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Assessment of Tree Diversity in Agroforestry Systems

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Abstract

A study was undertaken in North Eastern part of Karnataka under rainfed agroecological situation to document the existing agroforestry systems practiced by the farmers and to assess the diversity and density of tree species in the existing agroforestry systems. There were three prominent agroforestry systems practiced by the farmers. Bund (38.33%) and boundary planting (38.33%) were the major systems practiced by the farmers followed by the scattered planting (22.22 %). The higher species density and number of trees per hectare was observed in boundary planting (5.68 and 34.21, respectively) followed by the bund planting (5.43 and 27.71, respectively) and scattered planting (4.63, 20.19, respectively). Higher density of trees per hectare was observed with large famers (34.63) followed by the medium farmers (30.93) and small farmers (21.69). Among the districts, higher tree density per hectare was observed in Koppal (31.00) followed by Bidar district (29.75) and the least density was observed in Kalaburagi district (26.33). *Azadirachta indica*, *Acacia nilotica* and *Ziziphus mauritiana* were the preferredspecies.

Keywords: Tree density, Agroforestry, species density, species richness

Integrating trees on the farm land is an age old practice practiced by the millions of farmers to meet their diverse needs such as food, fodder, fuel wood and other marketable products and environmental benefits like shade, protection, soil conservation and fertility enrichment. Besides, the traditional agroforestry systems are ecologically more feasible, sustainable and profitable and these land use systems play an important role in the livelihood of the farmer by way of and additional income and also enhanced water quality, soil fertility, carbon sequestration and biodiversity.

The composition and pattern of these traditional based agroforestry land use system are location specific, performance biased, and preference of the farmer and culture of the countries (Nair *et al.,* 2008). However, in recent days these traditional based agroforestry land use systems and trees on the farm land are disappearing very rapidly due to the intensification of agricultural production systems and change in land use pattern (Nerlich *et al.,* 2013). The information and documentation of existing agroforestry systems and their composition with respect the species and density would help to improve qualitatively and economically the existing agroforestry systems and also help further promotion and adoption of these land use systems on the farm lands. With this background a study was conducted to know the existing agroforestry systems practiced by the farmers and to assess the diversity and density of the tree species found in the existing traditional based agroforestry systems in North Eastern part of Karnataka.

Material and Methods

A study was under taken in North Eastern part of Karnataka (comprising north eastern transitional zone, north eastern dry zone and northern dry zone of the state) to assess the tree diversity in the traditional based agroforestry systems under rainfed agroecological situation. The study area lies within the geographical region of North maiden; it spreads between 14^0 60' to 18^0 30'Northern latitude and 75^0 60, to 77^0 70' Eastern longitude. This region comprises of six districts namely Bidar, Bellary, Kalaburagi, Koppal, Raichur and Yadgir and covers an area of 44108 sq.km which accounts 23 per cent of total geographical area of Karnataka.The back ground information of the study area were collected by visiting District statistical office and interacting with staff of line departments and weather data was collected from the representative meteorological units located in the

study area. The average rainfall ranges between 600 to 900 mm with an elevation ranging from 350-650m. The soils of this region are deep to very deep black soils with medium deep black soils in major areas, while sandy loam and light structured soils are also found in some pockets. The major crops grown are pigeon pea, greengram, Bengalgram, groundnut, soybean, sunflower, safflower, sorghum, and pearlmillet, and cotton, sugarcane and paddy under irrigation.

Multistage purposive randomized sampling technique was used to select the samples for the study by selecting districts as unit (6 districts) and in each district two taluks were identified, in each taluk one village was identified and in each village 6 respondents of 2 each in small farmer (<2ha), medium farmer (2 to 4 ha) and large farmer (>4ha) were selected randomly among the list of the farmers who have already practicing agroforestry systems and in all the total sample size of the study was 72 farmers. Each study location was recorded with geographical coordinates with the GPS (Geographical Position System) and given in Fig.1.

