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Research article

Assessing and analyzing prevalent agroforestry systems in Medchal-Malkajgiri district, Telangana, India

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Abstract

This study, conducted during 2021–2023 in Medchal-Malkajgiri district, Telangana, India, delves into the dynamics of agroforestry systems and planting patterns, emphasizing their impact on productivity, carbon sequestration, and economic viability. The study involved surveying nine villages (out of 108 villages) in Medchal-Malkajgiri district of Telangana state with a sampling intensity of 5%. Villages were selected using simple random sampling and three agroforestry practicing farmers from each category - marginal, small, semi-medium and medium - were chosen as purposive random sampling from each village. Nine agroforestry systems were identified, with boundary + scattered planting emerging as the most popular. The research extensively evaluated biomass growth, crop yield, carbon sequestration, and economic returns across different systems. Boundary + scattered and bund + boundary planting were found to be the prominent agroforestry systems. There were significant variations in tree height and volume across different agroforestry systems. Scattered planting of trees had greater height and volume. There were no significant differences in straw yield among the treatments, while the sole crop recorded a higher grain yield compared to the agroforestry systems. Block + boundary + bund planting showed the highest net returns and B: C ratio. In terms of carbon storage, block + boundary + bund planting had numerically higher above-ground carbon stock. Additionally, the study unveiled rich indigenous biodiversity and highlighted the role of farmer categories in shaping agroforestry practices. The findings highlight the significance of specialized agroforestry practices for long-term and resilient agricultural ecosystems.

Keywords: Agroforestry, Carbon sequestration, Economics, Medchal-Malkajgiri.

Introduction

Forests represent intricate ecological networks primarily characterized by the dominance of trees and other woody vegetation (Brockerhoff *et al.*, 2017). Spanning approximately 4 billion hectares, forests encompass about 31% of the Earth's land surface. Their critical role in sustaining various ecosystem services is paramount, encompassing food production, nutrient cycling, water purification, provision of shelter, and cultural and recreational values (Shrestha *et al.*, 2025). Furthermore, forests yield essential resources and services vital to human populations globally. Approximately 1.6 billion individuals, constituting about a quarter of the world's population, depend on forests for their basic needs, employment, and subsistence. Specifically, around 20% of the world's population, including vulnerable groups such as women, children, and landless farmers, rely on forests for sustenance and income. Notably, around 40% of the impoverished rural population resides within forested regions (UN-DESA, 2021).

However, forests face formidable challenges, particularly deforestation and forest degradation. Since 1990, an average of 15.5 million hectares of forest has been lost annually. Agricultural expansion accounts for over 90% of deforestation, primarily through the expansion of croplands and pastures, which threatens biodiversity and undermines ecosystem services provided by forests (FAO and UN, 2020). In response to these challenges and to safeguard long-term food security, sustainable agricultural practices such as agroforestry have emerged as pivotal strategies (Malik *et al.*, 2008). Grounded in ecological principles and indigenous knowledge, agroforestry optimizes land-use efficiency, enhances soil fertility, reduces soil erosion, and provides multiple outputs such as timber, fruits, fodder, and fuelwood (Rather *et al.*, 2025; Kumar *et al.*, 2024; Sarvade *et al.*, 2019; Gupta *et al.*, 2015).

Currently, agroforestry is practiced on approximately 43% of the world's agricultural lands, supporting nearly 1.2 billion people (UN-DESA, 2021). In India, agroforestry systems widely integrate annual and seasonal crops depending on agro-climatic conditions and farmers' preferences. In the study area, the major crops cultivated under agroforestry systems include paddy, maize, cotton, vegetables, and pulses. Paddy is the predominant intercrop under irrigated agroforestry systems due to its economic importance and wider adoption by farmers. These crop-tree combinations contribute significantly to farm productivity, livelihood diversification, and ecological sustainability.

Despite its importance, there remains a pressing need for comprehensive information on the types, structure, and effectiveness of agroforestry systems to improve adoption and optimize their productivity (Verma, 1991). The composition and performance of agroforestry systems are influenced by site-specific factors such as farmer preferences, landholding size, ecological conditions, and market opportunities. Therefore, understanding existing agroforestry systems and their productivity is essential for improving their management and sustainability.

