interpretation, odds ratios are expressed in percentage change in odds:

$$\% \text{ change in odds} = (e^{\beta_i} - 1) \times 100 \quad (vi)$$

where β_i represents the estimated coefficient of the i th explanatory variable

The odds ratio (e^{β_i}) shows how the odds of a participant being "extremely willing" change when a predictor increases by one unit, while keeping all other variables unchanged. An odds ratio above 1 increases the likelihood of the outcome, while a value below 1 reduces it.

This modeling approach mirrors recent applied research using logistic regression to study willingness, adoption behavior, and decision-making among farmers and resource users (Ahmad *et al.*, 2023; Mishra, 2025; Bandi *et al.*, 2022). These studies employ the same logit specification to evaluate how demographic characteristics, awareness levels, and program experiences shape behavioral outcomes.

RESULTS AND DISCUSSION

Willingness to introduce/adopt the alley cropping practice

Table 2 summarizes the key descriptive statistics for all variables used in the regression analysis. Of the 54 respondents, 54% were male, and 46% were female. By age, 24.07% were younger than 35 years. Other age groups included 18.52% of respondents aged 35-45 years and 45-55 years. Likewise, 38.89% of total respondents were older than 55 years. Among the respondents, 22.22% identified as White, 27.78% as Black or African

American, and 50.00% as Asian. In terms of education, 61.11% had a graduate-level education (29.63% held a doctoral degree, and 31.48% had completed a master's degree. Regarding occupation, 31.48% of participants identified as farmers (16.67% as beginner farmers, 12.96% as farmers, and 1.85% as entrepreneurs). 59.26% reported high satisfaction, followed by Others (31.48% as

satisfied, 7.41% moderately satisfied, and 1.85% not at all satisfied). Regarding changes in knowledge following the field day, 44.44% reported an increase, 31.48% reported a significant increase, and 9.26% reported a moderate increase.

Tables 3 and 4 present the findings from bivariate and multivariate analyses using binary logistic regression to

Table 2: Summary statistics for the regression variables included in the analysis (based on 54 observations)

Variable	Descriptive statistics	
	Mean	SD
A. Dependent variable		
Willingness to Share Knowledge (Extremely willing=1)	0.61	0.49
Willingness to Apply Knowledge (Always=1)	0.56	0.50
B. Independent variables		
Socio-demographic characteristics		
Age (<35 years =1)	0.24	0.43
Gender (Male =1)	0.54	0.50
Race (White =1)	0.22	0.42
Education (Graduate =1)	0.61	0.49
Occupation (Farmer =1)	0.31	0.47
Field Day- Related Factors		
Satisfaction (Highly satisfied =1)	0.59	0.50
Post- event knowledge (Significantly increased=1)	0.37	0.49

Bivariate and multivariate results in willingness to share and apply acquired knowledge about climate-resilient alley cropping

examine participants' willingness to share and apply the knowledge gained from the alley cropping demonstration sites. Model 1 (bivariate model) assessed the association of each factor with respondents' willingness before controlling for other variables. It showed that the odds ratio of 9.29 ($p < 0.001$) indicates that highly satisfied participants were 9.29 times more likely to be willing to share what they learned

than those who were satisfied, moderately satisfied, or not at all satisfied. Similarly, respondents who reported that their knowledge significantly increased after the event were more likely to be willing (Odds Ratio = 4.00, $p < 0.05$). The odds ratio indicates that participants who experienced significant knowledge gains were about 4 times more likely to express willingness to share what they learned. The bivariate result showed that highly satisfied respondents were willing to share the knowledge they gained. However, it showed no evidence of a statistically meaningful association between

Table 3: Odds ratio from binary logistic regression assessing participants' willingness to share knowledge gained to introduce alley cropping (Sample size =54)

Independent Variables	Bivariate Model (Without adjustment)		Multivariable model (Fully adjusted)	
	Odds ratio	95% CI	Odds ratio	95% CI
Less than 35 years (yes=1)	1.59	0.44 - 6.67	3.36	0.55 - 28.47
Male (yes=1)	0.58	0.18 - 1.74	0.46	0.07 - 2.46
White (yes=1)	0.36	0.09 - 1.31	0.21	0.03 - 1.34
Graduate (yes=1)	0.95	0.30 - 2.90	0.30	0.04 - 1.57
Farmer (yes=1)	0.61	0.19 - 1.98	0.43	0.06 - 2.86
Highly satisfied (yes=1)	9.29***	2.77 - 35.46	16.13**	3.16 - 124.73
After the event, knowledge (Significantly increased=1)	4.00*	1.18 - 16.25	2.32	0.39 - 15.52
McFadden pseudo-R ²			0.33	
Model Chi- square (χ^2)			23.43**	
Degrees of freedom (df)			7	
-2 Log Likelihood (-2LL)			48.74	
Classification accuracy (%)			85.2	

