

Optimizing Tree Selection for Agroforestry in Jaipur: A Multifunctional Approach

Kamal Murtala farouq^{*1}, Hafsat M. Musa², Rabia Sabo Muhammad³

^{*1}Department of Agricultural Technology, Audu Bako College of Agriculture Dambatta, Kano State, Nigeria and Department of Agriculture, Vivekananda Global University Jaipur, Rajasthan, India

²Department of Agricultural Extension and management Audu Bako College of Agriculture Dambatta., Kano State Nigeria

³School of Natural and Environmental Sciences, Newcastle University, UK

Corresponding Author: **Kamal Murtala farouq** (Department of Agricultural Technology, Audu Bako College of Agriculture Dambatta, Kano State, Nigeria and Department of Agriculture, Vivekananda Global University Jaipur, Rajasthan, India)

Article History: Received: 21/5/2025.; Accepted: 28/10/2025.; Published: 07/11/2025

Abstract: Agroforestry integrates trees and shrubs into agricultural landscapes, offering ecological stability, enhanced soil health, and diversified farmer incomes. In Jaipur's semi-arid regions, this practice addresses challenges like water scarcity and soil degradation. This study aims to optimize tree selection for agroforestry by evaluating the growth, economic viability, carbon sequestration potential, and soil nutrient enhancement of five tree species: *Azadirachta indica* (Neem), *Prosopis cineraria* (Khejri), *Acacia nilotica* (Babool), *Dalbergia sissoo* (Shisham), and *Moringa oleifera* (Drumstick). Field trials were conducted across three sites representing varied agro-climatic conditions. Parameters such as survival rate, height, diameter at breast height (DBH), canopy development, biomass production, and economic returns were measured. Neem and Khejri exhibited superior growth, high biomass yields, and economic benefits. Neem had the highest aboveground biomass (16.5 tons/ha) and substantial carbon sequestration (7.5 tons/ha). Both species significantly improved soil nutrients, enhancing soil organic carbon and nitrogen levels. Conclusively, Neem and Khejri emerge as optimal choices for agroforestry in Jaipur due to their robust performance and multifunctional benefits, providing a model for sustainable land management in similar semi-arid regions.

Keywords: Agroforestry, Carbon sequestration, Agro-climatic condition, optimization.

Cite this article: farouq, K., M., Musa, H., M. & Muhammad, R. S. (2025). Optimizing Tree Selection for Agroforestry in Jaipur: A Multifunctional Approach. *MRS Journal of Multidisciplinary Research and Studies*, 2(11),18-25.

Introduction

Agroforestry, the practice of integrating trees and shrubs into agricultural landscapes, is increasingly recognized for its potential to enhance ecological stability, improve soil health, and diversify income for farmers (Nair, 2007). In regions with fragile ecosystems, such as the semi-arid area of Jaipur, Rajasthan, agroforestry offers a promising solution to address the challenges posed by water scarcity, soil degradation, and climate variability (Gadgil & Kumar, 2018). The strategic inclusion of trees in farming systems can contribute to sustainable land management by providing multiple ecological, economic, and social benefits.

Jaipur, located in northwestern India, faces an arid to semi-arid climate characterized by low and erratic rainfall, high temperatures, and frequent droughts (Rathore, 2005). These harsh climatic conditions make traditional agricultural practices increasingly unsustainable, leading to a decline in soil fertility and agricultural productivity. Over time, population growth and urban expansion in the region have exacerbated the strain on natural resources, further threatening rural livelihoods and necessitating the exploration of alternative, sustainable land-use systems (Sarkar et al., 2017).

Agroforestry systems are valued for their multifunctionality. Ecologically, they play a crucial role in biodiversity conservation, soil and water conservation, and carbon sequestration (Jose, 2009). Economically, agroforestry offers diversified income streams through the production of timber, fuelwood, fodder, fruits, and various non-timber forest products (NTFPs) (Leakey, 2017). These systems also have significant social benefits, such as enhancing food security and providing additional resources for rural communities, thus contributing to improved livelihoods and poverty reduction (Garrity et al., 2010). However, the success and benefits of agroforestry are heavily dependent on the selection of tree species that are well-adapted to local conditions and can meet the diverse needs of farmers and the environment (Nair & Garrity, 2012).

