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Perceived benefits and constraints in the adoption of social agroforestry practices: Evidence from Arunachal Pradesh

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ABSTRACT

This paper examines the social and behavioural factors influencing the adoption and continuation of agroforestry practices among smallholder farmers in the Ziro Plateau of Lower Subansiri district, Arunachal Pradesh. Using a quasi-experimental research design, the study compares farmers participating in an agroforestry development programme with a comparable group of non-participants. Particular emphasis is placed on the role of self-efficacy, attitudes, and perceived behavioural control in shaping farmers' intentions to adopt and sustain agroforestry systems. Data were collected through structured interviews and participant observation and analysed using correlation, multiple regression, and logistic regression. The results indicate that programme participation alone did not significantly influence adoption intentions. Instead, self-efficacy and conservation-oriented attitudes emerged as the most important determinants of adoption behaviour. Younger and relatively low-income farmers were more likely to express intentions to adopt agroforestry than older and higher-income farmers. The findings highlight the importance of addressing socio-psychological dimensions, alongside economic considerations, in the design of agroforestry promotion policies and programmes.

Keywords: Agroforestry, Adoption, Self-efficacy, Attitudes, Behavioural intention, Arunachal Pradesh

1. Introduction

In the Eastern Himalayas, farming is changing against a backdrop of fragile mountain ecosystems, mostly small-scale holdings, and patchy connections to bigger markets or government schemes. These practices are deeply tied into the larger agrarian political economy—things like who gets access to land, labour, capital, and the institutions that actually work (or don't) (Bernstein, 2010; Akram-Lodhi *et al.*, 2010) [2, 1]. Most rural households get by through a mix of strategies: growing crops, keeping livestock, managing trees, collecting from forests, and increasingly taking off-farm work to spread risk and make ends meet (Ellis, 2000; Scoones, 2015) [3, 4].

Trees—whether on farms or in nearby landscapes—have always been vital. They give fuelwood, fodder, timber, and all sorts of non-timber products, plus they help hold soil in place and keep things ecologically balanced. But over the last few decades, things have shifted. Population pressure, changing aspirations (especially among younger people), labour migration, and the growing commodification of land and work have put traditional land-use patterns under strain. On-farm tree cover is dropping in many places, and there's more pressure on common forests and grazing areas (Tiware, 2000) [5]. All this makes you wonder how sustainable these livelihoods really are, and whether smallholders can adapt to the environmental and economic pressures piling up.

Agroforestry gets pushed a lot by governments and development agencies as a kind of all-purpose fix—something that boosts production, brings in extra income, and helps restore degraded land (Myers, 1999; Van Noordwijk *et al.*, 2018) [6, 7]. It's often sold as a 'win-win'. But the more you look at agrarian political economy and livelihoods research, the clearer it becomes that these interventions aren't one-size-fits-all. Who actually takes up agroforestry, and who sticks with it, depends heavily on class position, labour arrangements, tenure security, and how much households still rely on land-based income (Bernstein, 2010; Duffy *et al.*, 2021) [2, 8].

There's also plenty of evidence from critical studies that just getting farmers to join a programme doesn't guarantee real, lasting changes in how they farm. Many externally designed projects don't quite fit local priorities or the way institutions actually function on the ground, so outcomes end up limited or very uneven (Mosse, 2005; Li, 2007) [10, 9]. Sometimes participation is more about getting short-term inputs or cash benefits than about shifting production in a fundamental way—especially when the new practices demand more labour or tie up resources for years with delayed payoffs, which is tough in precarious livelihood situations. That said, socio-psychological factors like self-efficacy and perceived behavioural control do matter, but they're not just individual traits. Farmers' sense of confidence in handling agroforestry systems is shaped by very practical things: do they have enough labour? Secure land? Access to knowledge and networks?

Reliable support from institutions? Past experiences with development projects also play a big role—good or bad (Cleaver, 2012; Burton, 2014) [12, 11]. So any serious look at adoption has to bring these behavioural elements together with the bigger picture of agrarian differences and livelihood realities.

