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Documentation and valuation of tree species used in traditional agroforestry systems by nyishi tribe of arunachal pradesh, eastern himalaya.

G. Pangging[1], S. J. Sangma[2], C.L. Sharma[3], and M. Sharma[4]

[1,2,3,4] *Department of Forestry North Eastern Regional Institute of Science and Technology (Deemed University)Nirjuli-791109, Arunachal Pradesh, India*

Abstract: Agroforestry is considered as a potential landuse system in the Eastern Himalaya for the protection of environment, food security, conservation of biological diversity, etc. The present study emphasised on both documentation and valuation of tree species used in agroforestry systems by the Nyishi tribe of Arunachal Pradesh. A total of 45 tree species representing 26 families were recorded. Arecaceae and Leguminosae were the dominant families. About 88.89% species of the tree species were used as fuelwood, followed by food (66.67%), field use (46.67%), tool (37.78%), construction (31.11%) and other uses (80%). Mangifera indica was found maximum Cultural Importance index value (3.27), Cultural value index (2.447) and Relative value index with relatively higher frequency of citation (FC=94) and use reports (NU=7). Terminalia chebula ranked 1st in Relative Frequency of citation value with highest number of citations (FC=102). However, male had significantly higher knowledge than female in certain use categories like medicine, field use, fodder and tools, which show that male, were more knowledgeable than females in the traditional agroforestry systems.
Keywords: Agroforestry, Himalaya, Nyishi, Trees, CI.

I. INTRODUCTION

Agroforestry is considered as one of the important sustainable land-use systems in which annual crop (food crops), perennial crop (trees) and/or livestock are combined together in a same piece of land either at the same time or alternately [1]. This landuse system has been traditionally practised by the indigenous communities for many generations through their unique traditional knowledge system (TKS). The tree component in the landuse system are important component as it provides both ecological goods [2] and services [3, 4, 5] such as conservation of biodiversity, carbon sequestration, nutrient cycling, soil and water conservation, recreation, etc. Moreover, this landuse system has the potential to meet most of the global emerging challenges viz., deforestation, land degradation, unsustainable farming practices, loss of biodiversity, nutrient loss, soil erosion, etc.

At the national level, planting of trees outside the conventional forest area has been given highest priority both at the national forest policy 1952 and 1988. The planting of trees in farmland is one of the initiatives, and has the potential to meet one of major goal of forest policy i.e., to meet 33.33% of geographical area under the forest and tree cover. The valuation and prioritisation of trees or woody species is one of the priority areas and it was done by using cultural important indices, composite salience [6] that have been reported in Bolivian Andes and sub-Sahel of Burkina [7].

Arunachal Pradesh is a "Biodiversity hotspot" area is well known for its traditional agroforestry system. It has been practised from many generations. The common agroforestry systems reported are agri-silvicultural system, agri-horticultural system, agro-silvi-horticultural system and aqua forestry [8]. Since, no study on the valuation and prioritisation of tree species in agroforestry systems has been reported from Arunachal Pradesh therefore the present study is taken up with aims (a) to document tree species used in the traditional agroforestry system by the *Nyishi* tribe of Arunachal Pradesh and (b) to value and prioritise the agroforestry trees based on ethnobotanical indices and (c) to compare the plant knowledge based on gender.

II. MATERIAL AND METHODS

The study was conducted in six fringe villages of Doimukh forest range viz., Rono, Midpu-II, Nonpu, Emchi, Midpu-I and Amba villages. The total numbers of informants surveyed were 112 consisting of 58 males and 54 females. In the survey, collection of information was done by semi-structured questionnaire through random sampling.

The use category of tree species was categorised into eight categories such as Food (FO), Fodder (FD), Fuel wood (FL), Medicine (MED), Tools (T), Field use (FU), Construction (C) and Other uses (O) [6]. The food category includes edible products obtained from plants, whereas tools category (agriculture implements, broom making, etc.); field use category (bio-fence, shade tree, soil and water conservation); construction (construction material obtained from plants such as timber); and other uses (ornamental plants, value added products, rituals, furniture, etc.).

