E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(10): 758-763
Received: 13-08-2024
Accepted: 16-09-2024

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Evaluation of the socio-economic impact of agroforestry practices in Ayodhya district, Uttar Pradesh

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i10j.2537

Abstract
This study evaluates the socio-economic impact of agroforestry practices in Ayodhya District, Uttar Pradesh. The research highlights the dominant tree species cultivated under various agroforestry systems, including Tectona grandis (teak)**,** Eucalyptus tereticornis, Dalbergia sissoo (shisham)**,** Swietenia macrophylla (mahogany**)**, Melia azedarach (Persian lilac)**,** Mangifera indica (mango)**,** Phyllanthus emblica (amla)**,** and Psidium guajava (guava)**.** Agroforestry adoption was primarily driven by the need for additional income, as reported by 50.6% of the farmers. Other significant reasons included its role as a source of emergency funds (23.33%) and as a source of fuelwood **(**11.67%), particularly in systems with commercial potential. The economic analysis revealed varying profitability across different agroforestry systems. The highest profitability was observed in Swietenia macrophylla-based bund plantations with a B:C ratio of 15, followed by Phyllanthus emblica-based systems (B:C ratio of 10) and agrisilvihorticulture systems (B:C ratio of 8). Eucalyptus-based bund and agrisilviculture systems also performed well with a B:C ratio of 7, while Tectona grandis bund plantations showed a relatively lower B:C ratio of 2. The study highlights the potential of agroforestry as a viable strategy for improving rural livelihoods and promoting sustainable land-use practices.

Keywords: Agro forestry systems, bund plantation, socio-economic analysis

Introduction
Agroforestry practices are highly valued by researchers and policymakers for their crucial role in delivering ecosystem services. As a sustainable land-use approach, agroforestry enhances productivity while offering significant social and economic benefits to farmers. While traditional agricultural systems primarily provide food and essential resources, integrating trees into farms contributes additional long-term outputs, including timber, fuelwood, fiber, and various non-timber forest products. These systems play a pivotal role in creating diversified and resilient farming landscapes (van Noordwijk *et al.*, 2020; Jhariya *et al.*, 2019a, b, 2021) [13, 4]. Eucalyptus-based agroforestry systems, in particular, have been widely adopted by farmers due to their ecological sustainability and ability to produce valuable products like timber and industrial pulp. These systems are not only socially acceptable but also contribute to environmental improvements such as soil and water conservation, enhanced soil fertility, and increased productivity. Furthermore, they offer a significant potential for carbon sequestration, playing a role in climate change mitigation (Raj *et al*., 2016; Khan *et al.*, 2020a, b) [10, 6, 7]. The additional products generated by agroforestry significantly improve farmers' livelihoods by increasing their economic gains. These benefits make agroforestry systems more productive and profitable compared to traditional monocropping systems. Many scientific studies have demonstrated the superior productivity of agroforestry over sole cropping systems, reinforcing its value as an integrated and sustainable agricultural approach (Lehmann *et al*., 2020; Raj *et al*., 2020a) [9, 11] Agroforestry stands as a vital, ecologically oriented natural resource management approach. By harmoniously integrating trees and woody perennials into farm and rangelands, it serves to diversify and sustain production systems. This strategy not only amplifies social and economic gains but also bolsters environmental well-being (Leakey, 2014) [8]. In Uttar Pradesh (U.P.), a state that is home to approximately 16.5% of India's population, agroforestry has evolved

significantly over the past two decades. Its role in enhancing agricultural diversification and sustainability underscores its importance in shaping the region's agrarian practices. Eucalyptus-based agroforestry systems, for instance, have become ecologically sound and socially accepted among farmers due to their ability to produce valuable products such as timber and pulp for industrial use (Jhariya *et al*., 2019) [4]. These systems also contribute to environmental benefits like soil and water conservation, improved fertility, and enhanced productivity, while offering significant potential for carbon sequestration (Raj *et al*., 2016; Khan *et al*., 2020) [10, 6, 7]. The adoption of agroforestry in U.P. highlights its capacity to improve livelihoods through higher economic returns. Additional outputs like timber, fuelwood, fiber, and non-timber forest products provide long-term benefits. Scientific studies and evidence from the region have shown that agroforestry systems often outperform sole cropping systems in terms of productivity and sustainability, reinforcing their role as a key element in resilient and diversified agricultural landscapes (Lehmann *et al*., 2020; van Noordwijk *et al*., 2020) [9, 13].