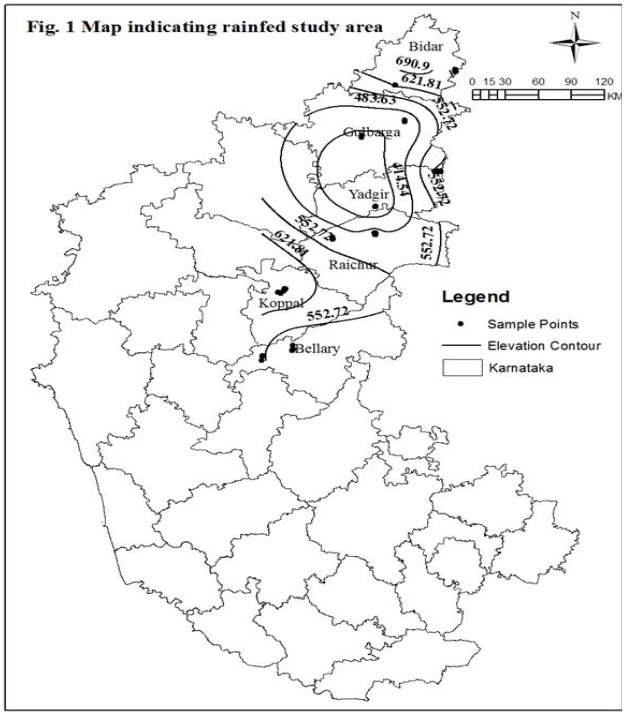

Fig. 1 : Map indicating rainfed study area

The information on the existing traditional based agroforestry systems, species richness, diversity and density were recorded by visiting the field physically and interviewing the farmers with structured questionnaire prepared for the study. The kind of agroforestry system practiced by the farmers in the study area were identified by visiting the field and classified based on the nature of the component and the pattern of tree planting on the farm land and the number of farmers practicing specific agroforestry systems were recorded and expressed in percentage out of the total farmers surveyed. Species richness, species density and tree density in the existing agroforestry systems were recorded with plot size of one hectare representing the total farm land of each individual farmer.

The data on species richness was obtained by aggregating number of species present and expressed in total number of species per agroforestry systems, per district and per category of farmers. The species density was calculated by aggregating total number of species found in different systems, farmers and per district and expressed as mean number per hectare. Similarly the tree density was calculated by counting total number of trees divided by the number of farmers and expressed as mean number per hectare. The dominance of the tree species on farm land was calculated by taking the relative density of the species which was calculated by dividing the total number of individual species to the overall total of all the species, and frequency of the species was calculated based the frequency of the occurrence of the species in all the sample plots. The data on the species diversity was also subjected to Shannon and Simpson's diversity index.

Results and Discussion

There were three prominent agroforestry systems practiced by the farmers and the majority of the farmers practiced bund planting (33.33 to 46.15 %) and boundary planting (30.77 to 47.37 %) followed by scattered planting (15.79 to 25.93 %) (Table I). However, considerable variation was noticed with respect to categories of farmer. The boundary planting was the major system practiced by the large farmer (47.37%) and medium farmer (40.74 %) whereas bund planting was the major system followed by the small farmer (40.15 %).

Among the districts, bund and boundary planting was the major system practiced by the farmers

TABLE I

Agroforestry systems followed by different categories of North Eastern part of Karnataka

Agroforestry Systems / Planting	Percentage of respondents following the agroforestry system Categories of Farmers			Average
	Large (n=19)	Medium (n=27)	Small (n=26)	
Bund Planting	36.84	33.33	46.15	38.89 (±0.82)
Boundary Planting	47.37	40.74	30.77	38.89 (±0.78)
Scattered Planting	15.79	25.93	23.08)	22.22 (±0.71)

