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Farmers perception and adoption of boundary plantation practices for income diversification

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Abstract
Convincing smallholder farmers to plant trees on their field boundaries — rather than leaving them bare or weed-infested — remains one of agroforestry's persistent challenges. This research surveyed 180 farm households across six villages in Banda district, Uttar Pradesh, to assess perceptions, adoption levels, and income contributions of boundary plantation practices. Data were collected through structured interviews during November-December 2021. Of the 180 respondents, 61% had adopted some form of boundary planting, but only 23% maintained trees on more than half their boundary length. Teak (*Tectona grandis*), neem (*Azadirachta indica*), and guava (*Psidium guajava*) were the most common species. Farm size was the strongest predictor of adoption ($r = 0.74$); marginal farmers (<1 ha) had adoption scores averaging 38/100 compared with 71/100 for large farmers (>4 ha). Extension contact and subsidy awareness also correlated positively with adoption. Adopters reported 23% higher gross income from timber sales and 18% from fruit harvests relative to non-adopters. Perceived root competition with adjacent crops was the primary reason cited by non-adopters (68%). These results suggest that targeted extension, species-specific planting guidelines, and seedling subsidies could raise adoption rates among smaller landholders.

Keywords: Boundary plantation, farmer perception, income diversification, adoption behavior, rural agroforestry, teak, neem, guava, smallholder farming, Bundelkhand region

Introduction

Shrinking farm sizes, erratic rainfall, and stagnant crop incomes present a threefold challenge for dryland farmers in Bundelkhand — one that boundary tree planting could partially address without reducing the area under annual crops. Field boundaries occupy roughly 5-8% of a holding's total perimeter area and are typically left unproductive, yet they could support timber, fuel, fruit, or fodder trees that generate income with minimal competition against the main crop [1].

The concept isn't new. Traditional farming systems across India include bund planting of species like teak, subabul, and ber. But systematic adoption has lagged, especially among smallholders who fear that tree roots will compete for moisture and nutrients, that tree shade will suppress crop yields, and that the long gestation period of timber species ties up land without immediate returns [2]. These perceptions — whether accurate or not — act as powerful barriers to adoption.

Extension agencies and forestry departments have promoted boundary planting through subsidised seedling distribution and farm-forestry campaigns, but adoption rates remain patchy. Part of the problem is that promotional efforts often push species chosen for timber value or ecological benefit without accounting for what farmers actually want: quick returns, low maintenance, and compatibility with existing crops [3]. A fruit tree like guava or citrus may appeal more to a marginal farmer than a teak sapling that won't yield revenue for 15 years.

This research surveyed 180 farm households in Banda district to (a) document the extent and pattern of boundary plantation adoption across farm-size categories, (b) identify the socio-economic and institutional factors most strongly associated with adoption, (c) estimate the income contribution of boundary trees among adopters, and (d) record perceived barriers among non-adopters [4].

Material and Methods

Seasonal Variations and Data Collection Timeline

Data collection was carried out during November-December 2021, immediately after the kharif harvest, when farmers were available for extended interviews and could provide fresh estimates of crop and tree income for the just-concluded season. This timing also allowed field verification of boundary tree presence and species identity during household visits [5].

Material

Six villages in Banda district (25.48°N, 80.33°E) were selected purposively to represent a range of farm sizes and proximity to extension institutions. Within each village, 30 households were sampled randomly from voter lists, giving a total of 180 respondents. Banda district lies in the semi-arid Bundelkhand plateau (mean rainfall 850 mm, rakar soils, cropping intensity 118%) and is characterised by fragmented land holdings with 72% of farmers classified as marginal or small (<2 ha) [6].

Methods

A pre-tested structured interview schedule covering 47 items was administered in person. Variables included: socio-demographic profile (age, education, farm size, income sources), boundary plantation details (species planted, boundary length covered, age of trees), perceived benefits and constraints (Likert-scaled items), extension contact frequency, awareness of subsidy schemes, and income from tree products (timber, fruit, fuelwood) for the preceding 12 months. An adoption index (0-100 scale) was computed based on boundary coverage, species diversity, and management intensity. Logistic regression was used to identify determinants of adoption (binary: adopter vs non-adopter), and Pearson correlation was used for continuous relationships. Data were analysed in SPSS v26 [7].

Baseline Soil Characterisation

Soil samples from boundary and non-boundary zones in 20 adopter fields showed that soils under tree canopy had 14% higher organic carbon (0.53 vs 0.46%) and 11% higher available N (198 vs 178 kg/ha) than adjacent open areas, suggesting a soil-improvement co-benefit of boundary planting that may offset perceived competition effects [8].