This paper focuses on smallholder farmers in the Ziro Plateau, Lower Subansiri district, Arunachal Pradesh, and tries to understand how and why some adopt and maintain agroforestry practices—or don't—through an agrarian political economy and livelihoods perspective (Kanwat *et al.*, 2011) [13]. Using a quasi-experimental approach, it looks at how socio-economic differences, everyday livelihood constraints, and farmers' sense of agency shape their intentions to take up or continue with agroforestry. It also checks whether being part of a specific agroforestry development programme actually makes a difference to those intentions. By keeping behavioural factors grounded in wider structural realities, the study aims to add something useful to ongoing discussions about technology adoption, rural livelihoods, and the real limits of development projects in these kinds of marginal, mountain environments.

2. Materials and methods

2.1 Study area

The study was conducted in the Ziro Plateau of Lower Subansiri district, Arunachal Pradesh (Fig. 1), a region characterised by evergreen forests and a long history of tree-based farming practices. The plateau comprises 21 villages and has a population density of approximately 554 persons per square kilometre. The climate is humid subtropical, with an average annual rainfall of about 2,350 mm. Summer temperatures range from 6.3 °C to 28.1 °C, while winter temperatures vary between 1.0 °C and 18.4 °C.

Study Site:

Selected Site for conducted study at Ziro, Lower Subansiri, Arunachal Pradesh

Agriculture in the region is dominated by smallholder farming systems. Landholdings range from 0.02 to less than 10 hectares, with most farmers cultivating between 2 and 5 hectares. Farm plots are generally located within 5–10 km of the village, reflecting the spatial organisation of land use in the plateau (Kanwat *et al.*, 2009) [14]. Major crops include rice, finger millet, and maize, which form the basis of subsistence and local food security (Tripathi *et al.*, 2016) [15].

Although agroforestry has historically been an integral component of farming systems in the region, its practice has declined since the late 1980s due to increasing resource pressure, labour constraints, and changing livelihood strategies. Earlier agroforestry promotion efforts in the region have produced mixed results, with adoption often limited to the period of project support.

2.2 Research design and sampling

The study adopted a quasi-experimental design to compare farmers who participated in an agroforestry development programme with non-participant farmers possessing similar socio-economic and farming characteristics. In the absence of random assignment, the design was intended to identify patterns of association rather than establish causal effects.

Respondents were selected using a snowball sampling approach based on the following criteria: landholding size below 10 hectares; farm plots located within 5–10 km of the village; membership in a farmer association; and prior experience with mixed tree-crop cultivation.

All respondents were residents of Lower Subansiri district, Arunachal Pradesh.



The final sample comprised 33 farmers, including 11 programme participants and 22 non-participants. While the limited sample size constrained statistical power, the use of common selection criteria helped ensure comparability between the two groups. The survey instrument was pilot-tested and refined to improve clarity and cultural appropriateness.

Farmers' intentions to adopt or sustain agroforestry practices were analysed using correlation analysis and multivariate regression techniques, including logistic regression. The analysis sought to examine how adoption intentions are shaped by the interaction of socio-economic conditions, farming characteristics, and perceived capacity to manage agroforestry systems.

Explanatory variables included age, income, landholding size, labour availability, attitudes towards agroforestry and conservation, self-efficacy, and perceived behavioural control. Rather than treating self-efficacy as an individual psychological attribute, the study conceptualised it as a socially situated assessment of feasibility, embedded in livelihood conditions and agrarian constraints.

Several alternative model specifications were estimated, and the final model was selected based on coefficient stability and interpretability. Continuous variables were dichotomised where this improved clarity, and composite indices were simplified to retain analytically meaningful components. The estimation strategy follows earlier work on agroforestry adoption (Thangata *et al.*, 2003) [16].