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$, CI-Confidence Interval

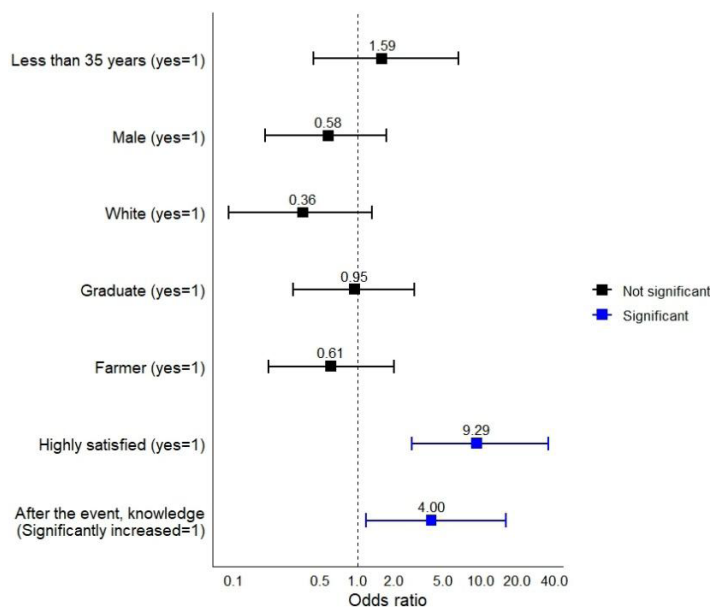


Figure 3: Forest plot of unadjusted odds ratios for factors influencing willingness to share knowledge to adopt alley cropping

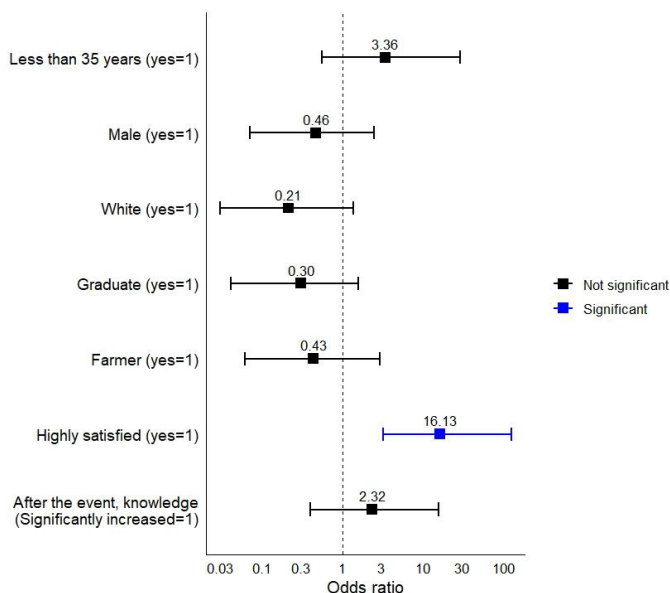


Figure 4: Forest plot of adjusted odds ratios for factors influencing willingness to share knowledge to adopt alley cropping

willingness and respondents' age, gender, race/ethnicity, education level, or occupational status, indicating that these demographic characteristics did not independently influence the outcome.

All independent variables were included in Model 2 (the fully adjusted model) to better understand how each factor contributed to willingness while controlling potential influencing factors. The chi-square statistic ($\chi^2 = 23.43$, $p < 0.01$) and McFadden pseudo-R-squared value of 0.3246 indicate a statistically significant, good model fit, in which the combined predictors improved the model's ability to explain respondents' willingness. The model had seven degrees of freedom, corresponding to the number of independent variables included. Likewise, the -2 Log Likelihood value was 48.74, and lower values indicate a better fit compared to a simpler

model. In addition, the classification accuracy of 85.2% among respondents suggests that the model performed well in predicting willingness based on the variables included. In the fully adjusted model, only highly satisfied participants (odds ratio: 16.13, CI: 3.16 - 124.73) with the demonstration sites were significantly more willing to share the knowledge. The odds ratio showed that they were 16 times more likely to be willing to share what they learned. However, demographics (age, gender, race, occupation, & education) and knowledge level did not significantly influence the willingness.