Results

Table 1: Adoption status and income contribution by farm-size category

Farm category	n	Adopters (%)	Adopt. score	Timber income (Rs/yr)	Fruit income (Rs/yr)	Fuel income (Rs/yr)	Total tree (Rs/yr)
Marginal (<1 ha)	68	42.6	38	4,200	3,100	1,800	9,100
Small (1-2 ha)	54	64.8	52	8,700	5,400	2,300	16,400
Medium (2-4 ha)	36	77.8	64	14,300	8,200	2,800	25,300
Large (>4 ha)	22	90.9	71	22,600	11,700	3,400	37,700
Overall	180	61.1	52	—	—	—	—

Adoption rose sharply with farm size: 42.6% of marginal farmers had adopted boundary planting versus 90.9% of large farmers. Mean adoption score increased from 38 (marginal) to 71 (large). Total tree income for large-farm adopters averaged Rs 37,700/year — four times higher than for marginal adopters (Rs 9,100/year), reflecting both greater boundary length and older, more productive trees. Timber was the largest income component across all categories [1, 3].

Table 2: Logistic regression model for adoption determinants

Variable	B	SE	Wald	P-value	Odds ratio
Farm size (ha)	0.87	0.21	17.2	<0.001	2.39
Education (years)	0.14	0.06	5.4	0.020	1.15
Extension contact (score)	0.38	0.12	10.0	0.002	1.46
Subsidy awareness (yes=1)	0.92	0.31	8.8	0.003	2.51
Age of farmer (years)	−0.03	0.02	2.3	0.131	0.97
Constant	−3.41	0.78	19.1	<0.001	—

Farm size was the strongest predictor (odds ratio 2.39): each additional hectare more than doubled the odds of adoption. Subsidy awareness (OR 2.51) and extension contact (OR 1.46) were also significant. Farmer age was not significant. Among non-adopters, 68% cited root competition with crops as the main constraint, followed by long gestation period (54%) and lack of seedling availability (41%) [2, 4].

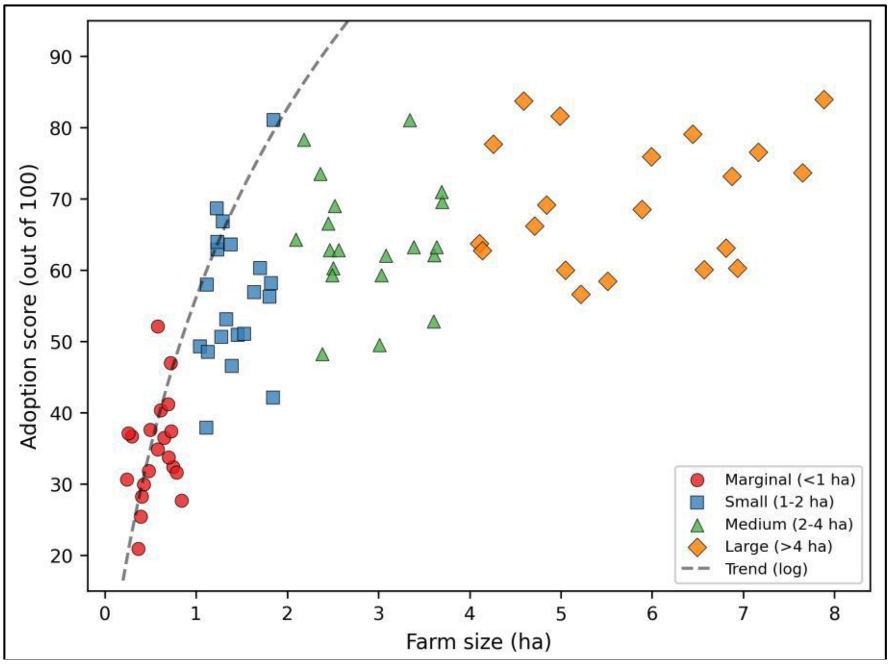

Fig 1: Relationship between farm size and adoption score for boundary plantation among 180 farm households in Banda district