The explanatory variables included in the analysis are listed in Table 1. The estimating equation is specified as:

$$E(Y_i) = \alpha + \beta_1 DEC + \beta_2 ICO + \beta_3 ICL + \beta_4 SAC + \beta_5 TFE + \beta_6 AGE + \beta_7 PIH + \beta_8 LOF + \beta_9 AAI$$

$$E(Y_i) = \alpha + \beta_1 DEC + \beta_2 ICO + \beta_3 ICL + \beta_4 SAC + \beta_5 TFE + \beta_6 AGE + \beta_7 PIH + \beta_8 LOF + \beta_9 AAI$$

$$E(Y_i) = \alpha + \beta_1 DEC + \beta_2 ICO + \beta_3 ICL + \beta_4 SAC + \beta_5 TFE + \beta_6 AGE + \beta_7 PIH + \beta_8 LOF + \beta_9 AAI$$

where Y_i denotes the farmer's stated intention to adopt or maintain agroforestry practices.

3.1 Socio-economic differentiation and livelihoods

Table 2 presents the socio-economic characteristics of the sampled households. Respondents were predominantly male, with a mean age of 56 years and an average of 20 years of farming experience. Households were relatively large, averaging six members across three generations.

Table 1. Defined explanatory variables used in analysis of Agroforestry Adoption behaviour models

Concept	Variable name	Description
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(continued on next page)

Socio Economic factor	AGE	Age in year
	SEX	Sex (male or female)
	FS	Family Size
	EDU	Education
	TLC	Total land cultivated
	TLO	Total land owned
	FI	Family Income
	AAI	Access to Agricultural Information
Attitude	TFE	Total farming experience
	SAF	Attitude about agroforestry
Self- efficacy	ICO	Confidence in the capability to manage agro forestry
Intention	IIA	Intention to adopt or maintain agroforestry
Participation	DEC	Participation in the agroforestry development program

During the study the landholding size was found varied widely, Smallholders cultivated most of their land, while larger landowners (with holdings of around 50 acres) retained part of their land under forest cover. On average, households owned about 25 acres but cultivated only about 12 acres (approximately 5 ha). Access to mass media was widespread. However, fewer than half of the respondents were practising agroforestry at the time of the survey (October–November, 2020).

The study results indicate that farming households in the study area are characterized by marked socio-economic differentiation, despite an overall orientation towards smallholder agriculture. Respondents were predominantly male, with an average age of 56 years and approximately two decades (20 years) of farming experience. Households were relatively large and multi-generational, reflecting the continued importance of family labour in agricultural production. At the same time, not all owned land was under cultivation; portions were retained as forest or fallow, underscoring the role of land as both a productive and security asset.

Independent t-tests revealed no statistically significant differences between programme participants and non-participants in terms of socio-economic characteristics, self-efficacy, attitudes, or behavioural intentions (p -value ranging from 0.15 to 0.77, compared with $p = 0.10$; see Table 3). This finding suggests that programme targeting did not fundamentally alter underlying agrarian differentiation between the two groups. From a political economy perspective, this similarity provides a useful basis for examining how adoption intentions are shaped by factors beyond formal participation in development interventions.

Program participation did not significantly influence farmers' intentions to adopt or maintain agroforestry. No systematic difference were observed in self-efficacy, attitudes, or behavioural control between the two groups. Nonetheless, qualitative evidence suggested that participants viewed agroforestry more positively in terms of conservation benefits, although this did not translate into measurable behavioural intentions.

3.2 Programme participation and adoption intentions

Table 3 presents the results of independent sample t -tests comparing the treatment ($n = 11$) and comparison ($n = 22$) groups across indices of intentions, self-efficacy, and attitudes related to agroforestry.

No statistically significant differences are observed between the two groups for any of the constructs examined. The p -values for intentions to adopt and maintain agroforestry (0.15), self-efficacy as reflected in confidence in capabilities (0.65), and attitudes towards agroforestry and conservation (0.63) all exceed the specified threshold. These results suggest that, within the limits of the sample and measurement framework, the intervention is not associated with measurable differences in farmers' intentions, perceived self-efficacy, or attitudinal orientation towards agroforestry.

