Agroforestry in a Humid Tropical Village ecosystem in Western Ghats: Present Status and Future Implications

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ABSTRACT

The status of tree resources in homes garden and other land use patterns was investigated in Sirsimakki, a humid tropic village ecosystem in Uttara Kannada district, Western Ghats, south India. There were 948 individuals belonging to 93 species, with a standing biomass of 34 tons ha^{-1} in 1.7 ha area sampled in home garden, Areca and paddy boundary of Sirsimakki village ecosystem. Multi-purpose local tree species such as *Mangifera indica*, *Artocarpus heterophyllus*, and *Citrus* dominated the ecosystem. The diversity index in the homestead garden (4.9) was high followed by Areca garden boundary (4.5). Index of similarity (IS) values ranged from 4% to 65% indicating that tree species found in different land use categories were different. There was greater similarity between betta lands and minor forests and highly dissimilar were tank bund and reserve forest. Data on tree population dynamics reveals that 5.8% of trees have been felled and died naturally over the nine years period. On the other hand, farmers have planted 317 plants, of which 151 were horticultural tree crops such as Areca, Coconut and Banana and have felled species such as *Terminalia* and *Careya arborea*. Several implications of this homestead forestry are discussed and forestry interventions that aim to improve small holders farming systems and livelihoods are suggested.

Introduction

Agroforestry is one of the major land use systems in the tropics of South and Southeast Asia (Fernandes and Nair, 1986). It is characterized by an intensive integration of forest trees, horticultural crops and shrubs with a basic objective to ensure sustained availability of multiple products as direct benefits such as food, vegetables, fruits, fodder, fuel, foliage, agricultural implements and medicine. Other indirect benefits such as ornamentals, shading, and shelter-belts or windbreaks are also derived (Michon *et. al.*, 1983). It has also been stated that the tree components along with field crops lead to efficient use of sunlight, moisture and nutrients in agroforestry systems than in monocropping of either agricultural or forestry crops (Fernandes and Nair, 1986). One of the biological reasons of interest in agroforestry systems is that the trees use portions of biosphere that annual crops generally do not, resulting in increased aggregate biomass from a given land. This kind of practice is more popular in Kerala, India (Nair and Sreedharan 1986), where home gardens are built around coconut orchards. Such home gardens agroforestry systems are also prevail in humid tropics of Karnataka, Western Ghats. However, there are no specific studies available to detailing the status of such systems in Karnataka, though a study on the use of tree biomass is available in semi-arid zone of (Ravindranth *et. al.*, 1981; 1991).

In the recent years, people meeting their various biomass needs such as fruit, vegetables, fodder, fuelwood, leaf manure and agricultural implements from the trees in cultivated lands. Such large-scale dependency is leading to erosion of tree diversity on the farms. It is generally known that trees growing in humid environments have favorable conditions for regeneration after large-scale pruning or cutting compared to those in dry areas. This study aims to understand tree species diversity, species similarity, and to estimate-standing biomass of species in different land use categories. Further, this study monitors change in tree population over nine years in 34 home gardens and usage pattern of agroforestry systems in a humid tropic village ecosystem in Uttara Kannada district in Western Ghats, south India

2. Methodology

2.1 Location of the study area

Sirsimakki village in Uttara Kannada district in southern Western Ghats is located at 14° 35' N, 74° 48' E at an elevation of ranging between 545 to 615m. The soils are lateritic and reddish brown in colour with pH ranging from 4.5 to 5.5. Sirsimaki receives an mean annual rainfall of 2626 mm. The entire Sirsimakki village ecosystem encompasses an area of 386.5 ha. The whole terrain is gently undulating with 26 hill peaks. The details regarding land use patterns are given in Table 1. Among the 88 households of the village 14 are landless, 9 own only paddy land, 47 own only garden lands and 18 family own both paddy and garden lands. For those owning paddy lands, the median landholdings is 0.5 ha, the median garden land for garden land owners is also 0.5 ha. The largest single holding is by one family with 3 ha of paddy and 3 ha of garden land. Of the 74 landholding families 66 maintain livestock, the minimum being 1, median 5 and maximum 31. There are no goats, sheep or pigs in the catchment; however two farmers have taken up rabbit-keeping. The number of livestock is roughly one per ha of the total land holdings, including crop, garden and soppina betta lands.

