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Ethno-Botanical Plant Diversity in Home Gardens based Agroforestry System in Kanchendzonga Biosphere Reserve, Sikkim, India

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ABSTRACT

A study was conducted to assess the present status, plant diversity, structure, uses, and importance of homestead garden for biodiversity conservation in Dzongu area, Sikkim, India. Assessment was done by means of multistage random sampling from a total of 100 households using a semi-structured questionnaire. A total of 102 plant species belonging to 54 families and72 genera were recorded from the study area. Dominating family in the homegarden was Moraceae with eight species followed by Rosaceae and Solanaceae with seven species each. The most dominating habit was observed for trees representing 39 % of species followed by 38% represented herbs, 7% represented shrubs. Out of the total documented species, the most dominating plant part used by homestead growers was fruits (45%) followed by leaves (29%) and wood (13%). The majority of the species is utilized for edible purpose (71%) followed by fodder (34%) and fuelwood (29%). This study presented the baseline data about plant diversity in the home gardens, uses of plants and arrangement of the plants in the home gardens.

Key Words:

Biodiversity, Dzongu, Home garden, Uses

INTRODUCTION

Homegarden is commonly defined as a piece of land with a definite boundary surrounding a homestead, being cultivated with diverse mixture of perennial and annual plant species, arranged in a multi-layered vertical structure, often in combination with raising livestock and managed mainly by household members for subsistence production (Hoogerbrugge and Fresco 1993; Kumar and Nair 2004; Subba et al. 2017). It is one of the complex ecosystem and promising approaches to supplement the need of the various wishes for the sustenance of rural life in the remote areas. It supports the major floral diversity of any region and reduces the

pressure on forest. Traditional homegardens have not only provided rural people with subsistence items such as foods, fruits, medicine, and cash income, but have played an important role in biodiversity conservation, especially for conservation of local crop varieties and species germplasms (Levasseur and Olivier 2000). Several studies reported that traditional homegardens contain high diversity of species and conserve many varieties of species in the tropics. In fact, most crop germplasms resources have been conserved effectively by indigenous people through their traditional practices (Le et al. 1999; Elias et al. 2004; Major et al. 2005). Traditional homegardens provide 40 % of the calories, 30% of the protein and 65% of the fuel to households in some parts of Indonesia (Wilson et al. 2003). Homegardens in Vietnam supply more than 50 % of vegetables, fruits, and herbs (Trinh et al. 2003). These crop varieties contain abundant genetic diversities of huge value to modern crop breeding. In a sense, traditional agro-ecosystems can be regarded as a kind of reservoir for storing crop and other economic plant diversity for use in the future (Blanckaert et al. 2004; Sousa et al. 2018).

In India homegarden are generally found in high rainfall areas comprising Kerala, Karnataka, North Eastern parts of India and West Bengal (Subba et al. 2018) and due to its diversity it is practiced in different in region of India but there is no such documented report from homegarden in Sikkim state. Sikkim, the hilly state which lies in Eastern Himalayan region and considered as the diversified hotspot of India and has still maintained its biodiversity through decades of homegarden approach, ethno-botanical uses of plants in their day to day life. An urban, semi-urban and rural people of Sikkim state are still rely on plants for different purposes, and to them homegarden is one of the easy approach to full-fill their requisite. It is one of the oldest agroforestry systems which is important for the conservation of biodiversity and provide a wide range of ecological benefits and services and a valuable set of products for rural people (Hodgkin 2001). The state has very much fond of homegarden practices and grows many local varieties since long time back; their selection of species is highly based on traditional culture and ecological knowledge. In the present era, both the government and small holder farmers are interested in some of the unused and fallow lands to more productive land use system including tree based system (Tomich et al. 1997). Keeping in view the present scenario of declining size and diversity of homegardens due to family fragmentation in the area, it was felt necessary to document the information about homegardens for further management and conservation of genetic diversity of Sikkim.

MATERIAL AND METHOD

Study Area

The present study was conducted in Dzongu area of North Sikkim, India during April, 2017 to April, 2018 using questionnaire-based personal interviews**.** The district having 4226 km geographic area is located between latitudes 27.51° N and longitudes 88.44° E and having a total population of 43354. The landscape is dominating by dense forest vegetation which includes alpine and desert scrub. Kanchenjunga is the highest peak at over 8,000 m, across its eastern border and can be seen evidently from the town of Singhik. District is dominating by ethnic indigenous communities like Lepcha, Bhutia, Subba and Sherpa.

