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Assessment of Agroforestry Adoption Patterns in Ayodhya District of Uttar Pradesh

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ABSTRACT

Agroforestry integrates trees with agricultural crops and/or livestock offering immense potential for agricultural resilience and livelihood security. However, its adoption is influenced by various socio-economic factors that needs to be systematically analyzed to formulate effective extension strategies and policy interventions. In this view, a study was conducted during 2024-25 to explore adoption pattern of agroforestry practices among farmers in Ayodhya district, Uttar Pradesh. Multistage random sampling method was implied to draw sample from the district. The data were collected and administered across various landholding categories through a structured questionnaire incorporating agroforestry adoption indicators. The correlation analysis was employed to determine relationships between socio-economic parameters and adoption levels of agroforestry practices. The study revealed that education level, landholding size, land ownership, participation in related trainings, and annual income were positively correlated with adoption levels. However, there was no discernible relationship between the use of agroforestry practices and age or family size. The findings suggested that enhancing extension activities with specific focus on training, demonstration of successful models, and providing technical support to farmers could improve agroforestry adoption rates. It also recommends policy interventions to promote agroforestry as a sustainable land-use system for improving farmers' livelihoods and ecosystem services in Ayodhya district.

Keywords Agroforestry practices, Extension activities, Land use system, Socio-economic factors, Sustainable agriculture.

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INTRODUCTION

Agroforestry, the deliberate combination of trees with crops and/or livestock on the same plot of land (Djordjević-Milošević and Milovanović 2020), represents one of humanity's oldest land management approaches, yet its recognition as a scientific practice remains relatively recent. It promises a pathway towards long-term resilience and sustainability in

Indian agricultural landscape, where millions of smallholder farmers struggle with soil degradation, climate variability, and economic instability (Touch *et al*. 2024). This integration of trees with agricultural crops not only optimizes land use but also provides multiple environmental benefits such as improved soil fertility, carbon sequestration, biodiversity conservation and watershed protection. In India, the significance of agroforestry has been further emphasized with the formulation of the National Agroforestry Policy in 2014, making it, the first country to adopt a comprehensive policy framework dedicated to promote agroforestry practices (Venn *et al.* 2024). This policy aimed at expanding the country's tree cover while supporting farmers' livelihoods through increased productivity and income diversification. According to estimates, agroforestry currently occupies approximately 28.43 million hectares, or about 8.65% of India's geographical area (Bhardwaj *et al.* 2024). However, there exists significant potential for expansion, particularly in agriculture-dominated states.

Uttar Pradesh with its rich alluvial plains, has agriculture as the mainstay of its economy. Being India's most populous state, it experiences agricultural intensification resulting in soil health deterioration and decreasing farm sizes. In such circumstances, agroforestry provides a practical solution to fragmented landholdings, monoculture practices and declining farm incomes. Despite significant regional heterogeneity, agroforestry systems are thought to have an average carbon sequestration potential of 25 t/ha over 96 million ha. In general, it is considered that a tree can store approximately 167 kg of CO_2 per year, or 1 ton of CO_2 annually for six mature trees. In spite of this, Uttar Pradesh has a forest cover, including tree cover, of only 9.96%, far less than the national goal of 33% of the total land area (ISFR 2023). Many districts have less than 1.0% forest cover, whereas the majority have between 1% and 2% (Srivastav and Singh 2024). It depicts that agroforestry in Uttar Pradesh's Eastern Plain districts is generally acknowledged to be in a developing state. Although, these techniques have been widely used, it was emphasized that the state's Eastern Plains and North Eastern Tarai zones should switch from monocropping to appropriate agroforestry systems, such as agri-silviculture, silvi-horticulture and silvo-pastoral systems (Handa 2019). These practices vary significantly depending on the site-specific tree species, socio-economic circumstances and agroclimatic zones (Verma *et al.* 2017). Because of agroforestry's challenging face in the state, Ayodhya with forest cover of 4.55% (ISFR 2023), is selected for the study to draw attention of policymakers in streamlining future strategies to implement agroforestry successfully.

Ayodhya district, beyond its cultural significance, possesses fertile soils and a predominantly agrarian economy with approximately 78% of its population dependent on agriculture. With an average landholding size of 0.76 hectares, smaller than the national average of 1.08 hectares (Kumar 2019), farmers in Ayodhya face significant challenges related to livelihood security and sustainable resource management. However, traditional agricultural practices often overlook the long-term ecological benefits that agroforestry systems offer. Despite several initiatives and programs promoting agroforestry—including tree plantation drives, subsidies, and training workshops—the ground-level adoption remains inconsistent. While some farmers have successfully integrated trees like Shisham (*Dalbergia sissoo*), Subabul (*Leucaena leucocephala*), Teak (*Tectona grandis*), Eucalyptus and fruit trees like guava, mango and amla into their farms and home gardens, many others either adopt them partially or not at all. Preliminary observations indicate that adoption rates are still below ideal, despite the well-known advantages of agroforestry and the favorable agroclimatic conditions in the Ayodhya district. Some agroforestry systems, particularly boundary plantations and home gardens, have long been practiced in the eastern Uttar Pradesh. However, farmers have not yet widely embraced more intensive and scientifically developed agroforestry systems (Pancholi *et al.* 2023).

