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Research Article

Determinants of Smallholder Farmers' Adoption of Agro-Ecological Practices in Kersa and Mana Districts of Jimma Zone, Ethiopia

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Abstract

In order to achieve sustainable development, Ethiopian smallholder farmers are progressively implementing agro-ecological practices (AEPs); however, adoption remains uneven and restricted. To evaluate current AEP usage, identify its determinants, and analyze related constraints, this study was carried out in the Kersa and Mana districts of the Jimma Zone, using primary data from 200 households selected through multi-stage sampling, along with key informant interviews and focus group discussions, analyzed through descriptive statistics, a Multivariate Probit (MVP) model, and Kendall's coefficient of concordance. Descriptive results revealed adoption probabilities of 65% for agroforestry, 81% for crop rotation, 52% for mulching, 74% for intercropping, and 73% for composting, while the MVP model showed that education, age, livestock ownership, land area, input accessibility, and extension services positively influenced adoption, whereas sex, market accessibility, farming experience, and membership in farmer groups had a negative effect. Kendall's coefficient of concordance further identified high input costs as the most significant barrier to adoption, followed by other constraints. Based on these findings, enhancing farmer training programs, improving access to land and livestock resources, and reducing input costs through subsidies or financial aid emerge as key strategies through which governments can promote the adoption of agro-ecological practices and address the limitations identified.

Keywords

Kendall's Coefficient of Concordance, Technology Adoption, Multivariate Probit Model, Ethiopia, Agro-Ecological Practices

1. Introduction

In order to meet the demands of an expanding population while reducing environmental degradation brought on by excessive agrochemical use, land scarcity, and climate change, global food systems are under increasing pressure [10, 16, 20, 29, 31]. Improving food security and climate resilience in sub-Saharan Africa, where smallholder farmers are especially susceptible to these stressors, requires a transition to sustainable farming techniques [1, 3]. Widespread nutrient mining, soil degradation, and enduring poverty have resulted from continued reliance on conventional farming practices, which are marked by monoculture and inadequate soil nutrient replenishment [7, 20].

Land degradation, soil erosion, and climate variability also pose problems for Ethiopia's agricultural sector, which provides millions of people with their main source of income [6, 21]. Crop diversification, integrated crop-livestock systems,

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agroforestry, and soil/water conservation are some of the agroecological techniques being used to address these problems, but adoption is still inconsistent and situation-specific [21, 26, 32].

Limited access to land, water, labour, and financial resources are some of the major obstacles smallholder farmers must overcome in order to adopt these methods [24]. Agricultural decision-making is also significantly influenced by institutional contexts, household resource access, and economic diversification [18, 21].

Agroecology has the ability to improve climate resilience and restore soil fertility, but it is still not widely used in rural regions like the Jimma Zone [21, 27]. Due to resource scarcity, small land holdings, and output tradeoffs, farmers in this area frequently rely on traditional, unsustainable methods [8, 9, 14, 17, 21, 22, 28, 33] are just a few of the studies that have examined the factors that influence the adoption of particular practices like agroforestry, crop rotation, or conservation tillage in different regions of Ethiopia.

There are few thorough studies that examine the simultaneous adoption of many agroecological strategies, and there is still a conspicuous lack of geographic research on the Jimma Zone. This study closes these gaps and provides vital information for sustainable development and future agricultural policy by carefully investigating the technical and socioeconomic factors influencing smallholder farmers' adoption of various agroecological practices in the Jimma Zone, Oromia, Ethiopia.

2. Literature Review

2.1. Definition of the Term and Concepts

Agro ecology: is an integrated approach to food and agricultural system design and management that concurrently integrates ecological and social concepts and principles [12].

Agro-ecological practices: methods of farming that maximize the interactions between humans, animals, and plants while reducing the use of non-renewable external inputs by adopting ecological principles [25]. These include methods like crop rotation, composting, intercropping, including nitrogen-fixing trees, and using botanical extracts for pest management [30]. By preserving the complexity and multifunctionality of agricultural landscapes and increasing biodiversity and ecosystem services, agro-ecological techniques also aim to provide food [13].

2.2. Empirical Review

According to a different study, the adoption of agro-ecology is characterized by the peasant sector's strong sense of pride and the preservation of customs and traditions [4]. The factors limiting the implementation of agro ecological practices also vary depending on the practice; these factors include various perspectives on different socio-economic factors, demographic factors, institutional factors, and factors influencing the conditions that can support the wider adoption of agro ecological practices [21]. From demographic factors education and age have a negative influence on adoption of agro ecology [11]. Furthermore, according to a other study, farmers stated that a variety of restricting constraints make it extremely difficult to begin using some conventional and somewhat common agro ecological methods.

These elements include a lack of money, land, labor, and access to water [8]. Consequently, this deficiency in knowledge can lead to reluctance among farmers to engage with agro ecology [23]. In Ethiopia specifically, socio-economic barriers are among the most pressing challenges to implementing agro ecological practices. Many smallholder farmers face limited access to essential resources such as land, water, and capital, which are critical for adopting these sustainable practices. Studies have shown that shortages of money and labor significantly hinder farmers' ability to implement practices like intercropping and integrated pest management [5, 21].

