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Determinants, Constraints, and Livelihood Implications of Agroforestry Adoption in the Indo-Gangetic Plains of Uttar Pradesh, India

Rahul Yadav

rahulyadav02072000@gmail.com

Acharya Narendra Deva University of Agriculture and Technology

Devendra Kumar

Acharya Narendra Deva University of Agriculture and Technology

Sachin Kumar

Forest College and Research Institute

Anjali Tiwari

Acharya Narendra Deva University of Agriculture and Technology

Shayma Parveen

Acharya Narendra Deva University of Agriculture and Technology

S Chandana

Navsari Agriculture University

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Abstract

Agroforestry is increasingly recognized as a climate-smart land-use strategy that enhances agricultural productivity, diversifies farm income, and improves environmental sustainability. However, information on agroforestry adoption patterns, species preferences, and adoption constraints remains limited in the Indo-Gangetic Plains of India. This study assessed agroforestry system diversity, species preferences, adoption patterns, and major constraints among farmers in Amethi district, Uttar Pradesh. A multistage sampling approach was used to survey 200 agroforestry-practicing households across 20 villages in the Jagdishpur and Musafirkhana blocks during 2023–2024. Data were collected through structured interviews, field observations, and farm visits and analyzed using descriptive statistics and chi-square (χ^2) tests. Eight agroforestry systems were identified, with agri-silviculture being the dominant system (71.5%), followed by agri-horticulture (13.0%) and agri-silvi-horticulture (8.0%). The distribution of agroforestry systems differed significantly among respondents ($\chi^2 = 215.3$, $p < 0.001$). Eucalyptus (61.5%) and teak (29.0%) were the most preferred tree species, while mango (58.0%) was the dominant fruit species. Tree species preference showed significant variation ($\chi^2 = 23.09$, $p = 0.001$), whereas fruit species distribution did not differ significantly between study blocks ($\chi^2 = 4.545$, $p = 0.606$). Paddy- and wheat-based agroforestry systems were the most widely adopted crop combinations. Major constraints included limited market information, high labour requirements, inadequate technical knowledge, irrigation limitations, crop–tree competition, and concerns regarding water use by certain tree species. The findings highlight the importance of strengthening extension services, market linkages, quality planting material supply, and institutional support to promote climate-resilient agroforestry and sustainable rural livelihoods.

Introduction

Agroforestry, the deliberate integration of trees, crops, and/or livestock within the same land management unit, is widely recognized as a sustainable land-use strategy that enhances agricultural productivity, improves rural livelihoods, and conserves natural resources (Wanjira et al., 2020; Jose, 2009). In the face of increasing challenges such as climate change, land degradation, biodiversity loss, and rising food demand, agroforestry has emerged as a climate-smart approach that promotes ecological sustainability and socio-economic resilience (FAO, 2023; Datta *et al*., 2024). The integration of woody perennials into farming systems provides multiple ecosystem services, including carbon sequestration, soil fertility improvement, nutrient cycling, biodiversity conservation, microclimate regulation, erosion control, and diversification of farm income (Jose, 2009; Ajit et al., 2017; Baig *et al*., 2021). Recent studies have further emphasized its role in climate-change adaptation and mitigation through enhanced farm resilience and environmental sustainability (Verma et al., 2021; Swadhi, R. (2025).). Globally, agroforestry is increasingly regarded as a nature-based solution for achieving several Sustainable Development Goals (SDGs), particularly those related to food security, climate action, land restoration, and poverty alleviation (FAO, 2023; IPCC, 2023; Rosenstock et al., 2019; Van *et al*., 2022). A recent meta-analysis of Indian agroforestry systems reported substantial carbon sequestration potential, with agri-horticultural systems exhibiting higher soil carbon storage than many other agroforestry

configurations (Tyagi *et al*., 2023). Similar studies have highlighted the significant role of agroforestry in enhancing carbon storage, biodiversity conservation, and ecosystem resilience across diverse agricultural landscapes (Mbow et al., 2014; Udawatta and Jose, 2023). Furthermore, climate-smart agroforestry systems have been shown to improve environmental sustainability while enhancing farm-level economic returns, making them highly relevant for smallholder agriculture under changing climatic conditions (Datta *et al*., 2024; Rosenstock et al., 2019; Swadhi, R. (2025).

India has a long tradition of agroforestry, with diverse indigenous systems adapted to various agroecological regions. Agroforestry contributes significantly to the production of timber, fuelwood, fodder, fruits, and medicinal products while supporting millions of rural households (Ajit et al., 2017; Chavan et al., 2024). Recognizing its importance, India became the first country to introduce a dedicated National Agroforestry Policy (2014) aimed at promoting tree-based farming systems, increasing tree cover outside forests, and enhancing farmers' income (Government of India, 2014). According to the Department of Agriculture and Farmers Welfare, agroforestry currently covers approximately 28.4 million hectares, representing about 8.65% of India's geographical area (DAFW, 2023). The India State of Forest Report (ISFR) 2023 reported a total forest and tree cover of 827,357 km² (25.17%), including 99,779 km² (3.41%) under tree cover, with national carbon stocks estimated at 7,285.5 million tonnes (FSI, 2023). Agroforestry is also considered a key strategy for achieving India's commitment of creating an additional carbon sink of 2.5–3.0 billion tonnes CO_2 equivalent by 2030 under the Nationally Determined Contributions (MoEFCC, 2023).

Despite its numerous benefits, agroforestry adoption remains uneven across regions and farming communities. Adoption decisions are influenced by socio-economic, institutional, ecological, and market-related factors such as education, landholding size, income, extension support, awareness, and market access (Bannister and Nair, 2003; Mercer, 2004; Baig *et al*., 2021). Conversely, labour requirements, delayed economic returns, limited technical knowledge, poor market infrastructure, and inadequate availability of quality planting material often constrain adoption (Sebuliba et al., 2023; Swadhi, R. (2025).