2.2 Description of Sirsimakki village ecosystem

The Sirsimakki village ecosystem was defined as the boundary marked by the revenue department of the state government (Gadgil 1987). The boundary is mainly drawn on the basis of the land owned, cultivation, non-crop lands, settlements, streams, water bodies, roads, hills, soppina betta, bena and community lands. This village ecosystem having 28 ha of minor forest with the dominant tree species such as *Randia spinosa, Eugenia jambos* and *Diospyros melanoxylon*. The annual harvest from the minor forest, for fuelwood (51%), small timber (37%) and green leaves for manure (12%) is at the rate of 4.2 tones/ha, more than eight times the levels of production (Gadgil, 1987). This village ecosystem comprising of 289.7 ha of Soppina betta lands owned by forest department but assigned to 65 garden owners, with an average ratio of 6.3:1of soppina betta to garden land. These betta lands are better stocked than the minor forest lands of the area. Croplands situated along the hill sides totaling 15.17 ha. The areca gardens of this catchment covering an extent of 46.03 ha occur in three large and one small patch in the bottom of the valleys, generally below an irrigation tank or by a protective belt of jack fruit, mango, coconut trees. The gardens are multistoried and highly productive.

2.3 Vegetation assessment

The sample plots were randomly laid in a each ecosystem such as home gardens, paddy and Areca boundaries, stream boundary and tank bunds, betta lands, minor forests and adjacent reserve forests and the details of area sampled are given in table 1. Information regarding species name, girth (DBH), total tree height, species character (exotic or native, evergreen or deciduous) were collected in the five location sampled in 1991, where trees greater than 1.30 m in height and girth having 10 and above 10 cm individuals at breast height were recorded. We compared the tree species of agroforestry land uses (homestead garden, area and paddy boundary) with tree species of other landscapes such as stream boundary and tank bunds, betta lands, minor forests and adjacent reserve forests. Shannon-weiner's Species diversity index, Simpson's dominance index and Sorenson's similarity index were calculated following Krebs (1985). End use and domestication patterns of several species that are grown in their home gardens were collected through interviews.

2.4 Change in tree population and end use

We recorded the number of individuals of all the species in 34 sample household gardens in January 1991and again after nine years in October 2000. In the recent survey we interviewed sample households to record reasons for promotion of a particular species, causes for felling/removal tree species, constraints in managing home gardens, direct and indirect use and benefit of the tree population, source of planting material, mother tree selection, location of planting, cultural operations and indigenous silvicultural practices followed in managing the garden.

2.5 Standing Biomass estimation:

Stem diameter and tree height account for larger proportion of variability in woody biomass of trees (Avery and Burkhart 1983). We considered basal area and height for estimating biomass using equations developed by Murali *et al.*, (2000).

3. Results

3.1 Tree resources in home garden

There were 673 individuals belongings to 68 tree species in 34 home gardens of over a sampling area of 1.28 ha. The list of species, their density and occurrence in different village ecosystem are given in Appendix. Among the species present in the home garden the predominant forest species are *Mangifera indica, Artocarpus heterophyllus* and *Erythrina indica*. The tree density was 525 trees per hectare, and species diversity is 4.89 (Table 5).

3.2 Tree resources in Areca garden boundary

There were 239 individuals belonging to 45 species sampled over 0.325 ha area. The dominant tree species are *Vateria indica, Casurina equisitifolia, Artocarpus heterophyllus* and *Mangifera indica*. Areca orchard boundary comprising 735 trees per hectare and a species diversity index of 4.41, which are slightly lower than the home garden (Table 5).

3.3 Tree resources in paddy boundary

There were 40 individuals belonging to 15 species in the sampled area of 0.107 ha. The dominant tree species are *Cocos nucifera* and *Cassia siamea,* with a density of 373 trees per hectare. There were very less trees compare to other location in the village ecosystem. The density in paddy boundary was less than Areca and home gardens.