The extent and nature of agroforestry adoption depend on several interlinked socio-economic and knowledge-based factors. Farmers' awareness about tree-crop interactions, rotation period, pre-sowing treatment, spacing, quality planting material, and management practices like pruning, weed control, and integrated nutrient management (INM), significantly

influence the success of agroforestry systems. Beyond technical knowledge, factors such as education level, landholding size, training exposure, and farming experience play crucial roles in the willingness and ability of farmers to adopt such systems comprehensively (Zabala *et al.* 2025). Previous studies (e.g., Dhyani *et al*. 2013, Singh *et al*. 2025) have highlighted that farmer with better exposure to extension services and institutional support are more likely to adopt agroforestry models. Conversely, limited awareness about government schemes, technical complexities in maintaining tree-crop compatibility, and lack of short-term economic returns often deter small and marginal farmers. Furthermore, there exists a disconnect between policy-level frameworks and on ground implementation, leading to sub-optimal benefits from agroforestry programs.

Considering India's commitments to land degradation neutrality, sustainable development goals (SDGs), and carbon sequestration targets under the Paris Agreement, the importance of agroforestry cannot be overstated. Several studies have examined adoption behaviors in different parts of India (Kumar *et al.* 2024a, Srivastav and Singh 2024), but regionally specific research focusing on Ayodhya district is limited. Understanding the drivers and barriers to adoption in a key agrarian region like Ayodhya offers replicable lessons for similar districts across Uttar Pradesh and beyond. In light of these considerations, the present study aimed to evaluate the current adoption levels of agroforestry practices in Ayodhya district and identify the key socio-economic factors influencing adoption. The findings are expected to inform extension strategies and policy interventions aimed at promoting agroforestry, ultimately contributing to sustainable agricultural development, enhanced farmer livelihoods, and improved ecosystem services.

MATERIALS AND METHODS

The present study was conducted in Ayodhya district, located in eastern Uttar Pradesh, India between 26°47′ N latitude and 82°12′ E longitude and has a geographical area of 2,764 square kilometers. The region lies in the Indo-Gangetic plain and supports diverse cropping systems suitable for agroforestry integration. To evaluate the adoption extent of Agroforestry practices among farmers, a survey was conducted during 2024–2025 in Ayodhya District. Among the eleven blocks in the district, six were purposely selected due to their easy accessibility and diverse agro-economic conditions. These blocks are recognized for their varied farming practices and offer a diverse range of socio-economic and agro-ecological characteristics, making them ideal for evaluating regional trends in agroforestry adoption. A multi-stage random sampling method was employed to ensure systematic data collection. In the first stage, two villages were randomly selected from each block, totalling 12 villages. In the second stage, 15 farmers were randomly chosen from each village to reflect the diversity of the farming community, resulting in a sample size of 180 respondents. This laborious sampling framework ensured that the study was both representative and resilient. Data collection involved both primary data which were gathered using a semi-structured interview schedule designed to capture the socio-economic and psychological attributes of respondents, as well as their adoption levels of agroforestry practices. Adoption levels were assessed through a scoring system based on the extent of agroforestry practices implemented by the respondents, with scores reflecting complete, partial, or no adoption. The questionnaire was pre-tested to ensure clarity and reliability and translated into local language for better comprehension. The collected data were analyzed using SPSS. Descriptive statistics and correlation analysis summarized the trends and factors influencing agroforestry adoption. Pearson's correlation coefficient assessed the association of each factor to agroforestry adoption predictions. Statistical significance was evaluated at $p<0.05$ and $p<0.01$. The purposive selection of blocks, combined with a robust sampling framework and rigorous data analysis, ensured that the study findings are reliable, representative and provide valuable insights for promoting sustainable agroforestry farming practices in Ayodhya district and similar agro-ecological regions.

RESULTS

The study revealed that boundary plantation was the most popular agroforestry technique among the respondents (Table 1). This was followed by farmers practicing both boundary plantation and agri-silvicul-

Table 1. Distribution of respondents according to their adoption of agroforestry practices (N=180).

Agroforestry practice	Frequency	Percentage
Boundary plantation	81	45
Agri-silviculture/ agrihorticulture	16	8.9
Both (Boundary plantation+ Agri-silviculture/horticulture)	42	23.3
Non-adopters	41	22.8

Table 2. Distribution of respondents according to the adoption levels (N=180). Mean: 30.91, SD:6.16, Min:19, Max:44.