Note: Values in parenthesis indicates standard deviation

followed by scattered planting. The Bund planting was the predominant agroforestry systems found in all the districts (41.67%) except the Koppal (50.00 %) and Gulbarga (41.67%) district (Table II) where boundary planting was preferred over bund planting. This indicates that the majority of the farmer retained the trees more on bund and boundary of the farm land rather going for the scattered planting as the retention of the trees on bund and boundary planting will have lesser limiting effect on crop performance compared to in- field scattering. Besides, farmer gets additional benefits from the bund area because of productive use which otherwise would have left unused. Further, boundary planting helps to protect the farm from stray cattle menace, erosive and desiccating wind, conserve soil from erosion, provide more opportune time for infiltration of rain water besides serving as a demarcation of the farm. The findings are in line with Varadaranganath and Madiwalar (2010), who reported bund planting and scattered planting were the major agroforestry systems followed in all the agroecological conditions. Behera and Dhir (2013) also reported that bund planting was the major practice followed by the farmers in rainfed condition (50.4%) in Bouda district of Odisha.

The total number of species recorded in the study area was 27 and the average mean species density per hectare and average mean number of trees per hectare were 5.35 and 28.57, respectively (Table III). Whereas, more number of species and higher mean species density per ha was observed with medium farmer (26, 5.48) followed by large farmer (24, 5.47) and lesser number of species and low mean species density per hectare was observed with small farmer (21, 5.12) (Table III). This was on the expected line as small farmers are more interested in harnessing immediate benefits due to smaller holdings while large

TABLE II

Agroforestry systems followed by farmers in different districts of North Eastern part of Karnataka

Districts / Agroforestry System	Percentage of respondents following the agroforestry systems			
	Bund planting	Boundary planting	Scattered planting	Standard Deviation
Bidar (n=12)	41.67	41.67	16.67	0.75
Gulbarga (n=12)	33.33	41.67	25.00	0.79
Yadgir (n=12)	41.67	33.33	25.00	0.84
Raichur (n=12)	41.67	33.33	25.00	0.84
Bellary (n=12)	41.67	33.33	25.00	0.84
Koppal (n=12)	41.67	50.00	16.67	0.72
Average (n=72)	38.89	38.89	22.22	0.77

TABLE III

Species richness, mean species density and mean number of trees per hectare in different land holding size, agroforestry systems and districts

	Species richness (Total number)	Species density (Mean species density /ha)	Tree density (Mean no. of Trees/ha)	S	H
Categories of farmer					
Large (n=19)	24	5.47 (±1.71)	34.63 (±6.35)	1.25	0.55
Medium (n=27)	26	5.48 (±1.97)	30.93(±8.84)	1.32	0.52
Small (n=26)	21	5.12 (±1.18)	21.69 (±4.23)	1.69	0.38
Agroforestry systems					
Bund Planting (n=28)	24	5.43(±1.43)	27.71 (±6.23)	1.35	0.51
Boundary Planting (n=28)	26	5.68(±1.93)	34.21(±8.29)	1.42	0.49
Scattered Planting (n=16)	17	4.63(±1.26)	20.19 (±4.79)	1.50	0.43
Districts					
Bidar (n=12)	11	5.25 (±0.75)	29.75(±8.71)	1.19	0.51
Kalaburgi (n=12)	12	5.25(±0.62)	26.33 (±8.77)	1.23	0.49
Yadgir (n=12)	20	6.25(±2.09)	27.00(±11.63)	1.60	0.42
Raichur (n=12)	14	5.50(±1.73)	26.50(±7.39)	1.28	0.49
Bellary (n=12)	13	3.67(±1.23)	28.00(±5.91)	0.93	0.58
Koppal (n=12)	20	6.17(±1.64)	31.00(±9.08)	1.43	0.49
Average (N=72)*	27	5.35(±1.64)	28.57 (±8.63)	1.44	0.48

Note: *Aggregated average value of total sample , Values in parenthesis indicates Standard Deviation, S-Shannon Index, H-Simpson Index

farmers are burdened with unwieldy land. However, the higher mean number of trees per hectare was noticed in large farmer (34.63) followed by the medium farmer (30.93) and small farmer (21.69) (Table III). The land holding will have the influence on the species composition and density. The large land holding farmers retained more number of species and density compared to the small farmer wherein, the latter maximum land area will be used for field crops. The results are in agreement with the Abebe *et al.* (2013) who reported increase in species richness and density with increase in the farm size. Bucagu *et al.* (2013) assessed the tree diversity in three categories of farmers of two ecological situations in Rawand and observed higher density of trees with wealthier farmer than the poor farmer.