In this context, the present research assessed and evaluated the prevalent agroforestry systems in Medchal–Malkajgiri district, focusing on the distribution, productivity, carbon sequestration potential, economic viability, and biodiversity of perennial tree components. The study aimed to generate location-specific information for improving agroforestry system design and management, thereby contributing to sustainable land use, rural livelihood enhancement, and environmental conservation.

Materials and Methods

The present study was conducted during 2021–2023 in Medchal–Malkajgiri district, located in the southern agro-climatic zone of Telangana state, India, at geographical coordinates of 17°37′48.79″ N latitude and 78°29′03.17″ E longitude. The district comprises 108 villages and is characterized by a semi-arid tropical climate, where agriculture is the primary livelihood activity. The selected villages represent a mixed farming ecosystem comprising irrigated wetland (paddy-based), dryland (rainfed crops) and garden land (horticulture-based) production systems integrated with agroforestry practices. Secondary information on rainfall, temperature, soil type, cropping pattern, and land-use characteristics was collected from government records and field verification.

A stratified random sampling method was adopted for the selection of respondents, wherein villages were considered as the primary sampling units. Based on a sampling intensity of 5%, nine villages were randomly selected from the total of 108 villages (Fig 1). Within each selected village, farmers were stratified based on landholding size, which constituted the sampling strata. The strata comprised four categories: marginal farmers (0–1 ha), small farmers (1–2 ha), semi-medium farmers (2–4 ha), and medium farmers (4–10 ha). This stratification ensured representation across different farm-size categories and facilitated comparative analysis of agroforestry practices.

Primary data were collected through personal interviews using a structured and pre-tested questionnaire, supplemented by field visits and direct observations (Verma, 1991). Information regarding landholding size, cropping pattern, tree species composition, tree management practices, agricultural inputs, crop yields, and socio-economic characteristics was documented.

The prevailing agroforestry systems in the study area were identified and classified through field observations and farmer interviews based on the spatial arrangement of trees and crop combinations, following the classification principles proposed by Nair (1985), illustrated in Fig 2. The identified agroforestry planting patterns included bund planting, boundary planting, scattered planting, bund + boundary planting, boundary + scattered planting, bund + boundary + scattered planting, and block + boundary + bund planting (Nair, 1985). A schematic representation of these planting patterns was prepared to illustrate their field layout and spatial configuration.

Biomass estimation of tree species: Tree biomass was estimated using a non-destructive method to account for differences in tree size, age, and species-specific growth patterns (Chaturvedi, 1981; Chaturvedi and Khanna, 1981). In each sampled agroforestry system, all trees present within the selected farm plots were inventoried. For each tree, girth at breast height (GBH) was measured at 1.37 m above ground level using a measuring tape, and tree height was measured using a Ravi altimeter following standard procedures (Chaturvedi and Khanna, 1981). Tree age was obtained from farmer recall and plantation records, wherever available. Tree volume was estimated using the standard forest mensuration formula (Chaturvedi and Khanna, 1981):

$$V = \frac{g^2}{4\pi} \times h$$

where V is tree volume (m^3 $tree_{-1}$), g is girth at breast height (m), h is tree height (m), and π = 3.1416.

The above-ground biomass (AGB) of each tree was estimated by multiplying tree volume by species-specific wood density (Yadav *et al.*, 2019): $AGB = V X WD$, where

AGB is above-ground biomass (kg $tree^{-1}$), *V* is tree volume (m^3 $tree_{-1}$), and *WD* is wood density (kg m^{-3}).
The biomass of all trees within a sampled farm was summed and extrapolated to a hectare basis (t ha^{-1}), thereby minimizing bias associated with variations in tree age, size, and species characteristics (Yadav *et al.*, 2019).

Carbon estimation: Carbon stock was estimated from the dry biomass using a standard carbon conversion factor of 0.45, as suggested by Brown and Lugo (1982) and Magnussen and Reed (2004): $C = AGB \times 0.45$, where *C* is carbon stock (t ha^{-1}) and *AGB* is above-ground biomass (t ha^{-1}). The total carbon stock for each agroforestry system was computed by summing the carbon stored in tree and crop biomass to assess the carbon sequestration potential of different planting patterns (Magnussen and Reed, 2004).

Crop productivity assessment: Crop productivity was assessed for paddy, the dominant intercrop cultivated in the study area. All sampled agroforestry farms cultivated paddy as the principal intercrop during the study period, making it suitable for evaluating tree–crop interactions across different agroforestry planting patterns. Grain and straw yields were recorded from selected farmers under each agroforestry system and sole-crop fields, and cross-verified through field observations and farmers' records (Chauhan *et al.*, 2015).