Methodology

Data was collected from the villages of Dzongu area of North Sikkimin which 100 respondents (home garden owners) were randomly selected for survey through providing both open and close ended questionnaire, direct observation and by a face to face interview. The data thus collected was analyzed for plant diversity and traditional utilization of the plants maintained in the home gardens.

The plant inventory survey was performed by using an open ended format which included common name and botanical name of plants, parts used and their uses. The survey was carried out with participatory observations, plants identification with local names and necessary photographs for further identification. Data pertaining to the diversity and arrangement of plant species was done strata wise in the selected home gardens.

RESULT AND DISCUSSION

The diversity of various plant species with their local name, botanical name, family, habitat, utilization pattern and part usedare given in Table 1. In the studied homegarden, there were four layered of vertical stratification of vegetation which can be categorized as tall plant species (*Acacia auriculiformis, Albizia chinensis, Dalbergia sissoo, Alnus nepalensis etc*) medium height plant species (*Aegle marmelos, Moringa oleifera etc.*) low height plant species mostly shrubs (*Abroma augusta, Calendula officinalis, Jasminum officinale etc*) and ground height vegetation mostly annuals or herbaceous plants (*Aconitum heterophyllum, Agaricus silvaticus, Allium cepa etc*). In the study area, it was observed that homestead gardeners do not follow any specific spatial arrangement pattern and scientific consideration for raising plants. Similar studies were carried out in different regions of India (Subba et al. 2018; Tangjang and Arunachalam 2009; Linger 2017). Homegardens exhibit complex and varied arrangement of plants both vertically and horizontally (Agbogidi and Adolor) creating a forest like multi-storey structure (Bajjukya and Piters 1998). Vertical arrangement is the result of variation in total height of the plants at their maturity and horizontal arrangement is because of intermixing of the species and their individuals forming statured canopy structured (Panwar and Chakravarty 2010).

The inventory of life forms in the present study documented 100 plant species belonging to 56 families and 75 genera. Dominating family recorded in the homegarden was Cucurbitaceae (7 species 7 genus), Fabaceae (7 species 6 genus), Moraceae (7 species 3 genus) followed by Rosaceae (5 species 3 genus) and Solanaceae (5 species 2 genus) in Fig 1. Genera with maximum species recorded is *Ficus* represented seven species and *Solanum* was represented by four species while *Allium, Bauhinia, Brassica, Capsicum, Cinnamomum, Dioscorea, Phaseolus, Prunus, Pyrus* and *Sehium* were represented by two species each in Fig 2. Family with most dominant genera was recorded in Cucurbitaceae (6) family followed by Fabaceae (3) etc. Similarly many studies reported that traditional agroecosystems all over the world often contain a high diversity of crop varieties (Huai and Hamilton 2009; Jaganmohan et al. 2013). It was reported that 320 crop cultivars are cultivated in traditional agriculture systems by indigenous groups in a small mountainous area in India (Arora 1997). In fact, most crop germplasms resources have been conserved effectively by indigenous people through their traditional practices (Major et al. 2005). It is observed by many researchers that in homegarden, species structure, its arrangement, richness and its diversity vary from place to place depending on cultural ecological and socio-economic factors. Species diversity of perennial plants was reported higher in home gardens located in slopes while diversity of annuals was greater in home gardens at flat land (Senanayake et al. 2009).

The documented flora consists of 40 tree species (*Alnus nepalensis, Areca catechu, Terminalia chebula, Bauhinia variegate etc.*), 39 herbs species (*Abelmoschus esculentus, Aconitum heterophyllum, Acorus calamus*etc), eight shrubs species (*Artemisia vulgaris, Calendula officinalis, Jasminum officinale, Rubus ellipticus, Solanum betaceum*etc), nine climbers species (*Sechium edule, Lagenaria siceraria, Cucurbita langenarius* and *Trichosanthes anguina*), three grasses species (*Zea mays, Dendrocalamus hamiltonii, Bambusa nutans*) one fungus

species (*Agaricus silvaticus*) and one fern species (*Diplazium esculantum*) in Fig 3. The gardens are highly diversified and influenced by the used practices of the indigenous communities, their knowledge, traditions, beliefs and needs (Tangjang and Arunachalam 2000) and considered by them as a sign of prestige and pride.