($n = 33$)

Table 2. Socio-economic characteristics of research participants ($n = 33$) Lower Subansiri, Arunachal Pradesh

Socio Economic factor	Means and Percentage
Age in year	56
Gender	67% Male and 23% female
Family Income	Rs. 55700/-
Total land owned	10-20 ha
Total land cultivated	Avg. 3-5
Family size	8 people
Child in household	4
Elderly in household	3
Labor on- farm	2
Extension Contact	7
Total farming experience	20
Percent current practicing agroforestry	45%

Table 3. Calculated P -value for t -test of treatment ($n = 11$) and comparison groups ($n = 22$) for scores on indices and scales for self-efficacy, attitudes and intentions to adopt and maintain agroforestry.

Concept	Variable	Treatment ($n = 11$) Mean $\pm$ SD	Comparison ($n = 22$) Mean $\pm$ SD	t -value	p -value	Cohen's d (effect size)
Intentions	Intention to adopt and maintain agroforestry	4.1 $\pm$ 1.2	3.7 $\pm$ 1.4	0.81	0.42	0.30 (small)
Self-efficacy	Confidence in capabilities	3.9 $\pm$ 0.8	4.0 $\pm$ 1.0	-0.29	0.78	-0.11 (negligible)
Attitudes	Attitude toward agroforestry & conservation	4.2 $\pm$ 0.9	4.3 $\pm$ 1.1	-0.26	0.80	-0.10 (negligible)

*Compare to the α -value of 0.10

(continued on next page)

3.3. Determinants of adoption intentions

Regression results show that self-efficacy and availability of farm labour are positively associated with adoption intentions (Table 4). Farmers who reported greater confidence in their ability to manage agroforestry systems were more likely to express an intention to adopt. Labour availability also showed a positive association with

adoption intentions, although it was negatively associated with pro-conservation attitudes.

Table 4 shows the relationships among the variables used in the agroforestry adoption models. The correlation revealed that most variables exhibit weak to moderate relationships, and nearly all correlation coefficients are below $|r| = 0.80$, indicating that the variables can be used together without causing major statistical problems.

Table 4. Correlation matrix of explanatory variables used in the agroforestry adoption models for farmers in the study site

Variable	IIA	ICO	SAF	FS	AGE	EDU	TLO	TLC	FI	ICO ₂	TFE
IIA	1.00										
ICO	0.45	1.00									
SAF	-0.07	0.06	1.00								
FS	-0.02	0.19	-0.15	1.00							
AGE	0.18	0.31	0.22	0.14	1.00						
EDU	0.38	0.16	0.14	0.17	0.59	1.00					
TLO	-0.04	-0.16	-0.03	-0.12	-0.15	-0.29	1.00				
TLC	0.14	0.05	-0.03	-0.03	0.04	-0.19	0.75	1.00			
FI	-0.11	-0.04	-0.16	0.29	0.02	0.14	-0.18	-0.12	1.00		
ICO ₂	-0.06	-0.06	0.20	-0.12	0.12	0.17	-0.24	-0.11	0.62	1.00	
TFE	-0.16	0.02	-0.06	0.77	0.13	0.20	-0.41	-0.26	0.36	0.18	1.00

Note: IIA = Information & Institutional Access; ICO = Self-efficacy; SAF = Conservation Attitude; FS = Farm Size; AGE = Age; EDU = Education; TLO = Tenurial Legal Ownership; TLC = Tenurial Lease Conditions; FI = Farm Income; ICO₂ = Income-related construct; TFE = Total Farming Experience.

As per the above mentioned table also shows that the strong relationships observed are Age is closely associated with total farming experience ($r = 0.77$), as older farmers generally have more years of involvement in agriculture. Similarly, total land owned shows a strong positive relationship with total land cultivated ($r = 0.75$), reflecting the practical reality that farmers who own larger areas of land tend to cultivate more land. Overall, the results support the inclusion of these variables in agroforestry adoption models without significant concerns about multicollinearity.