Various basic values are like frequency of citation (FC), use report (UR) [9], and number of uses (NU) were used. Whereas the ethnobotanical indices like Relative Frequency of Citation (RFC), Relative importance index (RI) [10], Cultural Value Index (CV) [11], Cultural importance index (CI) [12] were evaluated for valuation and prioritisation of tree species.

III.   RESULT AND DISCUSSION

In the present study, forty five (45) tree species belonging to 26 families were used in the traditional agroforestry system. The number of tree species used in the present study was higher than 33 woody agroforestry species reported from rural area of Bolivia [6] and however, it was lower than 90 woody species belonging to 32 families from sub-Sahel of Burkina Faso [7].

The tree species belongs to 26 families and the dominant family were Arecaceae and leguminosae that consists of 5 species each, followed by Lythraceae (4), Moraceae (3), Anacardiaceae (2), Annonaceae (2), Lamiaceae (2), Lauraceae (2), Myrtaceae (2), Phyllanthaceae (2) and rest of families with one species each viz., Apocynaceae, Calophyllaceae, Combretaceae, Dilleniaceae, Elaeocarpaceae, Euphorbiaceace, Malvaceae, Magoliaceae, Meliaceae, Moringaceae, Oxalidaceae, Rhamnaceae, Rosaceae, Rubiaceae, Sapindaceae, and Sapotaceae (Fig. 1).
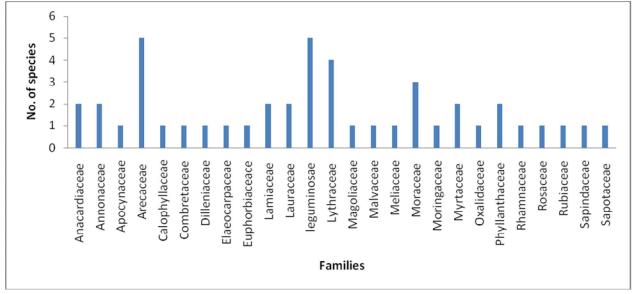

Fig. 1: The number of tree species and their family.

The following are the detail information on agroforestry tree species with their scientific names, family, parts used and uses (Table 1).

Table 1. The uses of tree in agroforestry systems.

Sl. No.	Scientific name	Family	Plant part	Uses
1	Alstonia scholaris L.	Apocynaceae	B, S, L	Fuel wood; agricultural tools; and medicinal value (latex is used to treat wounds of domesticated animals).
2	Anacardium occidentale L.	Anacardiaceae	S, B	Fuel wood and edible fruits.
3	Annona reticulata L.	Annonaceae	F, B	Fuel wood and edible food.
4	Anthocephalus cadamba (Roxb.) Miq.	Rubiaceae	S, B	Constructions material; furniture making; agriculture tools; and fuel wood.