The mode of harvesting of species varies from communities to communities and from species to species on the basis of

Table 1. Details of Homestead plants species present in study area

S. no	Scientific Name	Common name	Family	Habit	Utilization pattern	Part used
1	*Abelmoschus esculentus* (L.) Moench	Bhindi	Malvaceae	Herb	2	Fruit
2	*Aconitum heterophyllum* Wall. Ex Royle	Bikh	Ranunculaceae	Herb	1	Root
3	*Acorus calamus* L.	Bonjho	Acoraceae	Herb	2	Root
4	*Agaricus sp*	Chyau	Arctidae	Fungus	2	Fruiting body
5	*Allium cepa* L.	Piyaj	Lillaceae.	Herb	2	Bulb
6	*Allium sativum* L.	Lasun	Amaryllidaceae	Herb	2	Bulb
7	*Alnus nepalensis D. Don*	Utis	Betulaceae	Tree	4	Wood
8	*Ammomum subulatum* Roxb.	Elichi	Zingeberaceae	Herb	1,2	Seed & Fruit
9	*Ampelocissus sikkimensis* (Laws) Planch.	Pureni	Vitaceae	Herb	1	Whole plant
10	*Artemisia vulgaris* Linn.	titaypati	Asteraceae	Shrub	1	Leaves
11	*Astilberi vulgaris* Ham. Ex D. Don	Budhookhati	Saxifragaceae	Herb	1	Whole Plant
12	*Bambusa nutans* Wall. Ex Munro	Bans	Poaceae	Grass	2	Shoot
13	*Bauhinia purpurea* L.	Koiraalo	Fabaceae	Tree	1	Leaves, Bark & Flower
14	*Bauhinia variegata* L.	Kachnar	Fabaceae	Tree	2	Buds
15	*Bergenia ciliata* (Haw.) Sternb.	Pakhenbet	Saxifragaceae	Herb	1	Whole plant
16	*Bombax ceiba* L.	Semul	Bombacaceae	Tree	1	Flowers, Root, Gum, Leaves, &Shoots & Bark
17	*Brassica juncea* var. Rugosa	Rayo sag	Brassicaceae	Herb	2	Leaves
18	*Brassica oleracea* var. Italic	Brocauli	Brassicaceae	Herbs	2	Leaves

19	*Calendula officinalis* L.	Genda	Calendulea e	Shrub	1	Fruit
20	*Capsicum annum* L.	khorsani	Solanaceae	Herb	2	Fruit
21	*Capsicum spp.*	Khorsani	Solanaceae	Herb	3	Fruit
22	*Carica papaya* L.	Mewa	Caricaceae	Tree	2	Fruit
23	*Castanopsis hystrix* A.DC	JatKatus	Fagaceae	Tree	2	Fruit
24	*Castanopsis tribuloides*	katus	Fagaceae	Tree	2	Fruit
25	*Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W.Hill	Lapsi	Anacardiac eae	Tree	4,5	Wood
26	*Cinnamomum tamala* (Buch.-Ham.) Nees. & Eberm.	Tejpata	Lauraceae	Tree	1,2	Leaves
27	*Cinnamomum zeylanicum* J. Presl	Dalchini	Lauraceae	Tree	1,2	Bark
28	*Citrus reticulate* Blanco	Suntola	Rutaceae	Tree	2	Fruit
29	*Clematis buchnaniana* L.	Pinaaseyl ahara	Ranuncula ceae	Herbs	1	Root
30	*Colocasia esculenta* (L.) Schott	Taro	Araceae	Herb	2	Rhizome
31	*Coriandrum sativum* L.	Dhania	Apiaceae	Herb	2	Leaves & Seeds
32	*Cryptomeria japonica* (L.f.) D.Don	Dhupi	Crupressa ceae	Tree	7,8	wood
33	*Cucumus sativus* L.	Kakra	Cucurbitac eae	Herb	2	Fruit
34	*Cucurbita langenarius L.*	Pharsi	Cucurbitac eae	Climber	2	Fruit
35	*Curcuma longa* L.	Haldi	Zingiberac eae	Herb	2	Rhizome
36	*Daucus carota*	Gajor	Umbellifer ae	Herb	2	Tuber
37	*Dendrocalamus hamiltonii*	Baas	Poaceae	Grass	2	Tender shoots
38	*Dicloknema butyracea* (Roxb.) H.j.Lam	che	Sapotaceae	Tree	2,5	Fruits, leaf
39	*Dioscorea alata* L.	Pindalu	Dioscoreac eae	Herb	2	Rhizome
40	*Dioscorea bulbifera*	Githa	Dioscoreac eae	Herb	2	roots
41	*Diplazium esculantum*	Ningro	Dripteridac eae	Fern	2	Leaf bud
42	*Ficus auriculata* Lour	Khanew	Moraceae	Tree	4,5	Leaves & Wood
43	*Ficus hookeri*	Nebara	Moraceae	Tree	2	leaf
44	*Ficus infectoria*	Kabra	Moraceae	Tree	2,5	Fruit & Leaves