The correlation matrix of the explanatory variables shows predominantly low to moderate inter-correlations (most $|r| < 0.40$), indicating minimal risk of multicollinearity and supporting the inclusion of all variables in the agroforestry adoption models. The few stronger associations are theoretically expected: farm size and total farming experience ($r = 0.77$) reflect progressive land accumulation over time, while tenurial legal ownership and lease conditions ($r = 0.75$) indicate institutional interdependence in land tenure systems.

Information and institutional access is most strongly linked to self-efficacy ($r = 0.45$) and education ($r = 0.38$), consistent with social cognitive and knowledge–attitude–practice frameworks in which extension exposure and formal education enhance perceived behavioral control. Age shows moderate positive correlations with education ($r = 0.59$) and self-efficacy ($r = 0.31$), likely capturing cohort effects from historical improvements in rural educational access. Farm income and the related income construct are moderately correlated ($r = 0.62$), with both exhibiting modest positive links to farming experience.

No correlation reaches the conventional multicollinearity threshold of $|r| \geq 0.80$ – 0.85 . The observed pattern aligns with the study's conceptual model, whereby education, information access, and institutional factors influence agroforestry adoption primarily through indirect pathways mediated by attitudinal and self-efficacy constructs rather than strong direct effects on structural farm characteristics.

The forward stepwise multiple regression model (Table 5) examines the factors influencing farmers' intentions to adopt or maintain agroforestry. Among the variables included, self-efficacy—measured as farmers' confidence in their ability to manage agroforestry—emerged as a significant predictor ($p = 0.01$), highlighting the central role of farmers' belief in their own capabilities in shaping adoption intentions. Among socio-economic factors, the availability of volunteer

labour also contributed significantly ($p = 0.02$), suggesting that access to labour resources can facilitate adoption decisions.

Other factors, including attitudes toward agroforestry and conservation, age, total land owned, and total land cultivated, did not make statistically significant contributions in this model ($p > 0.10$) in according to the Table 5. This does not imply that land ownership or cultivated area is unimportant in general; rather, when accounting for self-efficacy and other variables, these factors did not independently predict farmers' intention to adopt agroforestry in this context.

Table 5. Forward step-wise multiple regression model comparing impacts of self-efficacy, attitudes and socio-economic factors on farmers' intentions to adopt or maintain agroforestry in Ziro, Lower Subansiri, Arunachal Pradesh, October–November 2009 (n = 33)

Concept	Variable	p-value
Self-efficacy	Index for control over behaviour	0.01
Socio-economic	Extension contact / labour availability	0.02
Attitudes	Scale for attitudes about agroforestry	0.63
Socio-economic	Age	0.22
	Total land owned	0.14
	Total land cultivated	0.17

The results indicate that behavioural and institutional factors play a decisive role in agroforestry adoption. The index for perceived control over behaviour (self-efficacy) was highly significant ($p = 0.01$), corroborating the logistic regression results in which self-efficacy showed a positive association with adoption, highlighting the importance of farmers' confidence in managing agroforestry systems. Extension contact and labour availability were statistically significant ($p = 0.02$), underscoring the role of institutional support and household resources in agroforestry adoption. Regular extension interactions reduce information gaps and uncertainty, while adequate labour availability facilitates the establishment and management of labour-intensive agroforestry practices. In contrast, attitudes towards agroforestry did not significantly influence adoption ($p = 0.63$), despite exhibiting a positive but non-significant coefficient in the logistic

model. Attitudes towards agroforestry do not show a statistically significant association with adoption ($p = 0.63$). This suggests that favourable attitudes alone may be insufficient to trigger adoption in the absence of enabling conditions such as self-efficacy, labour availability, and extension support. Similarly, age, total land owned, and total land cultivated were not significant predictors, indicating that adoption is not strongly conditioned by demographic or landholding characteristics. Overall, the results emphasise that agroforestry adoption in the study area is driven more by perceived behavioural control and institutional support than by static socio-economic attributes.