Economic analysis: Economic analysis was carried out to determine the financial viability of different agroforestry systems. The cost of cultivation included expenditure on seed, fertilizers, pesticides, fungicides, labor, irrigation, and machinery operations based on prevailing market rates (Bammanahalli, 2016). Gross returns were estimated by converting produce yield into monetary value, while net returns were calculated as: Net returns (₹ ha^{-1}) = Gross returns − Cost of cultivation. The benefit-cost ratio (B:C ratio) was computed as: B:C ratio = Gross returns/cost of cultivation (Bammanahalli, 2016).

***Species richness, tree density, and diversity*:** Species richness, tree density, and tree diversity were assessed for each agroforestry system and farmer category. Species richness was determined as the total number of tree species per hectare, while tree density was expressed as the total number of individual trees ha^{-1} (Thaman, 1975). Tree diversity was quantified using the Shannon diversity index (Shannon and Weaver, 1949) and Simpson's diversity index (Simpson, 1949) to assess species heterogeneity and dominance.

***Statistical analysis*:** The collected data were subjected to descriptive statistical analysis and one-way analysis of variance (ANOVA) at a 5% significance level using IBM SPSS Statistics (IBM Corp, 2023) to compare variations among agroforestry systems and farmer categories.

Results and Discussion

Farm holding size: Medchal-Malkajgiri district is home to 31 documented tree species, with a mean number of 23.84 trees per hectare (Table 1). Medium farmers had the highest number of recorded tree species (28), followed by semi-medium farmers (15), marginal farmers (14) and small farmers (13). The average number of trees per hectare was highest among medium farmers (59.15), followed by semi-medium farmers (13.85), small farmers (12.78) and marginal farmers (9.59). Semi-medium farmers had the highest Shannon-Weiner diversity index (2.01), followed by a similar index of 1.92 for all the remaining categories of farmers, i.e., marginal, small and medium farmers. These findings highlight the varying levels of tree diversity and density among different farmer categories in the Medchal-Malkajgiri district, emphasizing the importance of considering farmer classifications when assessing agroforestry systems. The results align with previous studies that observed higher species richness and densities on larger farms (Abebe *et*