45	*Ficus lacor* Buch.- Ham	Kabra	Moraceae	tree	2,5	Tender buds, leaf
46	*Ficus nemoralis* Sm.	Dudilo	Moraceae	Tree	4,5	Leaves & Wood
47	*Ficus religiosa* L. Forssk	Pipal	Moraceae	Tree	1, 6	Bark, Leaves, Latex &Fruit
48	*Ficus roxburghii*	Nebara	Moraceae	Tree	2	Flower, leaf
49	*Girardinia diversifolia* (Link) Friis	Sisnu	Urticaceae	Herb	6	Fibre
50	*Grewia optiva* J.R. Drumm. ex Burret	Shyalphusro	Malvaceae	Tree	5,4	Leaves & Wood
51	*Ipomea batatas* (L.) Lam.	Shaker khanda	Conolvulaceae	Herb	2	Root
52	*Jasminum officinale* L.	Chameli	Oleaceae	Shrub	1	Flower
53	*Juglans regia* L.	Okhar	Jglandaceae	Tree	2,7	wood
54	*Lagenaria siceraria* (Molina) Standl.	Lauka	Cucurbitaceae	Climber	2	Fruit
55	*Litsea polyantha*	Kutmero	Lauraceae	Tree	1,5	Fruit, Leaves
56	*Luffa acutangula* (L.) Roxb.	Jhingana	Cucurbitaceae	Climber	2	Fruit
57	*Lycopersicon esculentum*	rambeda	Solanaceae	Herb	2	Fruits
58	*Machilus edulis*	Lapchak awlo	Lauraceae	Tree	2	Fruits
59	*Manihot esculenta*	Simaltarul	Euphorbiaceae	Herb	2	root
60	*Michelia champaca* (L.) Baill. Ex Pierre	Champ	Magnoliaceae	Tree	1,4	Wood, Flowers, Fruit, Leaves, Roots
61	*Momordica balsamina*	Chuchey karela	Cucurbitaceae	Climber	2	Fruit
62	*Morus macroura* Miq.	Kimbu	Moraceae	Tree	2	Fruits
63	*Musa balbisiana* Colla	Kera	Musaceae	Tree	2	Fruit & Stem
64	*Nasturtium officinale* R.Br	Simrayo	Brassicaceae	Herb	2	Shoot
65	*Ocimum sanctum* L.	Tulsi	Lamiacae	Shrub	1	Whole plant
66	*Oroxylum indicum* (L.) Kurz	Totola	Bignoniaceae	Tree	1,2	Bark, Root & Fruits
67	*Panax pseudoginseng*	Ginseng	Araliaceae	Herb	1	Root
68	*Passiflor aedulis*	Garandel	Passiflorac	Climber	2	Fruit