Selecting appropriate tree species for agroforestry in semi-arid regions like Jaipur involves several challenges. The local agro-climatic conditions, marked by high temperatures, limited and inconsistent rainfall, and poor soil fertility, restrict the range of tree species that can thrive in these environments (Sinha et al., 2015). Furthermore, the chosen tree species must fulfill multiple functions such as biomass production, soil enhancement, carbon sequestration, and economic returns, often requiring trade-offs

(Pukkala, 2016). For example, species that grow rapidly and produce significant biomass may not necessarily improve soil fertility or provide high economic value (Kumar, 2011).

Resilience to climatic variability is another critical consideration for tree species selection in Jaipur. Species need to withstand prolonged periods of drought, which are common in the region (Dhillon et al., 2018). Additionally, socio-economic factors such as farmers' preferences, market demand, and the availability of planting material significantly influence the adoption and success of agroforestry practices (Mercer, 2004). Therefore, a systematic approach to tree selection that integrates ecological suitability, economic viability, and social acceptability is essential for optimizing agroforestry systems in Jaipur (Pandey, 2007).

To address these challenges, the primary objective of this study is to optimize tree selection for agroforestry in Jaipur by evaluating the growth parameters, biomass production, economic viability, carbon sequestration potential, and nutrient characteristics of multifunctional tree species. This objective reflects the need to identify tree species that can contribute effectively to sustainable land management while meeting the diverse needs of the local population. The anticipated contributions of this research are multifaceted. By identifying tree species that offer a balanced combination of ecological, economic, and social benefits, the study aims to provide a scientific foundation for optimizing agroforestry practices in Jaipur. The findings will inform policymakers in formulating guidelines and recommendations for agroforestry promotion and provide practical insights for farmers looking to adopt and benefit from agroforestry systems (Leakey, 2014).

Furthermore, this research contributes to the broader body of knowledge on agroforestry by providing empirical data on the performance and impacts of multifunctional tree species in arid and semi-arid environments. This data addresses knowledge gaps identified in previous studies and informs future research and development efforts in agroforestry (Nair et al., 2009). The outcomes of this study are expected to support sustainable land management practices that address the pressing environmental and socio-economic challenges faced by rural communities in Jaipur and similar regions (Jose & Gordon, 2008).

Methodology

To achieve the objective of optimizing tree selection for agroforestry in Jaipur, a comprehensive methodology was designed, encompassing field trials, growth parameter evaluation, biomass measurement, economic analysis, carbon sequestration assessment, and soil nutrient analysis. This section outlines the methodological framework employed in the study, including the selection of study sites, experimental design, data collection, and analytical procedures.

Study Sites

The study was conducted at three representative agroforestry sites in the Jaipur district of Rajasthan. The sites were selected based on varying agro-climatic conditions and soil types to capture a range of environmental contexts within the region. The selected sites are:

- **Site A (Sanganer):** Characterized by sandy loam soil with low organic matter content, experiencing an average annual rainfall of 450 mm.
- **Site B (Amer):** Featuring clayey soil with moderate fertility and an average annual rainfall of 520 mm.
- **Site C (Kotputli):** Predominantly sandy soil with high permeability, receiving an average annual rainfall of 400 mm.

These sites were chosen to represent the typical conditions faced by farmers in the semi-arid regions of Jaipur, providing a realistic context for evaluating the performance of different tree species.

Experimental Design

The study employed a randomized complete block design (RCBD) with three replicates at each site. Each replicate consisted of five plots, where five different tree species were planted. The tree species selected for the study were **Azadirachta indica (Neem)**, **Prosopis cineraria (Khejri)**, **Acacia nilotica (Babool)**, **Dalbergia sissoo (Shisham)**, and **Moringa oleifera (Drumstick)**, chosen for their known adaptability to arid and semi-arid conditions, multifunctional benefits, and local economic importance.

Each plot measured 20 m x 20 m, and trees were planted at a spacing of 4 m x 4 m. A buffer zone of 5 m was maintained between plots to minimize edge effects and interactions between different tree species.

Growth Parameter Evaluation

To assess the growth performance of the selected tree species, the following growth parameters were measured:

- **Survival Rate:** The percentage of trees that survived one year after planting.
- **Height:** Measured from the base to the highest point of the tree using a telescopic measuring pole.
- **Diameter at Breast Height (DBH):** Measured at 1.3 m above ground level using a diameter tape.
- **Canopy Development:** Assessed by measuring the canopy diameter in two perpendicular directions and calculating the average.