Sl. No.	Category	Respondents	
		Frequency (*f*)	Percentage (%)
1	Low	43	23.89
2	Medium	96	53.33
3	High	41	22.78
	Total	**180**	**100.00**

ture/agrihorticulture, while a significant population of about 22.8% were classified as non-adopters. Only a small population of farmers practiced agri-silviculture/agrihorticulture alone. The predominance of boundary plantation reflects farmers' preference for practices which did not impact primary crop cultivation areas. The combined approach of boundary plantation with agri-silviculture/agrihorticulture becomes more complex for farmers adoption of agroforestry systems.

As per Table 2, the results indicated that majority of respondents (53.33%) had medium level of adoption of agroforestry practices while 23.89 % and 22.78% had low and high level of adoption respectively. Hence, maximum farmers of the district fall under medium to low category for agroforestry adoption.

The data on specific agroforestry practices revealed different implementation levels across various management aspects (Table 3). A larger percentage of population was observed practicing fencing/ protection methods, weed management, adequate irrigation, and obtaining economic benefits. These practices represent fundamental farm management activities that provide immediate visible benefits, which likely explains their higher adoption rates. In contrast, practices requiring specialized knowledge

Table 3. Adoption rates for various measures of agroforestry practices (N=180).

Sl. No.	Statements	No		Partial		Complete		WM
		f	%	*f*	%	*f*	%	
1	Practice agroforestry	52	28.89	91	50.56	37	20.56	1.92
2	Tree-crop interaction knowledge	84	46.67	59	32.78	37	20.56	1.74
3	Pre-sowing treatment & proper spacing	74	41.11	81	45.00	25	13.89	1.73
4	Adequate irrigation	18	10.00	66	36.67	96	53.33	2.43
5	Use of QPM (quality planting material)	31	17.22	98	54.44	51	28.33	2.11
6	Obtain economic benefit	39	21.67	45	25.00	96	53.33	2.32
7	Plant MPTs/fodder trees	82	45.56	75	41.67	23	12.78	1.67
8	Adopt INM (integrated nutrient management)	31	17.22	96	53.33	53	29.44	2.12
9	Timely tending operations performed	92	51.11	62	34.44	26	14.44	1.63
10	Fencing/protection	11	6.11	25	13.89	144	80.00	2.74
11	Soil conservation practices like mulching	69	38.33	78	43.33	33	18.33	1.80
12	Rotation period awareness	55	30.56	78	43.33	47	26.11	1.96
13	Pest/Disease management	19	10.56	90	50.00	71	39.44	2.29
14	Weed management	13	7.22	51	28.33	116	64.44	2.57
15	Policy/scheme benefit availed	63	35.00	75	41.67	42	23.33	1.88

Table 4. Correlation coefficients between adoption score and socio-economic variables.

Variable	Correlation coefficient (r)	Significance
Age	-0.028	Non-significant
Education	0.262	Significant
Family type	-0.005	Non-significant
Farmer type	0.484	Significant
Land ownership	0.407	Significant
Land holding (ha)	0.516	Significant
Any related training	0.285	Significant
Farming exp	0.068	Non-significant
Income	0.303	Significant
Knowledge	0.476	Significant

or additional inputs showed substantially lower adoption levels. These included timely tending operations, pre-sowing treatment and proper spacing and planting multi-purpose trees (MPTs)/fodder trees. Similarly, the use of quality planting material (QPM) and adoption of integrated nutrient management (INM) showed moderate success among the farmers of the district.

Overall, a significant population of respondents were non-adopters whereas a higher percentage of respondents practice it partially. A similar pattern was observed in farmers' technical knowledge of tree-crop interactions, where a large proportion of respondents had no knowledge about it and only a fewer respondents demonstrated complete knowledge of these technical interactions.

Moreover, correlation analysis revealed significant relationships between several socio-economic variables and agroforestry adoption (Table 4). The strongest positive correlations were found with land holding size, farmer type, knowledge, and land ownership. These correlations were significant at the 0.01 level. Other significant positive correlations were observed with income, training and education.

Variables showing non-significant relationships with adoption included age, family type and farming experience. The negative correlation with age, though not statistically significant, suggests that younger farmers might be slightly more receptive to agroforestry innovations, but this trend was not strong enough to draw definitive conclusions.