5	Areca catechu L.	Arecaceae	F,S,Le	Edible fruit; construction of house; fuel wood and fodder.
6	Artocarpus heterophyllus Lam.	Moraceae	F, Le, Se, S	Edible fruit; fodder; vegetable; timber, furniture making; fuelwood and shade tree.
7	Averrhoa carambola L.	Oxalidaceae	F, B	Edible fruit; fuel wood; Medicinal value (fruit used to cure Jaundice).
8	Baccaurea ramiflora lour.	Phyllanthaceae	F, B.	Fuel wood and edible food.
9	Bauhinia variegata L.	Leguminosae	L, B, S	Fodder; vegetable (leaves); agriculture tools; shade tree and ornamental tree.
10	Bombax ceiba L.	Malvaceae	S, F	Flosses; fuelwood, and agricultural tools.
11	Caryota urens L.	Arecaceae	F, Se	Edible seed and ornamental tree.
12	Cassia fistula L.	Legumninosae	P, B	Edible pod; fuelwood; agricultural tools and ornamental tree.
13	Cinnamomum tamal (Buch.-Ham)	Lauraceae	L, B	Spices (leaves); fuel wood and construction of house.
14	Cocos nucifera L.	Arecaceae	F, Le	Edible fruit; broom; ornamental tree; medicinal value (Fruit).
15	Delonix regia (Hook.) Raf.	Leguminosae	S	Fuelwood, furniture making; agriculture tools and ornamental tree.
16	Dillenia indica L.	Dilleniaceae	F	Edible fruit; vegetable (fruit); and medicinal value (to treat stomach ache).
17	Duabanga grandiflora (D.C.) walp.	Lythraceae	S, B	Fuelwood; furniture making and construction of house.
18	Elaeocarpus floribundus Blume	Elaeocarpaceae	F	Edible fruit; fuelwood; agricultural tools; and pickle (fruit).
19	Erythrina stricta Roxb.	Leguminosae	S, B, Ba	Fuelwood; fodder; medicinal value (latex is used to prevent exceesive bleeding); bio-fence and ornamental tree.
20	Ficus sp.	Moraceae	W	Sacred tree; shade tree; ornamental tree; soil & water conservation and fuelwood.
21	Gmelina arborea Roxb. Ex	Lamiaceae	S, B.	Fuelwood; agricultural tools and furniture making.
22	Lagerstroemia speciosa (L.) pers.	Lythraceae	Fw, B	Fuel wood and ornamental tree.
23	Litchi chinensis sonn.	Sapindaceae	F	Edible fruit; fuelwood; ornamental tree and shade tree.
24	Litsea monopetala (Roxb.) Pers.	Lauraceae	B	Fuel wood.
25	Livistona jenkinsiana Griff.	Arecaceae	L, S, Se	Roofing material; handicraft items; ornamental tree and edible seed.
26	Mallotus tetracoccus (Roxb.) Kurz	Euphorbiaceae	S, B	Fuel wood and agricultural tools.
27	Mangifera indica L.	Anacardiaceae	F, B, Ba	Edible fruit; fuelwood; agricultural tools; medicinal values (bark is used to cure jaundice) and pickles (fruit).
28	Melia azadirachta L.	Meliaceae	L, B	Vegetables (leaves); fuelwood; medicinal values (leaves are used to cure itching); bio-fence and shade tree.

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29	Mesua ferrea L.	Calophyllaceae	S	Fuel wood; construction of house; shade tree and ornamental tree.
30	Michelia champaca L.	Magnoliaceae	S	Timber; construction material; agriculture tools and furniture making.
31	Mimusops elengi L	Sapotaceae	F, B	Edible fruit; shade tree and ornamental tree.
32	Moringa oleifera Lam.	Moringaceae	P, L	Vegetables (pod and leaves) and bio-fences.
33	Morus alba L.	Moraceae	F	Edible fruits; fuelwood and bio- fence.
34	Phoenix sylvestris (L.) Roxb.	Arecaceae	F	Edible fruit and ornamental tree.
35	Phyllanthus emblica L.	Phyllanthaceae	F	Edible fruit; fuelwood and pickle (fruit).
36	Polyalthia longifolia (Sonn.) Thwaites	Annonaceae	W	Fuelwood; fodder; agricultural tools and ornamental tree.
37	Prunus persica (L.) Batsch	Rosaceae	F	Edible fruit and fuel wood.
38	Psidium guajava L.	Myrtaceae	F, L	Edible fruit; fodder and medicinal values (leaves are used to cure dysentery).
39	Punica granatum L.	Lythraceae	F, B	Edible fruits and fuel wood.
40	Pyrus pyrifolia (Burm.f.)	Rosaceae	F, B	Edible fruits and fuel wood.
41	Syzygium cumini (L.) Skeels	Myrtaceae	F, B	Edible fruits and fuel wood.
42	Tamarindus indica L.	Leguminosae	F	Edible fruits; vegetable; value added products (chutneys, curries and pickles).
43	Tectona grandis L.f.	Lamiaceae	S, B	Fuel wood; construction of house; furniture making and agricultural tools.
44	Terminalia chebula Retz.	Combretaceae	F, S, B	Edible fruit; timber; furniture making, and medicinal values (fruit is used to cure indigestion and stomach ache).
45	Ziziphus jujuba Mill.	Rhamnaceae	F, L, B	Edible fruit, fodder and the branches as fuel wood.