Among the systems, the higher number of species, mean density of species per hectare and mean number trees per hectare was noticed under boundary planting (26, 5.68 and 34.21) followed by the bund planting (24, 5.43 and 27.71) and scattered planting (17, 4.63 and 20.19) (Table IV). It may be attributed to the fact that the boundary plantings are thickly planted and retained more species and cause least/ limited damage to the field crops compared the scattered planting.

The species richness and mean species density between the districts of the study area also revealed significant difference. The higher number of species and higher mean species density per hectare was observed in Yadagir district (20, 6.25) followed by the

TABLE IV

Dominant tree species found in different land holding size

Scientific Name	Large Farmer (n=19)			Medium Farmer (n=27)			Small Farmer (n=26)		
	Total no. of trees	RD	RF	Total no. of trees	RD	RF	Total no. of trees	RD	RF
Azadirachta indica A Juss.	482	73.25	100.00	598	71.62	100.00	339	60.11	100.00
Acacia nilotica (L.) Willd. ex Delile.	56	8.51	89.47	77	9.22	85.19	60	10.64	69.23
Ziziphus mauritiana Lam.	20	3.04	63.16	20	2.40	51.85	21	3.72	50.00
*Pongamia pinnata (*L.*)*Pierre.	14	2.13	15.79	4	0.48	11.11	10	1.77	15.38
Prosopis cineraria (L.) Druce.	12	1.82	42.11	12	1.44	29.63	14	2.48	26.92
Mangifera indica L.	11	1.67	15.79	4	0.48	11.11	11	1.95	23.08
Morinda pubescens Sm.	7	1.06	21.05	12	1.44	25.93	15	2.66	30.77
Hardwickia binata Roxb.	7	1.06	26.32	7	0.84	18.52	3	0.53	11.54
Cassia fistula L.	7	1.06	26.32	5	0.60	14.81	11	1.95	23.08
Tamarindus indica L.	6	0.91	26.32	25	2.99	37.04	17	3.01	34.62
Annona squamosa L.	6	0.91	15.79	10	1.20	22.22	13	2.30	26.92
Madhuca indica J.F. Gmel.	6	0.91	15.79	8	0.96	14.81	13	2.30	15.38
Acacia ferruginea DC.	4	0.61	15.79	7	0.84	18.52	3	0.53	11.54
Wrightia tinctoria (Roxb.) R.Br.	4	0.61	10.53	4	0.48	7.41	3	0.53	3.85
Balanites roxburghii Planch..	3	0.46	10.53	3	0.36	11.11	8	1.42	15.38
*Butea monosperma (*Lam.*)*Taub.	2	0.30	5.26	8	0.96	14.81	14	2.48	23.08
Leucaena leucocephala (Lam.) de Wit.	2	0.30	5.26	11	1.32	22.22	1	0.18	3.85
Melia azedarach L.	2	0.30	5.26	7	0.84	7.41	0	0.00	0.00
Pithecellobium dulce (Roxb.) Benth.	2	0.30	10.53	1	0.12	3.70	0	0.00	0.00
Santalum album L.	1	0.15	5.26	3	0.36	11.11	2	0.35	7.69
Borassus flabellifer L.	1	0.15	5.26	3	0.36	7.41	0	0.00	0.00
Limonia acidissima L.	1	0.15	5.26	0	0.00	0.00	1	0.18	3.85
Ailanthus excelsa Roxb.	1	0.15	5.26	2	0.24	7.41	0	0.00	0.00
Eucalyptus tereticornis Sm.	1	0.15	5.26	1	0.12	3.70	0	0.00	0.00
Albizia lebbek L Benth.	0	0.00	0.00	1	0.12	3.70	2	0.35	7.69
Ficus glomerata L.	0	0.00	0.00	1	0.12	3.70	0	0.00	0.00
*Chloroxylon swietenia (*Roxb.*)* DC.	0	0.00	0.00	1	0.12	3.70	3	0.53	7.69
Total no. of trees	658			835			564		
Mean no. of trees/ha	34.63			30.93			21.69		