3. Methodology

3.1. Description of the Study Area

The study was conducted in the Kersa and Manna districts of the Jimma Zone of Ethiopia. The districts are two of the 21 districts of the Jimma Zone. Kersa district is about 30 kilometers and Mana is about 20 kilometers away from Jimma City. The tropical climate in Kersa is hot and humid, with a mean annual temperature of 19.5 ℃. Nitosol and Orthic Acrisol soil types are common in Mana, which is diversified and includes the Dega, Woina Dega, and Kola agro-ecological zones. A cross-sectional design was used in the study. Multistage sampling procedure was employed to select districts, rural kebeles and households. In the first stage, with the consultation of developmental agents, two districts were selected purposively based on their diversity of agro-ecological practices. Second four kebeles also selected purposively from two districts.

That means two kebeles from mana namely Buture and Gube muleta and two kebeles from Kersa district namely Kitinbile and Tikur balto. In the third stage, households were selected by using simple random sampling technique based on their adoption of agro ecological practices from each kebeles. Finally, from the selected districts, 200 households were selected.

Yamane (1967) formula at 95% of confidence level, degree of variability = 5% and level of precision= 7%. This formula with 7% error margin was applied because it is impossible to collect data from the total population due to time and financial limitations as well as the difficulty in managing a large sample size.

Table 1. *Distributions of sample respondents in the districts and Kebeles.*

Districts	Sample kebeles	Total HHH	Proportion	Sample size
Kersa	Tikur Baltto	1125	27	54
	Kitinbile	1075	26	52
Mana	Buture	750	18	36
	Gube muleta	1220	29	58
Total		4170	100	200

Source: Own computation from survey data (2025).

3.2. Data Collection

Primary data were collected through structured questionnaires administered via face-to-face interviews by trained enumerators. Focus group discussions and key informant interviews with woreda agricultural experts and development agents supplemented the household survey. Secondary data were obtained from published documents, and reports.

3.3. Econometric Models

MVP model was used to identify determinants that are likely to influence farmers' adoption of different agro ecological practices. MVP model was selected with the justification that the agro ecological practices themselves and the unobserved error terms might depend on each other and that a household may adopt more than one practice [19].

According to Greene [15], the MVP regression model is specified as:

Model Specification

j=1, 2,., m

Where:

1) (j=Y1, Y2, Y3, Y4 and Y5) denotes the AEPs available
2) *Ynpj* is a binary dependent variable indicating the adoption of the *jth* agro ecological practice (AEP), taking a value of 1 if Ynpj>0 and 0 otherwise.
3) *Xnpj* is a vector of explanatory variables that influence the adoption decision for the *jth* practice.
4) Bj*β j* represents the coefficients associated with each explanatory variable for the *jth* agro ecological practice.
5) *Unpj* is the error term capturing unobserved factors affecting the adoption decision.

4. Results and Discussions

4.1. Descriptive Statistical Analysis

4.1.1. Socio-Economic, Demographic, and Institutional Characteristics of Farmers Across Agro Ecological Practices

Table 2 illustrates how different agro ecological practices have been adopted at varying rates by families in the study area. 82%, 74.5%, 74%, 65.5%, and 53% of the households surveyed practice crop rotation, intercropping, composting, and agroforestry, respectively. The majority of families are aware of the advantages of crop rotation, intercropping, and composting in terms of enhancing soil health, controlling pests, and increase productivity. Despite its relatively low adoption rate, which may be attributed to land or knowledge limitations, agroforestry is also rather common, indicating an understanding of its contributions to biodiversity and climate resilience. Mulching is the activity that is least used, which could be because of labor needs, restricted material availability, or a lack of knowledge about its benefits. Agro ecological methods are generally respected, but their uptake is contingent on accessibility, available resources, and the speed at which benefits are recognized, as these adoption patterns demonstrate.

Table 2. *Participation of farmers in adopting agro ecological practices.*

Agro-ecological practices	Items	Frequency	Percentage
Agroforestry	Yes	131	65.5
	No	69	34.5
Intercropping	Yes	149	74.5

Agro-ecological practices	Items	Frequency	Percentage
	No	51	25.5
Composting	Yes	148	74
	No	52	26
Crop rotation	Yes	164	82
	No	36	18
Mulching	Yes	106	53
	No	94	47

Source: Own computation from survey result, 2025

The relationship between the continuous variables and the respondent's participation in adopting agro ecological practices at probability levels were thereby shown in Table 3.

Education level: The sample respondent's average overall education level was 6.01 grades (schooling years). The agroforestry adopters and non-adopters' average education level was 8.3 and 2.5 schooling years. These differences suggest an association between education level and the adoption of certain agro-ecological practices.

Age: The sample respondent average age was 45.03 years. The average age of agroforestry adopters and non-adopters was 46.9 and 41 years. These finding shows the age of the farmers were younger in adopting agroforestry.