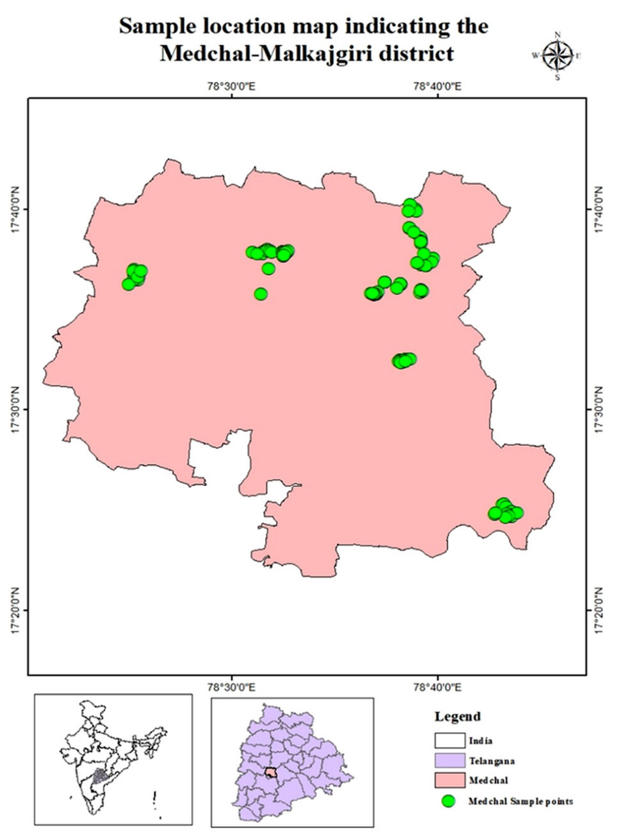

Fig 1. Location of study district

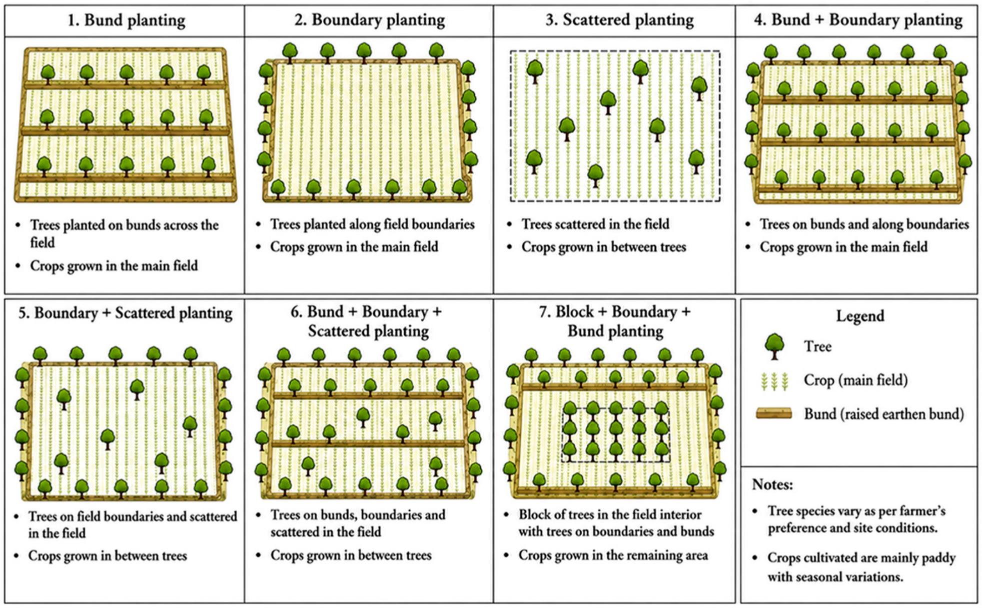

Fig 2. Classification and field layout of agroforestry planting patterns and spatial arrangements in the study area (prepared by authors)

al., 2013), while smaller-scale farmers play an important part in maintaining biodiversity (Bellow *et al.*, 2008; Sarvade *et al.*, 2020; Doddabasawa *et al.*, 2020).

Agroforestry systems: Boundary + scattered planting was the most popular, embraced by 41.67% of farmers, involving trees along field perimeters and scattered locations. Bund + boundary + scattered planting was used by 17.59% (Fig 3). The least common was bund planting, chosen by only 4.63% of farmers. Analysis across farmer categories revealed diverse practices (Fig 4). Marginal farmers, small farmers and semi-medium favored boundary + scattered planting, i.e., 51.83, 59.26% and 48.15%, while medium farmers showed a preference for bund + boundary + scattered planting (33.33%).

Table 2 reveals that the block + boundary + bund planting method had the highest number of trees ha^{-1} (152.29), followed by bund + boundary + scattered planting (29.89). The lowest tree density was recorded in bund planting (9.00). The higher tree density in block + boundary + bund planting and boundary planting can be attributed to the practice of planting closely on the bund and bund + boundary + scattered planting of the farm or orchard. This planting method protects against wind and sun damage, helps with soil conservation, and serves as a demarcation for the land, while also generating additional income. These findings are consistent with those of Abebe *et al.* (2013), who found that greater farm sizes were associated with higher species richness and density. However, the Shannon diversity index was significantly higher in bund + boundary + scattered planting (H′ = 1.56), indicating a more even distribution of tree species along the farm's boundary. The lower Shannon index in other agroforestry systems suggests an uneven distribution or a higher concentration of individuals of specific species.

Species richness, tree density and diversity: In Medchal–Malkajgiri district (Table 2), agroforestry systems comprised 31 tree species belonging to 18 families. Among these, the Fabaceae family contributed the highest number of species (6), followed by Aceraceae, Mimosaceae, and Myrtaceae with three species each. The study revealed that 87.10% of the recorded tree species were indigenous, indicating farmers' preference for native multipurpose tree species due to their adaptability, ecological compatibility, and diversified utility. Similar findings have been reported in the Siddipet district, where agroforestry systems recorded a high proportion (86.44%) of indigenous tree species, highlighting the importance of local tree diversity in sustaining agroecosystem productivity and resilience (Naveen *et al.*, 2025). Likewise, Chittapur and Murthy (2018) reported that traditional agroforestry systems in Karnataka conserved a higher proportion of indigenous multipurpose tree species, emphasizing their role in biodiversity conservation and livelihood support. These findings are also in agreement with Bajigo and Tadesse (2015) and Sarvade *et al.* (2016b), who reported higher conservation of indigenous tree species by farmers under traditional agroforestry systems.