Amethi district of Uttar Pradesh is predominantly agrarian, where agroforestry systems involving timber, fruit, and multipurpose tree species play an important role in supporting farm productivity and household livelihoods. However, information on agroforestry system diversity, species preferences, adoption patterns, and constraints remains limited. Therefore, the present study was conducted in the Jagdishpur and Musafirkhana blocks of Amethi district covering 200 agroforestry-practicing households. The study aimed to identify existing agroforestry systems, assess preferred tree and fruit species, analyse adoption patterns, and evaluate major constraints affecting agroforestry adoption. The findings are expected to support evidence-based policy formulation and promote climate-resilient, livelihood-oriented agroforestry development while contributing to SDGs related to poverty reduction, food security, climate action, and sustainable land management. The objectives of the present study include:

1. To identify different Agroforestry systems practiced by farmers in Jagdishpur and Musafirkhana Blocks of district Amethi.
2. To study the constraints and limited resource of Farmers for Agroforestry systems in Jagdishpur and Musafirkhana Blocks of district Amethi.

Materials and Methods

Study Area

The study was conducted in Amethi district of Uttar Pradesh, India, located in the central part of the Indo-Gangetic Plains (Fig. 1). The district lies between approximately 26°00'–27°00' N latitude and 81°30'–82°30' E longitude and is characterized by a subtropical climate with hot summers, moderate winters, and a monsoon season extending from June to September (ICAR, 2023; Jat et al., 2021). The average annual rainfall ranges between 900 and 1,100 mm, most of which is received during the southwest monsoon. Agriculture is the predominant occupation of the rural population, and farming systems are primarily based on rice–wheat and rice–pulse cropping sequences, which are characteristic of the Indo-Gangetic Plains and contribute significantly to regional food security (Ladha et al., 2009; Ajit et al., 2017; Chavan et al., 2024). The district was selected due to the widespread occurrence of traditional and commercial agroforestry practices and the increasing importance of tree-based farming systems in enhancing livelihood security and farm sustainability (Nair, 2012; Baig *et al*., 2021; Rizvi et al., 2024). Agroforestry systems in the region comprise combinations of timber, fruit, and multipurpose tree species integrated with annual agricultural crops, providing opportunities to assess adoption patterns and socioeconomic determinants of agroforestry development (Mercer, 2004; Jose, 2009; Datta *et al*., 2024; Swadhi, R. (2025).

Sampling Design and Data Collection

The study was conducted in Amethi district, Uttar Pradesh, India, using a multistage sampling approach. Jagdishpur and Musafirkhana blocks were purposively selected due to the prevalence of agroforestry practices. Ten villages were randomly selected from each block, resulting in 20 study villages. Agroforestry-practicing households served as the sampling units. A total of 200 respondents (100 from each block) were selected through proportionate random sampling. The sample size was considered adequate to ensure representative coverage of agroforestry farmers and reliable statistical inference at a 95% confidence level. Primary data were collected during 2023–2024 through personal interviews, field observations, and farm visits using a pre-tested structured questionnaire. Information on socio-economic characteristics, including age, education, family size, landholding, occupation, income, farming experience, livestock ownership, extension access, and agroforestry practices, was recorded. Similar methodologies have been employed in agroforestry adoption studies (Mercer, 2004; Baig *et al*., 2021; Datta *et al*., 2024). Secondary data on climate, soils, land use, and demographic characteristics were obtained from the District Statistical Handbook, DAFW, FSI (2023), and relevant literature.

Identification and Classification of Agroforestry Systems

Agroforestry systems were identified through field observations and farmer interviews following the classification framework proposed by (Wanjira et al., 2020). Systems were categorized based on the composition and arrangement of trees, crops, and livestock components. Similar approaches have been widely adopted for agroforestry inventory and characterization studies across diverse agroecological regions (Jose, 2009; Dagar and Tewari, 2018; Chavan et al., 2024). The major systems recorded included Agri-silviculture (AS), Agri-horticulture (AH), Agri-silvi-horticulture (ASH), Agri-silvi-pastoral (ASP), Silvi-pastoral (SP), multipurpose trees on farmland, trees and shrubs on pasturelands, and mixed woodlots/boundary plantations. Frequency and percentage distributions were computed to determine their prevalence among respondents (Ajit et al., 2017; Baig *et al*., 2021; Datta *et al*., 2024). The classification and quantification of agroforestry systems provide a basis for understanding system diversity, farmer preferences, and the role of tree-based farming in supporting sustainable livelihoods and climate-resilient agriculture (Nair, 2012; Rizvi et al., 2024).

Assessment of Farmers' Perceptions and Constraints

Farmers' perceptions regarding agroforestry benefits, including income enhancement, soil fertility improvement, environmental conservation, diversification of farm production, and climate resilience, were assessed using a structured interview schedule. Responses were summarized through frequency and percentage analysis (Baig *et al*., 2021; Datta *et al*., 2024). Constraints affecting agroforestry adoption were identified through farmer responses. Major constraints included long gestation periods of trees, competition between trees and crops, lack of quality planting material, inadequate technical knowledge, limited market information, high labour requirements, insufficient institutional support, livestock and pest damage, irrigation constraints, transportation difficulties, perceived high water consumption by trees, and land occupation or shading effects. The frequency and percentage of respondents reporting each constraint were calculated and ranked accordingly (Sebuliba et al., 2023; Swadhi, R. (2025).). The severity of each constraint was assessed using Garrett Ranking Technique. The percent position was calculated as:

$$\text{Percent Position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

where:

Rij = rank given for the i th constraint by the j th respondent

Nj = total number of constraints ranked by the j th respondent

The obtained scores were converted into Garrett values and ranked accordingly.