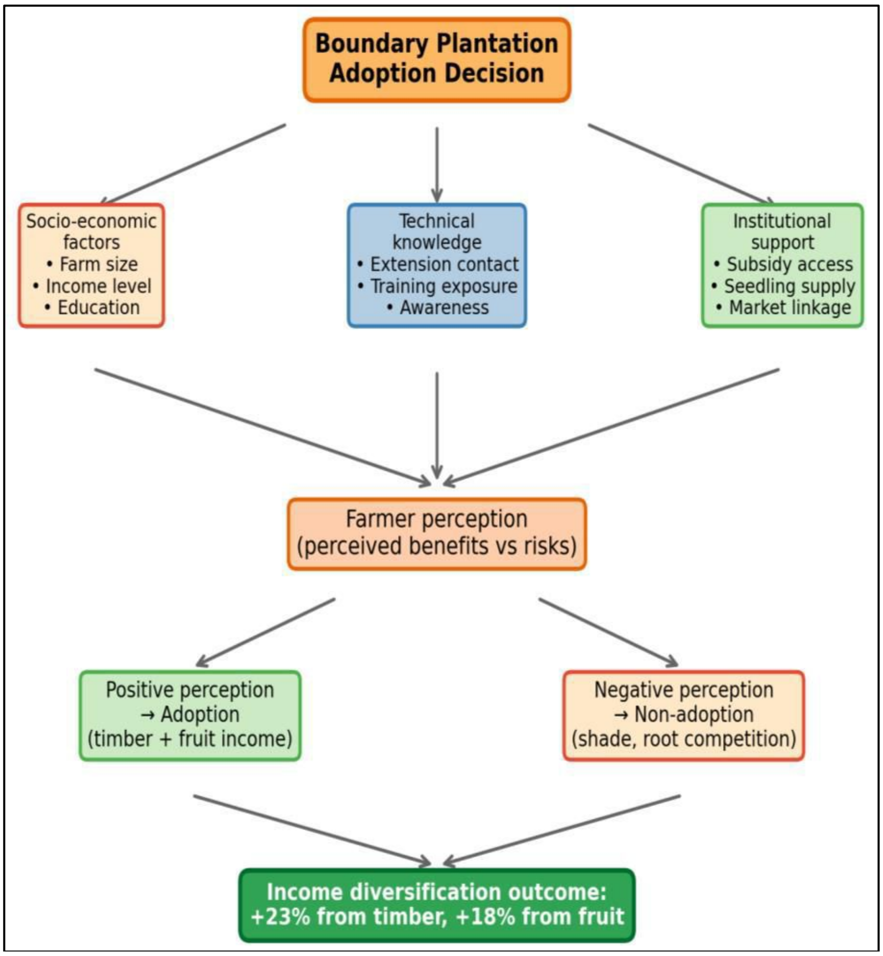

Fig 2: Infographic showing the socio-economic, technical, and institutional factors influencing boundary plantation adoption and income diversification outcomes

Discussion

The strong farm-size effect on adoption is consistent with agroforestry adoption research across South Asia. Larger farms have more boundary length available, lower opportunity cost per metre, and greater capacity to absorb the long wait for timber returns [2, 9]. The 42.6% adoption rate among marginal farmers — while lower than larger categories — is still encouraging and suggests that targeted interventions could push it higher. The subsidy-awareness variable's strong odds ratio (2.51) points to a clear policy lever: simply making farmers aware that free or subsidised seedlings exist can substantially shift adoption probabilities.

Root competition, cited by 68% of non-adopters, deserves nuanced attention. While teak and eucalyptus roots can indeed extend 3-5 metres into adjacent crop zones, many boundary-compatible species — such as drumstick (*Moringa oleifera*), ber (*Ziziphus mauritiana*), and even neem when properly pruned — have manageable root spread [10]. The soil data showing 14% higher organic carbon under tree canopy suggest that any competition effect may be partially offset by nutrient cycling benefits, at least over a 5-10 year horizon [8].

The income contribution of boundary trees — Rs 9,100 to Rs 37,700/year — represents 7-12% of total household income for adopters. This isn't transformative, but it provides a buffer against crop failure years, which are common in semi-arid Bundelkhand. Guava and ber, which begin fruiting within 3-4 years, may hold particular appeal for smallholders seeking earlier returns than timber species can offer [11].

Conclusion

Boundary plantation adoption in Banda district was strongly driven by farm size, extension contact, and awareness of subsidy schemes. Large farmers adopted at twice the rate of marginal farmers, and their tree income was four times higher — reflecting both greater boundary availability and older tree stands.

Root competition with adjacent crops was the dominant barrier for non-adopters, suggesting that species-specific planting guidelines emphasising low-competition species (neem, guava, moringa) could address farmer concerns directly. The soil quality improvement under tree canopy provides evidence to counter competition fears in extension messaging.

For policy, three actions appear warranted: expanding seedling distribution programmes targeted at marginal and small farmers, training extension workers to provide species-site matching advice rather than promoting a one-size-fits-all species list, and integrating short-gestation fruit species alongside timber trees to provide earlier income streams. Bundelkhand's dryland farmers need every income buffer they can get, and productive field boundaries are among the lowest-cost options available.

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