			ae			
69	*Passiflora edulis* Sims	Garandale	Passifloraceae	Herb	1	Leaves, Stem, & Flowers
70	*Persia americana*	famphale	Rosaceae	Tree	2	Fruit
71	*Phaseolus unguiculata*	Mazibori	Leguminoceae	climber	2	pods
72	*Phaseolus vulgaris* L.	Beans	Fabaceae	Herb	2	Fruit
73	*Prunus armeniaca* L.	Arubakhada	Rosaceae	Tree	2	Fruit
74	*Prunus dome*	Arucha	Rosaceae	Tree	2	Fruit
75	*Prunus persica* (L.) Batsch	Aru	Rosaceae	Tree	2	Fruit
76	*Psidium guajava* L.	Ambak	Myrtaceae	Tree	2	Fruit
77	*Punica granatum* L.	Darim	Lythraceae	Tree	2	Fruit
78	*Pyrus communis* L.	Naspati	Rosaceae	Tree	2	Fruit
79	*Pyrus pashia* Ham. Ex D. Don	Passi	Rosaceae	Tree	1,2	Fruits
80	*Raphanus raphanistrum* L.	Mula	Brassicaceae	Herb	2	Tuber
81	*Rhus semialata*	Bhakimlo	Anacardaceae	Tree	1,2	Fruits
82	*Rubus ellipticus* Sm.	Aeiselu	Rosaceae	Shrub	1,2	Root & Fruit
83	*Rumex nepalensis*	Halhalay	Polygonaceae	Herb	1	Root
84	*Schima wallichii* (DC.) Korth.	Chilauni	Theaceae	Tree	2,3	Fruit &Bark
85	*Sechiumedule*(Jacq.) Sw.	Ishkush	Cucurbitaceae	Climber	1,2	Whole plant
86	*Solanum betaceum* Cav	Rukhtamatar	Solanaceae	Shrub	2	Fruit
87	*Solanum lycopersicum*	Tamatar	Solanaceae	Herb	2	Fruit
88	*Solanum melongena* L.	Baigun	Solanaceae	Herb	2	Fruit
89	*Solanum tuberosum*	aloo	Solanaeae	Herb	2	Tuber
90	*Spondias mangifera*	Amaro	Anacardiaceae	Tree	3	Fruit
91	*Terminalia chebula*	Harra	Combretacese	Tree	2	Fruit
92	*Trigonella foerumgraecum*	Methi	leguminosae	Herb	2	seeds
93	*Tupistra nutan* Wall. Ex Lindl.	Nakima	Asparagaceae	Herb	2	Root &Stem
94	*Urtica dioca*	Sisnu	Urticaceae	Shrub	2	Shoot nut
95	*Vicia faba* L.	Bakuleysimb	Fabaceae	Herb	2	Seed
96	*Vignaum bellate*	Masyam	Leguminosae	Climber	2	Pod
97	*Viscum articulatum*	Harchur	Santalaceae	Herb	1	Whole

							plant
98	*Zanthoxylum* DC.	*armatum*	Timbur	Rutaceae	Shrub	1	Fruits
99	*Zea mays* L.		Makai	Poaceae	Grass	2	Fruit
100	*Zingiber* Roscoe	*officinalis*	Adaua	Zingiberaceae	Herb	2	Rhizome

Index: 1-Medicinal, 2-Edible, 3-Fruits,4-Fuelwood, 5-Fodder, 6-Religious, 7-Timber, 8-Beauty Care