B-Branches; BA-Bark; F-Fruits; Fw-Flower; L-Latex; Le-Leaves; P-Pod; S-Stem; Se-Seed; W- Whole plant

The utilisation pattern of the 45 plant species used traditional agroforestry highest in fuelwood category i.e., 88.89% species of the tree were used as fuelwood, followed by food (66.67%), field use (46.67%), tool (37.78%), construction (31.11%) and other uses (80%), etc. (Table 2).

Table 2. The utilisation pattern of the tree species of agroforestry systems.

Sl. No.	Use category	Number of species	% of species
1	Food	30	66.67%
2	Fuel wood	40	88.89%
3	Medicine	11	24.44%
4	Fodder	6	13.33%
5	Field use	21	46.67%
6	Tools	17	37.78%
7	Construction	14	31.11%

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| 8 | Other uses | 36 | 80% |

The cultural important index (CI) was used as a tool to identify the cultural importance trees utilised in traditional agroforestry system. The value of CI varied from 0 to 8. Mangifera indica was ranked 1st with 3.273 index value, with both highest value of use reports (UR = 360) and number of use category (NU=7), followed by Terminalia chebula (3.264), Mesua ferrea (2.636), Psidium guajava (2.573), Artocarpus heterophyllus (2.536), Melia azadirachta (2.373), Dillenia indica (2.273), Erythrina stricta (2.191), Anthocephalus cadamba (2.136), Livistona jenkinsiana (2.136), etc. In the food (FO) category, highest total CI value was found in both Areca catechu and Psidium guajava i.e., 0.782, whereas in FL category, Psidium guajava was ranked first in total CI value (0.755); M category (Melia azadirachta); FD category (Psidium guajava); FU category (Moringa oleifera); T category (Cocos nucifera); in C category (Anthocephalus cadamba), and O category (Tectona grandis) (Table 3 and Table 4).

Table 3. Cultural Importance Index (CI) of tree species used in agroforestry system.

Species	FO	FL	M	FD	FU	T	C	O	CI
Mangifera indica L.	0.691	0.700	0.445		0.027	0.227	0.555	0.627	3.273
Terminalia chebula Retz.	0.627	0.600	0.573			0.245	0.618	0.600	3.264
Mesua ferrea L.		0.600			0.564	0.318	0.582	0.573	2.636
Psidium guajava L.	0.782	0.755	0.436	0.591				0.009	2.573
Artocarpus heterophyllus Lam.	0.664	0.618		0.345	0.255		0.164	0.491	2.536
Melia azadirachta L.	0.500	0.564	0.609		0.182			0.518	2.373
Dillenia indica L.	0.673	0.555	0.209		0.518			0.318	2.273
Erythrina stricta Roxb.		0.618	0.573	0.009	0.436			0.555	2.191
Anthocephalus cadamba (Roxb.) Miq		0.518			0.209	0.209	0.609	0.591	2.136
Livistona jenkinsiana Griff.	0.627				0.527		0.500	0.482	2.136
Gmelina arborea Roxb. Ex		0.645				0.318	0.600	0.564	2.127
Tectona grandis L.f		0.436				0.364	0.618	0.673	2.091
Averrhoa carambola L.	0.691	0.445	0.336					0.582	2.055
Duabanga grnadiflora (D.C.)Walp		0.518			0.200	0.291	0.564	0.473	2.045
Elaeocarpus floribundus Blume.	0.636	0.527				0.245		0.564	1.973
Tamarindus indica L.	0.645	0.555	0.009		0.200			0.527	1.936
Ziziphus jujuba Mill.	0.609	0.473		0.291	0.009			0.555	1.936
Bauhinia variegata L.	0.564	0.573		0.318	0.009	0.200		0.245	1.909
Michelia chamapaca L.		0.491				0.300	0.555	0.545	1.891
Bombax ceiba L.		0.518				0.273	0.509	0.555	1.855
Cocos nucifera L.	0.609		0.018		0.164	0.518		0.518	1.827
Moringa oleifera Lam.	0.582				0.591			0.636	1.809
Areca catechu L.	0.782	0.482					0.445		1.709
Syzygium cumini (L.) Skeels	0.727	0.636						0.282	1.645
Cinnamomum tamala (Buch.-Ham.)	0.564	0.509					0.009	0.527	1.609
Phoenix sylvestris (L.) Roxb.	0.755				0.245			0.609	1.609
Cassia fistula L.	0.009	0.518			0.200	0.327		0.536	1.591