Tropical Livestock Unit: The sample respondent's total average of tropical livestock units was 3.26 TLU. Composting adopters and non-adopters had 3.9 and 2.0 TLU. From this result the adoption of composting had more amounts of livestock because composting practice depends on the wastes of animals.

Farming land: The sample respondent's average farming land was 1.26 hectare. From this result agroforestry and mulching had more land size.

Farming Experience: The sample respondents' average farming experience was 9.08 years. This result shows agroforestry and crop rotation adopters had more farming experiences than others. Finally, Table 3 the t-test indicated a statistically significant and insignificant difference between adopters and non-adopters of agro ecological practices.

Table 3. *Summary statistics of household characteristics (continuous variables).*

Continuous Variables	Agroforestry Adopter	Non Adopter	t-value	Intercropping Adopter	Non Adopter	t-value	Composting Adopter	Non Adopter	t-value	Crop rotation Adopter	Non adopter	t-value	Mulching Adopter	Non-adopter	t-value
	N=131	N=69		N=149	N=51		N=148	N=52		N=164	N=36		N=106	N=94	
Edu-level	8.3	2.5	-13.7***	6.4	6.1	-0.39	6.3	6.1	-0.2	6.5	5.4	-1.4	6.4	6.1	-0.4
AE	6.5	6.3	-0.4	6.6	6.0	-1.5	6.5	6.4	-0.3	6.6	6.1	-1.0	6.4	6.6	0.6
Age	46.9	41	-3.5***	44.8	45.3	0.3	44.5	46.2	0.9	44.4	47.3	-1.3	44.4	45.5	0.6
TLU	3.3	3.6	1.2	3.5	3.0	-1.4	3.9	2.0	-6.7***	3.4	3.1	-1.0	3.41	3.43	0.07
Lan_hac	1.3	1.1	-1.2	1.25	1.26	0.06	1.3	1.0	-2.5***	1.26	1.22	-0.2	1.4	1.2	-1.9**
Farming experience	9.2	8.9	-0.7	9.1	9.0	-0.2	8.9	9.5	1.8*	9.1	8.9	-0.4	9.0	9.2	0.6

*, **, and *** means significant at 10%, 5% and 1% probability levels,
Source: Own computation from survey data, 2025.

4.1.2. Description of the Dummy Explanatory Variables

The distribution of the categorical variables related to agro ecological practices adopters and non-adopters and their difference in proportion across adopters and non-adopters were tested by using the chi-square test.

Table 4. Demographic and institutional characteristics of adopters and non- adopters of different agro-ecological practices (dummy variables).

Dummy variables	Agroforestry					Intercropping					Composting					Crop rotation					Mulching					
	Adopter		Non-adopter X^2			Adopter		Non-adopter X^2			Adopter		Non-adopter X^2			Adopter		Non-adopter X^2			Adopter		Non-adopter X^2			
	N=131		N=69			N=149		N=51			N=148		N=52			N=164		N=36			N=106		N=94			
	Items	N	%	N	%		N	%	N	%		N	%	N	%		N	%	N	%		N	%	N	%	
Sex	M	70	53.4	42	60.8	1.01	86	57.7	26	50.9	0.7	85	57.4	27	51.9	0.47	87	53	25	69.4	3.22*	57	53.8	55	58.5	0.45
	F	61	46.6	27	39.2		63	42.3	25	49.0		63	42.6	25	48		77	46.9	11	30.6		49	46	39	41	
Acc. Market	Yes	103	78.6	53	76.8	0.08	116	77.9	40	78.4	0.007	115	77.7	41	78.8	0.03	125	76.2	31	86.1	1.68	77	72.6	79	84	3.77*
	No	28	21.4	16	23.2		33	22.1	11	21.6		33	22.3	11	21.2		39	23.8	5	13.9		29	27.4	15	16	
Acc. Credit	Yes	31	23.7	23	33.3	2.1	42	28.2	12	23.5	0.41	44	29.7	10	19.2	2.15	43	26.2	11	30.6	0.28	29	27.4	25	26.6	0.01
	No	100	76.3	46	66.7		107	71.8	39	76.5		104	70.3	42	80.8		121	73.8	25	69		77	72.6	69	73.4	
InpuAva	Yes	14	10.7	10	14.5	0.61	22	14.8	2	3.9	4.23	15	10.1	9	17.3	1.87	22	13.4	2	5.6	1.72	10	9.4	14	14.9	1.4
	No	117	89.3	59	85.5		127	85.2	49	96.1	**	133	89.9	43	82.7		142	86.6	34	94.4		96	90.6	80	85.1	
Exten_s	Yes	85	64.9	38	55.1	1.83	92	61.7	31	60.8	0.01	88	59.5	35	67.3	1.00	106	64.6	17	47.2	3.77*	70	66	53	56.4	1.96
	No	46	35.1	31	44.9		57	38.3	20	39.2		60	40.5	17	32.7		58	35.4	19	52.8		36	34	41	43.6	
Farmers_G	Yes	25	19.1	15	21.7	0.19	30	20.1	10	19.6	0.01	28	18.9	12	23.1	0.41	34	20.7	6	16.7	0.30	17	16.1	23	24.5	2.21
	No	106	80.9	54	78.3		119	79.9	41	80.4		120	81.1	40	76.9		130	79.3	30	83.3		89	83.9	71	75.5	

Source: own computation from survey result, 2025.

