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Assessment of Adoption Patterns of Agroforestry Systems and Tree Species Preferences in Southern Districts of Karnataka

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Abstract

Agroforestry has traditionally been a way of life and livelihood in India for centuries. Now it is receiving enormous attention as a resource efficient, environmentally positive method of farming. Based on the agroclimatic conditions several models have been proposed and a few of them have also been demonstrated for easy adaptability. However, agroforestry systems practiced by the farmers and tree species preferred by them varies with the area and in Karnataka, they are not well documented. Hence, a study was carriedout to understand the agroforestry systems practiced by the farmers and the tree species preferred inthe southern districts of Karnataka (*viz*., Bengaluru Urban, Bengaluru Rural, Chikkaballapur, Tumakuru and Hassan). A purposive sampling technique was adapted for the survey. The list of farmers who practice agroforestry systems (collected tree species seedling from the Forest Department) was obtained from the Karnataka Forest Department (KFD). A total of 170 farmers were randomly identified and their farms were visited. The agroforestry systems practiced and crop combinations were recorded during the survey. The data collected across the districts from various farmers were converted and expressed in terms of percentage values. The G-test and correlation analysis indicated that Agrisilviculture, block plantation and Silvi-olericulture are the major agroforestry systems practiced in these five districts. Further, farmers in these areas prefer fast growing trees *viz*., Silver oak, Hebbevu and Mahagony and slow-growing trees such as Teak, Sandalwood and Jamun. The study also revealed that only a few crops namely Maize, Ragi and Field bean are being grown under the Agrisilviculture system in the southern districts of Karnataka. Bengaluru (Urban and Rural) and Chikkaballapur districts followed closer spacing, whereas in Tumakuru and Hassan slightly wider spacing was adopted by the farmers. It was observed that farmers do not follow any specific spacing pattern with regard to tree species planting. These results are helpful in developing and designing policies and also promoting agroforestry in Karnataka.

Keywords : Agroforestry, Karnataka, Agrisilviculture, Tree species, Crop combination, Spacing

Agroforestry is referred as the growing of woody perennials in the same area and at the same time along with agricultural crops or fodder plants in the form of a spatial mixture or a temporal sequence on farmlands and has been practiced for centuries (Dhyani, 2018). In India, agroforestry has long been a way of life and a source of income. While agroforestry as a science has just recently emerged, it is thought that agroforestry practices originated in India during the Vedic era. Many have examined the long history and diversity of agroforestry systems and practices in India (Tejwani, 2001; Prasad & Dhyani, 2010 and Kumar *et al.*, 2017). Agroforestry systems that might have originated in the Neolithic period

around 7000 BC, are still extensively practiced in the North Eastern Hilly (NEH) region and other humid and hilly parts of the Indian subcontinent. It has now been recognized globally that agroforestry has the potential to achieve ecosystem sustainability while optimizing agricultural productivity, profitability and diversity (Viswanath *et al.*, 2018). The systems vary enormously in their structural complexity, species diversity, productive and protective attributes and also in socioeconomic dimensions (Pandey, 2007). The practice of Agroforestry has traditionally been a way of life and livelihood in India for centuries. Agroforestry will contribute to increasing the forest cover as envisaged in our Forest Policy (1988). In addition, agroforestry meets the requirement of food, fuel, fodder, timber and also conserves the soil and water, improves soil fertility and enhances socio-economic conditions of the farmers by generating additional income on the farmland (Sathish and Kushalappa, 2007). Agroforestry solutions are often location-specific in their relevance, performance and farmer's acceptability (Pattanayak *et al.,* 2005).

There has been immense diversity in the combinations of cultivation of tree species along side agricultural crops globally. In Europe, for instance, the practice was to completely fell the derelict forests, burn them, and cultivate agricultural crops (King, 1968). The situation is no different locally in India, wherein traditional agroforestry systems in some form or other are practiced in almost all ecological and geographical regions of India. Interestingly, there is immense diversity in agroforestry systems within the country (Viswanath *et al.*, 2018). Structurally, agroforestry systems can be grouped as Agrisilviculture, Agrihorticulture, Silvipastoral, Agrisilvipastoral systems and other specialized systems (Viswanath *et al.*, 2018). However, on the basis of the nature of components, twenty common agroforestry systems have been identified in different agroecological regions of India. They are namely Agrisilviculture (trees + crops), Boundary plantation (tree on boundary + crops), Block plantation (block of tree+ block of crops), Energy plantation (trees + crops during initial years), Alley cropping (hedges + crops), Agrihorticulture (fruit trees + crops), Agrisilvihorticulture (trees + fruit trees + crops), Agrisilvipasture (trees + crops + pasture or animals), Silviolericulture (tree + vegetables), Hortipasture (fruit trees + pasture or animals), Hortiolericulture (fruit tree + vegetables), Silvipasture (trees + pasture/ animals), Forage Forestry (forage trees + pasture), Shelterbelts (trees + crops), Windbreaks (trees + crops), Live Fence (shrubs and under trees on boundary), Silvi or Hortisericulture (trees or fruit trees + sericulture), Hortiapiculture (fruit trees + honeybee), Aquaforestry (trees + fishes) and Homestead (multiple combinations of trees, fruit trees, vegetable etc.) (Dhyani, 2018).