Methodology

Agroforestry, in various forms, has been extensively promoted across different parts of India, including southern Karnataka, parts of Andhra Pradesh, and eastern Uttar Pradesh. Eastern Uttar Pradesh was strategically selected for this study due to its well-established linkages between farmers and industries, which facilitate commercial agroforestry practices. Based on preliminary research, Ayodhya district in eastern Uttar Pradesh emerged as an ideal focus area for its significant agroforestry activities. Using a multi-stage random sampling method, Ayodhya district was chosen for detailed study.Within the district, four blocks—Milkipur, Amaniganj, Sohawal, and Bikapur—were identified. From each block, three villages were randomly selected, and 10 farmers practicing agroforestry were chosen from each village, resulting in a total sample size of 120 farmers across 12 villages. The collected data were post-stratified to compare agroforestry practices across various farm-holding size categories, providing a deeper insight into the dynamics of agroforestry in the region. The study primarily employed tabular analysis methods along with benefit-cost (B:C) analysis to evaluate the economic viability of agroforestry systems. The B:C ratio was calculated using the approaches outlined by Gittinger (1982) [2] and Jain and Singh (2000) [3], which provide a robust framework for economic assessment. In this study, the Benefit-Cost Ratio (B:C) was determined using the formula:

B:C ratio = Present Value of cost/present value of benefits

Where PVB and PVC are calculated by discounting future benefits and costs to their present values using a specific discount rate, typically 10%.

Mango based agrihorticulture system

Eucalyptus based Bund System

Mahagoni based bund system

Interaction with farmers

Fig 1: Various agroforestry systems in the study area.

Results and Discussion

The study's findings are structured around the analysis of Ayodhya districts, evaluated within the frameworks of commercial agroforestry systems.

Characteristics of Sample Farmers

The study included 120 farmers from the Ayodhya district. Table 1 provides a summary of how these farmers were categorized across different groups.

Table 1: Composition of sample farmers in Ayodhya

Ayodhya District		
Farmers category	**Number (%)**	**Average holding size (ha)**
Marginal (1ha)	42 (35)	0.89
Small (1-2 ha)	53 (48.33)	1.67
Medium / large (>2ha)	25(45.83)	3.92
Total	120 (100)	2.16

The sample farmers in both districts were categorized into three groups based on their total landholdings: marginal, small, and medium to large farmers. In Ayodhya, marginal farmers had an average landholding of 0.55 ha, small farmers held 1.53 ha, and medium to large farmers had 2.92 ha, resulting in an overall average holding size of 2.92 ha. Mean while, in Sultanpur, marginal farmers averaged 0.19 ha, small farmers held 1.54 ha, and medium to large farmers had 3.2 ha, with an overall average holding size of 1.88 ha.

Agroforestry in Ayodhya district

The district practices five main agroforestry systems, which include planting trees along field bunds or farm boundaries and combining tree cultivation with seasonal crops through methods like agrisilviculture, agrisilvihorticulture, silvipastoral, and agrihorticulture. The most common tree species in the area are *Tectona grandis* (Teak) and *Eucalyptus tereticornis* hybrids. Other species, such as *Mangifera indica* (Mango), *Dalbergia sissoo*, *Swietenia macrophylla*, and *Melia azedarach*, are also present. These trees are often grown along field boundaries or integrated into agroforestry systems like agrisilvihorticulture and agrihorticulture, either paired with Teak and Eucalyptus or as independent plantations.

A study conducted in 12 villages across four blocks—Milkipur, Amaniganj, Sohawal, and Bikapur—of Ayodhya district involved interviews with 160 farmers to understand the agroforestry systems they practice. The findings, summarized in Table-2, reveal that the majority of farmers (45%) adopt bund or boundary plantations as their preferred agroforestry system. This is followed by 26.67% of farmers practicing agrisilviculture, 11.67% using agrisilvihorticulture, and 9.16% employing agrihorticulture systems. The least common system was silvipastoral, practiced by only 7.5% of the farmers.

Table 2: Agroforestry systems practiced in Ayodhya district

Agroforestry Systems	No. of farmers	Major tree species
Bund/Boundary plantations	54 (45%)	*Tectona grandis*, *Eucalyptus tereticornis*, *Dalbergia sissoo*, *Swietenia macrophylla*, and *Melia azedarach*
Agrisilviculture	32 (26.67%)	
Silvipastoral	9 (7.5%)	
Agrisilvihorticulture	14 (11.67%)	*Mangifera indica*, *Phyllanthus emblica*, *Psidium guajava*, *Tectona grandis*, *Eucalyptus tereticornis* and *Dalbergia sissoo*,
Agrihorticulture	11 (9.16%)	*Mangifera indica*, *Phyllanthus emblica and Psidium guajava*,

Area coverage and tree density under agroforestry

The average area covered under agroforestry varies across different farm-size categories. Among farmers who have adopted agroforestry systems, large farmers allocate an average of 48% of their total landholding to these practices (as shown in Table-7). Medium farmers dedicate approximately 40.11% of their land, while small farmers allocate an average of 35.95%.