Species	C	FD	FO	FL	FU	MED	O	T	
Phyllanthus emblica L.	0.573	0.455						0.545	1.573
Litchi chinensis Sonn.	0.718	0.355	0.009		0.173			0.227	1.482
Delonix regia (Hook.) Raf.		0.591				0.045	0.227	0.491	1.355
Prunus persica (L.)	0.673	0.618							1.291
Ficus sp.		0.273			0.527			0.473	1.273
Pyrus pyrifolia (Burm.f.)	0.655	0.609							1.264
Caryota urens L.	0.627							0.573	1.200
Mimosa elengi L.	0.009	0.427			0.245			0.482	1.164
Annona reticulata L.	0.645	0.500							1.145
Morus alba L.	0.545	0.373			0.218			0.009	1.145
Polyalthia longifolia (Sonn.)		0.509		0.009	0.009	0.009		0.609	1.145
Alstonia scholaris (L.) R. Br.		0.445	0.382			0.282			1.109
Punica granatum L.	0.636	0.400							1.036
Lagerstroemia speciosa (L.)		0.473						0.555	1.027
Baccaurea ramiflora Lour.	0.609	0.364							0.973
Litsea monopetala (Roxb.) Pers.		0.545						0.273	0.818
Anacardium occidentala L.	0.455	0.345							0.800
Mallotus tetracocus (Roxb.)Kurz.		0.591				0.009			0.600

Construction (C), Fodder (FD), Food (FO), Field use (FL), Filed use (FU), Medicine (MED), Other uses (O), Tool (T),

Mangifera indica was ranked 1st based on Cultural value index i.e., 2.447 with relatively higher frequency of citation (94) and use reports (NU=7), followed by Terminalia chebula (2.270), Artocarpus heterophyllus (1.660), Psidium guajava (1.477), Mesua ferrea (1.468), Melia azadirachta (1.254), Dillenia indica (1.175), Erythrina stricta (1.158), Anthocephalus cadamba (1.129), Bauhinia variegate (1.054), etc. (Table 4).

Table 4. Ranking of tree species based on ethnobotanical indices.

Species	Ranking			
	RFC	CI	CV	RI
Mangifera indica L.	7	1	1	1
Terminalia chebula Retz.	1	2	2	2
Artocarpus heterophyllus Lam.	6	5	3	3
Psidium guajava L.	2	4	4	4
Mesua ferrea L.	3	3	5	5
Melia azadirachta L.	8	6	6	7
Dillenia indica L.	14	7	7	11
Erythrina stricta Roxb.	9	8	8	8
Anthocephalus cadamba (Roxb.) Miq	10	9	9	9
Bauhinia variegata L.	31	18	10	6
Ziziphus jujuba Mill.	11	16	11	10
Tamarindus indica L.	17	17	12	13
Duabanga grandiflora (D.C.)Walp	25	14	13	14

Gmelina arborea Roxb. Ex	5	11	14	17
Cocos nucifera L.	27	21	15	15
Tectona grandis L.f	16	12	16	18
Livistona jenkinsiana Griff.	19	10	17	21
Averrhoa carambola L.	23	13	18	23
Elaeocarpus floribundus Blume.	18	15	19	19
Litchi chinensis Sonn.	15	29	20	12
Cassia fistula L.	28	27	21	16
Bombax ceiba L.	22	20	22	22
Michelia chamapaca L.	26	19	23	24
Cinnamomum tamala (Buch.-Ham.)	33	25	24	27
Moringa oleifera Lam.	12	22	25	28
Areca catechu L.	4	23	26	25
Delonix regia (Hook.) Raf.	30	30	27	26
Phoenix sylvestris (L.) Roxb.	13	26	28	29
Syzygium cumini (L.) Skeels	20	24	29	31
Polyalthia longifolia (Sonn.)	39	36	30	20
Phyllanthus emblica L.	29	28	31	33
Mimosa elengi L.	37	35	32	30
Morus alba L.	40	37	33	32
Ficus sp.	32	32	34	34
Alstonia scholaris (L.) R. Br.	34	39	35	35
Prunus persica (L.)	21	31	36	36
Pyrus pyrifolia (Burm.f.)	24	33	37	37
Caryota urens L.	35	34	38	38
Annona reticulata L.	38	38	39	40
Punica granatum L.	36	40	40	39
Lagerstroemia speciosa (L.)	42	41	41	42
Baccaurea ramiflora Lour.	41	42	42	41
Anacardium occidentale L.	43	44	43	43
Litsea monopetala (Roxb.) Pers.	46	43	44	46
Mallotus tetracocus (Roxb.)Kurz.	45	46	46	45