Figure 4. Forest plot of adjusted odds ratios for factors influencing willingness to share knowledge to adopt alley cropping

Figures 3 and 4 present forest plots showing the unadjusted and adjusted odds ratios from the regression

analysis of factors associated with willingness to share knowledge about the introduction of alley cropping. Odds ratios greater than 1 indicate higher willingness. Table 5 summarizes findings from the unadjusted

Table 4: Odds ratio from binary logistic regression assessing participants' willingness to share knowledge gained to introduce alley cropping (Sample size =54)

Independent Variables	Bivariate Model (Without adjustment)		Multivariable model (Fully adjusted)	
	Odds ratio	95% CI	Odds ratio	95% CI
Less than 35 years (yes=1)	0.61	0.17- 2.14	2.47	0.43 - 18.80
Male (yes=1)	1.31	0.44- 3.89	1.13	0.24 - 5.25
White (yes=1)	1.16	0.32- 4.47	1.58	0.28 - 10.31
Graduate (yes=1)	0.47	0.15- 1.44	0.26	0.04 - 1.17
Farmer (yes=1)	1.74	0.54- 5.97	1.11	0.20 - 6.43
Highly satisfied (yes=1)	8.00***	2.45- 29.54	6.87*	1.67 - 34.64
After the event, knowledge (Significantly increased=1)	5.71**	1.69- 23.39	4.23	0.88-3.35
McFadden pseudo-R ²			0.25	
Model Chi- square (χ^2)			18.74**	
Degrees of freedom (df)			7	
-2 Log Likelihood (-2LL)			55.46	
Classification accuracy (%)			74.07	

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$, CI-Confidence Interval

(bivariate) and fully adjusted logistic regression models, examining factors that affect respondents' willingness to apply the knowledge they gained to introduce and improve climate-resilient alley cropping systems. The bivariate model results demonstrate that two factors significantly affected respondents' willingness to apply the acquired knowledge. Those who were satisfied with the field day and those who perceived they gained knowledge after the event showed higher willingness. The odds ratio showed that highly satisfied participants (OR = 8.00, $p < 0.001$) were eight times more willing to apply the knowledge. Likewise, respondents who perceived a significantly increased knowledge level (OR = 5.71, $p < 0.01$) were five times more willing to apply the knowledge. However, socio-demographic information, like age, gender, race/ethnicity, educational level, and occupational status, had no statistically significant effect on participants' willingness in the bivariate logistic regression models.

In the fully adjusted model, where all predictors were evaluated together, only high satisfaction remained a significant predictor (OR = 6.87, $p < 0.05$). The odds ratio indicates that highly satisfied participants were six times more likely to apply the knowledge to introduce and improve climate-resilient alley cropping. Although participants who reported gaining knowledge had even higher odds of applying the information, this association did not reach statistical significance in the full model regarding willingness. Model fit statistics indicate that the fully adjusted logistic regression model performed well in explaining respondents' willingness to apply the acquired knowledge. The McFadden pseudo-R² of 0.2525 suggests that approximately 25% of the variation in willingness is explained by the predictors. The chi-

square statistic of 18.74 ($p < 0.01$) indicates a statistically significant improvement in fit compared to the null model. Additionally, the -2 Log Likelihood value of 55.46 and the classification accuracy of 74.07% further support that the model performed well in predicting participants' willingness. However, in both models, demographic background such as age, gender, racial identity, occupation, educational level, and perceived knowledge after the event did not significantly influence respondents' willingness to apply the knowledge. Overall, the regression model results highlight that satisfaction with the content presented during the field day plays a significant role in motivating participants to introduce and improve alley cropping.

Figure 6. Forest plot of adjusted (multivariate) odds ratios for factors influencing willingness to apply the acquired knowledge to introduce alley cropping

Figures 5 and 6 present forest plots showing the unadjusted and adjusted odds ratios from the regression analysis of factors associated with participants' willingness to apply knowledge to introduce alley cropping.

Overall, the study shows that the climate-resilient alley cropping field days effectively enhanced participants' willingness to share and apply the knowledge gained about climate-resilient alley cropping. Over half of survey participants (59.14%) reported a high level of satisfaction. The logistic regression analysis further showed that participant satisfaction was the strongest and only consistent predictor of both knowledge sharing and application after controlling for socio-demographic characteristics. Most respondents reported improved understanding of climate-resilient alley cropping after participating in the event, suggesting that field-