DISCUSSION

A practical attitude to agroforestry adoption is shown in the respondents' preference of boundary plantations, where farmers favor systems that result in the least amount of interference to current farming systems. This result corresponds with Castle *et al.* (2021), who noted that while boundary plants have little effect on primary agricultural operations, they are frequently the starting point for farmers to enter agroforestry. The comparatively low adoption rate of agri-silviculture/agrihorticulture system, indicates that farmers may view direct tree integration in crop fields as more complicated or risky. This finding is in accordance with research by Kumar *et al.* (2024b), who found that farmers are reluctant to implement more intricate agroforestry systems because they are worried about the effects on yield and the management needs. The significant percentage of non-adopters demonstrates enduring obstacles to the uptake of agroforestry. In their research on the adoption pattern of agroforestry in North India, Srivastav and Singh (2024) found comparable percentages. This suggests that even with the acknowledged advantages of agroforestry, there are still major obstacles in the way of encouraging broader adoption among farming communities. Farmers' concern on safeguarding their financial investments while minimizing competition for resources can be observed with the high adoption rates for weed control and fencing/protection. These results are in accordance with the findings of Partel *et al.* (2024), who reported that among the first actions farmers embraced when they started agroforestry were preventive measures. The higher adoption rate of these management measures is attributed to their long-term practice in traditional farming methods and these are well known among farming community.

The comparatively high adoption of economic benefit techniques and proper irrigation showed that farmers prioritize productivity and profitability, which are the main factors influencing agricultural decision-making. On the other hand, the low adoption of trained techniques like timely tending operations and planting MPTs/fodder trees suggests a lack of knowledge and resources. Technical expertise was also found to be a major barrier to the adoption of

more advanced agroforestry techniques (Dhyani *et al.* 2013). In addition, the moderate adoption levels for using quality planting material and integrated nutrient management suggested that while farmers recognized their importance, complete implementation faces barriers such as availability, cost or technical complexity. Many farmers are experimenting with agroforestry practices but have not fully committed to comprehensive implementation, according to the general trend of agroforestry practice in the district which depicts their inclination to traditional practice of growing agricultural crops. This aligns with the findings of Rathore *et al.* (2022), who examined agroforestry systems in central India and found that most farmers were partial adopters, describing a similar range of adoption.

Analysis of socio-economic determinants highlighted the significance of resource availability in the agroforestry implementation through a positive correlation between land holding size and adoption. Larger landholdings provide farmers more freedom to try out innovative methods and set aside space for growing trees. This result lines up with Tega & Bojago (2024) study findings, which revealed that land holding size was a significant determinant of agroforestry adoption in various places. According to Ayisi *et al.* (2022), resource-rich farmers are typically more inclined to adopt new approaches, and the substantial association with farmer type illustrates how different types of farmer handle innovation and risk differently. Moreover, the crucial role of awareness and technical understanding for promoting the adoption of agroforestry is underscored by the substantial correlation between adoption and knowledge levels. This was confirmed by findings of Singh *et al*. (2024), who emphasized knowledge as a necessary condition for effective adoption of agroforestry.

The strong correlation with land ownership highlighted the significance of tenure security in long-term investments like agroforestry, and it was in conformity with Ibrahim *et al.* (2022), who found that land tenure was a major determinant of farmers' willingness to invest in tree planting. In addition, positive correlation between education and adoption suggested that higher education improves farmers' access to the knowledge about innovative agricultural practices and its easy interpretation. This is in accordance with findings of Chavan *et al.* (2022), who found that highly educated farmers were more receptive to extension activities and more likely to adopt recommended practices. The strong correlation of adoption rate with training highlighted how crucial targeted capacity building is in promoting the agroforestry practices. Similar findings about the efficacy of training programs in enhancing the adoption rates were observed by Pandey *et al.* (2024). Moreover, the non-significant correlations with family type and age imply that these demographic variables have little bearing on the adoption of agroforestry. This is in line with some research that found no significant association (Kumar *et al.* 2025) but contradicts other studies that found age to be a significant effect. Age-related differences in the results point to context-specific factors that might vary by location and cultural context. Experience in traditional agriculture does not always translate into a stronger desire to adopt agroforestry practices, as seen by the lack of a significant association between adoption and farming experience. This result is consistent with findings of Wienhold and Goulao (2023), who observed that seasoned farmers occasionally show more resistance to innovative practices that differ from conventional methods.

CONCLUSION

This study illustrates that although agroforestry is practiced by majority of farmers in Ayodhya district, its comprehensive and technical adoption remains limited. Among agroforestry systems, boundary plantations were more prevalent due to its least interference with existing farming practices while integrated systems remaining underutilized. Moreover, the knowledge-intensive practices remain under adopted, emphasizing need for targeted trainings and awareness. Land holding, knowledge levels, income and education level also significantly influenced the agroforestry adoption, underscoring the importance of resource access and capacity building. These findings imply that access to policy benefits, technical assistance, and training programs will be essential for encouraging agroforestry adoption in eastern Uttar Pradesh. Policymakers and extension organizations must create successful local models to encourage

farmer-to-farmer learning and on-field demonstrations. Hence, the study highlights need for a holistic approach to agroforestry promotion that addresses socio-economic and technical constraints leading to sustainable land management, improved livelihood and enhanced environmental benefits.

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