Agroforestry is receiving enormous attention as a resource-efficient, environmentally positive method of farming. Research on traditional farming systems in many areas of the world suggests that complex polycultures with trees have many advantages over modern systems of extensive, intensively managed, annual monocultures (Dhyani, 2018). The agroforestry sector finds increasing relevance in the states where wood-based industries are essential (Arunachalam *et al.*, 2022). The estimated total area covered by agroforestry systems is around 28.427 Mha, which is about 8.65 per cent of the total geographical area of the country (328.747 Mha) (Arunachalam *et al.,* 2022). Agroforestry helps to meet around half of the fuelwood needs ofthe country, around two-thirds of small timber, plywood (70-80%), raw material for paper pulp (60%) and green fodder requirement of livestock (9-11%), as well as meeting the subsistence needs of households for food, fruit, fibre, medicine, etc. (Dhyani, 2018 and Imder Dev *et al.,* 2018).

Agroforestry systems are most prevalent in the arid and semi-arid regions of the country. The state of Karnataka has more than 70 per cent of its total geographical area classified under arid or semi-arid region, which accounts for 17-18 per cent of the land area under this category in the country (Nautiyal *et al.,* 2015). Further, due to low and erratic rainfall, agricultural productivity and returns in Karnataka are often low. Hence, addition of tree components is helpful to improve overall productivity and

sustainable yield. Additional income mainly comes from the tree component: hence, species selection is an important aspect of the agroforestry system. Based on the agroclimatic conditions, several models have been proposed forthe farmers. Several of them have also been demonstrated for easy adaptability. However, the agroforestry systems practiced by the farmers and the tree species they prefer are not well documented. In this context, documentation of agroforestry systems adopted by the farmers will help in building the knowledge base of the science of agroforestry. It will be helpful in implementing some of the most promising agroforestry systems directly on the farmer's fields. Besides, it will also help in future planning of agroforestry research. Thus, a survey was conducted to document the existing agroforestry systems practiced and tree species planted in the farms by the farmers in the southern part of Karnataka.

Material and Methods

Study Area : A study was undertaken in the southern part of Karnataka to assess the agroforestry systems practiced and tree species preferred by farmers in their fileds. Among the different districts in Southern Karnataka the study was carried out in five selected districts namely Tumakuru (4 talukas and 29 villages), Chikkaballapur (2 talukas and 14 villages), Bengaluru Urban (2 talukas and 3 villages), Bengaluru Rural (3 talukas and 5 villages) and Hassan (5 talukas and 21 village). In Tumakuru, Bengaluru Urban and Rural districts, farmers are growing crops such as pulses, groundnut, sunflower, paddy, perennials like coconut and arecanut, whereas, in the case of Chikkaballapur and Hassan districts, farmers grow horticultural, floricultural, sericulture and vegetable crops.

Tumakuru : The total area of Tumakuru district is around 10,597 sq. km with an elevation of 822 m. Tumakuru is characterized by a semi-arid climate and typical tropical weather. The district's annual mean temperature is 27.08°C and receives about 669 mm of rainfall. The soil is red sandy loam and deep to medium black (CGWB, 2012b).

Chikkaballapur : The district of Chikkaballapur is located in the Eastern Dry Climate Zone and is spread over 4,244 sq. km with an average elevation of 915 m. It has a semi-arid climate with hot summers and mild winters, typical of tropical monsoon weather. The district is located in the semi-arid climatic zone, with an average rainfall of 736 mm and temperature ranges between 14.4°C (January) to 35.7°C (April). The soil type is red sandy soil (Chikkaballapur PLP report, 2016-17 & CGWB 2012a).

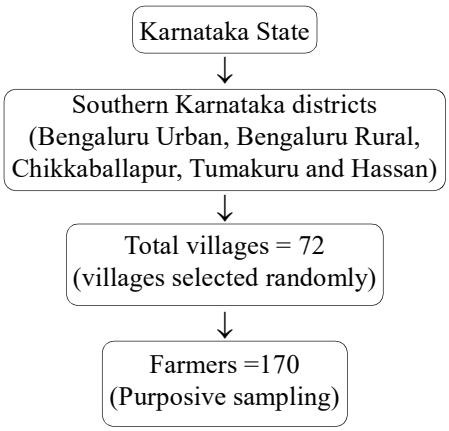
Bengaluru Urban : The total area of Bangalore Urban is 2,196 sq. km with a minimum elevation of 722 m and a maximum elevation of 965 m. The temperature ranges between 16°C to 32°C with an average annual precipitation of 846 mm. The soil type is red laterite and red, fine loamy to clayey soils.

Bengaluru Rural : The geographical area of Bangalore Rural is 2,298 sq. km with temperatures ranging from 14.6°C to 32.8°C. The district is situated over 900 m above sea level and the average rainfall is 798 mm. The distribution of different soil types, Alfisols is red sandy loam in major areas and clay lateritic soils are also noticed in patches.

Hassan : Hassan district lies between 12°13′ and 13° 33′ North latitudes and 75°33′ and 76°38′ East longitudes and its altitude ranges between 800-953m above MSL. It has a total area of 6,826.15 km^2. The geography is mixed with the mountainous region to the west and south west (Bisle Ghat) and the maidan regions in the north, south and east. The average temperature is 22.1°C and rainfall is around 1,142 mm and the soil type is sandy loam. *(Note:* Rainfall data of different districts obtained from www.data.opencity.in website).