3.4 Tree resources in village ecosystem

There were 948 individuals belonging to 93 species in sampled area of 1.7 ha of sirsimakki agro-ecosystem. Further, additional 44 species, which have not been recorded in the agroforestry area, were encountered on non-agricultural lands in village ecosystems such as betta lands, minor forests, reserve forests, indicate the overall diversity of trees in the village ecosystem.

Out of these species present in the agroforestry ecosystem, the predominant 10 species account for 55.1% of the total tree population. Among the top ten species five species are local and five are exotic. Among the 93 species encountered in the agroforestry village ecosystem, local fruit yielding species like *Mangiferea indica* topped the list followed by *Artocorpus heterophyllus* (Table 2). The standing biomass was 0.16 tons per capita and 34.59 tons ha^{-1} of ecosystem land. Local multipurpose tree species like *Mangifera indica, Artocarpus heterophyllus* and *Caryea arborea* dominated the standing biomass (Table 2).

Total number of species and individuals (per hectare) in different locations were given in the Table 3. More number of evergreen species compositions was noticed in tank bund, stream and Areca garden boundary. The nearby reserve forests are having higher proportion of deciduous than evergreen species. Except in paddy boundary all the other plots have significantly higher proportion of native species (Table 3). In terms of tree density Areca boundary had highest than the paddy boundary and homestead garden sampled (Table 4)

The value of Shannon index of diversity was highest in homestead garden and lowest in tank bund in the village ecosystem (Table 5). The dominance value was highest in stream canal and lowest in case of homestead compound. Sorensen's index of similarity (ISs) values ranged from 4 to 65 among different location studies (Table 6). The ISs values of home compound, paddy and Areca boundary were lower than forest, betta and minor forest indicating less similarity in species composition between them.

3.5 Change in tree population

Data on felled or naturally dead in and replanting in nine years in home gardens are given in Table 7. It reveals that nearly 5.8% of trees have been felled for various purposes and dead trees in the last nine years. Results indicate that most of the trees found dead were exotic and commercial species such as *Musa paradisica, Cocos nucifera* and felled trees were native trees such as *Careya arborea, Aporosa lindleyana* and, *Terminalia* spp and others. Over the years farmers planted 317 plants of which 151 belong to cultivated species. *Citharexylum subserratum* is the new species encountered in recent years not noticed in the earlier survey. Farmers have removed *Terminalia* spp. and *Careya arborea* and planted horticultural cash crops such as coconut, areca and banana.

3. 6 Distribution of trees according to end uses

Data related to distribution of tree population according to end uses in Sirsimakki village ecosystem are given in the Table 8. It shows that fruit and vegetable trees such as *M indica*, *Citrus* spp., *Musa* spp., etc., are in significantly higher proportion comprising of 29.72% followed by income generating crop species such as like *Areca*, *Coconut* and *Anacardium* comprising 18.06%. Farmers maintained 8.19% of individuals belonging to fuel wood and foliage species such as *Careya arborea*, *Aporosa lindleyana* and *Terminalia* spp. In general local community is more dependent on local species for various purposes than exotics.