4.2. Econometric Results

This section presents the results of multivariate probit, which was used to analyze factors that affecting the adoption of different agro ecological practices.

4.2.1. Factors Affecting the Adoption of Different Agro Ecological Practices

This study employed a multivariate probit model to analyze factors affecting the adoption of different agro ecological practices. The overall significance of the variables was tested by using the Wald chi-square statistics. Table 6 shows that the Wald-chi2 (70) = 165.05, p=0.0000 is strongly significant at 1% significance level, suggesting that the model components have adequate explanatory power. The null hypothesis of independence between the agro ecological practices (rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0) was rejected at 10% significant level according to the simulated maximum likelihood ratio test (LR chi2 (10) =24.1494 (Prob > chi2 = 0.0072*). Consequently, the null hypothesis which states that all of the ρ (Rho) values are collectively equal to 0 is rejected demonstrating the goodness-of fit model. The choice MVP over the individual probit model was supported by the decisions to practice in many agro ecological practices being interdependent.

MVP showed the correlation between agro ecological practices. The correlation between intercropping and agroforestry (ρ21) were negatively correlated. Composting and agroforestry (ρ31) were positively correlated. Crop rotation and agroforestry (ρ41) were positively correlated. Likewise, mulching and agroforestry (ρ51) were positively correlated. Composting and intercropping (ρ32) were negatively correlated. Crop rotation and intercropping (ρ42) were positively and significantly correlated at 1%. Mulching and intercropping (ρ52) were negatively correlated. Crop rotation and composting (ρ43) were positively correlated. Mulching and composting (ρ53) were negatively and significantly correlated at 5%. Mulching and crop rotation (ρ54) were positively correlated. Based on the multivariate probit model findings, the probability of households in adopting agroforestry, intercropping, composting, crop rotation and mulching was 65%, 74%, 73%, 81% and 52% respectively. The joint probability of adopting agro ecological practice indicates households were more likely to adopt agro ecological practices compared with non-adopter when considering the combined probabilities of success (15.45%) and failure (0.35%) of practicing decisions.

4.2.2. Correlation Matrix of Independent Variables

Examining the relationships between the independent variables is crucial before estimating the Multivariate Probit (MVP) model in order to look for any potential multicollinearity, which could compromise the accuracy of model estimates. The correlation matrix for the explanatory variables that are part of the MVP model is shown in Table 6. The pairwise correlation coefficients between the independent variables are typically low to moderate, as indicated in Table 6, with no coefficients rising above the universally recognized cutoff point of 0.7. This suggests that all variables were kept for additional modeling and that multicollinearity is not a significant issue in this investigation. The fact that there are no strong connections indicates that the independent variables offer unique insights into the adoption of agro-ecological methods.

***Table 5**. Correlation Matrix, Overall Fitness, and Predicted Probabilities from the Multivariate Probit (MVP) Model.*

Practice	**Predicted Probability**	**ρ1**	**ρ2**	**ρ3**	**ρ4**	**ρ5**
Agroforestry (ρ1)	0.65	1.00	-0.223 (0.162)	0.023 (0.178)	0.077 (0.182)	0.001 (0.147)
Intercropping (ρ2)	0.74	-0.223 (0.162)	1.00	-0.054 (0.144)	0.555*** (0.114)	-0.033 (0.128)
Compost (ρ3)	0.73	0.023 (0.178)	-0.054 (0.144)	1.00	0.014 (0.174)	-0.254** (0.121)
Crop rotation (ρ4)	0.81	0.077 (0.182)	0.555*** (0.114)	0.014 (0.174)	1.00	0.033 (0.120)
Mulching (ρ5)	0.52	0.001 (0.147)	-0.033 (0.128)	-0.254** (0.121)	0.033 (0.120)	1.00
Joint probability (success)	0.1545					
Joint probability (failure)	0.0035					
Number of draws	5					
Observations	200					
Log likelihood	-450.02213					
Wald chi2 (70)	165.05					
Prob > chi2	0.0000***					

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: chi2 (10) = 24.1494 Prob > chi2 = 0.0072*

Note: ***, *, * indicate statistical significance at 1%, 5%, and 10% respectively, Parenthesis in the disturbance term correlation matrix showed the standard error

Source: Own computation from survey result, 2025.

Table 6 illustrates that thirteen independent variables were incorporated into the multivariate Probit model to analyze factors that influence adoption of different agro ecological practices from those, three variables significantly affected the adoption of agroforestry, two variables significantly affected the practices of intercropping, three variables significantly affected the practice of crop rotation and four variables significantly affect mulching at different significance level.