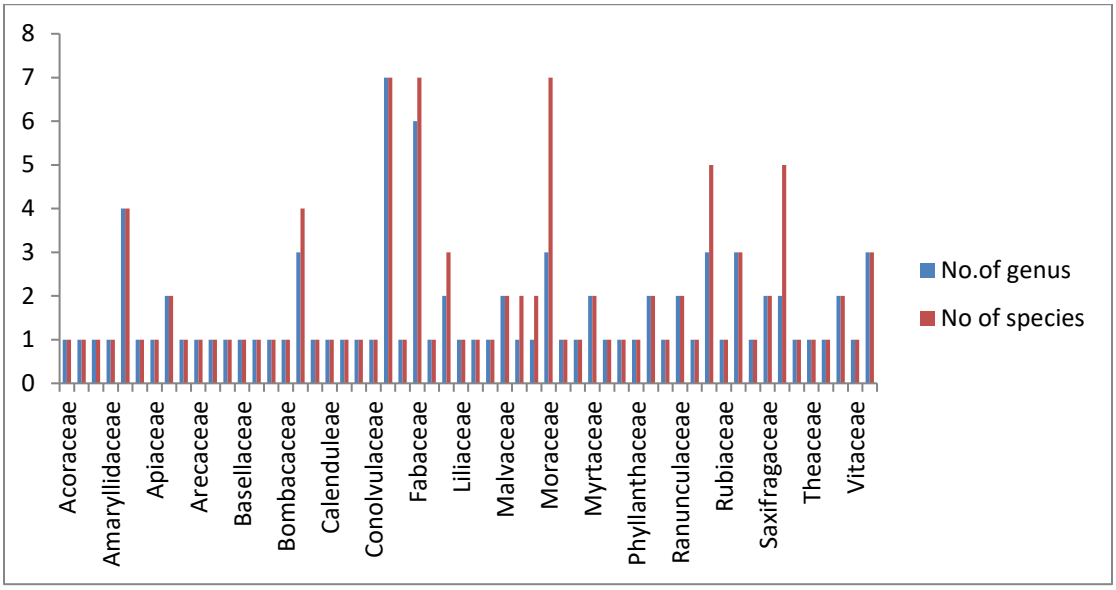


Fig 1. Families with number of genus and number of species

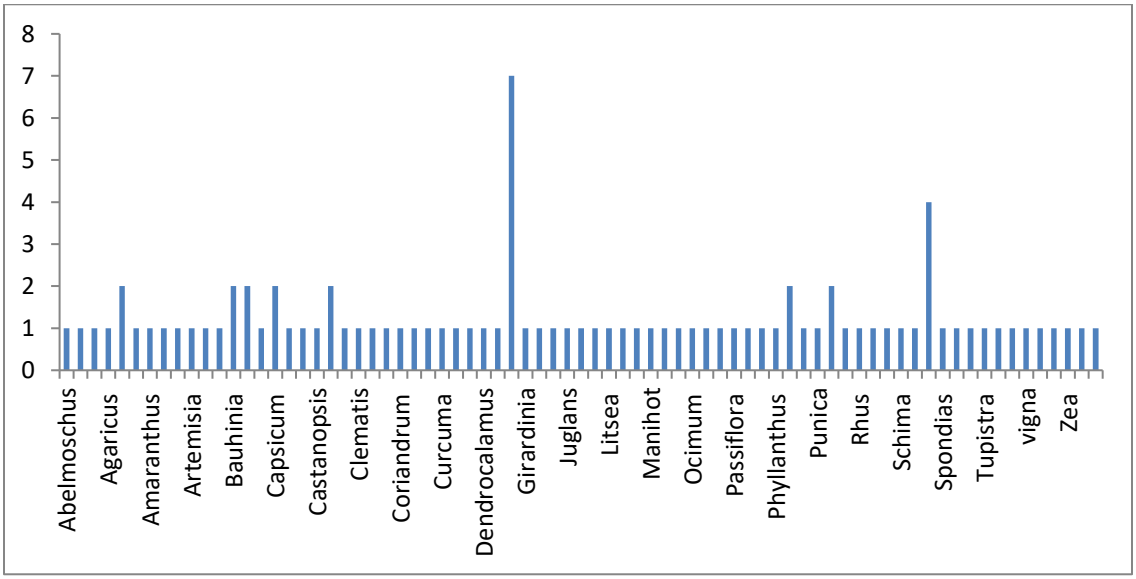
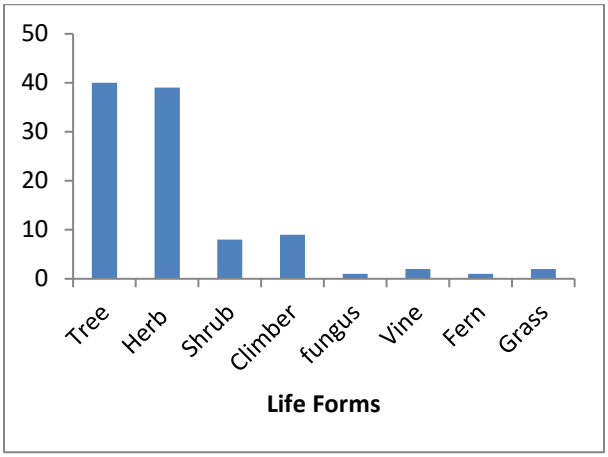