Table 3: Area coverage under agroforestry among the sample farmers

Farmer Category	Average Total Land holding (ha)	Average Total Land under agro forestry systems (ha)	% area under agro forestry systems
Marginal/Small farmers	0.89	0.32	35.95
Medium farmers	1.67	0.	40.11
Large farmers	3.92	1.9	48.46

Determinants of agroforestry: The factors influencing the adoption of agroforestry were identified through interviews with sample farmers in Ayodhya district, as detailed in Table-8. A majority of the farmers (55.83%) cited agroforestry as an important source of additional income. Other key reasons for adopting agroforestry included its role as an emergency source of cash (23.33%), providing supplemental employment opportunities (5.83%), and benefits such as soil conservation (11.67%) and availability of fuelwood (11.67%).

Table 4: Determinants of agroforestry in Ayodhya district

Major Reason	Frequency	Percentage
Additional income	67	55.83
Source of money in emergency	28	23.33
Source of fuelwood	14	11.67
Source of employment	7	5.83
Others	4	3.33
Total	120	100.0

Cost-Benefit Analysis of Agroforestry Systems: An economic analysis of various agroforestry systems was conducted, considering factors such as rotation periods, cropping patterns, and the number of farmers who harvested crops during the evaluation period. The analysis focused on bund or boundary plantations, agrisilviculture, silvipastoral, agrihorticulture, and agrisilvihorticulture systems, each assessed separately for five major tree species. Farmers commonly practiced bund planting with species such as *Tectona grandis* (teak), *Eucalyptus tereticornis*, *Dalbergia sissoo* (shisham), *Swietenia macrophylla* (mahogany), and *Melia azedarach* (neem-like tree). For agrihorticulture systems, species like *Mangifera indica* (mango), *Phyllanthus emblica* (amla), and *Psidium guajava* (guava) were included. To enable a comparative economic assessment, exclusive systems for key tree species (*Eucalyptus tereticornis*, *Tectona grandis*, *Swietenia macrophylla*, *Phyllanthus emblica*, and *Mangifera indica*) were analyzed with average tree densities per hectare. The cost-benefit ratio (B:C) was calculated, incorporating tree rotation periods and a standardized cropping pattern. The cropping sequence considered for this evaluation included sugarcane for the first two years, followed by a paddy-wheat rotation in subsequent years.The results revealed that the B:C ratio, discounted at 10%, was 13, indicating highly favorable economic returns for agroforestry systems. The average annual net returns from these systems amounted to Rs. 2,98,931/- at current prices. In comparison, pure crop rotations without tree integration yielded significantly higher annual net returns of Rs. 38,86,105.

Table 5. Cost-benefit analysis of different agroforestry systems adopted in Ayodhya District

Particulars	Value/amount (Rs/ha)
Input cost for trees	81595
Input cost for crops	443000
Total Costs	524595
Return from trees	3609700
Return from crops	801000
Total returns	4410700
Net returns for the rotation	3886105
Annual average net return	298931
B:C ratio (discounted at 10%)	13

An economic evaluation was carried out for Eucalyptus-based bund plantations, featuring a tree density of 400 trees per hectare with 2-meter spacing, managed over an eight-year rotation cycle. The cropping sequence incorporated sugarcane for the first two years, followed by a wheat and rice rotation in subsequent years, reflecting common practices among farmers (Table-6). The analysis revealed a Benefit-Cost (B:C) ratio of 7.00, calculated at a discount rate of 10%. The average annual net returns from the Eucalyptus bund plantation were estimated at Rs. 82,357/-, offering significant economic benefits. In comparison, pure crop rotations yielded higher net returns of Rs. 5,76,500/- per annum. A similar pattern of yield was also reported in the Kaushambi district which is also supported by Ahirwar *et al*. (2015) [1].