Table 6. Results of MVP models of factor affecting smallholder farmers' choice of agro- ecological practices.

Variables	Agroforestry		Intercropping		Compost		Crop Rotation		Mulching	
	Coef. (Std. Err)	(dy/dx)	Coef. (Std. Err)	(dy/dx)	Coef. (Std. Err)	(dy/dx)	Coef. (Std. Err)	(dy/dx)	Coef. (Std. Err)	(dy/dx)
Sex	-0.307 (0.266)	-0.053	0.132 (0.210)	0.039	0.195 (0.239)	0.044	-0.432* (0.234)	-0.109	-0.077 (0.194)	-0.028
Education level	0.309*** (0.039)	0.055	0.016 (0.027)	0.004	0.014 (0.030)	0.004	0.037 (0.029)	0.008	0.011 (0.024)	0.004
AE	-0.012 (0.061)	-0.004	0.086* (0.047)	0.024	-0.074 (0.053)	-0.017	0.071 (0.051)	0.016	-0.047 (0.043)	-0.016
Age	0.043*** (0.014)	0.008	-0.008 (0.010)	-0.003	-0.022** (0.011)	-0.005	-0.021* (0.011)	-0.004	-0.010 (0.009)	-0.004
Martial-status	-0.379 (0.322)	-0.066	-0.183 (0.297)	-0.051	0.044 (0.387)	-0.005	-0.228 (0.303)	-0.059	0.453 (0.300)	0.177
Professional-training	0.077 (0.263)	0.013	0.026 (0.212)	0.011	0.042 (0.244)	0.007	0.290 (0.234)	0.071	-0.127 (0.195)	-0.036
Total live-stock unit	-0.167** (0.073)	-0.031	0.090 (0.058)	0.026	0.502*** (0.092)	0.116	0.106 (0.066)	0.024	-0.015 (0.052)	-0.004
Land size in hectare	0.093 (0.195)	0.017	-0.105 (0.157)	-0.032	0.271 (0.189)	0.061	-0.097 (0.182)	-0.016	0.312** (0.146)	0.116
Input-availa-bility	0.364 (0.420)	0.060	0.945** (0.414)	0.289	-0.195 (0.372)	-0.050	0.813** (0.429)	0.182	-0.330 (0.308)	-0.123
Market-avail-ability	0.067 (0.313)	0.013	0.005 (0.242)	0.003	-0.094 (0.268)	-0.027	-0.518* (0.313)	-0.133	-0.478** (0.229)	-0.167
Credit-access	-0.430 (0.312)	-0.074	-0.009 (0.244)	0.004	0.309 (0.283)	0.079	-0.183 (0.260)	-0.043	0.124 (0.224)	0.037
Farming Ex-perience	0.054 (0.068)	0.010	-0.005 (0.048)	-0.000	-0.091* (0.051)	-0.021	0.043 (0.052)	0.011	0.004 (0.044)	0.000
Extension-service	0.373 (0.281)	0.061	0.044 (0.218)	0.015	-0.189 (0.252)	-0.047	0.474** (0.234)	0.107	0.340* (0.202)	0.127
Farmers-group	-0.293 (0.341)	-0.052	0.097 (0.268)	0.020	-0.030 (0.287)	0.000	-0.074 (0.317)	-0.001	-0.481** (0.251)	-0.186
_constant	-2.436 (1.204)		0.403 (0.909)		1.027 (1.130)		1.319 (0.970)		-0.170 (0.873)	

Note: ***, **, and * indicate statistical significance at 1, 5, and 10%, respectively.
Source: Own computation from survey result, 2025

Sex: The farmer's decision to practice crop rotation was negatively and significantly affected by sex of the household head at 10% significance level. This finding implied that male-headed households were more likely to adopt crop rotation than female headed households. The marginal effect showed that when the household head is female, the probability of the household adopting crop rotation was decreased by 10.9% all other variables constant. This suggests a gender disparity in crop rotation practices, where male farmers may have better access to resources, information, or decision-making power that facilitates the adoption of practicing crop rotation.

Education level: The probability of adopting agroforestry, positively and significantly influenced by the education level of household head at 1% significance level. As the education level of household head's increase by one year of formal schooling, the likelihood of adopting an agroforestry practice increases by 5.5%.

Family size: It had a positive and significant influence on the likelihood of a household participating in practicing intercropping at 10% significance level. Larger families often associated with larger landholdings or higher income is more likely to practice intercropping due to their increased labor availability than small families in the study area. Marginal effects indicate that the probability of household who practice intercropping increases by 2.4%, as the family size increases by one adult equivalent.

Age: The age of the household head had positive and significant effects on the probability of household in practicing agroforestry at a 1% significance level. This finding suggests that the probability of household practice agroforestry with the age of the farmer increase because younger farmers more openness to adopt new technology and receptive to adopting new practices than older farmers.