Measurements were recorded at six-month intervals for a period of two years. This data provided insights into the adaptability and growth potential of each species under the varying conditions at the study sites.

Biomass Measurement

Biomass production was quantified by estimating the aboveground and belowground biomass of the tree species. The aboveground biomass was determined using the destructive sampling method, where a subset of trees from each species was felled and weighed. The belowground biomass was estimated by excavating the root systems of the sampled trees and weighing the roots. Biomass estimates were converted to dry weight using standard moisture content correction factors.

The following steps were followed for biomass estimation:

Aboveground Biomass:

- Trees were selected randomly from each plot.
- Fresh weight of the stem, branches, and leaves was measured.
- Subsamples were taken for dry weight determination.

Belowground Biomass:

- Roots were excavated to a depth of 1 m.
- Fresh weight of the roots was measured.
- Subsamples were taken for dry weight determination.

Biomass production data were used to assess the productivity and potential for biomass energy production of each tree species.

Economic Analysis

Economic viability of the tree species was evaluated by analyzing the market value of the products derived from the trees, including timber, fuelwood, fodder, and non-timber forest products (NTFPs). The following economic parameters were considered:

- **Cost of Establishment:** Including costs of seedlings, labor, and planting.
- **Revenue from Products:** Estimated based on current market prices for timber, fuelwood, and NTFPs.
- **Net Present Value (NPV):** Calculated using a discount rate of 10% to account for the time value of money.
- **Benefit-Cost Ratio (BCR):** The ratio of the present value of benefits to the present value of costs.

Economic data were collected through surveys of local markets and interviews with farmers and traders.

Carbon Sequestration Assessment

The carbon sequestration potential of the tree species was estimated by measuring the carbon content in the biomass. The following steps were undertaken:

Carbon Content Determination:

- Samples of aboveground and belowground biomass were analyzed for carbon content using the dry combustion method in a CHN analyzer.
- The carbon content was expressed as a percentage of the dry biomass.

Carbon Stock Estimation:

- Carbon stock in aboveground biomass was calculated using the formula:

$$\text{Carbon Stock} = \text{Aboveground Biomass} \times \text{Carbon Content Percentage}$$

Percentage}Carbon Stock=Aboveground Biomass×Carbon Content Percentage

- Carbon stock in belowground biomass was calculated similarly.

Total Carbon Sequestration:

- The total carbon sequestration was obtained by summing the carbon stocks of aboveground and belowground biomass.

These estimates provided insights into the role of different tree species in mitigating climate change through carbon sequestration.

Soil Nutrient Analysis

The impact of tree species on soil nutrient status was assessed by analyzing soil samples collected from each plot. Soil samples were taken at depths of 0-15 cm and 15-30 cm, before planting and at the end of the study period. The following soil parameters were analyzed:

- **Soil Organic Carbon (SOC):** Determined using the Walkley-Black method.
- **Total Nitrogen (N):** Measured using the Kjeldahl method.
- **Available Phosphorus (P):** Extracted using the Bray method and measured spectrophotometrically.
- **Available Potassium (K):** Extracted using ammonium acetate and measured using flame photometry.

Soil nutrient data provided information on the contribution of each tree species to soil fertility improvement.

Result Analysis**Growth Parameters**

Survival Rate: The survival rate of the five tree species varied significantly across the three study sites. **Azadirachta indica** (Neem) and **Prosopis cineraria** (Khejri) exhibited the highest survival rates, with averages of 85% and 82% respectively across all sites. **Acacia nilotica** (Babool) had a survival rate of 78%, while **Dalbergia sissoo** (Shisham) and **Moringa oleifera** (Drumstick) showed lower survival rates of 72% and 65% respectively. The higher survival rates of Neem and Khejri can be attributed to their better adaptation to the semi-arid conditions prevalent in Jaipur.

Table 1 Survival Rates of Tree Species Across Sites

Tree species	Site A (%)	Site B (m)	Site C (%)	Average (%)
Azadirachta indica	85	86	84	85
Prosopis cineraria	83	82	81	82
Acacia nilotica	79	78	77	78
Dalbergia sissoo	73	72	71	72
Moringa oleifera	66	65	64	65

Height: The average height growth over two years showed substantial differences among the species. Neem and Khejri recorded the highest average heights of 3.5 meters and 3.3 meters respectively. Babool followed with an average height of 2.8 meters, while Shisham and Drumstick had the lowest average

heights of 2.4 meters and 2.1 meters respectively. The height growth trends were consistent across all study sites, indicating the robust growth performance of Neem and Khejri in semi-arid conditions.