Growth and tree biomass: The study evaluated and compared tree growth in various agroforestry systems. Results (Fig 5) reveal that scattered planting exhibited the highest girth (112.73 cm), height (9.17 m) and above-ground biomass (285.42 Kg $tree^{-1}$). Bund

Table 1. Botanical name, family and their major uses of trees found in agroforestry systems of Medchal - Malkajgiri district

S. No.	Species name	Family	Major use	Nativity
1	*Acacia nilotica* (L.) Delile	Mimosaceae	Timber, Fodder	Native
2	*Ailanthus excelsa* Roxb.	Simarubaceae	Timber	Native
3	*Alangium salviifolium* (L.f.) Wangerin	Carnaceae	Timber	Native
4	*Albizia amara*	Mimosaceae	Timber, Fodder	Native
5	*Albizia lebbeck* (L.) Benth.	Mimosaceae	Timber, Fodder	Native
6	*Annona squamosa* L.	Annonaceae	Fruit	Native
7	*Azadirachta indica* A. Juss.	Meliaceae	Timber, Fodder, NTFP, Religious	Native
8	*Borassus flabellifer* L.	Arecaceae	Fruit, NTFP	Native
9	*Butea monosperma* (Lam.) Taub.	Fabaceae	Timber, Religious	Native
10	*Citrus limon* (L.) Burm. f.	Rutaceae	Fruit	Native
11	*Cocos nucifera* L.	Arecaceae	Fruit, Religious	Native
12	*Delonix regia* (Hook.)Raf.	Caesalpinacae	Timber	Exotic
13	*Diospyros melanoxylon* Roxb.	Ebenaceae	Timber, NTFP	Native
14	*Eucalyptus tereticornis* Sm.	Myrtaceae	Timber, Medicinal	Exotic
15	*Ficus benghalensis* L.	Moraceae	Religious	Native
16	*Ficus hispida* L. f.	Moraceae	Timber	Native
17	*Hardwickia binata* Roxb.	Fabaceae	Timber, Fodder	Native
18	*Holoptelea integrifolia* Planch.	Ulmaceae	Timber	Native
19	*Leucaena leucocephala* (Lam.)de Wit	Fabaceae	Timber , Fodder	Exotic
20	*Mangifera indica* L.	Anacardiaceae	Fruit , Timber	Native
21	*Melia dubia* Cav.	Meliaceae	Timber, Fodder	Exotic
22	*Moringa oleifera* Lam.	Moringaceae	Fruit, Timber	Native
23	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	NTFP	Native
24	*Pithecellobium dulce* (Roxb.)Benth.	Fabaceae	Fruit, Timber	Native
25	*Pongamia pinnata* (L.)Pierre	Fabaceae	Timber, NTFP	Native
26	*Psidium guajava*	Myrtaceae	Fruit, Timber	Native
27	*Syzygium cumini* (L.) Skeels	Myrtaceae	Fruit, Timber, Religious	Native
28	*Tamarindus indica* L.	Fabaceae	Fruit, Timber, NTFP	Native
29	*Tectona grandis* L.f.	Verbenaceae	Timber	Native
30	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae	Timber	Native
31	*Ziziphus mauritiana* Lam.	Rhamnaceous	Fruit, Timber	Native

planting and boundary planting also performed well across these metrics. Conversely, block + boundary + bund planting showed the lowest measurements. These findings underscore the growth performance disparities in different agroforestry systems, offering insights for effective system management. The higher growth observed under scattered planting could be attributed to factors like tree age and reduced competition, whereas closely spaced trees in block plantings likely experienced more competition. Overall, significant differences in biomass were observed based on management techniques applied in different agroforestry systems. The results align with prior research highlighting variations in tree growth under diverse planting patterns (Avinash and Ansari, 2013; Gupta *et al*., 2015; Singh *et al*., 2015b; Sarvade *et al*., 2019).