Table 6: Cost-benefit analysis of Eucalyptus based bund system

Particulars	Value/amount (Rs/ha)
Input cost for trees	8500
Input cost for crops	80000
Total Costs	88500
Return from trees	520000
Return from crops	145000
Total returns	665000
Net returns for the rotation	576500
Annual average net return	82357
B:C ratio (discounted at 10%)	7.00

The cost benefit analysis of Eucalyptus based agrisilviculture with a tree density of 481 trees ha-1 and a seven year rotation under sugarcane (first two years) followed by only wheat in the next five years, as followed by the farmers was worked out (Table-7). The B:C worked out to 7.00 at a discount rate of 10 per cent. The average annual net returns worked out to Rs. 191428/- whereas, pure crop rotation gave a net return of only Rs. 1340000/- per annum. This finding is also supported by Yadav (2013) [4] in Khargone Block of Khargone District Madhya
Pradesh.

Table 7: Cost-benefit analysis of Eucalyptus based Agrisilviculture Systems

Particulars	Value/amount (Rs/ha)
Input cost for trees	12000
Input cost for crops	83000
Total Costs	95000
Return from trees	1300000
Return from crops	135000
Total returns	1435000
Net returns for the rotation	1340000
Annual average net return	191428
B:C ratio (discounted at 10%)	7.00

The cost benefit analysis of Tectona grandis based bund with a tree density of 266 trees ha-1 with 3m spacing and a seven year rotation under sugarcane (first two years) followed by only wheat in the one years, as followed by the farmers was worked out (Table-8). The B:C worked out to 2.00 at a discount rate of 10 per cent. The average annual net returns worked out to Rs. 411000/- whereas, pure crop rotation gave a net return of only Rs. 822000/- per annum.

Table 8: Cost-benefit analysis of Tectona grandis based Bund system

Particulars	Value/amount (Rs/ha)
Input cost for trees	23000
Input cost for crops	78000
Total Costs	101000
Return from trees	798000
Return from crops	125000
Total returns	923000
Net returns for the rotation	822000
Annual average net return	411000
B:C ratio (discounted at 10%)	2

The cost-benefit analysis of Phyllanthus emblica-based agrihorticulture systems, with a tree density of 278 trees per hectare and a 6x6 meter spacing, was conducted using a seven-year rotation cycle. This system involved sugarcane cultivation during the first two years, followed by wheat cultivation for the next five years, as practiced by farmers (Table-11).The Benefit-Cost (B:C) ratio, calculated at a 10% discount rate, was found to be 3.00, indicating solid profitability. The average annual net returns for this system were calculated to be Rs. 28,879 per hectare, which is significantly higher than the Rs. 11,734 per hectare per annum from pure crop rotation.

Table 9: Cost-benefit analysis of *Phyllanthus emblica* based Agrihorticulture systems

Particulars	Value/amount (Rs/ha)
Input cost for trees	14100
Input cost for crops	63000
Total Costs	77100
Return from trees	250200
Return from crops	136000
Total returns	386200
Net returns for the rotation	309100
Annual average net return	30910
B:C ratio (discounted at 10%)	10

The cost-benefit analysis of *Swietenia macrophylla*-based bund systems, with a tree density of 261 trees per hectare and 3-meter spacing, was conducted using a seven-year rotation cycle. This system incorporated sugarcane cultivation during the first two years, followed by wheat cultivation for the subsequent five years, reflecting the practices adopted by farmers (Table-10). The Benefit-Cost (B:C) ratio, evaluated at a 10% discount rate, was found to be 15.00, indicating exceptional economic efficiency. The average annual net returns from this system were calculated to be Rs. 1,99,360 per hectare, significantly higher than the Rs. 29,9045 per hectare per annum obtained from pure crop rotations.

Table 10: Cost-benefit analysis of *Swietenia macrophylla* based Bund system

Particulars	Value/amount (Rs/ha)
Input cost for trees	12655
Input cost for crops	81000
Total Costs	93655
Return from trees	252700
Return from crops	140000
Total returns	392700
Net returns for the rotation	299045
Annual average net return	19936
B:C ratio (discounted at 10%)	15

The cost-benefit analysis of Mangifera indica (Mango) and Eucalyptus-based agrisilviculture systems, with a tree density of 156 trees per hectare and a seven-year rotation period, was conducted using the cropping sequence of sugarcane, wheat, and rice (annual). This analysis reflects the actual practices followed by the farmers. The Benefit-Cost (B:C) ratio, calculated at a discount rate of 10%, demonstrates the economic efficiency of the system. The results revealed that the average annual net returns for the combined agrisilvihorticulture system amounted to Rs. 67,432 per hectare, showcasing the system's profitability. In comparison, a pure crop rotation system yielded significantly lower net returns of only Rs. 53,946 per hectare per annum (table-11), underscoring the financial advantages of integrating trees into agricultural systems. These findings highlight the economic viability and sustainability of agroforestry practices, particularly for long-term income generation and resource optimization. The same trend was also reported by Samriti (2015) in diferent agroforestry systems in the low hills of Himachal Pradesh.