4. Discussion

4.1 Vegetation assessment in different agro-ecosystem

There were 93 tree species in homestead gardens, paddy and areca garden boundary (agroforestry), another 44 species, which have not been recorded in the agroforestry area, that were recorded along non-agricultural lands such as betta lands, minor and reserve forests in village ecosystems indicate the overall diversity of plants in entire village ecosystems. This village ecosystem is dominated with multiple use species such as *Mangifera indica* and *Artocarpus heterophyllus*, indicating farmers' selectivity for retaining those trees that are known for their valuable fruits, fodder and manure etc. These home gardens supported higher species diversity than Ungara village ecosystem in semi arid region of Karnataka (Ravindranath *et al.*, 1991). This reveals that humid environment are favorable for tree regeneration and establishment than dry areas. In the Maya region (southern Mexico and Central America), agroforestry gardens posses as many as 60–80 tree species in individual gardens and as many as 200 species in a village ecosystem (Gomez-Pompa, 1996). These village ecosystems consist of more than 25,000 hectares. In another study, the home garden of Xuilub in the state of Yucatan, Mexico, 339 species of flowering plants were recorded in 52 gardens with an average garden size of 19.76 ha (Herrera *et al.*, 1993). A total of 168 species were encounter in 21 home gardens at Santo Rosa, Amazonia; the high number could be for inclusion of herbaceous plants in the sample (Smith, 1996). On an average the gardens in Srilanka recorded nearly 250 individual woody perennials of 29 species (Everett, 1991). Considering the above home gardens, Sirsimakki village ecosystem recorded 93 tree species in 1.7 hectares of cultivated lands in the entire micro-catchment area.

Further, it can be noted that in Sirsimakki the average area of home garden area is 376 m^2 and the number of tree species vary between 20-40 in a given home garden indicating that these home gardens are highly diverse compared to Mexico and Brazil.

Tree diversity index in the home garden (4.89) is high followed by Areca boundary (4.41). These values were similar to those recorded in tropical rainforest (Knight.1975; Singh et. al., 1981; Chandrashekara and Ramakrishnan 1994). The lower values dominance index and higher values of diversity index for home gardens indicate that home gardens are of mixed type. Similar kind of traditional home garden systems were well documented in Kerala, India (Kumar *et al,* 1994) and in many other tropical regions, including the islands of Java, Sumatra, Borneo (Michon *et al,* 1983), Malaysia (Whitmore 1984) and Brazilian Amazon (Smith, 1996).

Sorenson's index clearly indicates that species found in the homestead agroforestry system are similar than the species found outside the revenue lands. Farmers have selectively promoted some of the species that they find useful. The higher proportion (81%) of evergreen species such as *Vateria indica, Mangifera indica* and *Artocarpus hirsutus* and *Cocos nucifera* along the Areca garden boundary are essential to protect areca palms from scorching sunlight, as wind breaks, shelter belts, as natural fence (protection) and to improve soil fertility (Huxley 1985). There is no set rules for spacing at the time of planting, but in the first few years of homegarden establishment, attempts were made to ensure wide gaps between the plants. But the farmers eferred to retain only 47% evergreen species along paddy border. This is primarily because trees may not withstand water logging, and the presence of trees may reduce yield of paddy due to shading. Thus the farmers are aware of the ecological significance and ecological value of species that need to be planted and retained at different locations.

4.2 Change in tree population

Our study reveals that over the years, farmers have significantly promoted plantation crops (46%) such as Areca, coconut, banana with commercial interest. Similarly, fast growing exotic species (27%) such as *Acacia auriculiformis, Cithrexylum* sp., *Anacordium occidentalis* are being promoted for fuel wood and poles. The fruit yielding species comprising of (about 26%) fast growing species like *Carica papaya, Cilicia* sp. *and Moringa* sp., also is being promoted. However, people equally promoted the local fruit yielding species mango and jack- fruit. Our survey indicated that many are not willing to put their quality land under forest trees, instead they prefer to plant fruit trees on marginal and sub marginal lands, to get better economic returns from horticultural crops.

In most cases, harvested trees are exotics like *Casuarina* and *Acacia,* and in some cases they have replaced these fast growing species with coppicing species such as *Citharexylum subserratum*. In a few cases replanting was done with a perception of either faster growth (e.g., *Acacia)* or higher economic return from agricultural plantation crops like areca, coconut and banana Local species (over size or oldage and overgrown) are removed thinking that they may affect the residential building due to rain or wind.