Survey : Purposive sampling technique was adopted for the survey. The list of farmers who were practicing agroforestry systems (*i.e.,* those who had planted trees on their farmland) in five identified districts was collected from the Divisional Office (District Centre) of Karnataka Forest Department. In total, 170 farmers were randomly identified and their farms were visited. Out of 170, 60 farmers from Tumakuru, 22 farmers from Bengaluru Urban, 10 farmers from Bengaluru Rural, 18 farmers from Chikkaballapur and 60 farmers from Hassan districts were identified and interviewed.

Agricultural fields of farmers were visited and the agroforestry systems practiced were identified and recorded (Dhyani, 2018). The tree species grown were identified using monographs and field guides (Endale *et al.,* 2017) and recorded. An overview of the sample selection process is shown in the following flowchart.



Tree Species used in the study : *Melia dubia* Cav. (Hebbevu), *Swietenia mahagoni* (L.) Jacq. (Mahagony), *Santalum album* L. (Sandalwood), *Tectona grandis* L.f. (Teak), *Artocarpus heterophyllus* Lam. (Jack), *Azadirachta indica* A. Juss. (Neem), *Grevillea robusta* A. Cum. exR. Br. (Silver oak) and *Syzygium cumini* L. (Jamun), *Pterocarpus santalinus* (Red Sanders) and *Gmelina arboria* (Shivane) were the main species studied.

Data Analysis : The data collected from various farmers across the districts regarding agroforestry systems and tree species were converted and expressed in terms of percentage values. Further, if the same farmer was practicing multiple agroforestry systems, for analysis purposes, he was treated as a separate farmer. The spacing between trees was recorded using a measuring tape.

G-Test Goodness of Fit Test : To study the association between agroforestry systems and districts, a likelihood analysis *i.e.,* a non-parametric Chi-square test (G-test; used if the number in a cell is < 5) was performed.

Correlation and regression statistical analysis was performed to understand associations between spacing (row and plant) and tree species (Snedecor and Cochran, 1989).

Results and Discussion

Agroforestry Practices : The agroforestry systems practiced by the farmers in the selected five districts of southern Karnataka are shown in Table 1. The agroforestry practices namely Agrisilviculture, Block plantation and Silviolericulture (including vegetables) were found to be the major ones in all the selected districts of Karnataka. In Bengaluru Urban district, the majority of the farmers were practicing Block plantation (37.04%) agroforestry system followed by Agrisilviculture (25.93%). Around 18.52 per cent of the farmers did not follow defined agroforestry systems, but they were planting the trees in a scattered manner in their farm lands. In case of Bengaluru Rural district, farmers were predominantly practicing Agrisilviculture (30.95%) system, Block plantation (26.19%) and Silviolericulture (19.05%) agroforestry systems, respectively. In Chikkaballapur district also, a greater number of farmers were found practicing Block plantation (27.27%) agroforestry system followed by Agrisilviculture (24.24%) and Silviolericulture (18.18%). Compared to Bengaluru urban areas in Bengaluru rural and Chikballapur districts farmers were growing vegetables in agroforestry plots. In Tumakuru district, the highest percentage of farmers were practicing Agrisilviculture (26.40%) followed by Block plantation (25.60%) and Silviolericulture (14.40%) agroforestry system. These districts are known to be the hub for the vegetable market. Additionally, in Chikkaballapur district, farmers were found practicing road side tree planting, *i.e.,* avenue tree planting system (15.15%). Probably to reduce pollution as several farms are along the roadside and near highways. In Hassan district, the majority of farmers were practicing Agrisilviculture (28.57%) system, Silviolericulture (21.80%) system, Block plantation (14.29%) and avenue plantation (10.53 %), respectively. The district has a suitable climate for cultivation of plantation crops such as coffee, pepper and tea, etc., therefore, the majority of the farmers were practicing Silvi-horticulture agroforestry systems. Since the district has both hilly and plain zones, we observed more diverse (species composition) agroforestry systems compared to other southern districts.

Table 1

Agroforestry systems practiced by farmers in selected districts of Karnataka

Agroforestry systems	Districts of Karnataka				
	Bengaluru Urban (n=27)	Bengaluru Rural (n=42)	Chikka-ballapur (n=33)	Tumakuruu (n=125)	Hassan (n=133)
Agrisilviculture (trees + crops)	25.93	30.95	24.24	26.40	28.57
Boundary plantation (tree on boundary + crops)	00.00	00.00	00.00	01.60	0.75
Block plantation (block of tree+ block of crops)	37.04	26.19	27.27	25.60	14.29
Agrihorticulture (fruit trees + crops)	00.00	07.14	00.00	00.00	00.00
Agrisilvihorticulture (trees + fruit trees + crops)	03.70	00.00	09.09	08.00	07.52
Silviolericulture(tree + vegetables) *	07.41	19.05	18.18	14.40	21.80
SilviPasture (trees + pasture/animals)	03.70	00.00	00.00	05.60	07.52
Bund Planting (trees on bunds + crops)	03.70	00.00	00.00	02.40	04.51
Scattered planting (trees randomly planted + crops)	18.52	07.14	06.06	09.60	04.51
Avenue Planting (trees along the road in farm)	00.00	09.52	15.15	06.40	10.53

*Including horticultural plantation crops, n=number of farmers

Note : Agroforestry systems classification model adopted from Dhyani, 2018

The association between the specific agroforestry system adopted or practiced by the farmers with the locality (districts) was verified with the G-test, the analysis indicated a significant relationship between the percentage of farmers and agroforestry species combinations adopted (N=370, G-test value = 61.28 significance at $P<0.05$).