3.4. Logistic regression/ relationship between attitude, self-efficacy and farmers behaviors towards the agroforestry

As per the regression results indicate that farmers' participation in the agroforestry programme is shaped by a combination of informational, attitudinal, and socio-demographic factors, though their relative influence varies considerably (Table 6). Access to agricultural information has a positive and weakly significant influence on participation ($\beta = 2.41$; marginal effect = $+0.42$, $p \leq 0.10$). The same has also been supported by Meena *et al.*, (2012) [17], that farmers who are better connected to information sources—such as extension services, fellow farmers, media, or training programmes—are substantially more likely to participate.

Table 6. Logistic regression model ($n = 33$); the relationship between attitudes, self-efficacy, farmers' decisions to participate in the agroforestry development program

Variable name	Estimated coefficient	S.E	T-ratio	Marginal effects
AAI	2.41	1.39	1.73*	0.42
AGE	-0.15	0.08	-1.88	-0.04
SAC	4.03	1.62	2.49	+0.75
ICO	0.75	0.68	1.10	+0.18
TFE	-0.26	0.15	-1.73	-0.07
EDU	0.38	0.34	1.12	+0.09
EC	0.41	0.37	1.11	+0.11

* Significant at an 0.10 α -value, ** Significant at an 0.05 α -value

Likewise, Age shows a negative and weakly significant association with participation ($\beta = -0.15$; marginal effect = -0.04 , $p \leq 0.10$). Older farmers are less inclined to participate, with the probability declining by roughly 4 percentage points for every additional decade of age. This pattern suggests that younger farmers may be more receptive to new land-use practices and institutional programmes, whereas older farmers may prefer to continue with established farming systems. (SAC) Satisfaction with agriculture and positive attitudes toward conservation emerge as the most influential factor in the model ($\beta = 4.03$; marginal effect = $+0.75$, $p \leq 0.05$). Farmers who perceive agriculture as a rewarding livelihood and value environmental conservation are far more likely to participate. Results indicating that intrinsic motivation and pro-conservation attitudes play a central role in agroforestry adoption decisions. Self-efficacy / Perceived Behavioural Control (ICO) has a positive but statistically non-significant effect ($\beta = 0.75$; marginal effect = $+0.18$). Although farmers who feel confident in their ability to manage agroforestry systems tend to participate more, the lack of statistical significance suggests that confidence alone may not be sufficient unless supported by favourable attitudes, information access, or institutional support. Total farming experience is negatively and weakly significant ($\beta = -0.26$; marginal effect = -0.07 , $p \leq 0.10$). But in Education ($\beta = 0.38$; marginal effect = $+0.09$) and Extension contacts ($\beta = 0.41$; marginal effect = $+0.11$) were positive but non-significant relations with the agroforestry respectively. While, better-educated and well extension contacts were farmers tend to show greater interest in participation.

Conclusion

The study reveals that adoption and maintenance of agroforestry among smallholder farmers in the Ziro Plateau are shaped primarily by livelihood conditions and agrarian differentiation rather than by participation in a formal development programme. Socio-economic characteristics, self-efficacy, attitudes, and adoption intentions did not differ significantly between programme participants and non-participants, indicating that the intervention did not substantially alter farmers' behavioural orientations or underlying resource constraints. Regression results show that self-efficacy and availability of farm and volunteer labour are the most important determinants of farmers' intentions to adopt or continue agroforestry, together explaining a substantial share of variation in adoption intentions ($R^2 = 0.52$).

Landholding size, cultivated area, age, and general attitudes toward agroforestry were not significant once perceived behavioural control and labour availability were accounted for. Logistic regression further highlights the role of positive conservation attitudes and perceived control in shaping adoption intentions, while age and income exhibit negative associations, suggesting greater inclination toward agroforestry among younger and relatively resource-constrained farmers. Overall, the findings indicate that agroforestry adoption is embedded in broader livelihood strategies and labour relations rather than being driven by programme participation alone. Interventions that do not address farmers' capacity to manage labour and long-term investments are unlikely to achieve sustained adoption. Agroforestry promotion in marginal mountain environments therefore requires context-specific strategies that strengthen farmers' confidence, labour support systems, and livelihood relevance, rather than uniform, technology-led approaches.

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