Table 11: Cost-benefit analysis of Magnifera indica and Eucalyptus based Agrisilvihorticulture system

Particulars	Value/amount (Rs/ha) Mango	Value/amount (Rs/ha) Eucalyptus	Value/amount (Rs/ha) M+E
Input cost for trees	9300	2040	11340
Input cost for crops	58000	58000	58000
Total Costs	63300	60040	69340
Return from trees	312000	176800	488800
Return from crops	12000	120000	120000
Total returns	432000	296800	608800
Net returns for the rotation	368700	236760	539460
Annual average net return	36870	33822	67432
B:C ratio (discounted at 10%)	10	7	8

Conclusion

The primary driver for adopting commercial agroforestry in eastern Uttar Pradesh is the assurance of a steady income. Additionally, the availability of fuelwood is a significant factor encouraging farmers to grow trees on their farmlands under these systems. Various tree-based commercial agroforestry practices have proven to be more profitable than traditional cropping patterns in this region. Incorporating trees into farming systems enhances income and employment opportunities for farm households while meeting their wood requirements. Different forms of agroforestry play essential roles in supporting livelihoods and contributing to industrial development. These systems need to be nurtured carefully to ensure their sustainability.

References

1. Ahirwar RF, Verma AK, Shekhawat LS. Cost and income structure of wheat cultivation in Vindhyan Plateau of Madhya Pradesh. Economic Affairs. 2015;60(1):83-88.
2. Gittinger JP. Economic analysis of agricultural products. Baltimore: Johns Hopkins University Press; 1982.
3. Jain SK, Singh P. Economic analysis of industrial agroforestry: Poplar (*P. deltoides*) in Uttar Pradesh (India). Agroforestry Systems. 2000;49(3):255-273.
4. Jhariya MK, Banerjee A, Meena RS, Yadav DK. Sustainable agriculture, forest and environmental management. Singapore: Springer Nature Singapore; 2019. p. 606. https://doi.org/10.1007/978-981-13-6830-1 (eISBN: 978-981-13-6830-1).

5. Jhariya MK, Meena RS, Banerjee A. Ecological intensification of natural resources for sustainable agriculture. Singapore: Springer Nature Singapore; 2021. p. 655. https://doi.org/10.1007/978-981-33-4203-3 (eISBN: 978-981-334-203-3).
6. Khan N, Jhariya MK, Yadav DK, Banerjee A. Herbaceous dynamics and CO2 mitigation in an urban setup—a case study from Chhattisgarh, India. Environmental Science and Pollution Research. 2020;27(3):2881-2897. https://doi.org/10.1007/s11356-019-07182-8.
7. Khan N, Jhariya MK, Yadav DK, Banerjee A. Structure, diversity and ecological function of shrub species in an urban setup of Sarguja, Chhattisgarh, India. Environmental Science and Pollution Research. 2020;27(5):5418-5432. https://doi.org/10.1007/s11356-019-07172-w.
8. Leakey RR.B. Definition of agroforestry revisited. Agroforestry Today. 1996;8(1):5-7.
9. Lehmann LM, Smith J, Westaway S, Pisanelli A, Russo G, Borek R, Sandor M, Gliga A, Smith L, Ghaley BB. Productivity and economic evaluation of agroforestry systems for sustainable production of food and non-food products. Sustainability. 2020;12(13):5429. https://doi.org/10.3390/su12135429.
10. Raj A, Jhariya MK, Bargali SS. Bund based agroforestry using Eucalyptus species: a review. Current Agriculture Research Journal. 2016;4(2):148-158.
11. Raj A, Jhariya MK, Khan N. Agroforestry systems: a boon for developing country. Advances in Environmental Studies. 2020;4(2):368-375.
12. Samriti. Socioeconomic analysis of different agroforestry systems in low hills of Himachal Pradesh. Thesis. Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP, India; 2015.
13. Noordwijk VM, Speelman E, Hofstede GJ, Farida A, Abdurrahim AY, Miccolis A, *et al*. Sustainable agroforestry landscape management: changing the game. Land. 2020;9(8):243.
14. Yadav M. An evaluation of optimum and profitable combination of crop-livestock enterprise in Khargone Block of Khargone District, Madhya Pradesh. M.Sc. (Ag.) Thesis. R.V.S.K.V.V., Gwalior, Madhya Pradesh, India; 2013.