These results indicated that Agrisilviculture, block plantation and Silviolericulture were the major agroforestry systems practiced by farmers in the selected southern districts of Karnataka. The findings are in-line with earlier studies like Chaturvedi and Das (2002), Anonymous (2006), Varadaranganatha & Madiwalar (2010), Raghavendra & Prasanna (2017) and Doddabasawa & Murthy (2017). They have also stated that Agrisilviculture and block planting systems are the predominant agroforestry systems in Karnataka. Additionally, several authors have stated that Bund Planting (trees on bunds + crops) and Silvipasture (trees + pasture / animals) are also predominant agroforestry systems as they support animal husbandry. However, in our survey, we found only a few farmers practicing Silvipasture and bund planting systems.

Tree species preferred in agroforestry systems : Tree species planted in agroforestry systems by the farmers aregiven in Table 2. The study revealed that in Bengaluru Urban area the highest percentage of farmers planted Jamun trees (22%), followed by Mahagony (16%), Silver oak (14%) and Jack (11%). In Bengaluru Rural district, the majority of the farmers planted Silver oak (19 %) and Jamun (17%) in their farmland. They also planted equally Sandalwood, Teak and Jack (around 12 %) in their farms. Only 7 per cent of the farmers preferred species other than the major listed tree species. It was noticed that in Bengaluru (Rural and Urban) farmers had not preferred planting Red Sanders and Shivane trees in their farms.

In Chikkaballapur district, about 21 per cent of farmers planted Sandalwood in their farms and around 18 per cent of framers preferred species like Hebbevu, Mahagony and Teak in the agroforestry systems. Fifteen per cent of the farmers preferred other tree species over the listed ones. Interestingly, farmers from Chikkaballapur district had shown no interest in planting multipurpose tree species like Jamun, Jack and Neem along with agricultural crops.

TABLE 2

Major tree species preferred by the farmers in the Agrisilviculture system

Agroforestry tree species	Districts					
	Bengaluru Urban (n=27)	Bengaluru Rural (n=42)	Chikkaballapur (n=33)	Tumakuru (n=125)	Hassan (n=133)	Overall Average
Hebbevu	5	7	18	18	15	13
Mahagony	16	7	18	9	7	11
Sandalwood	5	12	21	10	8	11
Teak	8	12	18	13	11	12
Silver oak	14	19	6	12	18	14
Jamun	22	17	0	8	8	11
Jack	11	12	0	9	12	9
Neem	5	7	0	10	10	6
Red Sanders	0	0	3	9	5	3
Shivane	0	0	0	0	6	1
Other	14	7	15	4	2	8

Note : N-370; G-test significant at 5% probability; G=77.71 (table value 55.76)

In Tumakuru district 18 per cent of farmers preferred and planted Hebbevu. The other tree species preferred by farmers included Teak (13%), Silver oak (12%), Sandalwood (10%) and Neem (10 %), respectively.

In Hassan district, 18 per cent of farmers preferred Silver oak followed by Hebbevu (15%), Jack (12%), Teak (11%) and Neem (10%), respectively. Compared to other districts only Hassan district farmers preferred and planted Shivane in the agroforestry systems.

The association between the tree species preferred or grown by the farmers with the locality (districts) was verified with the G test, the analysis indicated a significant relationship between the species and the locality (N=370, G test value =77.71 significance at $P<0.05$).

Overall, it was noticed that farmers prefer Silver oak, Hebbevu and Mahagony, probably due to the fast-growing nature, early rotation age and easy marketing. Raghavendra and Prasanna (2017) have reported similar results in Hassan. The other tree species, namely Teak, Sandalwood and Jamun are also preferred as they are economically important but slow-growing. The tree species like Red Sanders and Shivane were not preferred in these districts (except Hassan).

Species combinations in Agrisilvicultre and Silvihorticulture agroforestry systems : The data on the combination of crops with tree species practiced by farmers in the southern districts of Karnataka is presented in Table 3. The results showed that the majority of the farmers in Bengaluru Urban district were growing Maize, Ragi and Avare in the Agrisilviculture agroforestry system. Horticulture species like Jack, Jamun, Rose-apple, Silver oak, trumpet tree, Pomegranate and Lemon are preferred in the Silvihorticulture system. Further, it was also noticed that Bengaluru Urban farmers are involved in producing vegetable seedlings in plant nurseries. In Bengaluru Rural district, farmers preferred only Maize and Ragi in the Agrisilviculture system. Species like Guava, Jamun, Papaya, leafy vegetables, Beans, Beetroot and Carrot were grown in the Silvihorticulture agroforestry system. In Chikkaballapur district, it was observed that Maize, Avare and Pigeonpea are preferred in the Agrisilviculture system and Mango, Jack, Anola, Chrysanthemum, Coconut, Chilli, Leafy vegetables,

TABLE 3

Crops and tree species combinations in agroforestry systems in southern districts of Karnataka

District	Agricultural crops	Horticultural crops
Bengaluru Urban	Maize, Ragi and Avare	Jack, Jamun, Rose apple, Silver oak trumpet tree, Pomegranate and lemon
Bengaluru Rural	Maize and Ragi	Guava, Jamun, Papaya, leafy vegetables, Beans, Beetroot and Carrot
Chikkaballapur	Maize, Avare and Pigeonpea	Mango, Jack, Aonla, Chrysanthemum, Coconut, Chilli, Leafy vegetables, Cashewnut and lemon
Tumakuru	Maize, Ragi, Groundnut and Mulberry plants	Jamun, Jack, Arecanut, Coconut, Mango, Vegetables, Guava, Curry leaf, Apple, Turmeric and Sapota
Hassan	Maize and Ragi	Jack, Jamun, Coffee, Pepper, Arecanut, Beetle vein, Coconut, Vegetables, Pomegranate, Tamarind, Mango, Banana, Beans, Cinnamon, Cashew and Turmeric