CI-Cultural Important Index, RFC-Relative Frequency of Citation, RI-Relative Important Index

Based on Relative Importance Index, Mangifera indica was ranked 1st i.e., 0.961 with relatively higher frequency of citation (FC=94) and use reports (NU=7), followed by Terminalia chebula (0.929), Artocarpus heterophyllus (0.899), Psidium guajava (0.852), Mesua ferrea L. (0.838), Bauhinia variegate (0.826), Melia azadirachta (0.813), Erythrina stricta (0.813), etc. (Table 4).

Artocarpus heterophyllusi was ranked 1st based on Relative Frequency of Citation i.e., 0.927 with highest number of citation (FC=102), followed by Psidium guajava (0.918), Mesua ferrea L. (0.891), Areca catechu (0.891), Gmelina arborea (0.882), Artocarpus heterophyllus (0.873), Mangifera indica (0.855), etc. (Table 4).

Table 5. Variation in knowledge of use of agroforestry species between male and female.

	FO	FL	MED	FD	FU	T	C	O
Male	17.81±	20.34±	4.48±	1.86±	7.10±	4.55±	6.48±	17.74±
(N=58)	6.39	9.75	2.33	1.21	4.36	2.66	3.26	10.57
Female	17.57±	21.02±	2.65±	1.28±	3.70±	3.78±	6.50±	17.518±
(N=54)	5.59	8.34	1.43	0.79	1.79	2.12	2.83	7.86
P value	0.593	0.822	2.37E-05	0.004	7.540E-05	0.138	0.801	0.248

Construction (C), Fodder (FD), Food (FO), Field use (FL), Filed use (FU), Medicine (MED), Other uses (O), Tool (T). (Mean ± SD).

In the present study, no significance difference of plant knowledge was found between male and female in selected use categories such as food category, fuelwood category, construction category and other uses category. This study was similar to the finding of plant knowledge between male and female of the Tripuri tribe [13]. However, significance difference of plant knowledge was found higher in male than female in certain use categories such as medicine category, field use category, fodder category and tools category (Table 5). This difference of plant knowledge was mainly due to specific nature of work done especially done by male such as use of trees for shade purpose, bio fencing, tools, medicinal purposes, etc.

IV. CONCLUSION

The Nyishi tribe of fringe villages of Doimukh forest range utilised 45 culturally important tree species belonging to 26 families in the traditional agroforestry system. The Arecaceae and Leguminosae are the dominant families. About 88.89% species of the tree are used as fuelwood, followed by food (66.67%), field use (46.67%), tool (37.78%), construction (31.11%) and other uses (80%) etc. Mangifera indica is ranked 1st based on CI, CV and RI value; whereas Artocarpus heterophyllus ranked 1st in RFC value with highest number of citation (FC=89). Both Areca catechu and Psidium guajava have highest CI value in food category, whereas Psidium guajava have higher CI value in FL category, Melia azadirachta (M category); Psidium guajava (FD category); Moringa oleifera (FU category); Cocos nucifera (T category); Anthocephalus cadamba (C category), and Tectona grandis (O category). The community bears good plant knowledge in traditional agroforestry system. However, male members are found significantly higher plant knowledge than female especially in use categories like medicine, field use, fodder and tools.

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