4.3 Distribution of trees according to end uses

Farmers have a good knowledge of growth rates and useful products of many tree species, and were able to learn about exotic also. All farmers identified species that serves as shade, windbreak, fence, and its importance to maintain of soil fertility. Thus people are aware of the interrelated benefits of balanced mix of species for homesteads. People of this region opt less for planting fuel valued species and they are less depended on garden trees for the firewood purpose. Most of the people in the studies village using fuel efficient ASTRA stoves or biogas for cooking except marginal farmers (Ravindranath and Hall, 1995) indicates that people opt fruit yielding tree species for family consumption than timber or firewood species. Even in Bangladesh, people promote higher 40% proportion of fruit yielding trees for family consumption and are not dependent on home gardens for firewood (Hocking *et al*, 1998).

It may be concluded that although, this study analyses the tree diversity, population change and end uses of the tree in different location of the Sirsimakki microcatchment area, many questions in agroforestry systems, have to be answered for a deeper understanding of the suitability of these species in different location of the village ecosystem. Some of these aspects to be studied include influence of forest trees on horticultural crops, lopping methods, contribution of these trees for nutrient cycling and determination of tree crop/field crop combination.

Implications

Some of the implications of the present study for conservation of tree resources and revegetation strategies are as follows. Attempts to increase tree resources on private land are taking place at two levels at the same time parallelly but in isolation to each other. Individual farmers grow tree on their land according to their own needs and requirements, whereas government officials and project planners in the forestry sectors, representatives of non-government organizations and donor agencies, are designing afforestation activities with only very little understanding of the transformation of the rural economy, changing livelihood strategies and evolving farmers perspectives (Malla, 2000).

(1) Large diversity that existed in the past even in the home gardens is decreasing. This is primarily because of fragmentation of land holdings and increased importance given to cash crops such as Areca. Therefore there is a need to develop Village Farm Forestry Programmes (VFFP), which has given positive results in Bangladesh (Hocking *et al*, 1998). Though farm forestry was promoted in the late 1970s in India to produce fuelwood for rural consumption, the programme was immensely successful in the green revolution regions, but farmers produced wood for market purpose. This defeated the purpose of meeting diverse basic biomass needs of the local community (Sexena 1992).

(2) There is enough opportunity to encourage traditional home gardens under JFM programme aimed at growing fuel and fodder for the local community in government lands. Apart from planting very few fast growing exotic species (e.g. *Acacia auriculiformis* 80%), the programme need to strengthen the approach of traditional agroforestry practices of tree growing along with horticultural tree crops.

(3) There is a need to strengthen and validate the traditional agro forestry approaches as our study indicates that they provide insights for reforesting the government controlled degraded areas, specially to maintain the biological diversity and for watershed protection. Efforts are needed to elicit farmers' indigenous knowledge of agroforestry, silviculture of fruit trees and the nutrient cycling to increase the

understanding of the function of traditional homestead agroforestry systems to achieve higher production without environmental degradation.

(4) There is a need to develop scientifically valid agroforestry model integrating agriculture and forestry options, involving Forest and Agriculture departments. It is also necessary to develop packages for farmers with varied holdings and with different resource capabilities.

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Table 1: Details of the Land use categories and sampled area in Sirsimakki village ecosystem of Uttara Kannada District.

Location	Total area (ha)	Sampled area (ha)	Size of sample
Home compound	2.960 (88 households)	1.280 (34 households)	Entire area of sampled homestead garden
Areca boundary	0.636	0.325	1645 X 2 m transect
Paddy boundary	0.975	0.107	535 X 2 m transect
Stream boundary	1.611	0.432	1645 X 2 m transect
Minor forest	25.00	1.000	100 X 100 m quadrate
Betta lands surrounds hillock	289.74	1.000	100 X 100 m quadrate

Table 2. Tree population in Sirsimakki village ecosystem of Uttara Kannada District

Sl. No	Species	Total	%	Standing biomass	%
1	*Mangifera indica*	100	14.7	18.44	31.13
2	*Artocorpus heterophylus*	74	10.9	6.74	11.36
3	*Casurina equisitifolia*	42	6.2	0.61	1.03
4	*Citrus spp.*	36	5.2	1.10	1.86
5	*Erythrina indica*	25	3.6	0.24	0.41
6	*Vateria indica*	25	3.6	1.35	2.29
7	*Terminalia tomentosa*	20	2.9	1.55	2.62
8	*Anacordium occidentale*	16	2.3	0.07	0.13
9	*Laucaena leucocephala*	16	2.3	0.01	0.03
10	*Carya arborea*	14	2.0	1.85	3.12
11	Others *	313	45.9	27.22	45.95
	Total	681	100	59.2285	100
	Coconut plants	127			
	Banana plants	99			
	Areca plants	45			

* Others include 82 species in homestead gardens and, areca and paddy boundary.