Cashewnut and Lemon in the Silvihorticulture agroforestry system. In Tumakuru district, farmers were practicing growing Ragi, Maize and Groundnut in the Agrisilviculture system. In the Silvihorticulture agroforestry system Jamun, Jack, Arecanut, Coconut, Mango, Vegetables, Guava, Curry leaf, Apple, Turmeric and Sapota were preferred. Compared to Bengaluru Urban, Bengaluru Rural and Chikkaballapur, Tumakuru farmers were growing mulberry crops in their agroforestry system. Whereas, in the case of Hassan district, farmers were practicing majorly Maize and Ragi in the Agrisilviculture system and Jack, Jamun, Coffee, Pepper, Arecanut, Betel vine, Coconut, Vegetables, Pomegranate, Tamarind, Mango, Banana, Beans, Cinnamon, Cashew and Turmeric in the Silvihorticulture agroforestry system. Compared to other districts, Hassan district farmers were growing more plantation and spice crops in the agroforestry system. This could be because of the fact that Hassan has a suitable climate for the cultivation of plantation and spice crops.

Overall, it was observed that only few selected crops namely Maize, Ragi and Avareare being grown under the Agrisilviculture system in all the five districts of Karnataka. Further, Pigeonpea, Groundnut and Mulberry are also grown in afew cases. Similar results have been reported by Rai and Shivashankar (1994) during the survey of agroforestry practices in Karnataka. These results are in conformity with the findings of Madiwalar and Devaranavadgi (2003) on documentation of suitable agroforestry models in a few districts of Karnataka.

Tree species combinations: The data on tree species combinations in farm lands is provided in Table 4. Among the different agroforestry tree species combinations, the preferred combination by the farmers is presented here. Farmers in Bengaluru Urban preferred Mahagony planting along with the major identified agroforestry trees species. Neem and Jamun combination was more preferred in this district. Hebbevu and Jack were also considered for mixed plantations. In Bengaluru Rural district, Silver oak and Mahagony were planted in combination with the major agroforestry tree species. Jack and Teak were also grown considerably in this district. In Chikkaballapur district, Sandalwood, Mahagony, Hebbevu and Silver oak were preferred in combination with the major agroforestry tree species. In some cases, Honge (*Pongamia*) was also preferred. In Tumakuru district, Jamun and Jack were planted along with the other agroforestry trees. Hebbevu, Silver oak and Neem were also equally preferred by the farmers as tree combinations. Sandalwood and Red Sanders trees were planted by the farmers in the district. In Hassan district, the diversity of agroforestry systems was comparatively high. Mahagony, Silver oak,

TABLE 4

Agroforestry tree species combinations observed in five districts of Karnataka

Districts/ Species	Bengaluru Urban	Bengaluru Rural	Chikkaballapur	Tumakuru	Hassan
Hebbevu	Mahagony & Teak	Silver oak & Sandalwood	Mahagony, Silver oak and Sandalwood	Mahagony, Jamun, Jack, Silver oak, Sandalwood and Honge	Neem, Jamun, Silver oak, Jack, Teak and Shivane
Mahagony	Hebbevu, Neem, Jamun, Jack, Silver oak and Teak	Silver oak	Hebbevu, Teak and Sandalwood	Hebbevu, Jamun, Jack, Silver oak, Teak and Red Sanders	Neem and Jack
Sandalwood	Mahagony & Neem	Mahagony	Mahagony, Red Sanders & Honge	Hebbevu, Teak & Red Sanders	Mahagony, Jack, Silver oak, Teak
Teak	Mahagony and Hebbevu	Silver oak and Jack	Mahagony, Hebbevu and and Sandalwood	Hebbevu, Jamun, Jack, Silver oak	Mahagony and Hebbevu
Silver oak	Mahagony	Mahagony, Hebbevu, Jack & Teak	Mahagony and Hebbevu	Hebbevu, Neem, Jamun and Sandalwood	Mahagony Hebbevu, Jack, Teak, Sandalwood and Shivane
Jamun	Mahagony & Neem	-	-	Neem and Guava	Neem, Jack, Silver oak, Teak, Shivane,
Jack	Mahagony, Neem and Jamun	Silver oak and Teak	-	Mahagony, Neem and Red Sanders	Mahagony, Neem, Jamun. Silver oak and Teak
Neem	Mahagony, Jamun and Jack	Mahagony	-	Jack and Red Sanders	Mahagony, Hebbevu, Jamun, Silver oak and Sandalwood
Red Sanders	-	-	Sandalwood and Honge	Neem, Jamun, Jack, Silver oak, Honge and Sandalwood	Neem and Shivane
Shivane	-	-	-	-	Hebbevu, Neem, silver oak, Teak and Red Sanders

Hebbevu, Neem, Jack, Teak and Shivane were preferred along with the other tree species. In some cases, Sandalwood and Red Sanders were also grown as mixed plantations.