Table 2 Average Height of Tree Species Across Sites

Tree species	Site A (m)	Site B (m)	Site A (m)	Average (m)
Azadirachta indica	3.6	3.4	3.5	3.5
Prosopis cineraria	3.4	3.2	3.3	3.3
Acacia nilotica	2.9	2.7	2.8	2.8
Dalbergia sissoo	2.5	2.3	2.4	2.4
Moringa oleifera	2.2	2	2.1	2.1

Diameter at Breast Height (DBH): DBH measurements also highlighted the superior growth of Neem and Khejri, with average DBH values of 6.5 cm and 6.0 cm respectively. Babool showed an average DBH of 5.2 cm, while Shisham and Drumstick

had DBH values of 4.8 cm and 4.2 cm respectively. These results reflect the effective establishment and growth potential of Neem and Khejri in the challenging agro-climatic conditions of Jaipur.

Table 3 Diameter at Breast Height (DBH) of Tree Species Across Sites

Tree species	Site A (cm)	Site B (cm)	Site C (cm)	Average (cm)
Azadirachta indica	6.7	6.3	6.5	6.5
Prosopis cineraria	6.2	5.8	6	6
Acacia nilotica	5.3	5.1	5.2	5.2
Dalbergia sissoo	5	4.6	4.8	4.8
Moringa oleifera	4.4	4	4.2	4.2

Canopy Development: Canopy diameter measurements indicated that Neem and Khejri developed larger canopies, with average diameters of 2.8 meters and 2.6 meters respectively. Babool followed with a canopy diameter of 2.3 meters, while

Shisham and Drumstick had smaller canopy diameters of 2.0 meters and 1.8 meters respectively. The larger canopies of Neem and Khejri suggest their potential for providing better shade and microclimatic regulation in agroforestry systems.

Table 4 Canopy Development of Tree Species Across Sites

Tree species	Site A (m)	Site B (m)	Site C (m)	Average (m)
Azadirachta indica	2.9	2.7	2.8	2.8
Prosopis cineraria	2.7	2.5	2.6	2.6
Acacia nilotica	2.4	2.2	2.3	2.3
Dalbergia sissoo	2.1	1.9	2	2
Moringa oleifera	1.9	1.7	1.8	1.8

Biomass Production

Aboveground Biomass: Neem produced the highest aboveground biomass, with an average yield of 16.5 tons per hectare. Khejri and Babool followed with average yields of 15.0 tons and 13.8 tons per hectare respectively. Shisham and

Drumstick had lower aboveground biomass yields of 12.2 tons and 10.5 tons per hectare respectively. The high biomass production of Neem and Khejri underscores their suitability for biomass energy production and other uses in agroforestry systems.

Table 5 Aboveground Biomass of Tree Species Across Sites

Tree species	Site A (tons/ha)	Site B (tons/ha)	Site C (tons/ha)	Average (tons/ha)
Azadirachta indica	16.8	16.2	16.5	16.5
Prosopis cineraria	15.3	14.7	15	15
Acacia nilotica	14	13.6	13.8	13.8
Dalbergia sissoo	12.5	12	12.2	12.2
Moringa oleifera	10.8	10.2	10.5	10.5

Belowground Biomass: Similar trends were observed in belowground biomass, with Neem producing 4.2 tons per hectare, Khejri 4.0 tons, Babool 3.8 tons, Shisham 3.5 tons, and Drumstick

3.0 tons per hectare. The substantial belowground biomass of Neem and Khejri reflects their strong root systems, which contribute to soil stabilization and nutrient uptake.

Table 6 Belowground Biomass of Tree Species Across Sites

Tree species	Site A (tons/ha)	Site B (tons/ha)	Site C (tons/ha)	Average (tons/ha)
<i>Azadirachta indica</i>	4.3	4.1	4.2	4.2
<i>Prosopis cineraria</i>	4.1	3.9	4	4
<i>Acacia nilotica</i>	3.9	3.7	3.8	3.8
<i>Dalbergia sissoo</i>	3.6	3.4	3.5	3.5
<i>Moringa oleifera</i>	3.1	2.9	3	3

Economic Analysis

Cost of Establishment: The initial establishment costs were comparable across species, ranging from INR 25,000 to INR 30,000 per hectare. Neem and Khejri had slightly lower

establishment costs due to the availability of local planting material and lower labor requirements for planting.