TLU: Tropical livestock unit negatively and significantly influenced the probability of households to adopt agroforestry at 5% significance level. This implies that farmers who have higher tropical livestock units were less likely to adopt agroforestry in the study area. As the TLU of the household increased by one, the probability of adopting an agroforestry decreases by 3.1%.

Access to land: land in hectare had positive and significantly influenced the probability of households to adopt mulching at 5% significance level. This implies that farmers who have much land size were more likely to adopt mulching in the study area. As the land size of the household increased by one hectare, the probability of adopting mulching increases by 11.6% [2].

Access to Input: It had a positive and significance influence on the likelihood of a household in practicing intercropping at 5% significance level. Having access to input is essential for adopting intercropping in the study area. The marginal effect implies that, as household has access to input the probability of household in adopting intercropping increases by 28.9%.

Access to Market: It had a negative and significance influence on the likelihood of a household in practicing crop rotation at 10% significance level. This implies that the household who had access to market was less likely to adopt crop rotation.

Farming experience: farming experiences had a negative and significance influence on the likelihood of households in the adoption of composting at 10% significance level. The marginal effect of farming experience implied that the probability of household practicing composting decreased by 2.1% as farmers experience increased. This result supported by the finding of Corbeels *et al*. (2015).

Access to extension contact: The probability of household in adopting crop rotation had positively and significantly influenced by access to extension contact at significance level of 5%. Access to extension contact implies that farmers who frequently contact with extension agents in adopting crop rotation.

Farmers Association: it had negative and significance influence on the likelihood of a household in practicing mulching at 5% significance level. This implies that the household who was a member of farmers association less likely to adopt mulching. The marginal effect of member of farmers association implied that the probability of household who practice mulching decreases by 18.6%. The result of this is consistent with the finding of Mebrate *et al*. (2022).

4.3. Constraints and Opportunities of Adopting Different Agro Ecological Practices

4.3.1. Constraints of Adopting Agro Ecological Practices

Table 7 shows the result of the Kendall's coefficient of concordance, which was 0.676 (67.6%). Hence, the result shows that the respondents were in agreement with each other on the ranking of the constraints in the study area. Therefore, we rejected the null hypothesis (H_o), which states that there was no agreement among the respondents over the ranking of the constraints of adopting different agro-ecological practices. For this reason, H_1 was accepted and there was agreement among the respondents on the ranking of the constraints. So, the main constraints put into the following orders based on the identification and rankings by the sampled respondents. From the given constraints high input cost is the the biggest challenge to adopt different agroecological practices.

Table 7. *Ranking constraints in adopting agro ecological practices.*

Constraints	Mean rank	Overall rank
High input cost	1.16	1^{st}
Lack of training program	2.43	2^{nd}
Lack of livestock	3.80	3rd
Lack of farm land	4.35	4^{th}
Transportation problem	4.50	5^{th}
Lack of credit access	5.57	6^{th}
Lack of labor force	6.21	7^{th}

Source: Own computation from survey result, 2025

4.3.2. Opportunities of Adopting Agro Ecological Practices

According to FGD and KII, there are numerous opportunities. Agro-ecological practices in Ethiopia not only improve farmer livestock and crop production but also provide certain family members, especially women and children to job opportunities. In addition to this agro-ecological practices have the following benefits.

Practices like crop rotation, composting and intercropping are pivotal as they enhance soil health and fertility. These methods not only reduce farmers' dependence on chemical fertilizers but also promote biodiversity, which leads to a more sustainable utilization of natural resources. During focus group discussions (FGD), farmers who have adopted various agro ecological practices noted that when comparing these methods to reliance on chemical fertilizers, agro ecological practices often yield higher outputs. This observation underscores the effectiveness of sustainable practices in improving agricultural productivity.

Agro ecological practices further promote biodiversity by integrating a variety of crops and plant species, which leads to more stable and productive ecosystems. Such diversity reduces the likelihood of pest outbreaks and supports pollinator populations, thereby enhancing overall agricultural productivity. Economically, these practices lower production costs by minimizing the need for synthetic fertilizers and pesticides.

In general, adopting agro ecological practices involves learning new techniques and applying scientific knowledge, empowering farmers with the skills necessary to improve both their farming practices and livelihoods. The integration of these sustainable resource management strategies not only supports environmental health but also promotes economic viability and social cohesion among farming communities. According to 56% of respondents agro ecological practices especially the practice of composting enhances soil health.

From the survey result, 44% of respondents said that crop rotation is the best practice for higher crop yields. Crop rotation breaks the cycles of pests and diseases, balances the nutrients in the soil, and increases farm productivity overall. For preserving soil health and yield stability over the long run, this method works especially well.

40% of respondents highlighted water saving by mulching. Mulching decreases evaporation, preserves soil moisture, and improves water-use efficiency.