Spacing followed in tree planting : Spacing and intercropping are known to affect the tree growth parameters such as tree height, diameter at breast height, crown diameter, basal area and tree volume *etc.* and the productivity of the entire land. Thus, tree spacing is considered as an important factor for growth and development. The spacing recommendation varies with species, genotype, location, etc. the general recommended spacing for

Hebbevu is 6 x 4 m, Mahagony is 6 x 6 m, Sandalwood is 3.6 x 3.6 m, Teak is 2 x 2 or 3 x 3 or 5 x 5 m (high density with periodic felling), Silver oak is 6 x 6 m, Jamun is 8 x 8 m or 10 x 10 m, Jack is 10 x 10 m, Neem is 5 x 5 m or 10 x 10 m, Red Sanders 4 x 4 m and Shivane 2 x 2 or 4.5 x 4.5 m in Karnataka State (Devakumar *et al.,* 2023). Among the different districts studied, 5 x 5 and 5 x 6 m appears to be the most common spacing. In Bengaluru Urban, Bengaluru Rural and Chikkaballapur, spacing ranged from 3 x 4 m to 5 x 6m whereas in Hassan it ranged from 5 x 5 and 5 x 8 m. In Tumakuru district, the spacing ranged from 4 x 5 to 5 x 8 m (Table 5). These findings are similar to the work of Ali *et al.* (2024). The relationship between tree species and spacing was also analysed. It was observed that farmers do not follow any specific spacing pattern with regards to tree species planting. All the species were planted in different spacing. The correlation analysis indicated no specific relationship exists between the species and spacing practiced by the farmers (Fig. 1). The planting spacing mainly depends on the available land rather than the species selected or its growth habit. Therefore, expected yield in these agroforestry systems may not be achieved with this kind of spacing.

TABLE 5

Spacing followed for different species in different district of Karnataka

Districts/ Species	Bengaluru Urban	Bengaluru Rural	Chikkaballapur	Tumakuru	Hassan
3*4	Sandalwood	-	-	-	-
4*4	Jamun	Jamun	Mahagony, Teak and Sandalwood	-	-
4*5	Jack	Silver oak & Mahagony	-	Silver oak, Hebbevu & Neem	-
4*6	-	Hebbevu and Mahagony	Teak, Mahagony, Sandalwood and Hebbevu	Hebbevu & Silver oak	-
5*5 oak,	Jamun, Mahagony, Jack and Neem	Mahagony	Teak, Hebbevu, Silver oak and Mahagony	Teak, Sandalwood, Neem, Jack, Silver oak, Mahagony and Red Sanders	Neem, Silver Red Sanders, Jack, Hebbevu & Mahagony
5*6	Silver oak, Neem, Teak, Sandalwood, Hebbevu, Mahagony, Jamun and Jack	Hebbevu, Silver oak, Teak and Sandalwood	Hebbevu, Teak, Mahagony, Sandalwood, and Red Sanders	Teak, Silver oak, Mahagony, Jamun, Hebbevu, Red Sanders, Neem, Sandalwood and Jamun	Silver oak, Sandalwood, Jack, Teak, Red Sanders, Jamun Hebbevu and Mahagony
5*8	-	-	-	Neem and Mahagony	Silver oak, Mahagony, Jack, Hebbevu, Teak, Sandalwood, Neem, Jack and Shivane
6*5	-	-	-	-	Hebbevu, Silver oak and Jamun