RD- Relative Density, RF-Relative frequency

Koppal district (20, 6.17) and least mean species density per hectare was observed in Bellary district (3.67) (Table III). However higher tree density per hectare was recorded in Koppal district (31.00) followed by Bidar district (29.75) and the least was noticed in Kalaburagi district (26.33) (Table III). This could be partly due to rainfall distribution as Yadgir and Koppal receive relatively more rainfall. That apart, the sampling units of Koppal and Yadgir districts were located in higher elevations. Bucagu *et al.* (2013) assessed the tree diversity in agroforestry systems of two ecological situations in Rawand and reported higher diversity and richness in the higher elevation which favours the tree growth with reduced temperature and congenial environmental conditions which favours the tree growth. Further, they also attributed the reasons for the difference in diversity and density to biophysical and socioeconomic condition of the region. However, the contrasting result was noticed in Bidar district which is also located in higher elevation with low number of species (11) but higher tree density per hectare (29.58) (Table III). Poor socioeconomic / education background may be main reason for lower species composition, while higher tree density could be attributed higher rainfall and elevation which favour tree growth. Thus, apart from elevation other factors such as type of farmer, preference of the farmer and kind of agroforestry system will affect the species richness and density. In Koppal district the prominent of agroforestry system was boundary planting (50.00%) and here more number of large farmers was found whereas in Bidar district more number small and medium farmers had entered the sample.

In the investigation *Azadirachta indica* was found to be the prominent species (100 %) followed by *Acacia nilotica* (69.23 to 89.47%) and *Ziziphus mauritiana* (50 to 63.16 %) (Table IV). Within the agroforestry systems *Azadirachta indica, Acacia nilotica* and *Ziziphus mauritiana* were found to be prominent species in bund and boundary planting, where as *Azadirachta indica, Acacia nilotica, Tamarindus indica* and *Prosopis cineraria* were found dominant in scattered planting (Table V). However, difference in the frequency of species occurrence revealed difference between the districts; *Azadirachta indica* was the most prominent species in all the districts. Prominent species observed in Bidar and Kalaburagi districts were *Azadirachta indica, Acacia nilotica* and *Ziziphus mauritiana*. In Yadagir district the prominent species were *Azadirachta indica*, *Tamarindus indica* and *Acacia nilotica*. *Azadirachta indica*, *Acacia nilotica*, *Prosopis cineraria* and *Ziziphus mauritiana* were the prominenet species observed in Raichur district. In Bellary the prominent species were *Azadirachta indica, Acacia nilotica* and *Prosopis cineraria*. In Koppal districts the prominent species were *Azadirachta indica*, *Acacia ferruginea* and *Cassia fistula*. The *Azadirachta indica, Acacia nilotica* and *Ziziphus mauritiana* were dominant over all samples. This might be due to the suitable ecological conditions for these species and farmers' preferred these species for their value in terms of wood, food, fodder etc. The variation in the frequency of occurrence between the districts is attributed to the variation in the elevation, temperature and rainfall and also the preference of the farmers. The findings are in line with the Vodouhe *et al.*(2011) who in Benin (West Africa) observed *Vitellaria paradoxa* (90%), *Parkia biglobosa* (75%) and *Lannea microcarpa* (29%) as the three most frequent species on the farm land. They also opined that farmers retain trees of multipurpose species to get wood, fuel, fodder and also other benefits like shade and soil fertility improvement.