Statistical Analysis

Data were coded, tabulated, and analyzed using IBM SPSS Statistics Version 25.0. Descriptive statistics such as frequencies, percentages, means, and standard deviations were computed. Chi-square (χ^2) tests were employed to examine differences in agroforestry system adoption, species preferences, and farmers' perceptions. Statistical significance was determined at $P \leq 0.05$ and $P \leq 0.01$ levels.

Results and Discussion

Distribution of Agroforestry Systems

A total of 200 agroforestry farmers were surveyed across Jagdishpur and Musafirkhana blocks of Amethi district. Eight different agroforestry systems were identified in the study area. Agri-silviculture was the dominant agroforestry system, adopted by 143 farmers (71.5%), followed by agri-horticulture (13.0%) and agri-silvi-horticulture (8.0%). Other systems such as agri-silvi-pastoral (2.5%), multipurpose trees on farmland (2.0%), trees and shrubs on pasture (2.0%), silvi-pasture (0.5%), and mixed woodlots (0.5%) showed relatively (Fig. 2**)** low adoption rates. Adoption patterns were similar in both blocks, indicating a strong preference for tree-crop combinations over more complex (Table 2) agroforestry systems. The chi-square analysis revealed significant variation in the distribution of agroforestry systems among respondents ($\chi^2 = 215.3$, $p < 0.001$), suggesting that farmers strongly favored specific agroforestry models.

Agroforestry System Components and Crop Combinations

The agri-silviculture system consisted mainly of Eucalyptus, Teak, Arjun, Shisham, Mahua, Neem, and Mahogany integrated with paddy, wheat, mustard, sugarcane, pea, potato, and lentil crops. Agri-horticulture systems were dominated by mango, aonla, guava, papaya, banana, and citrus combined with field crops. Agri-silvi-horticulture systems incorporated tree, fruit, and agricultural crop components simultaneously. Silvi-pastoral and agri-silvi-pastoral systems integrated fodder grasses such as maize, jowar, barley, Napier grass, Bermuda grass, and Palamora grass with tree species. These systems provided multiple ecological and economic benefits including diversification of farm production, enhanced biodiversity, soil conservation, and livelihood support.

Preferred Tree Species in Agroforestry Systems

Among the tree species recorded on farmers' fields, Eucalyptus was the most preferred species, accounting for 123 individuals across both blocks, followed by Teak (58 trees). Other species including Mahua, Arjun, Neem, Shisham, and Mahogany occurred at much lower frequencies. Eucalyptus represented approximately 61.5% of the total recorded trees, highlighting its economic importance and adaptability (Fig. 3) in the study area. A significant difference was observed in tree species distribution

($\chi^2 = 23.09$, $p = 0.001$), (Table 3**)** indicating clear farmer preference toward selected commercially valuable species.

Preferred Fruit Species in Agroforestry Systems

Among fruit species, mango was the most widely adopted species, with 58 occurrences across the study area. Guava, aonla, citrus, papaya, banana, and jackfruit were present in comparatively lower numbers. Mango accounted (Fig. 4) for the majority of fruit-based agroforestry plantations, (Table 4**)** reflecting its economic significance and suitability under local agro-climatic conditions. No significant difference was observed in fruit species distribution between blocks ($\chi^2 = 4.545$, $p = 0.606$).

Paddy-Based Agroforestry Systems

Paddy-based agroforestry represented one of the most important crop-based systems in the study area. The highest adoption intensity was observed at 0.4 ha, where 52 farmers (26.0%) practiced paddy-based agroforestry. The second highest adoption level occurred at 0.3 ha (17.5%). Adoption ranged from 0.1 to 1.5 ha, indicating (Table 1) substantial variability among farmers. Musafirkhana farmers generally maintained larger paddy-based agroforestry areas compared to Jagdishpur farmers.

Wheat-Based Agroforestry Systems

Wheat-based agroforestry was also widely practiced. The highest frequency of adoption was recorded at 0.4 ha, where 53 farmers (26.5%) cultivated wheat under agroforestry conditions. Adoption intensity ranged from 0.2 to 1.3 ha. Musafirkhana block exhibited a relatively higher concentration of farmers adopting wheat-based agroforestry at moderate to high intensity levels.

Pea-Based Agroforestry Systems

Pea-based agroforestry was poorly represented in the study area. Out of 200 respondents, 194 farmers (97%) did not practice pea-based agroforestry. Only five farmers reported adopting pea-based systems at low intensity levels ranging from 0.1 to 0.15 ha. The results indicate minimal integration of pea crops within existing agroforestry systems.

Sugarcane-Based Agroforestry Systems

Sugarcane-based agroforestry adoption was limited. Approximately 85.5% of respondents did not cultivate sugarcane under agroforestry systems. Among adopters, the highest frequency was observed at 0.4 ha (5.5%), followed by 0.2 ha (4.5%). Adoption levels varied from 0.2 to 0.5 ha.

Potato-Based Agroforestry Systems

Potato-based agroforestry systems were adopted by only 12.5% of farmers, whereas 87.5% reported no adoption. The majority of adopters cultivated potato under agroforestry at 0.1–0.2 ha. Jagdishpur exhibited slightly greater adoption compared to Musafirkhana.

Constraints Affecting Agroforestry Adoption

Several constraints limited agroforestry adoption in the study area (Table 5**)**. Major constraints included high labour requirements (54–60%), limited awareness regarding agroforestry technologies (49–52%), crop yield reduction due to tree shade (39–47%), lack of market information (73–74%), concerns regarding water (Fig. 5) consumption by Eucalyptus (63–74%), transportation limitations, and inadequate irrigation facilities. Farmers also reported land occupation by trees and tenancy-related restrictions as barriers to agroforestry expansion.