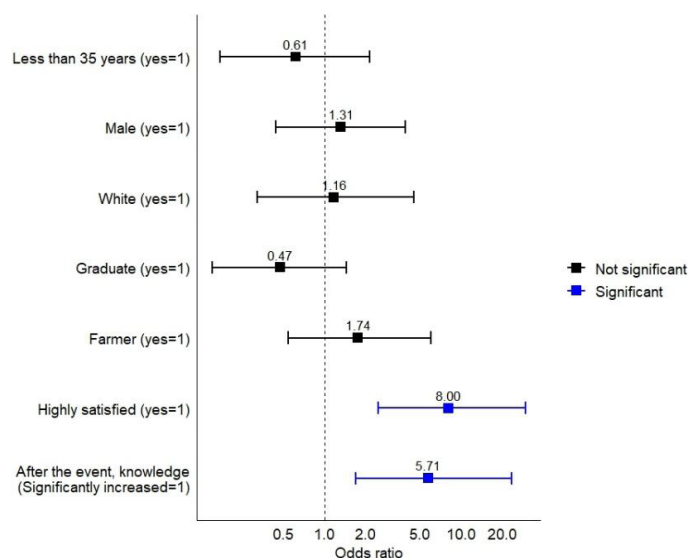


Figure 5: Forest plot of unadjusted (bivariate) odds ratios for factors influencing willingness to apply the acquired knowledge to introduce alley cropping

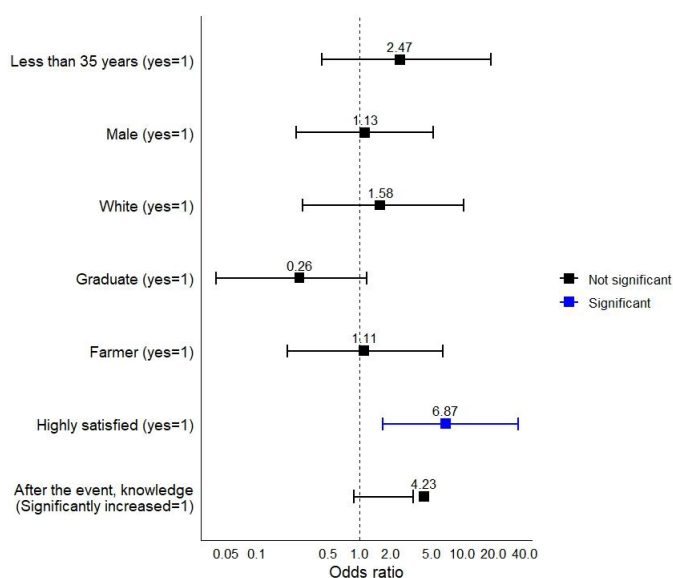


Figure 6: Forest plot of adjusted (multivariate) odds ratios for factors influencing willingness to apply the acquired knowledge to introduce alley cropping

based educational programs remain effective tools for transferring agricultural knowledge. Therefore, training extension personnel and intermediaries is highly important, as they deliver research-based knowledge to farmers at the local level (Mishra *et al.*, 2024). These findings align with previous studies identifying training programs, demonstrations, and experiential learning as important mechanisms for improving farmers' understanding of farm management practices (Hailu *et al.*, 2025; Mishra *et al.*, 2024). High participant satisfaction further indicates that field days can effectively engage producers and provide relevant information for decision-making. Similarly, Safdar *et al.* (2014) found that extension programs encourage better farming practices and that educational campaigns improve farmers' ability to address evolving environmental challenges. Likewise, Elias *et al.* (2016) highlighted that farmers' satisfaction with extension

services reflects how they perceive the extension services, whether the quality and usefulness meet expectations, address needs, and generate meaningful benefits. Overall, effective extension and community education programs can guide farmers toward better, more sustainable practices. Long-term impact occurs only when ideas are put into action (Pawar & Channaveer, 2025).

CONCLUSION

Climate-resilient alley cropping is attracting increasing attention as farmers seek practical ways to adapt to changing weather and improve the long-term sustainability of their farms. This study examined how extension field day events influenced participants' understanding, knowledge gains, and intentions related to climate-resilient alley cropping (CRAC) in Maryland. The findings indicate that the field day was effective in

improving participants' knowledge and generating high levels of satisfaction. Survey responses showed that participants left the field days with a better understanding of alley cropping and expressed a strong willingness to share and apply the knowledge gained, suggesting the potential for wider outreach of climate-resilient practices through community networks. Respondents generally perceived climate-resilient alley cropping as beneficial for improving farm productivity while promoting healthier soil, storing more carbon, and reducing emissions and chemical fertilizer use. At the same time, several barriers to adoption were identified, including high start-up costs, limited institutional support, inadequate technical knowledge, and insufficient extension assistance. Overall, the findings suggest that extension-based field day programs can play an important role in building awareness, strengthening positive perceptions, and encouraging the integration of climate-resilient alley cropping practices into farming systems. The findings of this study provide the basis for the following recommendations. Expand field days and demonstration activities to raise awareness and deepen practical understanding of climate-resilient alley cropping among farmers and landowners. Strengthen extension and technical assistance services to provide ongoing guidance and support for establishing and managing alley cropping systems. Promote farmer-to-farmer learning and community outreach activities to encourage knowledge sharing and wider dissemination.

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