The majority of the farmers opined that the competition with field crops (54.23%), followed by lack of irrigation facility (42.16%) and small land holding (36.15%) is the main constraints for limited on-farm and species diversity through integration of trees on the farm land of rain fed situation (Fig. 2). As per the preference of tree species is concerned, the majority of the farmer preferred fruit yielding species for planting (63.89%) followed by fodder yielding trees (40.28%) and fuel wood yielding (31.94%) (Fig.3). The findings concur with Behera and Dhir (2013) who reported that majority of the agroforestry practicing farmers of Boudha districts of Odisha preferred fruit yielding species (82.2%) followed by timber (56.8%) and short rotation species (49.9%). Thus, importance to food and fodder in these ecologically endangered areas comes to the fore.

TABLE V

Dominant tree species found in different agroforestry systems

Scientific Name	Bund Planting (n=28)			Boundary Planting (n=28)			Scattered Planting (n=16)		
	Total no.	RD	RF	Total no.	RD	RF	Total no.	RD	RF
Azadirachta indica A Juss.	551	71.01	100.00	659	68.79	100.00	209	64.71	100.00
Acacia nilotica (L.) Willd. ex Delile.	67	8.63	82.14	94	9.81	82.14	32	9.91	75.00
Ziziphus mauritiana Lam.	22	2.84	53.57	32	3.34	67.86	7	2.17	31.25
Tamarindus indica L.	15	1.93	35.71	21	2.19	28.57	12	3.72	37.50
Prosopis cineraria (L.) Druce.	13	1.68	28.57	14	1.46	32.14	11	3.41	37.50
Morinda pubescens Sm.	12	1.55	25.00	13	1.36	25.00	9	2.79	31.25
Annona squamosa L.	12	1.55	28.57	14	1.46	21.43	3	0.93	12.50
*Pongamia pinnata (*L.*)*Pierre.	11	1.42	14.29	10	1.04	17.86	7	2.17	6.25
Cassia fistula L.	11	1.42	25.00	7	0.73	17.86	5	1.55	18.75
*Butea monosperma (*Lam.*)*Taub.	10	1.29	17.86	9	0.94	14.29	5	1.55	12.50
Madhuca indica J.F. Gmel.	9	1.16	17.86	12	1.25	10.71	6	1.86	18.75
Hardwickia binata Roxb.	7	0.90	14.29	5	0.52	14.29	5	1.55	31.25
Leucaena leucocephala (Lam.) de Wit.	5	0.64	10.71	8	0.84	14.29	1	0.31	6.25
Wrightia tinctoria (Roxb.) R.Br.	5	0.64	7.14	6	0.63	10.71	0	0.00	0.00
Mangifera indica L.	4	0.52	10.71	16	1.67	21.43	6	1.86	18.75
Acacia ferruginea DC.	4	0.52	14.29	8	0.84	17.86	2	0.62	12.50
Melia azedarach L.	4	0.52	7.14	5	0.52	3.57	0	0.00	0.00
Santalum album L.	3	0.39	10.71	3	0.31	10.71	0	0.00	0.00
Balanites roxburghii Planch..	3	0.39	10.71	11	1.15	21.43	0	0.00	0.00
Borassus flabellifer L.	2	0.26	7.14	2	0.21	3.57	0	0.00	0.00
Ailanthus excelsa Roxb.	2	0.26	7.14	1	0.10	3.57	0	0.00	0.00
Eucalyptus ***tereticornis*** **Sm.**	2	0.26	7.14	0	0.00	0.00	0	0.00	0.00
Albizia lebbek L Benth.	1	0.13	3.57	2	0.21	7.14	0	0.00	0.00
Pithecellobium dulce (Roxb.) Benth.	1	0.13	3.57	2	0.21	7.14	0	0.00	0.00
Limonia acidissima L.	0	0.00	0.00	1	0.10	3.57	1	0.31	6.25
Ficus glomerata L.	0	0.00	0.00	1	0.10	3.57	0	0.00	0.00
*Chloroxylon swietenia (*Roxb.*)* DC.	0	0.00	0.00	2	0.21	7.14	2	0.62	6.25
Total no. of trees	776			958			958		
Mean no. of trees/ha	27.71			34.21			34.21		