Farmers' Perceptions toward Agroforestry

Constraint analysis revealed that lack of market information was the most important barrier to agroforestry adoption (mean score = 73.5%), followed by perceived high water use by Eucalyptus (68.5%) and labour requirement (57.0%). Limited awareness (50.5%) and crop disturbance due to tree shade (43.0%) were also reported as important constraints. Transportation and irrigation constraints received moderate scores (27.0%), whereas lease restrictions (8.95%) and land occupation by trees (8.5%) were perceived as relatively less important. These findings indicate that information, market access, and management-related challenges exert a stronger influence on agroforestry adoption than land-tenure constraints in the study area.

Table 1
Adoption Pattern of Major Crop-Based Agroforestry Systems in Amethi District, Uttar Pradesh (n = 200)

Crop-based Agroforestry System	Adoption Status	Number of Farmers	Percentage (%)	Adoption Range (ha)	Most Common Adoption Level (ha)
Paddy-based Agroforestry	Adopted	200	100.0	0.1–1.5	0.4 (26.0%)
Wheat-based Agroforestry	Adopted	200	100.0	0.2–1.3	0.4 (26.5%)
Pea-based Agroforestry	Adopted	6	3.0	0.1–0.15	0.1–0.15
	Not Adopted	194	97.0	–	–
Sugarcane-based Agroforestry	Adopted	29	14.5	0.2–0.5	0.4 (5.5%)
	Not Adopted	171	85.5	–	–
Potato-based Agroforestry	Adopted	25	12.5	0.1–0.2	0.1–0.2
	Not Adopted	175	87.5	–	–

Table 2
Distribution of Agroforestry Systems Adopted by Farmers

Agroforestry System	Jagdishpur (n = 100)	Musafirkhana (n = 100)	Total (n = 200)	Percentage (%)
Agri-Silviculture	71	72	143	71.5
Agri-Horticulture	12	14	26	13.0
Agri-Silvi-Horticulture	8	8	16	8.0
Agri-Silvi-Pastoral	5	0	5	2.5
Multipurpose Trees on Farmland	3	1	4	2.0
Trees & Shrubs on Pasture	0	4	4	2.0
Silvi-Pasture	0	1	1	0.5
Mixed Woodlots	1	0	1	0.5
Total	**100**	**100**	**200**	**100**

Table 3
Preferred Tree Species Adopted in Agroforestry Systems

Tree Species	Jagdishpur	Musafirkhana	Total	Percentage (%)
Eucalyptus	63	60	123	61.5
Teak	25	33	58	29.0
Mahua	4	2	6	3.0
Arjun	2	2	4	2.0
Neem	2	1	3	1.5
Shisham	2	1	3	1.5
Mahogany	2	1	3	1.5
Total	**100**	**100**	**200**	**100**

Table 4
Preferred Fruit Species Adopted in Agroforestry Systems

Fruit Species	Jagdishpur	Musafirkhana	Total	Percentage (%)
Mango	30	28	58	58.0
Guava	5	4	9	9.0
Aonla	3	5	8	8.0
Citrus	2	3	5	5.0
Papaya	4	3	7	7.0
Banana	4	5	9	9.0
Jackfruit	3	3	6	6.0
Total	**51**	**51**	**102**	**100**

Table 5
Garrett-Type Priority Ranking of Constraints Affecting Agroforestry Adoption

Constraint	Jagdishpur (%)	Musafirkhana (%)	Mean Score (%)	Rank
Lack of market information	73	74	**73.5**	I
Perceived high water use by Eucalyptus	63	74	**68.5**	II
Labour requirement	54	60	**57.0**	III
Limited awareness	49	52	**50.5**	IV
Crop disturbance due to tree shade	39	47	**43.0**	V
Transportation constraints	27	27	**27.0**	VI
Irrigation constraints	27	27	**27.0**	VI
Lease restrictions*	8.5	9.4	**8.95**	VII
Land occupation by trees	6	11	**8.5**	VIII

Figure 3. Preferred Tree Species Adopted in Agroforestry Systems

Figure 2. Distribution of Agroforestry Systems Adopted by Farmers

Limitation of the Study

The study was limited to 200 agroforestry-practicing households from the Jagdishpur and Musafirkhana blocks of Amethi district, which may restrict the generalization of findings to other regions. The analysis

was based primarily on farmers' responses and field observations, which may be influenced by personal perceptions and recall bias. In addition, the study focused mainly on adoption patterns, species preferences, and constraints, without assessing the long-term economic returns, productivity, carbon sequestration potential, or ecological impacts of different agroforestry systems.

Conclusion

The study revealed that agroforestry is an important and well-established farming practice in Amethi district, Uttar Pradesh. Among the identified systems, Agri-silviculture (71.5%) was the most widely adopted, followed by Agri-horticulture (13.0%) and Agri-silvi-horticulture (8.0%). Farmers mainly preferred commercially valuable species such as Eucalyptus, Teak, and Mango, while paddy- and wheat-based agroforestry systems were the dominant crop combinations. These systems contribute to higher farm income, livelihood diversification, and better utilization of farm resources. However, the expansion of agroforestry is constrained by factors such as limited market information, high labour requirements, lack of technical knowledge, crop–tree competition, inadequate irrigation facilities, and concerns regarding water use by certain tree species. Strengthening extension services, improving access to quality planting material, developing market linkages, and enhancing institutional support can help overcome these challenges. Overall, agroforestry has considerable potential to promote sustainable and climate-resilient agriculture in the region while contributing to SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land) through improved livelihoods, environmental conservation, and increased tree cover outside forests.

Declarations

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Author Contribution

Rahul Yadav contributed to the conceptualization and design of the study, conducted field investigations, performed data analysis, and prepared the original manuscript. Devendra Kumar provided supervision, methodological guidance, validation of results, and manuscript review. Sachin Kumar assisted in data analysis, interpretation of results, and manuscript writing and editing. Anjali Tiwari contributed to field surveys, data collection, and literature review. Shayma Parveen assisted in data validation, visualization, and manuscript review. Chandana S. contributed to methodology development, supervision, validation of findings, and critical revision of the manuscript. All authors read and approved the final manuscript and agreed to be accountable for the content of the work.