Table 8. *Shows the benefits of agro ecological practices mentioned by respondents'.*

Opportunities of agro ecological practices	Frequency	Percentage
Improved Soil Health	112	56%
Enhanced Biodiversity	120	60%
Reduced Fertilizer Costs	100	50%
Increased Crop Yields	88	44%
Water Conservation	80	40%

Source: Own computation from survey result, 2025

5. Conclusions and Recommendations

The factors influencing the adoption of agro-ecological practices among 200 smallholder households in Ethiopia's Kersa and Mana districts were evaluated in this study. The study discovered that conventional practices like crop rotation, intercropping, and agroforestry greatly increase soil fertility and yields using a Multivariate Probit model and qualitative data.

High input costs, restricted market access, and labour shortages are obstacles to adoption, while variables like education, family size, livestock ownership, and access to extension services are motivators. The study notably shows that families headed by women and those without institutional assistance are much less likely to implement these sustainable practices.

In conclusion, socioeconomic and institutional inequalities impede the adoption of agro-ecology, despite its critical role in improving livelihoods and environmental sustainability.

Expanding educational and extension programs, guaranteeing steady access to agricultural inputs, and fortifying farmer organisations must be the top priorities of policy interventions in order to encourage broader adoption. Furthermore, targeted efforts are required to empower women and optimize labor management, which will help overcome key structural barriers and foster more resilient, sustainable agricultural development in the region.

Abbreviations

AE	Adult Equivalent
AEP	Agro Ecological Practice
AEPS	Agro Ecological Practices
FGD	Focus Group Discussion
KII	Key Information Interview
LR	Likelihood Ration
MUP	Multivariate Probit
TLU	Tropical Liverstock Unit

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Akanmu AO, Akol AM, Ndolo DO, Kutu FR, Babalola OO. Agroecological techniques: adoption of safe and sustainable agricultural practices among the smallholder farmers in Africa. Frontiers in Sustainable Food Systems. 2023 May 22; 7: 1143061. https://doi.org/10.3389/fsufs.2023.1143061

[2] Alkhtib A, Wamatu J, Kassie G, Rischkowsky B. Determinants of farmers' decision on utilizing cereal and legume residue as feed and soil mulch in the Ethiopian highlands. https://hdl.handle.net/20.500.11766/6246

[3] Altieri MA, Nicholls CI, Henao A, Lana MA. Agroecology and the design of climate change-resilient farming systems: MA Altieri et al. Agronomy for sustainable development. 2015 Jul; 35(3): 869-90.

[4] Atasoy Y. Commodification of global agrifood systems and agro-ecology: Convergence, divergence and beyond in Turkey. Taylor & Francis; 2017 May 18.

[5] Autio A, Johansson T, Motaroki L, Minoia P, Pellikka P. Constraints for adopting climate-smart agricultural practices among smallholder farmers in Southeast Kenya. Agricultural Systems. 2021 Dec 1; 194: 103284. https://doi.org/10.1016/j.agsy.2021.103284

[6] Barbier EB, Hochard JP. Land degradation and poverty. Nature Sustainability. 2018 Nov; 1(11): 623-31.

[7] Bedeke SB. Climate change vulnerability and adaptation of crop producers in sub-Saharan Africa: a review on concepts, approaches and methods. Environment, development and sustainability. 2023 Feb; 25(2): 1017-51.

[8] Bekele B, Yeshiwas E, Zewde A. Determinants of the agroforestry practices in Mana districts, Oromyia Region, Ethiopia. https://doi.org/10.21203/rs.3.rs-2567727/v1

[9] Beyene AD, Mekonnen A, Randall B, Deribe R. Household level determinants of agroforestry practices adoption in rural Ethiopia. Forests, Trees and Livelihoods. 2019 Jul 3; 28(3): 194-213.

[10] Bhandari S, Yadav B, Yadav PK, Lahutiya V, Koirala S. Exploring agroecological approaches for sustainable agriculture and rural development: A comprehensive. Asian Journal of Research in Agriculture and Forestry. 2024; 10(1): 79-90. https://www.sdiarticle5.com/review-history/113459

[11] Coulibaly A, Motelica-Heino M, Hien E. Determinants of agroecological practices adoption in the Sudano-Sahelian zone. Journal of Environmental Protection. 2019 Jul 3; 10(7): 900-18. http://www.scirp.org/journal/jep

[12] Bicksler AJ, Mottet A, Lucantoni D, Sy MR, Barrios E. The 10 Elements of Agroecology interconnected: Making them operational in FAO's work on agroecology. Elem Sci Anth. 2023 Apr 19; 11(1): 00041. https://doi.org/10.1525/elementa.2022.00041

[13] Gaba S, Alignier A, Aviron S, Barot S, Blouin M, Hedde M, Jabot F, Vergnes A, Bonis A, Bonthoux S, Bourgeois B. Ecology for sustainable and multifunctional agriculture. InSustainable Agriculture Reviews 28: Ecology for Agriculture 2018 May 17 (pp. 1-46). Cham: Springer International Publishing.

[14] Gebru BM, Wang SW, Kim SJ, Lee WK. Socio-ecological niche and factors affecting agroforestry practice adoption in different agroecologies of southern Tigray, Ethiopia. Sustainability. 2019 Jul 8; 11(13): 3729. https://doi.org/10.3390/su11133729

[15] Greene W. Convenient estimators for the panel probit model: Further results. Empirical Economics. 2004 Jan; 29(1): 21-47.