Crop yield: Crop productivity was assessed under different agroforestry planting patterns using Paddy as the test crop, as it is the dominant and most widely cultivated crop in the study area under irrigated conditions and is commonly integrated with tree

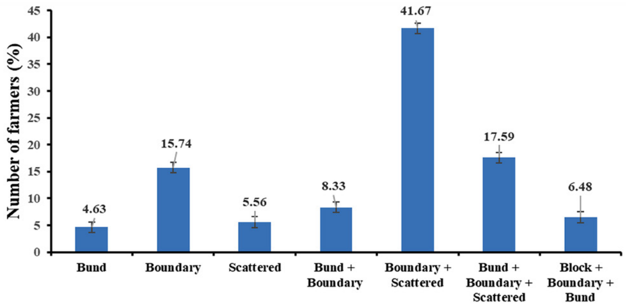

Fig 3. Agroforestry systems followed by farmers

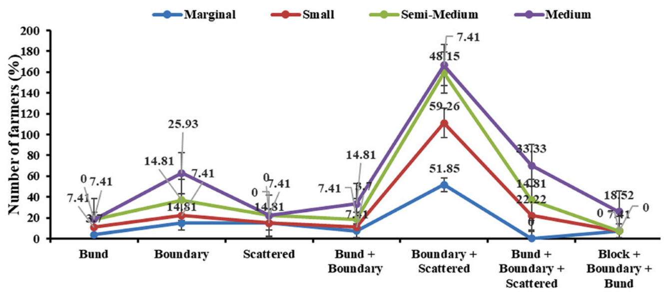

Fig 4. Agroforestry systems followed by different categories of farmers

components by farmers. Paddy was selected because of its economic importance, uniform cultivation across all farmer categories, and suitability for evaluating tree–crop interactions under agroforestry systems. In addition to paddy, the major crops cultivated under agroforestry systems in the study area included Maize, Cotton, Vegetables, and seasonal pulses, depending on irrigation availability and farmer preference.

Fig 6 compares the productivity of paddy under different agroforestry planting patterns and sole cropping. The results indicated no significant differences in straw yield among treatments, whereas grain yield differed significantly. Sole cropping recorded the highest grain yield (6.33 t ha^{-1}) due to the absence of competition from trees for light, water, and nutrients. Among agroforestry systems, boundary planting recorded the highest grain yield (6.19 t ha^{-1}), which was statistically on par with bund planting (6.16 t ha^{-1}), indicating minimal interference of tree components with crop growth due to their peripheral arrangement. In contrast, block + boundary + bund planting recorded the lowest grain yield (5.91 t ha^{-1}), likely due to higher tree density and greater competition for growth resources.

These findings highlight that tree arrangement significantly influences crop productivity, with peripheral tree planting systems such as boundary and bund planting allowing better crop performance compared to intensive planting configurations. Similar observations were reported by Chauhan *et al.* (2015), who found higher grain yields in sole cropping compared to tree-based systems due to reduced competition effects. The results suggest that boundary planting offers a balanced approach for integrating trees into farmlands without substantially reducing paddy yield, thereby enhancing system productivity and sustainability.

Carbon sequestration potential: Figs 7a and b present the above-ground biomass and carbon stock across different agroforestry planting patterns. Among the evaluated systems, block + boundary + bund planting recorded the highest carbon stock (7.07 t ha^{-1}), followed

Table 2. Species richness, tree density and tree diversity in different land holding size, agroforestry planting patterns

Categories	Species richness	Tree density per ha	Shannon-Weiner index	Simpson Index
Farmer Categories				
Marginal (n =27)	14	9.59	1.92	0.20
Small (n =27)	13	12.78	1.92	0.19
Semi medium (n =27)	15	13.85	2.01	0.20
Medium (n =27)	28	59.15	1.92	0.27
Planting Pattern				
Bund (n =5)	4	9.00	1.29	0.30
Boundary (n =17)	7	13.24	1.65	0.23
Scattered (n = 6)	5	9.67	1.20	0.36
Bund + Boundary (n = 9)	13	19.22	2.04	0.18
Boundary + Scattered (n = 45)	16	9.69	1.95	0.22
Bund + Boundary + Scattered (n =19)	26	29.89	2.56	0.64
Block + Boundary + Bund (n =7)	7	152.29	1.00	0.52
District				
Medchal – Malkajgiri (n =108)	31	23.84	2.24	0.17