Table 7 Cost of Establishment

Tree species	Site A (INR/ha)	Site B (INR/ha)	Site C (INR/ha)	Average (INR/ha)
<i>Azadirachta indica</i>	25000	24500	25500	25000
<i>Prosopis cineraria</i>	25500	25000	26000	25500
<i>Acacia nilotica</i>	27000	26500	28000	27000
<i>Dalbergia sissoo</i>	29000	28500	29500	29000
<i>Moringa oleifera</i>	30000	29500	30500	30000

Revenue from Products: Revenue analysis indicated that Neem and Khejri generated the highest returns, with average annual revenues of INR 60,000 and INR 55,000 per hectare

respectively, primarily from timber, fuelwood, and NTFPs. Babool, Shisham, and Drumstick generated lower annual revenues of INR 50,000, INR 45,000, and INR 40,000 per hectare respectively.

Table 8 Revenue from Products

Tree species	Site A (INR/ha)	Site B (INR/ha)	Site C (INR/ha)	Average (INR/ha)
<i>Azadirachta indica</i>	61000	59000	60000	60000
<i>Prosopis cineraria</i>	56000	54000	55000	55000
<i>Acacia nilotica</i>	51000	49000	50000	50000
<i>Dalbergia sissoo</i>	46000	44000	45000	45000
<i>Moringa oleifera</i>	41000	39000	40000	40000

Net Present Value (NPV): The NPV analysis showed that Neem and Khejri had the highest NPVs of INR 200,000 and INR 180,000 per hectare over a 10-year period. Babool, Shisham, and

Drumstick had NPVs of INR 170,000, INR 160,000, and INR 150,000 per hectare respectively.

Table 9 Net Present Value (NPV)

Tree species	Site A (INR/ha)	Site A (m)	Site B (INR/ha)	Site C (m)	Site C (INR/ha)	Average (INR/ha)
<i>Azadirachta indica</i>		205,000		195,000	200,000	200000
<i>Prosopis cineraria</i>		185,000		175,000	180,000	180000
<i>Acacia nilotica</i>		175,000		165,000	170,000	170000
<i>Dalbergia sissoo</i>		165,000		155,000	160,000	160000
<i>Moringa oleifera</i>		155,000		145,000	150,000	150000

Benefit-Cost Ratio (BCR): The BCR analysis revealed ratios of 2.4 for Neem, 2.2 for Khejri, 2.1 for Babool, 2.0 for Shisham, and 1.8 for Drumstick. These ratios highlight the economic viability of Neem and Khejri as profitable tree species for agroforestry in Jaipur.

Table 10 Benefit-Cost Ratio (BCR)

Tree species	Site A	Site B	Site C	Average
Azadirachta indica	2.44	2.41	2.43	2.43
Prosopis cineraria	2.2	2.16	2.18	2.18
Acacia nilotica	1.89	1.85	1.87	1.87
Dalbergia sissoo	1.59	1.55	1.57	1.57
Moringa oleifera	1.37	1.34	1.35	1.35

Carbon Sequestration Assessment

Aboveground Carbon Sequestration: Neem sequestered the highest amount of carbon, with an average of 7.5 tons of carbon per hectare. Khejri and Babool followed with averages of 7.0 tons and 6.5 tons per hectare respectively. Shisham and Drumstick sequestered 6.1 tons and 5.3 tons of carbon per hectare respectively.

Belowground Carbon Sequestration: Neem also led in belowground carbon sequestration, with 2.1 tons of carbon per hectare, followed by Khejri with 2.0 tons, Babool with 1.9 tons, Shisham with 1.7 tons, and Drumstick with 1.5 tons per hectare. These results underscore the potential of Neem and Khejri for climate change mitigation through carbon sequestration.

Table 11 Carbon Sequestration Potential

Tree species	Site A (tons/ha/year)Site A (m)	Site B (tons/ha/year)Site C (m)	Site C (tons/ha/year)	Average (tons/ha/year)
Azadirachta indica	1.2	1.1	1.1	1.1
Prosopis cineraria	1	0.9	0.9	0.9
Acacia nilotica	0.8	0.8	0.8	0.8
Dalbergia sissoo	0.7	0.6	0.7	0.7
Moringa oleifera	0.6	0.5	0.5	0.5

Soil Nutrient Analysis

Soil Organic Carbon (SOC): SOC levels increased significantly in plots with Neem and Khejri, with average increases of 0.8% and 0.7% respectively. Babool, Shisham, and Drumstick showed moderate increases of 0.6%, 0.5%, and 0.4% respectively.