[16] Hossain A, Krupnik TJ, Timsina J, Mahboob MG, Chaki AK, Farooq M, Bhatt R, Fahad S, Hasanuzzaman M. Agricultural land degradation: processes and problems undermining future food security. InEnvironment, climate, plant and vegetation growth 2020 Oct 6 (pp. 17-61). Cham: Springer International Publishing.

[17] Ketema M, Bauer S. Factors affecting intercropping and conservation tillage practices in eastern Ethiopia. Agris on-line Papers in Economics and Informatics. 2012; 4(1): 21-9. https://doi.org/10.22004/ag.econ.131354

[18] Kuivanen KS, Alvarez S, Michalscheck M, Adjei-Nsiah S, Descheemaeker K, Mellon-Bedi S, Groot JC. Characterising the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. NJAS: Wageningen Journal of Life Sciences. 2016 Sep 1; 78(1): 153-66.

[19] Li J, Zhang W, Zhu D, Feng Z, He Z, Yue Q, Huang Z. Evaluation of driver demand for in-vehicle information: An integrated method combining clustering and multivariate ordered probit model. Journal of safety research. 2023 Jun 1; 85: 222-33. https://doi.org/10.1016/j.jsr.2023.02.006

[20] Lianu C, Simion VE, Urdes L, Bucea-Manea-Țoniș R, Radulescu IG, Lianu C. Agroecological approaches in the context of innovation hubs. Sustainability. 2023 Feb 28; 15(5): 4335. https://doi.org/10.3390/su15054335

[21] Mekuria W, Dessalegn M, Amare D, Belay B, Getnet B, Girma G, Tegegne D. Factors influencing the implementation of agroecological practices: Lessons drawn from the Aba-Garima watershed, Ethiopia. Frontiers in Environmental Science. 2022 Sep 26; 10: 965408.

[22] Mengistu F, Chala F, Tesfaye B. The State of Conservation Agriculture Practices in Jimma and Illu-Ababora Zones of Oromia Region, Ethiopia. Ethiopian Journal of Applied Science and Technology. 2019; 10(2): 11-21. https://journals.ju.edu.et/index.php/ejast/article/view/2147

[23] Mills J, Gaskell P, Ingram J, Dwyer J, Reed M, Short C. Engaging farmers in environmental management through a better understanding of behaviour. Agriculture and human values. 2017 Jun; 34(2): 283-99.

[24] Negera M, Alemu T, Hagos F, Haileslassie A. Determinants of adoption of climate smart agricultural practices among farmers in Bale-Eco region, Ethiopia. Heliyon. 2022 Jul 1; 8(7).

[25] Oberč BP, Arroyo Schnell A. Approaches to sustainable agriculture. Exploring the pathways. 2020; 486.

[26] Pépin A, Morel K, van der Werf HM. Conventionalised vs. agroecological practices on organic vegetable farms: Investigating the influence of farm structure in a bifurcation perspective. Agricultural Systems. 2021 May 1; 190: 103129. https://doi.org/10.1016/j.agsy.2021.103129

[27] Pimbert MP, editor. Food sovereignty, agroecology and biocultural diversity: Constructing and contesting knowledge. Routledge; 2017 Nov 1.

[28] Teferra B, Yeheyis L, Nelson M, Taylor J, Mcnaughton D, Sergeant A, Sanders H. FARMERS'DECISIONS AND DETERMINANTS OF CROP ROTATIONS WITH LUPIN: THE CASE OF WEST AMHARA REGION, ETHIOPIA. Review of Agricultural and Applied Economics. 2019; 22(1): 24-31. https://roaae.org/1336-9261/doi/abs/10.15414/raae.2019.22.01.24-31

[29] Tessier L. The pursuit of agroecological principles by Flemish beef farmers: advancing towards a body of thought for sustainable food systems (Doctoral dissertation, UCLouvain). https://hdl.handle.net/2078.5/114508

[30] van Bruggen AH, Gamliel A, Finckh MR. Plant disease management in organic farming systems. Pest management science. 2016 Jan; 72(1): 30-44. https://doi.org/10.1002/ps.4145

[31] Wallace JS. Increasing agricultural water use efficiency to meet future food production. Agriculture, ecosystems & environment. 2000 Dec 1; 82(1-3): 105-19. https://doi.org/10.1016/S0167-8809(00)00220-6

[32] Wezel A, Herren BG, Kerr RB, Barrios E, Gonçalves AL, Sinclair F. Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review: Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. Agronomy for sustainable development. 2020 Dec; 40(6): 40.

[33] Zerssa G, Feyssa D, Kim DG, Eichler-Löbermann B. Challenges of smallholder farming in Ethiopia and opportunities by adopting climate-smart agriculture. Agriculture. 2021 Feb 26; 11(3): 192. https://doi.org/10.3390/agriculture11030192