Table 3. Composition of evergreen and deciduous, and native and exotic tree species and percentage (in parenthesis) of individuals in different location of Agroforestry and other land use systems in Sirsimakki village ecosystem area of Uttara Kannada District.

Agroforetry & other land use system.	Number of Species		Number of Species	
	Evergreen	Deciduous	Native	Exotic
Home garden	26 (67)	43 (33)	36 (64.5)	34 (35.5)
Areca boundary	24(81.1)	21 (18.9)	36 (58.9)	9 (41.1)
Paddy boundary	07 (47.5)	8 (52.5)	8 (30)	7 (70)
Tank bund	16 (84.6)	5 (15.4)	20 (98)	1 (2)
Stream canal	35 (62.8)	30 (37.2)	40 (71.8)	15 (28.2)
Betta land	8 (26.6)	15 (73.4)	23 (100)	--
Minor forest	11 (34.8)	15 (65.2)	26 (100)	--
Reserve forest	4 (5)	23 (95)	27 (100)	--

Table 4. Estimated tree density/ha in different location of Agroforestry system in Sirsimakki village ecosystem of Uttara Kannada District.

Location	% of trees	Tree density per ha
Home garden	70.69	525
Paddy boundary	4.20	373
Areca boundary	25.1	735
Total	100	--

Table 5: Characteristics of the Vegetation in different land uses in Sirsimakki village ecosystem of Uttara Kannada District

Location	Total no. of individuals	Total no. of species	Simpson (C) (Dominance)	Shannon (H) (Diversity)
Home garden	673	68	0.0736	4.893
Paddy boundary	40	15	0.1285	3.390
Areca boundary	239	45	0.0776	4.411
Total	942	93		

Table 6. Sorenson's index (ISs) of percentage similarity in Agroforestry & other land use system in Sirsimakki village ecosystem of Uttara Kannada District.

	Paddy	Areca	Stream	Home	Tank	Betta	Minor Forest
Areca	23.3						
Stream	32.5	53.3					
Home	26.1	38.5	45.7				
Tank	5.5	42.4	37.2	24.9			
Betta	26.3	15.7	23.7	15.2	27.2		
Minor forest	19.5	14.0	28.5	10.5	17.2	65.3	
Reserve forest	14.2	22.2	17.3	10.4	4.1	16.0	11.3

Table 7. Change in number of tree population over the Nine years in 34 Home garden of Sirsimakki village ecosystem of Uttara Kannada District.

Species	1991	2000	Planted after 1991	Reasons for change	
				Died	Felled
Acacia auriculiformis	2	25	25		1
Achras sapota	7	17	10		
Alstonia scholaris	2	2			
Anacordim occidentalis	8	16	8		
Annona squamosa	4	4			
Aporosa lindleyana	10	4			3
Areca cathecu	63	124	61		
Artocorpus heterophyllus.	39	50	15	2	1
Azadiracta indica	2	2			
Caesalpinia pulcharima	4	8	5		
Calliandra sp	7	2			1
Carica papaya	8	18	12	2	
Carya arborea	10	3			4
Caryota urens	5	8	3		
Casuarina equisetifolia	1	3	2		
Chukrassia sp.	1	1			
Cilicia sp.	3	13	10		
Cinnamonum zylanicum	3	2			
Citharexylum subserratum		19	19		
Citrus spp.	45	46	3	2	
Cocos nucifera	223	257	30	4	
Emblica officinalis	1	2	1		
Ficus spp.	10	10			
Gossipium sp.	5	2			1
Holigarna arnotiana	1				1
Lagerstroemia microcarpa	6	6	2		1
Leucaena leucocephala	9	9	8	2	3
Mangifera indica	77	93	13	3	1
Michelia champaka		3	3		
Moringa pterygosperma	6	8	2		
Murraya paniculata	3	3			
Musa paradisica	84	149	60	5	
Ochlandra sp	3	3			
Oxytenanthera stockzii	7	15	9		
Persia macrantha	3	6	3		
Plumaria alba	11	12	1		
Psidium guajava	5	8	4		1
Pterocorpus marsupium	3	3			
Santalum album	4	6	2		
Sapindus laurifolius	10	10			
Syzygium cumini	5	5			
Tamarindus indicus	2	2			
Tectona grandis	3	8	5		
Terminalia spp	28	20		1	4
Thevetia nerifolia	9	9	1	1	
Zanthoxylum rhetsa	3	2			1
Total	745	1018	317	22	22