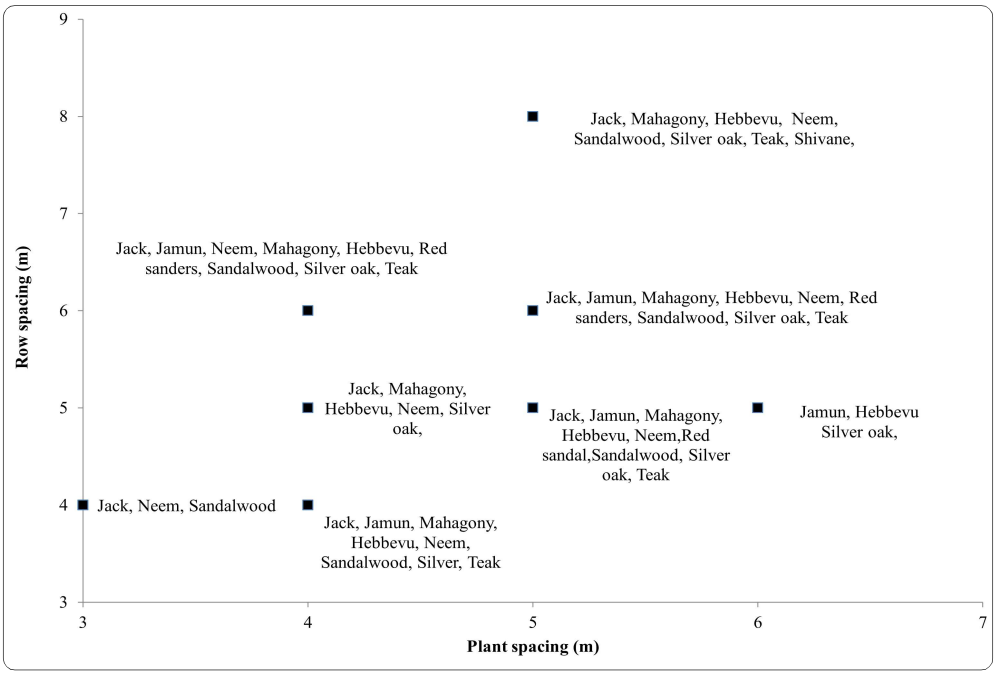


Fig. 1: Species and spacing combinations in selected districts of Karnataka

Agroforestry is known to enhance farm resilience, boost income and support biodiversity. Trees require minimal irrigation after establishment, providing timber, fodder and fuelwood while improving soil health (Xu *et al.,* 2019 and Krishnakanth & Nagaraja, 2020). These systems increase household nutrition and income, often outperforming monocropping (Pandey, 2007 and Kowar, 1992). Popular tree species like *Eucalyptus*, *Acacia* and teak offer high market value. Agroforestry also mitigates climate risks, conserves water and sustains ecosystems. In spite of several advantages, agroforestry is still not adopted by most of the farmers in the state. The key barriers to agroforestry adoption could be financial constraints, lack of quality seedlings and in adequate government support (Okaliand Sumberg, 1985 and Tiwari *et al.*, 1990). Land tenure issues and restrictive policies further discourage investment. Farmers face challenges such as long gestation periods, crop competition from tree roots, water scarcity and limited farm sizes (Krishnamurthy, 1990 and Anil Kumar *et al.,* 1999). Other obstacles include inadequate market access, regulatory restrictions, limited industrial knowledge and low farmer awareness (Michael *et al.,* 1989). Socio-economic factors like land holding size, irrigation access and livestock income also impact adoption (Dhanya *et al.,*2013). Addressing these issues requires improved land tenure security, awareness programmes and better training in agroforestry practices.

Agroforestry or tree-based farming has proven to be an effective and feasible adaptation strategy. This method requires no significant capital investment yet enhances farm productivity and profitability while promoting sustainability. The increasing demand for agroforestry systems is driven by their significant ecological and economic benefits. The study identifies Agrisilviculture, Block Plantation and Silvioleri culture as the primary agroforestry systems practiced by farmers in the selected southern districts of Karnataka. In Karnataka, farmers prefer agroforestry tree species based on factors like market demand, soil adaptability, water availability and multipurpose use. In this study, among tree species, Silver Oak, Hebbevu and Mahogany are the most preferred probably due to their fast growth, early rotation age and market demand. Teak, Sandalwood and Jamun, which are economically valuable are also cultivated despite their

slower growth rates. The attitude of farmers is oriented towards income generating crops, both at fast-growing and highvalue slow growers.

In terms of agricultural crops, Maize, Ragi and Avare are commonly grown under the Agrisilviculture system, with Pigeonpea, Groundnut and Mulberry cultivated in some cases. Spacing practices vary across districts, with closer spacing observed in Bengaluru (Urban and Rural) and Chikkaballapur, while Tumakuru and Hassan farmers adopt slightly wider spacing. However, the analysis reveals that farmers do not adhere to standardized spacing guidelines when integrating tree species into agroforestry systems, leading to diverse planting densities.

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REFERENCES

ALI, S., VASUDEV, K. L., DEVAGIRI, G. M., HEGDE, R. AND NAIK, K., 2024, Growth performance of *Melia dubia* in agroforestry in the central dry zone of Karnataka. *International Journal of Advanced Biochemistry Research,* **7** (2) : 478 - 481.

ANIL KUMAR, A., BABU, B. AND RAMACHANDRAN, V., 1999, Attitude of farmers towards agroforestry programmes in Kerala. *Indian Journal of forestry,* **22** (2) : 155 - 159.

ANONYMOUS, 2006, Package of practice for Northern Dry Zone of Karnataka, UAS, Dharwad publication, pp. : 280 - 307.

ARUNACHALAM, A., RIZVI, R. H., HANDA, A. K. AND RAMANAN, S. S., 2022, Agroforestry in India: Area estimates and methods. *Current Science,* pp. : 743 - 744.

CENTRAL GROUND WATER BOARD (CGWB) 2012a, Groundwater information booklet Chikkaballapur District. Ministry of CGWB Water Resources, Government of India, pp. : 20.

CENTRAL GROUND WATER BOARD (CGWB) 2012b. Groundwater information booklet Tumakuru District. Ministry of Water Resources, Government of India, pp. : 26.

CHATURVEDI, O. P. AND DAS, D. K., 2002, Studies on rooting patterns of 5-year-old important agroforestry tree species in North Bihar, India. *Forests, trees and Livelihoods*, **12** (4) : 329 - 339.

CHIKKABALLAPUR DISTRICT, PLP report, 2016-17 (https://www.nabard.org/auth/writereaddata/tender/2110165408CHIKKABALLAPUR%20PLP%202016-17%20FINAL.3-9.pdf).

DEVAKUMAR, A. S., KRISHNAMURTHY, R. AND VENKATASHIVA REDDY, J. S., 2023, *Aranya Krishi* (Kannada), Published by the Dept. of Kannada Studies, Directorate of Education, UAS, Bangalore, Pages 90.

DHYANI, S. K., 2018. Agroforestry in Indian perspective. In: Agroforestry Opportunities for Enhancing Resilience to Climate Change in Rainfed Areas (Rajeshwar Rao, G., Prabhakar, M., Venkatesh, G., Srinivas, I. and Sammi Reddy, K. (Eds.). ICAR - Central Research Institute for Dryland Agriculture, Hyderabad, India, **224** : 12 - 28.

DHANYA, B., SYAM VISWANATH AND SEEMA PURUSHOTHAMAN, 2013, Crop yield reduction in *Ficus* Agroforestry Systems of Karnataka, Southern India: Perceptions and Realities, *Agroecology and Sustainable Food Systems*, **37** : 727 - 735.