References

1. Ajit, Dhyani, S. K., Handa, A. K., Newaj, R., Chavan, S. B., Alam, B., … Gunasekaran, S. (2017). Estimating carbon sequestration potential of existing agroforestry systems in India. *Agroforestry Systems*, *91*(6), 1101–1118. https://doi.org/10.1007/s10457-016-9986-z
2. Baig, M. B., AlZahrani, K. H., Al-Shaikh, A. A., Wafa A. Abu Risheh, A., Straquadine, G. S., & Qureshi, A. M. (2022). Food security in the Kingdom of Saudi Arabia face to emerging dynamics: the need to rethink extension service. In *Food security and climate-smart food systems: building resilience for the global south* (pp. 157–187). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-92738-7_9
3. Bannister, M. E., & Nair, P. K. R. (2003). Agroforestry adoption in Haiti: the importance of household and farm characteristics. *Agroforestry systems*, *57*(2), 149–157. https://doi.org/10.1023/a:1023973623247
4. Chavan, S. B., Uthappa, A. R., Chichaghare, A. R., Kumar, D., Sirohi, C., & Kakade, V. D. (2024). Agroforestry Systems for Ecosystem. *Sustainable management and conservation of environmental resources in India*, 105. https://doi.org/10.1201/9781003469278-6
5. Dagar, J. C., & Tewari, V. P. (Eds.). (2018). *Agroforestry: anecdotal to modern science*. Springer. https://doi.org/10.1007/978-981-10-7650-3_2
6. Datta, P., & Behera, B. (2024). India's approach to agroforestry as an effective strategy in the context of climate change: An evaluation of 28 state climate change action plans. *Agricultural Systems*, *214*, 103840. https://doi.org/10.1016/j.agsy.2023.103840
7. Department of Agriculture and Farmers Welfare (DAFW). (2023). *Annual Report 2022–23*. Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.
8. Dhyani, S. K., & Handa, A. K. (2013). Area under agroforestry in India: An assessment for present status and future perspective. *Indian Journal of Agroforestry*, *15*(1), 1–11. https://doi.org/10.1007/978-81-322-1662-9_11
9. Food and Agriculture Organization (FAO). (2023). *The State of the World's Forests 2023*. Food and Agriculture Organization of the United Nations, Rome.
10. Forest Survey of India (FSI). (2023). *India State of Forest Report 2023*. Forest Survey of India, Dehradun, India.
11. Government of India. (2014). *National Agroforestry Policy, 2014*. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi.
12. ICAR (2023). *Handbook of Agriculture*. Indian Council of Agricultural Research, New Delhi.
13. ICFRE. (2024). *Wood Demand and Supply Outlook in India*. Indian Council of Forestry Research and Education, Dehradun, India.
14. IPCC. (2023). *Climate Change 2023: Synthesis Report*. Intergovernmental Panel on Climate Change, Geneva, Switzerland.
15. Jat, H. S., Datta, A., Choudhary, M., Sharma, P. C., & Jat, M. L. (2021). Conservation Agriculture: factors and drivers of adoption and scalable innovative practices in Indo-Gangetic plains of India–a

review. *International Journal of Agricultural Sustainability*, *19*(1), 40–55. https://doi.org/10.1080/14735903.2020.1817655

16. Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry systems*, *76*(1), 1–10. https://doi.org/10.1007/s10457-009-9229-7
17. Ladha, J. K., Kumar, V., Alam, M. M., Sharma, S., Gathala, M., Chandna, P., … Balasubramanian, V. (2009). Integrating crop and resource management technologies for enhanced productivity, profitability, and sustainability of the rice-wheat system in South Asia. *Integrated crop and resource management in the rice–wheat system of South Asia*, *2009*, 69–108.
18. Mbow, C., Van Noordwijk, M., Luedeling, E., Neufeldt, H., Minang, P. A., & Kowero, G. (2014). Agroforestry solutions to address food security and climate change challenges in Africa. *Current opinion in environmental sustainability*, *6*, 61–67. https://doi.org/10.1016/j.cosust.2013.10.014
19. Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: a review. *Agroforestry systems*, *61*(1), 311–328. https://doi.org/10.1023/b:agfo.0000029007.85754.70
20. Ministry of Environment, Forest and Climate Change (MoEFCC). (2023). *India's Updated Nationally Determined Contributions (NDCs)*. Government of India, New Delhi.
21. Nair, P. K. R. (2012). Carbon sequestration studies in agroforestry systems: a reality-check. *Agroforestry systems*, *86*(2), 243–253. https://doi.org/10.1007/s10457-011-9434-z
22. NITI Aayog. (2023). *Climate Resilient Agriculture and Sustainable Land Use in India*. Government of India, New Delhi.
23. Rizvi, J., Dhyani, S. K., Arunachalam, A., Rouge, J. C., & Singh, A. (2024). The National Agroforestry Policy in India, transforming Indian agriculture landscape and 1inspiring other nations: The role of ICRAF and its partners.
24. Rosenstock, T. S., Dawson, I. K., Aynekulu, E., Chomba, S., Degrande, A., Fornace, K., … Steward, P. (2019). A planetary health perspective on agroforestry in Sub-Saharan Africa. *One Earth*, *1*(3), 330–344. https://doi.org/10.1016/j.oneear.2019.10.017
25. Sebuliba, E., Isubikalu, P., Turyahabwe, N., G, M. M. J., Eilu, G., Kebirungi, H., … Ekwamu, A. (2023). Factors influencing farmer choices of use of shade trees in coffee fields around Mount Elgon, Eastern Uganda. *Small-scale Forestry*, *22*(2), 213–234. https://doi.org/10.1007/s11842-022-09523-x
26. Singh, C., Gupta, H., Khanduri, V. P., Singh, B., Rawat, D., & Kumar, M. (2026). Multipurpose Trees in Agroforestry Systems of the Northwestern Himalaya. In *Himalayan Agroforestry Systems: Challenges and Opportunity to Sustainable Development* (pp. 1–38). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-032-25096-4_1
27. Swadhi, R. (2025). Innovative strategies for widespread adoption in a climate-smart future: Scaling up agroforestry. In *Agroforestry for a Climate-Smart Future* (pp. 473–496). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-8282-0.ch016
28. Tyagi, A., & Haritash, A. K. (2026). Potential of agroforestry for environmental and socio-economic sustainability in India. *Mitigation and Adaptation Strategies for Global Change*, *31*(5), 41. https://doi.org/10.1007/s11027-026-10309-1