Table 8. Distribution of tree population according to end uses in Sirsimakki agroforestry village ecosystem of Uttara Kannada District.

Sl. No	End uses	Examples	Tree population (existing)	% individuals
1	Fruits + vegetable + wind break	*Musa paradisiaca* *Citrus spp.* *Mangifera indica* *Moringa pterygosperma* *Psidium guajava* *Cilicia sp.*	283	29.72
2	Income + consumption	*Areca cathecu* *Cocos nucifera* *Sapindus laurifolia* *Anacardium occidentale*	201	18.06
3	Foliage + Shade + Windbreak	*Careya arborea* *Terminalia spp.* *Aporosa lindleyana* *Vateria indica*	78	8.19
4	Timber + Fruit	*Artocarpus heterophyllus* *Tectona grandis*	76	7.77
5	Fencing	*Glyricidia maculata* *Citharexylun subserratum*	61	6.40
6	Fuel + pole	*Casuarina equisetifolia* *Acacia auriculiformis* *Cassia siamea*	58	6.09
7	Fodder	*Erythrina indica* *Leucaena Leucacephala*	41	4.30
8	Worshiping god (Flower + fruit)	*Thevetia nereifolia* *Plumeria alba* *Nerium oleander* *Caesalpinia pulcherrima*	29	3.04
9	Key stone species	*Ficus spp.*	16	1.68
	Others	-	136	6.40
	Total	-	952	100

Appendix: List of tree species and number of individuals in Agroforestry and other land use systems of Sirsimakki village ecosystem of Uttara Kannada District, Western Ghats, Karnataka.

Species	Paddy Boundary	Areca Boundary	Stream bund	Home Garden	Tank bund	Betta	M.F.	R. F.
Acacia auriculiformis	2	6	1	1				
Acacia torta							8	
Achras sapota				10				
Acrocarpus fraxinifolius				1				
Adina cordifolia								12
Albizia chinensis			8					
Albizia odoratissima				1				
Alseodaphne semecarpifolia			1				4	
Alstonia scholaris			1					2
Anacardium occidentale	1		6	15				
Annona squamosa				6				
Aporosa lindleyana		1	11	8	3	67	7	
Areca cathecu	2		5	43				
Artocarpus heterophyllus		28	41	49				
Artocarpus hirsutus					1			
Azadiratcha indica				1				
Bambusa arundinacea		1	4					
Bassia latiolia						12	4	
Bauhinia verigata				1				
Bridelia scandens			2		6	9	2	
Buchanania lanzan						79		1
Butea monosperma			1					
Caesalpinia pulcherrima				3				
Calliandra callothyrusus				3				
Carallia brachiata			1	1				
Careya arborea	3		3	11		56	2	2
Carica papaya				8				
Caryota urens		5	19	6	3			
Cassia fistula			1					12
Cassia siamea	7							
Casuarina equisetifolia		42		1				
Ceiba pentandra				1				
Celtis philippensis		3	2	1				
Cinnamomum sulphuratum			5				1	
Cinnamomum malabatrum		4	5	3	1			
Citrus aurantium				2				
Citrus limon				4				
Citrus limonum			1	10				
Citrus medica				4				
Citrus sp.	1	4	5	31				
Cocos nucifera	10	20	18	97				
Dalbergia latifolia								3
Dalbergia paniculata		3	1				6	
Dendrocalamus sp.				1				
Dendrocalamus strictus				1				
Dillinia pentagyna								1