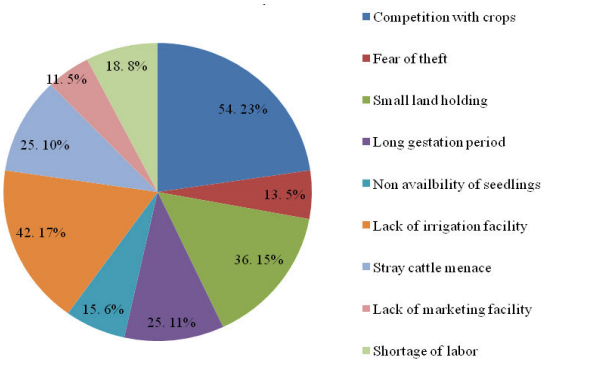

Fig. 2: Constraints integrating trees on the farm land by the farmers in the study area

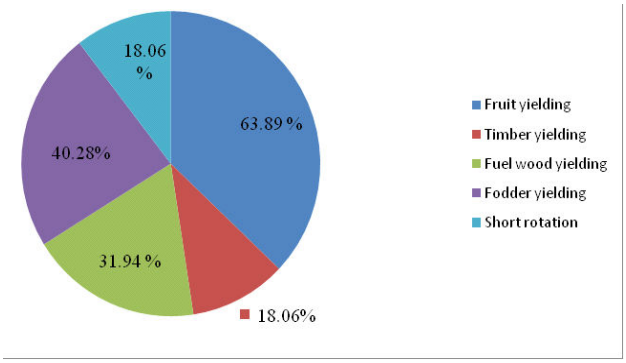

Fig.3: Kind of tress prefered by the farmers in the study area

The study recorded that, the three major traditional based agroforestry systems in the region practiced by the famers. The number of species, species density and tree density varied with land holding size, ecological condition of the area and preference by the farmers. The study found that, out of 27 tree species *Azadirachta indica, Acacia nilotica* and *Ziziphus mauritiana* were found to be the prominent species of the region because of the ecological conditions that suitable for these species and further the farmers preferred more. The results of this study will help in further integration of the trees on the farm land and improvement of the existing agroforestry systems.

References

ABEBE, T., STERCK, F. J., WIERSUM, K. F. AND BONGERS, F., 2013, Diversity, composition and density of trees and shrubs in agroforestry homegardens in Southern Ethiopia. *Agrofor. Syst.*, **87** : 1283–1293.

BEHERA, M. C. AND DHIR, B. C., 2013, Phyto-sociological study of woody components in traditional agro-forestry systems of Boudh district, Odisha, India. *Int. J. of Farm Sci.,* **3** (2) : 63-76.

BUCAGU, C., VANLAUWE, B., VAN WIJK, M. T. AND GILLER, K. E., 2013, Assessing farmer's interest in agroforestry in two contrasting agro-ecological zones of Rwanda. *Agrofor. Syst.,* **87** : 141–158.

NAIR, P. K. R., GORDON, A. M. AND MOSQUERA-LOSADA, M. R., 2008, Agroforestry. In: Jorgenson SE, Fath BD (eds) Ecological engineering: *encyclopedia of ecology*, **1**:101–110. Elsevier, Oxford.

NERLICH, K., GRAEFF-HONNINGER, S. AND CLAUPEIN, W., 2013, Agroforestry in Europe: a review of the disappearance of traditional systems and development of modern agroforestry practices, with emphasis on experiences in Germany. *Agrofor. Syst.*, **87** (2) : 475-492.

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

VODOUHE, G., FIFANOU, COULIBALY, O., GAUTHIER AND SINSIN, B., 2011, Traditional agroforestry systems and biodiversity conservation in Benin (West Africa). *Agrofor. Syst.*, **82** : 1-13.

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