29. van Noordwijk, M., Catacutan, D. C., Duguma, L. A., Pham, T. T., Leimona, B., Dewi, S., … Minang, P. A. (2023). Agroforestry matches the evolving climate change mitigation and adaptation agenda in Asia and Africa. In *Agroforestry for sustainable intensification of agriculture in Asia and Africa* (pp. 21–52). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-4602-8_2
30. Verma, K., Sharma, P., Kumar, D., Vishwakarma, S. P., & Meena, N. K. (2021). Strategies sustainable management of agroforestry in climate change mitigation and adaptation. *International Journal of Current Microbiology and Applied Sciences*, *10*(01), 2439–2449. https://doi.org/10.20546/ijcmas.2021.1001.282
31. Wanjira, E. O., & Muriuki, J. (2020). Review of the status of agroforestry practices in Kenya. *Background Study for Preparation of Kenya National Agroforestry Strategy (2021–2030). DOI*, *10*.

Figures



Figure 1

Location of Study Area

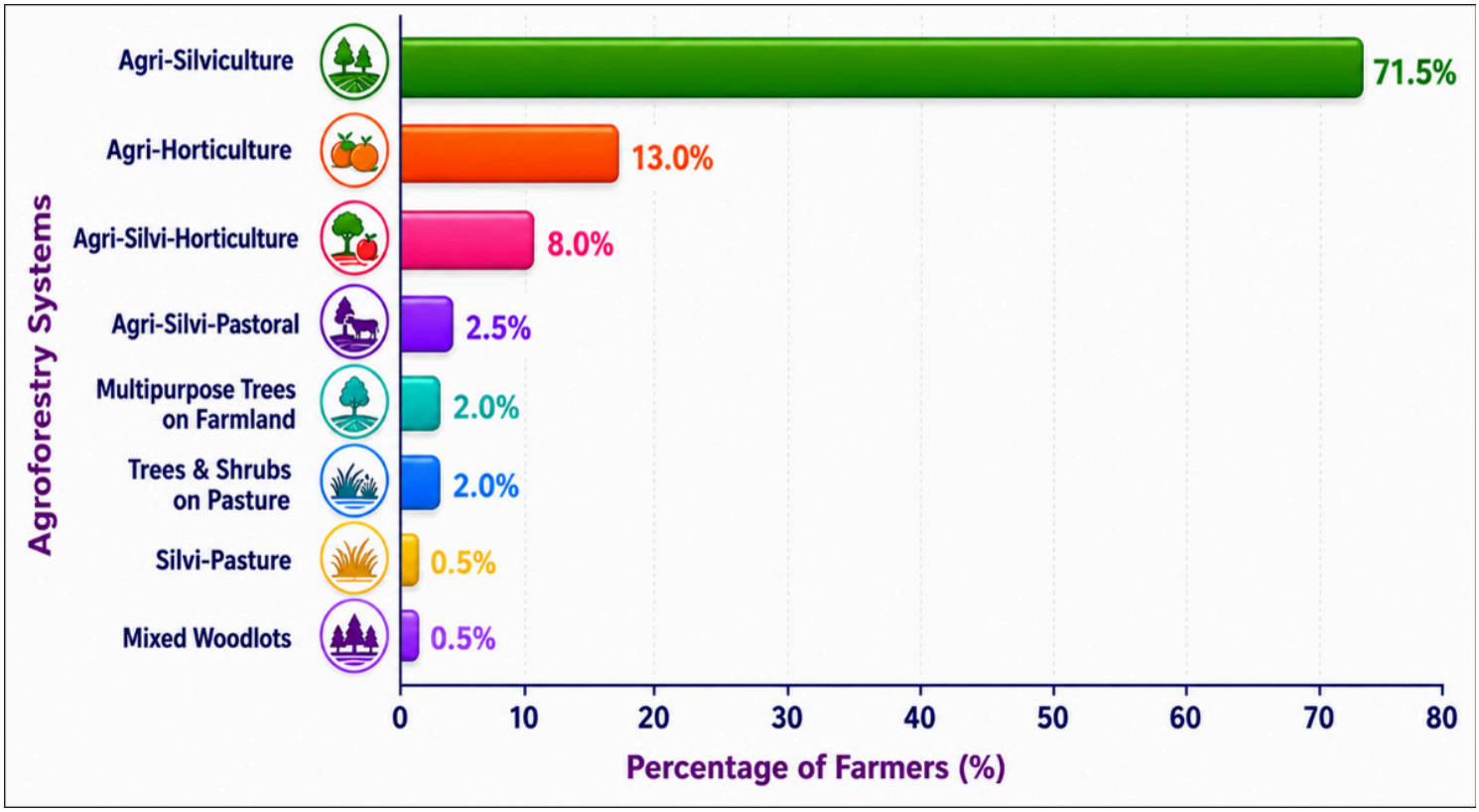


Figure 2

Distribution of Agroforestry Systems Adopted by Farmers

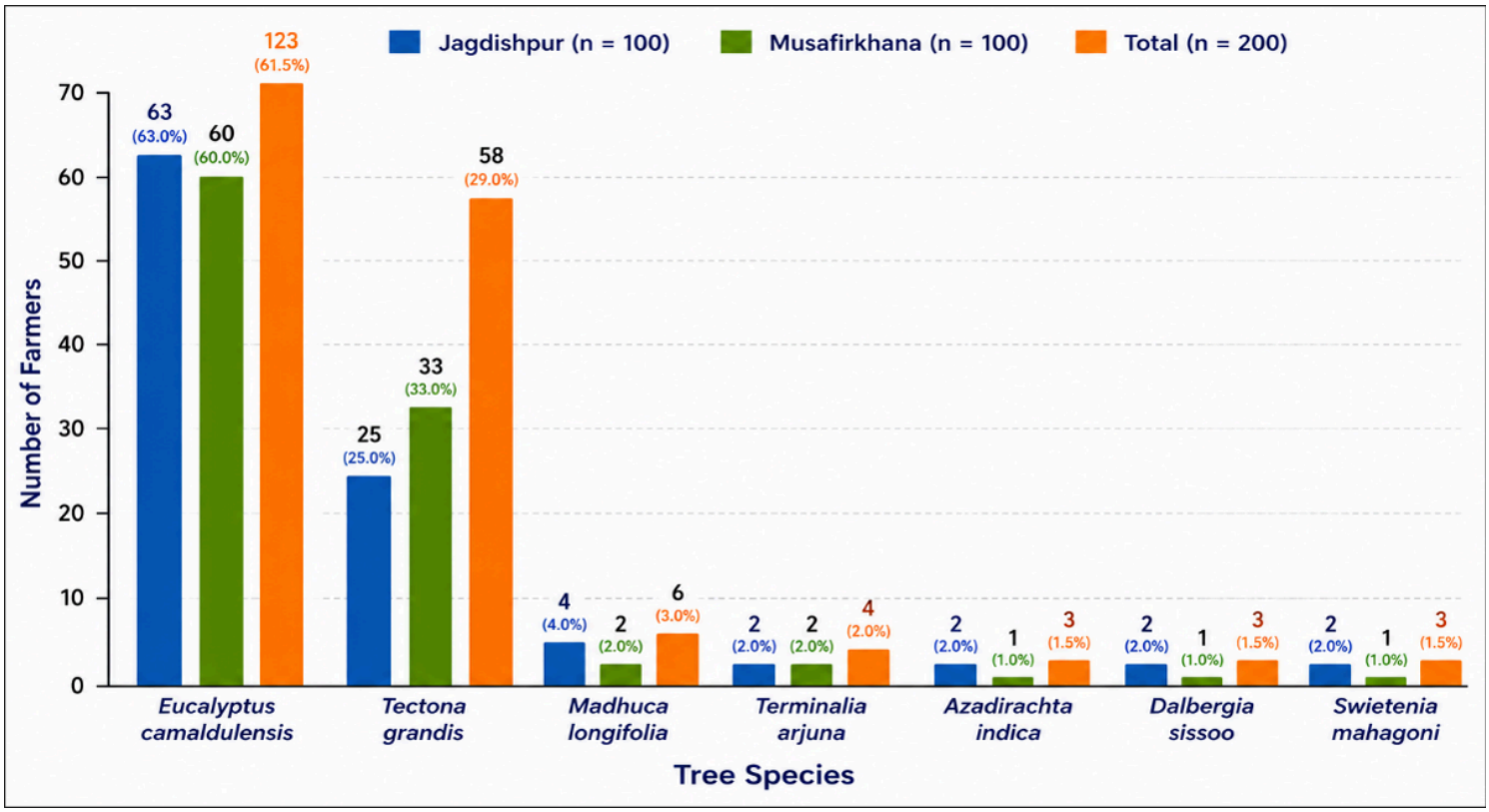


Figure 3

Preferred Tree Species Adopted in Agroforestry Systems

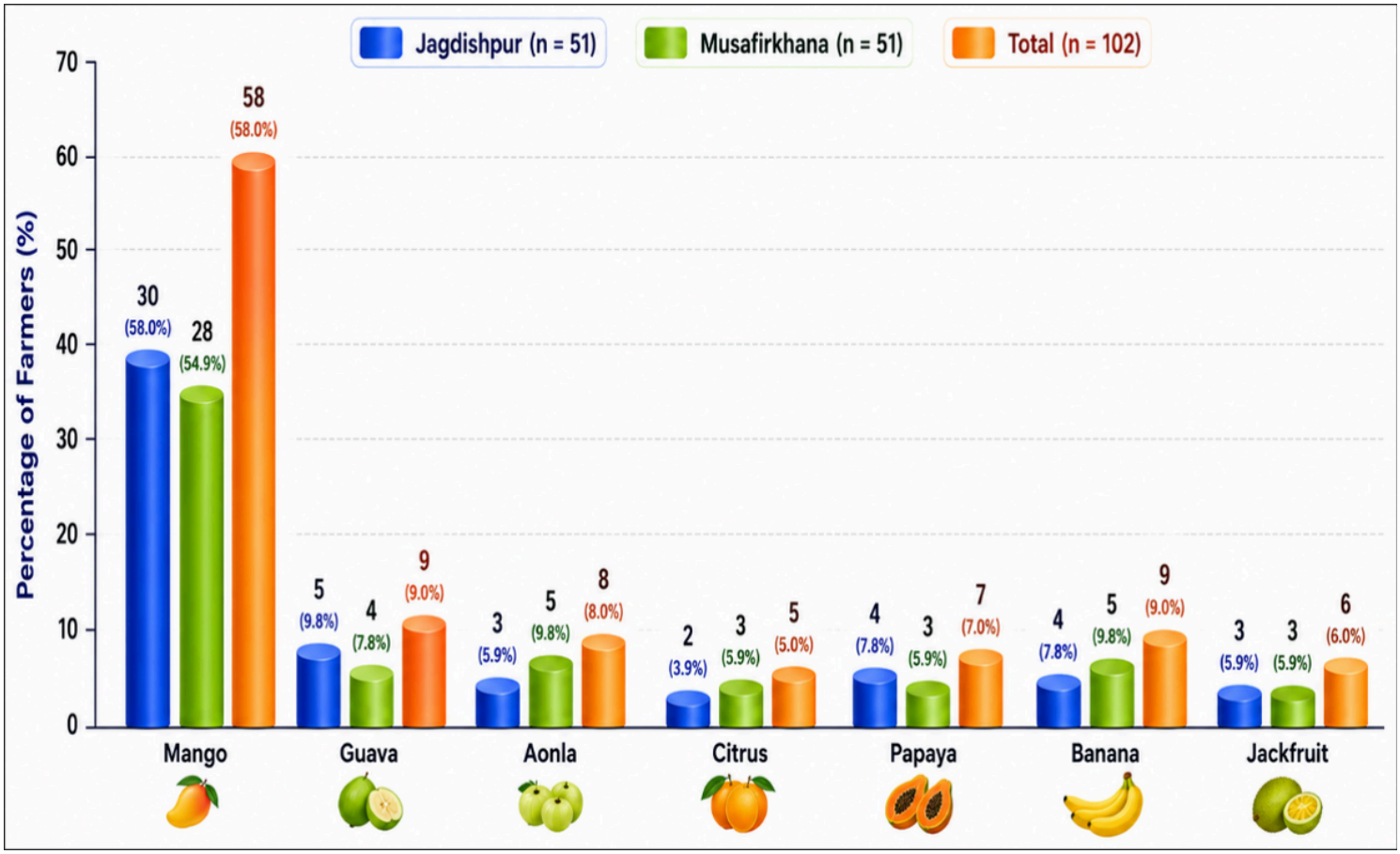


Figure 4

Preferred Fruits Species Adopted in Agroforestry Systems

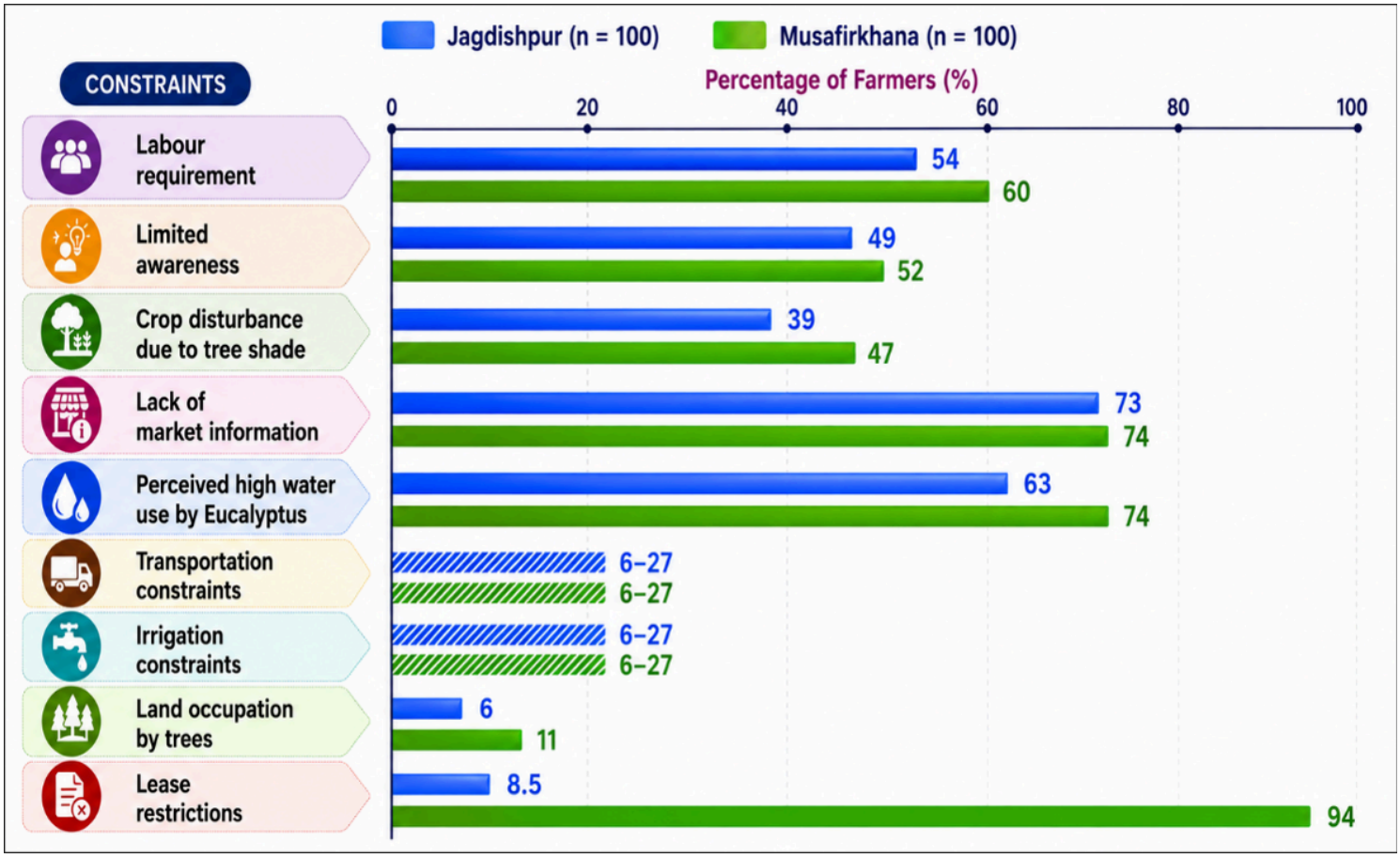


Figure 5

Major Constraints Affecting Agroforestry Adoption