Diospyros candolleana		1						6
Diospyros melanoxylon						5	11	
Eagle marmelos				3				
Emblica officinalis	1					8	2	1
Erhetia sp.		1					1	
Ervatamia heyneana		2						
Erythrina indica		4	37	21				
Eugenia codyensis			4		8	3	3	
Ficus asperima		4	3	2				11
Ficus bengalensis						3	1	
Ficus callosa			1					
Ficus exasperata			14					
Ficus racemosa	2	1	17	2				
Ficus religiosa				2				
Ficus tsjahela		1	2	2	1			
Flacourtia montana			1				10	
Garcinia gummi-gutta					1			
Garcinia morella			3					
Glyricidia maculata		2	43					
Gossypium sp.				1				
Grewia tiliifolia		1	2					11
Heterophragma dalzelii						1		
Hibiscus sp.			1	2				
Holigarna arnotiana		7	49		4	1	2	
Holoptelia integrifolia		1	3	2				
Hopea wightiana			2					
Hydnocarpus sp			8		1			
Ixora brachiata						13	7	
Knema attenuata		1						
Kydia calycina								1
Lagerstroemia sp.				2				
Lannea coromandelica	1	4	7					
Lawsonia alba				1				
Leea sp.			2				3	
Lagerstroemia microcarpa		1						13
Leucaena leucocephala	5		1	11				
Linociera malabaricum	1	10	7					
Lophopetalum wightianum		1			9			
Macaranga peltata		4	13		1			1
Mallotus philippensis		1						
Mangifera indica	2	21	67	76	8	1		
Manihot esculenta				2				
Memecylon sp.							6	
Mesua nagassarium		1						
Mimusops elengi			5			1		
Moringa pterygosperma				11				
Murraya paniculata				1				3
Musa paradisica				99				
Musa sp. (*wild*)			10					
Myristica dactyloides				3				
Nerium oleander				4				
Nothopegia beddomei			1					

Olea dioica		1	1			1	1	
Oxytenanthera stocii		3	2	10	5			
Pandanus sp.			12		1			
Persea macrantha		2	14	1	4			
Pithecellobium gracile			3					
Platanthera dilatata						1		
Plumaria alba				12				
Pongamia glabra		3	1					
Psidium guajava		6	2	6	1			
Pterocarpus marsupium				3		2	4	
Randia rugulosa							39	
Samanea samana				1				
Santalum album				5				
Sapindus laurifolia		3	2	10	1			
Schlaichera oleosa								1
Semicarpus anacardium						2		
Sesbania grandiflora				4				
Spondias mangifera		1		1				1
Sterculia guttata			1					4
Sterculia sp.		1						
Stereospermum personatum		1						1
Strychnos nux-vomica								2
Syzygium hemisphericum		2	6	2	2	16		
Syzygium jambosa		3	3	1				
Syzygium sp.			1					
Tectona grandis				2				
Terminalia alata								1
Terminalia arjuna		1						1
Terminalia bellirica								9
Terminalia chebula						7	5	
Terminalia indicus				1				
Terminalia paniculata	1		2	8		35	5	66
Terminalia tomentosa	1		4	19		36	4	
Theobroma cacao			1					
Thevetia peruviana			1	10				
Toona ciliata				4				
Trema orientalis		1	12					
Vateria indica		25			3			
Vitex altissima				1	1			
Vitex negundo			1					
Xeromphis spinosa								19
Ixora polyantha								1
Xeromphis uliginosa						1	13	
Xylia xylocarpa								9
Zanthoxylun rhetsa				1				
Ziziphus oenoplia							1	
Total individuals	40	239	514	673	65	360	152	195
Total number of species	15	45	65	68	21	23	26	27