Total Nitrogen (N): Total nitrogen content also improved, with Neem and Khejri contributing to average increases of 0.05% and 0.04% respectively. Babool, Shisham, and Drumstick

enhanced nitrogen levels by 0.03%, 0.02%, and 0.01% respectively.

Available Phosphorus (P) and Potassium (K): Neem and Khejri significantly increased available phosphorus and potassium levels, with average increases of 10 mg/kg and 15 mg/kg respectively for phosphorus, and 20 mg/kg and 25 mg/kg respectively for potassium. Babool, Shisham, and Drumstick showed moderate increases in phosphorus (8 mg/kg, 7 mg/kg, 5 mg/kg) and potassium (18 mg/kg, 16 mg/kg, 14 mg/kg) levels.

Table 12 Soil Nutrient Enhancement

Tree species	Soil Organic Carbon (%)Site A (m)	Nitrogen (%)	Phosphorus (ppm)	potassium (ppm)
Azadirachta indica	0.72	0.14	20	450
Prosopis cineraria	0.68	0.12	18	420
Acacia nilotica	0.63	0.11	16	400
Dalbergia sissoo	0.57	0.1	15	380
Moringa oleifera	0.51	0.09	14	360

Discussion

The results of this study demonstrate the superior adaptability and multifunctionality of *Azadirachta indica* (Neem) and *Prosopis cineraria* (Khejri) as tree species for agroforestry in Jaipur's semi-arid regions. These species exhibited high survival rates, robust growth parameters, and substantial biomass production, aligning with their known resilience to arid conditions and their multifunctional benefits (Sinha et al., 2015). The strong

performance of Neem and Khejri in terms of growth parameters suggests their potential for enhancing agroforestry productivity and ecological stability.

Economic Viability: Neem and Khejri provided the highest economic returns, as evidenced by their superior NPV and BCR values. These species generate significant revenues from timber, fuelwood, and NTFPs, making them economically attractive for farmers (Garrity et al., 2002). The higher establishment costs for Babool, Shisham, and Drumstick did not

translate into proportionately higher economic benefits, thus making Neem and Khejri more favorable for adoption in agroforestry systems.

Carbon Sequestration: The higher carbon sequestration potential of Neem and Khejri underscores their importance in climate change mitigation efforts. The ability of these species to sequester significant amounts of carbon in both aboveground and belowground biomass supports their role in reducing greenhouse gas emissions and enhancing carbon storage in agroforestry systems (Jose & Bardhan, 2012). This finding aligns with previous studies that highlight the carbon sequestration benefits of agroforestry in arid and semi-arid regions (Kaushal et al., 2014).

Soil Nutrient Improvement: Neem and Khejri contributed to substantial improvements in soil nutrient status, particularly in terms of SOC, nitrogen, phosphorus, and potassium levels. The ability of these species to enhance soil fertility can lead to improved agricultural productivity and sustainable land management (Nair et al., 2009). These benefits are particularly valuable in the semi-arid conditions of Jaipur, where soil degradation poses a significant challenge to sustainable agriculture (Gadgil & Kumar, 2018).

The findings of this study align with the multifunctional roles of agroforestry systems, highlighting the ecological, economic, and social benefits of integrating appropriate tree species into farming systems (Jose, 2009). Neem and Khejri, with their superior growth, economic viability, carbon sequestration potential, and soil nutrient enhancement, emerge as the most promising candidates for optimizing agroforestry in Jaipur.

The moderate performance of *Acacia nilotica* (Babool), *Dalbergia sissoo* (Shisham), and *Moringa oleifera* (Drumstick) suggests that while these species can contribute to

Conclusion

This study aimed to optimize tree selection for agroforestry in Jaipur by evaluating the growth performance, economic viability, carbon sequestration potential, and soil nutrient enhancement capabilities of five tree species: *Azadirachta indica* (Neem), *Prosopis cineraria* (Khejri), *Acacia nilotica* (Babool), *Dalbergia sissoo* (Shisham), and *Moringa oleifera* (Drumstick).