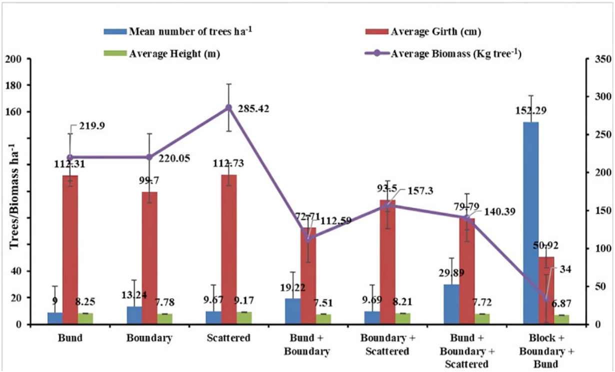

Fig 5. Growth and tree biomass of trees in different agroforestry systems

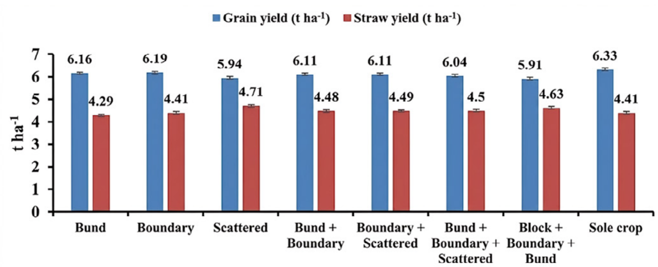

Fig 6. Grain and straw yield of paddy in different agroforestry systems

by bund + boundary + scattered planting (6.63 t ha⁻¹). In contrast, sole crop paddy cultivation recorded the lowest carbon stock (4.83 t ha⁻¹). The higher carbon sequestration observed in diversified agroforestry systems was mainly attributed to greater tree density, higher biomass accumulation, and the presence of multipurpose woody perennials. Trees contributed substantially to total carbon storage, highlighting the importance of agroforestry systems in mitigating atmospheric carbon and enhancing ecosystem sustainability.

The results clearly indicate considerable variation in carbon sequestration potential among different agroforestry planting patterns. The block + boundary + bund planting system demonstrated superior performance due to its intensive tree integration and higher above-ground biomass production, which also provides additional outputs such as timber, fodder, fuelwood, and other plant-based resources. Similar findings have been reported in earlier studies, which demonstrated higher carbon storage potential in agroforestry systems compared to sole cropping systems (Henry *et al.*, 2009; Singh *et al.*, 2015b; Sarvade *et al.*, 2016a; Sarangle *et al.*, 2018; Sarvade *et al.*, 2019). Similar trends of higher biomass accumulation and carbon sequestration in diversified agroforestry and silvipastoral systems were also reported by Rather *et al.* (2025) and Tudu *et al.*, (2022) under Himalayan and sub-humid agroecosystems, respectively.

These findings emphasize the significant role of diversified agroforestry systems in climate change mitigation, sustainable land management, and the enhancement of ecosystem services, thereby contributing towards achieving Sustainable Development Goal 13 (Climate Action). The study further highlights that appropriate tree planting configurations can substantially improve biomass production and carbon sequestration potential in semi-arid agricultural landscapes.

Cost-benefit analysis: Figs 8a and 8b present the cumulative cost–benefit analysis of different agroforestry planting patterns in Medchal–Malkajgiri district. The economic analysis was carried out at the system level, considering the combined contribution of all tree species and associated agricultural crops present within each agroforestry planting pattern, rather than evaluating individual tree species separately. The total cost of cultivation included expenditure on crop inputs, labour, irrigation, plant protection measures, and management of tree components, while gross returns were estimated from the cumulative value of agricultural produce, tree products, timber, fruits, and non-timber forest products (NTFPs).

Among the agroforestry planting patterns, block + boundary + bund planting recorded the highest net returns (₹184,159.7 ha⁻¹) with a benefit-cost ratio (B:C ratio) of 2.05, indicating superior economic performance due to higher tree density and diversified product output. This was followed by bund + boundary + scattered planting, which recorded net returns of ₹64,680.9 ha⁻¹ with a B:C ratio of 1.85. In contrast, bund + boundary planting recorded the lowest net returns (₹60,162.9 ha⁻¹) and the lowest B:C ratio (1.79).