Fig 2. Genera with number of species



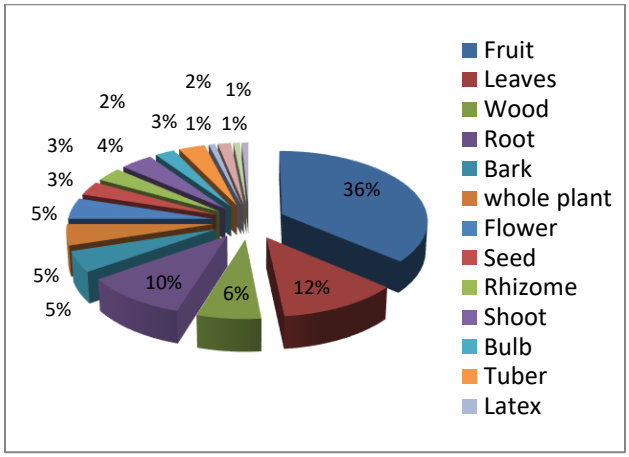


Fig 3. Life forms with number of species

Fig 4. Plant part used

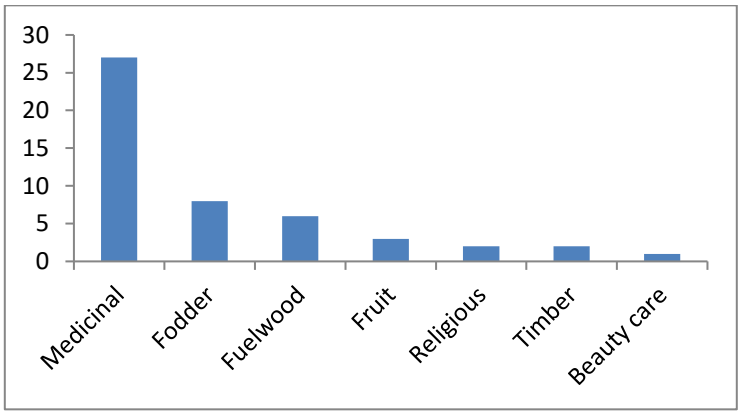


Fig 5. Utilization pattern of plants

their knowledge and beliefs. Mostly destructive methods are followed by the people, which able to create the species in endangered category in coming future. The mode of harvesting of species varies from communities to communities and from species to species on the basis of their knowledge and beliefs. Mostly destructive methods are followed by the people, which able to create the species in endangered category in coming future. Among the used species, the most dominated mode of harvesting by homestead growers were fruits with 36% species (*Abelmoschus esculentus, Lagenariasi ceraria*) followed by leaves with 12% species (*Basella alba, Bauhinia purpurea, Brassica juncea*), root with 10% species (*Bombax ceiba, Acorus calamus, Aconitum heterophyllum etc*),wood with 6% species (*Grewia optiva,, Terminalia chebula*) (Fig. 4). Other plant parts like bark, flower, seed, rhizome etc. were sparsely used for folk lore. The reason for this variation was that rural people depend more on homestead forest for their livelihood security as well as certain amount of family income. Our results were consistent with the findings of other studies: the most frequently utilized plant parts were bark, leaves, roots, branches, stem, fruits, seeds (Alagesaboopathi 2014; Shah et al. 2014).In some cases, the whole plant including the roots was utilized (Shukla and Chakravarty 2012; Suresh et al. 2013). Most of the ethnobotanical studies confirmed that leaves were the major portion of the plant used in the treatment of diseases (Ignacimuthu et al. 2008; Choudhary et al. 2012). Similar findings were reported from Uttarakhand (Gairola et al. 2014; Sharma et al. 2012).

There are so many factors which affect the decision of farmers for growing particular species or group of species. The

farmers were ardent to grow fruit yielding species, timber trees for cash income, medicinal plants etc. In the surveyed area, homestead plant species generally used for edible purpose, medicinal plants, fruit, fuelwood, fodder, religious, timber and beauty purposes were identified (Fig. 5).Among them, 71% used for edible purpose (*Zingiber officinalis, Zea mays, Vicia faba, Trichosanthes anguinaetc*), 26% is used for medicinal purpose (*Viscum articulatum, Syzygium cumini, Sechium edule, Rumex nepalensis etc.*), 29% fuel wood (*Michelia champaca, Moringa oleifera, Grewia optiva, Ficus auriculataetc*), 34% fodder (*Litsea polyantha, Ficus infectoria, Grewia optiva, Choero spondiasaxillaris*) while the least were observed in religious (*Mangifera indica, Ficus religiosa* and *Girardinia diversifolia*), timber (A*lnus nepalensis, Cryptomeria japonica, etc*), fruit (*Schima wallichii*) and beauty care (*Cryptomeria japonica*).

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