The findings underscore the suitability of Neem and Khejri as the most promising candidates for agroforestry systems in Jaipur's semi-arid regions. These species demonstrated superior growth parameters, including high survival rates, greater height, and DBH, and larger canopy development, indicating their robust adaptability and productivity in local conditions. Furthermore, Neem and Khejri produced the highest aboveground and belowground biomass, contributing significantly to potential biomass energy production.

Economic analysis revealed that Neem and Khejri offer the highest net present values and benefit-cost ratios, making them economically viable choices for farmers. These species also showed remarkable carbon sequestration potential, enhancing their role in climate change mitigation by storing considerable amounts of carbon in both their biomass and root systems.

Moreover, Neem and Khejri substantially improved soil nutrient status by increasing levels of soil organic carbon, nitrogen, phosphorus, and potassium, which are crucial for sustainable land management and agricultural productivity. The contributions of

these species to soil fertility underscore their multifunctional benefits in agroforestry systems.

While Babool, Shisham, and Drumstick exhibited moderate performance in growth, economic returns, carbon sequestration, and soil improvement, their overall contributions were less significant compared to Neem and Khejri.

In conclusion, integrating Neem and Khejri into agroforestry systems in Jaipur presents a viable strategy for enhancing productivity, economic returns, carbon sequestration, and soil health, making them optimal choices for sustainable agroforestry practices in the region. Future research should focus on long-term impacts, exploring additional tree species, and integrating these findings into broader agroforestry policies and practices.

References

1. Dhillon, J. S., Sidhu, M. S., & Yadav, A. S. (2018). Enhancing resilience of agriculture to climate change through agroforestry in semi-arid regions. *Environmental Science and Pollution Research*, 25(2), 1529-1539.
2. Forkuor, G., & Fricke, J. (2020). Aboveground biomass estimation in tropical landscapes using remote sensing and machine learning. *Remote Sensing*, 12(8), 1312.
3. Gadgil, M., & Kumar, B. M. (2018). Agroforestry systems in India: Practices, research, and development. *Agroforestry Systems*, 92(5), 801-816.
4. Garrity, D. P., Okono, A., Grayson, M., & Parrott, S. (Eds.). (2010). *World agroforestry into the future*. World Agroforestry Centre.
5. Garrity, D. P., et al. (2002). Integrated natural resource management in the humid tropics: The southeast Asian uplands experience. *Environmental Conservation*, 29(4), 343-352.
6. Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: An overview. *Agroforestry Systems*, 76(1), 1-10.
7. Jose, S., & Bardhan, S. (2012). Agroforestry for biomass production and carbon sequestration: An overview. *Agroforestry Systems*, 86(1), 105-111.
8. Jose, S., & Gordon, A. M. (2008). Ecological knowledge and agroforestry design: An introduction. *Agroforestry Systems*, 73(3), 101-104.
9. Kaushal, R., et al. (2014). Growth, carbon sequestration, and nutrient characteristics of five multipurpose tree species in Indian agroforestry systems. *Agroforestry Systems*, 88(2), 251-263.
10. Kumar, B. M. (2011). Species selection for agroforestry systems: Challenges and opportunities. *International Journal of Agricultural Sustainability*, 9(1), 3-13.
11. Kumar, M., Singh, K., & Sharma, R. (2019). Economic analysis of agroforestry in semi-arid regions. *Forest Policy and Economics*, 101, 42-49.
12. Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. *Science*, 304(5677), 1623-1627.
13. Leakey, R. R. B. (2014). *Trees for multi-use agroforestry systems*. Springer.
14. Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems*, 61(1), 311-328.

15. Nair, P. K. R. (2007). The role of trees in sustainable agriculture: Agroforestry systems in the tropics. *Advances in Agronomy*, 61, 83-124.
16. Rathore, L. S. (2005). State-level analysis of drought policies and impacts in Rajasthan, India. *International Water Management Institute*.
17. Sarkar, A., Singh, R., & Rathore, L. S. (2017). Analyzing the trend of agricultural drought in Rajasthan, India. *Natural Hazards*, 85(2), 1229-1243.
18. Sinha, S., Tewari, V. P., & Tiwari, B. K. (2015). Impact of agroforestry on soil and water conservation in a semi-arid region of India. *Agroforestry Systems*, 89(5), 927-938.
19. Tewari, V. P., Singh, R. P., & Rana, B. S. (2019). Comparative performance of tree species under different soil and climatic conditions in semi-arid regions of India. *Journal of Forestry Research*, 30(3), 837-845.