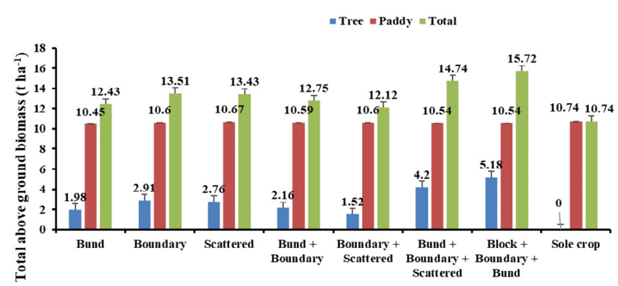

Fig 7a. Total biomass in different agroforestry systems

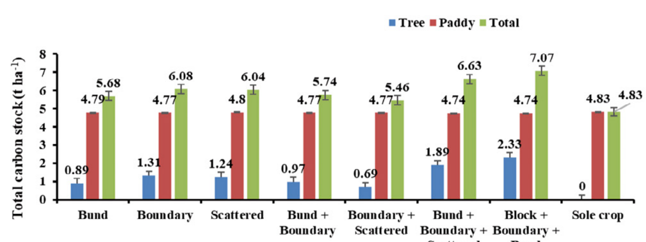

Fig 7b. Total carbon stock in different agroforestry systems of Medchal-Malkajgiri district

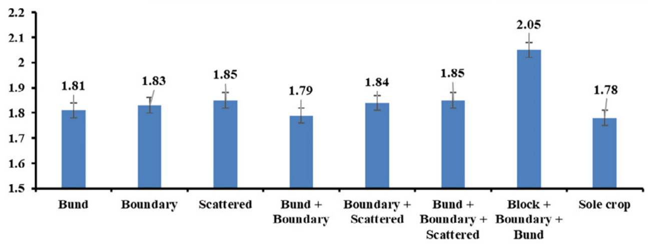

Fig 8a. Net returns from different agroforestry systems

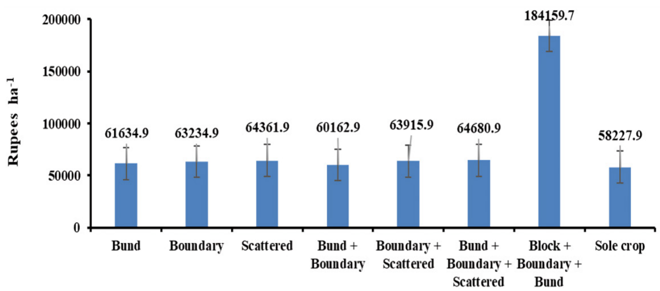

Fig 8b. Benefit: cost analysis of different agroforestry systems

The higher economic returns observed in intensive agroforestry planting patterns may be attributed to the cumulative income generated from multiple tree species and crop components, which enhanced total productivity and diversified income sources. The integration of tree species contributed significantly through timber, fruits, fodder, and NTFPs, thereby increasing the economic resilience of farming systems. The higher economic returns observed under diversified planting configurations may also be associated with improved fodder productivity and ecosystem services, as reported in silvipastoral systems of semi-arid India (Kumar *et al.*, 2024). Similar findings were reported by Doddabasawa *et al.* (2020) in a mango + teak-based agroforestry system, where higher net returns and B:C ratios were observed due to diversified tree-crop combinations. Likewise, Singh *et al.* (2015a) reported that agrisilviculture systems generated the highest net returns (₹277,415 ha^{-1} $year^{-1}$), while silvipasture systems recorded the highest B:C ratio (3.34), emphasizing the economic viability of integrated tree-based land-use systems.

Conclusion

The adoption of agroforestry systems in Medchal-Malkajgiri district is largely influenced by farmers' economic needs and prevailing local ecological conditions. The study revealed considerable variation in agroforestry practices among different farmer categories based on landholding size. Medium farmers recorded higher tree species richness and tree density due to greater land availability, whereas small and marginal farmers contributed significantly to biodiversity conservation by maintaining diverse tree species within limited landholdings. Among the recorded species, *Tectona grandis* was the most preferred due to its high economic value, while several other tree species were retained for their multiple uses, such as timber, fodder, fruits, and non-timber forest products. Agroforestry systems with higher tree species richness and density exhibited greater biomass production and carbon sequestration potential, which contributed to enhanced economic returns per unit area. The study also demonstrated that planting patterns such as bund planting, boundary planting, and scattered planting offer a balanced approach to improving agricultural productivity, enhancing farm income, and delivering environmental benefits, including carbon sequestration and biodiversity conservation. However, constraints such as limited awareness, management challenges, and resource availability need to be addressed to improve adoption and long-term sustainability. Overall, the findings provide location-specific evidence supporting the promotion of economically viable and climate-resilient agroforestry systems as a sustainable land-use strategy for semi-arid regions of Telangana.

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