DODDABASAWA AND MURTHY, M. M., 2017, Assessment of tree diversity in agroforestry systems, *Mysore J. Agric. Sci.,* **51** (3) : 522 - 529.

ENDALE, Y., DERERO, A., ARGAW, M. AND MUTHURI, C., 2017, Farmland tree species diversity and spatial distribution pattern in semi-arid East Shewa, Ethiopia. *Forests, trees and Livelihoods,* **26** (3) : 199 - 214.

INDER DEV, RAM, A., BHASKAR, S. AND CHATURVEDI, O. P., 2018, Role of Agroforestry in current scenario. In *Agroforestry for Climate Resilience and Rural Livelihood*, Scientific Publishers: Jodhpur, India, pp. : 1 - 10.

KING, K. F. S., 1968, Agri-silviculture the Taungya system, Bulletin number 1, Department of Forestry, University of Ibadan, Nigeria, pp. : 109.

KOWAR, G. R., 1992, Studies on alley cropping and agroforestry system in black soil under paper presented at the National workshop on Agricultural bio-diversity Conservation, January 27-29, 1999, Kenya College of Communication and Technology, Kenya.

KRISHNAKANTH, B. N. AND NAGARAJA, B. C., 2020, Agroforestry as an adaptation to climate variability in semi-arid regions of Karnataka, India. *Annals of Arid Zone*, **59** (1&2) : 29 - 36.

KRISHNAMURTHY, K., 1990, An economic analysis of agroforestry in Mettupalayam taluk in Coimbatore district. *Thesis*, (Unpub), TUAU, Coimbatore.

KUMAR, Y., THAKUR, T. K. AND THAKUR, A., 2017, Socio-cultural paradigm of Agroforestry in India. *International Journal of Current Microbiology and Applied Sciences*, **6** (6) : 1371 - 1377.

MADIWALAR, S. L. AND DEVARANAVADGI, S. B., 2003, Report on documentation of suitable agroforestry models in Bijapur, Bagalkot and Gadag Districts. Univ. Agric. Sci., Dharwad Publication, 38.

MICHAEL, F., MUSSAK, S. AND JAIN G. LAARMAN, 1989, Farmers production of timber trees in the Cacao coffee region of coastal Ecuador, Department of Forestry, Agroforestry System, **9** :155 - 170.

NAUTIYAL, S., BHASKAR, K. AND KHAN, Y. I., 2015, Biodiversity of semiarid landscape. Switzerland: Springer International Publishing. Switzerland, pp. : 398.

OKALI, C. AND SUMBERG, J. E., 1985, Sheep and goats, men and women: Household relations and small ruminant development in southwest Nigeria. *Agricultural Systems*, **18** (1) : 39 - 59.

PANDEY, D. N., 2007, Multifunctional agroforestry systems in India. *Current Science,* **92** : 455 - 463.

PATTANAYAK, S. K., MERCER, D. E., SILLS, E. AND YANG, J. C., 2005, Taking stock of agroforestry adoption studies. *Agrofor. Sys.,* **57** : 173 - 186.

PRASAD, R. AND DHYANI, S. K., 2010, Review of agroforestry contributions and problems in arid ecosystem for livelihood support in India. *Journal of Soil and Water Conservation,* **9** (4) : 277 - 287.

RAGHAVENDRA, S. M. AND K. T. PRASANNA, 2017, Documentation of different Agroforestry systems in dry and transition zones of Hassan district. *Mysore J. Agric. Sci.,***51** (3) : 540 - 543.

RAI, S. N. AND SHIVASHANKAR, K., 1994, A survey of agroforestry practices in Karnataka. A publication of Karnataka Forest Department of extension. Planning Forestry Extension Programmes: *Report of a Regional Expert Consultation, ICRAF Reprint*, **65** : 24 - 48.

SATHISH, B. N. AND KUSHALAPPA, C. G., 2007, Systems of Karnataka - An overview. *Agroforestry: Systems and Practices*, pp. : 451 - 457.

SNEDECOR, G. W. AND COCHRAN, W. G., 1989, Statistical Methods. 8th Edition, Iowa State, University Press, Ames.

TEJWANI, K. G., 2001, Agroforestry in India. *Concept Publishing Company*. Concept Publishing Company, pp. : 233.

TIWARI, S. C., GULARIA, J. AND SHARMA, R. K., 1990, Capital and credit needs of western Himalayan farmers for agroforestry. *Agricultural Situation in India*, **45** (9) : 589 - 591, Columbus, Ohio.

VARADARANGANATHA, G. H. AND MADIWALAR, S. L., 2010, Studies on species richness, diversity and density of tree/shrub species in agroforestry systems. *Karnataka Journal of Agricultural Sciences,* **23** (3) : 452 - 456.

VISWANATH, S., LUBINA, P. A., SUBBANNA, S. AND SANDHYA, M. C., 2018, Traditional agroforestry systems and practices: A review. *Adv. Agric. Res. Technol*. J., **2** (1) : 18 - 29.

www.ceew.in(https://www.ceew.in/publications/sustainable-agriculture-india/agroforestry).

www.data.opencity.in (https://data.opencity.in/dataset/karnataka-annual-rainfall-districts-taluks -and-hoblis)

XU, H., BI, H., GAO, L. AND YUN, L., 2019, Alley cropping increases land use efficiency and economic profitability across the combination cultivation period. *Agronomy,* **9** (1) : 1 - 19.