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HORTICULTURE

Floristic Structure, Composition and Functional Characteristics of Homegardens in Garhwal Region, Uttarakhand, India

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Abstract

In the present investigation was carried out to access the floristic structure, composition and functional characteristics of homegardens in Garhwal region, Uttarakhand during 2013-14. Here, we had selected two districts on the basis of maximum (Uttarkashi) and minimum (Rudraprayag) geographical area of the state. The result showed that floristic tree diversity was maximum contributed by agroforestry crops (64%, 53.84%, 62.5%, 66.7%) and followed by horticulture crops (36%, 46.16%, 37%, 33.3%) with respect to Malkhi, Khumera, Kurura and Panchan gaun village respectively. The contribution of forest and van panchayat for fuel-wood were estimated 13.5 and 5 kg, 11.5 and 6.5 kg, 2.6 and 6.2 kg/day for group of farmers during rainy, winter and summer seasons, respectively. We observed that 35 species of trees (forest trees+ fruit trees), 18 species of agriculture crops, 13 species of vegetable crops, 9 species of grasses and 13 species of shrub were identified from the study area.

Highlights

- Homegardens represent intimate, multistory combinations of various perennial and annual crops, sometimes in association with domestic animals, around the homestead which serves as a permanent or temporary.
- The result showed that floristic tree diversity was maximum contributed by agroforestry crops (64%, 53.84%, 62.5%, 66.7%) and followed by horticulture crops (36%, 46.16%, 37%, 33.3%) with respect to Malkhi, Khumera, Kurura and Panchan gaun village respectively.
- Total floristic diversity was observed 35 species of trees (forest trees+ fruit trees), 18 species of agriculture crops, 13 species of vegetable crops, 9 species of grasses and 13 species of shrub.

Keywords: Homegardens, floristic structure, composition, Garhwal region, Uttarakhand

Homegardens agroforestry system is one of the most prevalent types of land use systems suitable to high rainfall areas in tropical conditions. Homegardens represent intimate, multistory combinations of various perennial and annual crops, sometimes in association with domestic animals, around the homestead which serves as a permanent or temporary (Kumar, 2017; Kumar and Tripathi, 2017). It is a traditional land use practice around a homestead where several plant species are maintained by members of the household and their products are intended primarily for household consumption (Shrestha *et al.*, 2001). Compared to other agricultural or horticultural ecosystems, homegardens are very species rich and well suited for ex situ conservation of many rare/endangered species, besides fruit and timber trees. Homegardens structure also varies from place to place according to the local physical environment, ecological characteristics, socioeconomic and cultural factors (Abdoellah 1990; Kumar and Nair 2004; Kumar and Tripathi, 2017). Besides species composition, annual

income from the homegardens biodiversity was also found to correlate with household size in the offshore island of Bangladesh (Alam and Masum, 2005). Ramakrishnan (2001) suggested adopting the north eastern Indian experience linked with natural resource management initiatives as a basis for traditional societies.

Forest cover of the country estimated that 21.34% of the total geographical area of the country and total forest plus tree cover area estimate that 24.16% of the total geographical area. Himalayan mountain system covers only 18% of the geographical area of India, but accounts for more than 50% of India's forest cover and for 40% of the species endemic to the Indian subcontinent. About 45.32% of total geographical area of Uttarakhand is covered with forest (FSI, 2015). Plant community plays a pivotal role in sustainable management by maintaining biodiversity and conserving the environment (Farooquee and Saxena, 1996). The knowledge of the floristic composition of a plant community is a prerequisite to understand the overall structure and function of any ecosystem (Suyal *et al.*, 2010; Kumar and Desai, 2016a,b). A plant community is the collection of plant species growing together in a particular location that show a definite association with each other (Muller-Dombois and Ellengberg, 1974). The most common method of defining this diversity at the ecosystem level is the species. Species diversity is considered as a spatial form of textural diversity and treated both in structure and dynamics of the plant community (Maarel, 1988). However, the concept of diversity is generally concerned with the representation of variability involved in the natural communities. The comparative analysis of species abundance distributions based on species abundance models with associated diversity indices can provide valuable information on the diversity of a community (Magurran, 1988). Although considered ecologically and functional important, there is a lack of information on the traditional homegardens of Garhwal region, Uttarakhand. Therefore, we studied the floristic structure, composition and functional characteristics of homegardens in Garhwal region.

Materials and Methods

The state of Uttarakhand is situated in the northern part of India and shares an international boundary with China in the north and Nepal in the east. It has an area of 53,483 km^2 and lies between latitude 28° 43′ and 31° 28′ N and longitude 77° 34′ and 81° 03′ E. The recorded total forest and tree cover of the State is 21,505 km^2, which constitutes 45.43% of its geographical area (FSI, 2015). The population density of Uttarakhand is 829 persons per sq. km whereas in India the average is 382 persons per sq. km. Uttarakhand state is divided into two agro climatc zones only, i.e., the hill and plains. The land use pattern of Uttarakhand are given in which clearly shows that 64% of the land area of Uttarakhand is under forest cover and about 14% area under agriculture.

Fig. 1: District map of Uttarakhand

The present study was conducted in North-Western Himalayan agro-climatic zone (800 masl–7000 masl) and district selected on the basis of size of the geographical area of the Uttarakhand state in India. The maximum geographical area of district is Uttarkashi (30° 43' N and longitude 78° 27' E) and minimum in Rudraprayag (30° 43' N and longitude 78° 27' E) of the Uttarakhand (Fig. 1), which covering 7591 km^2 and 2328 km^2 of the total geographical area of the state. The year consists of three seasons: dry summer season (April-June), warm rainy season (July-September), and winter season (October-March). Annual mean temperature of Rudraprayag district is 18.5° C and annual average rainfall is 1628 mm. About 70 to 80% of total rainfall is received during rainy season. Annual mean temperature of Uttarkashi district is 21.2° C and annual average rainfall is 1208 mm in year 2013-14.

Climate and Weather: The climate and weather of Uttrakhand is humid sub-tropical with cold winters and hot dry summers. The maximum daily temperature in summer may reach up to 42°C and minimum temperature in winter may fall down to 0.5°C. Monsoon sets in the second or third week

of June and continues up to the end of September. Generally, south-west monsoon sets in the second or third week of June and continues up to the end of September. The mean annual rainfall is about 1450 mm, of which 80-90% is received during the rainy season (July to September). The weekly variations of important meteorological parameters during the experimental period was collected from the meteorological observatory located at the Crop Research Centre and shown in Fig. 2.

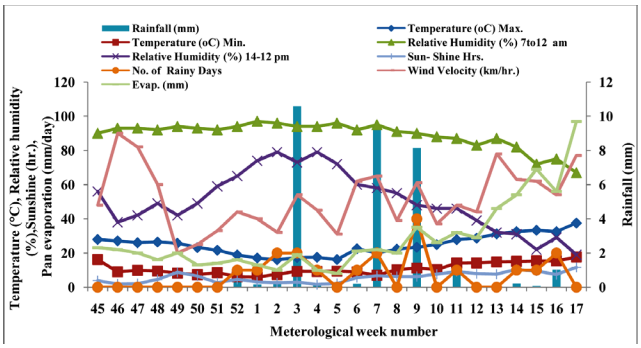

Fig. 2: Weekly average weather parameters during the experimental period of 14th November to 24th April, 2013-14

Sampling: Three stage sampling technique was applies while study conducted. The first stage of sampling plan was the selection of block from the selected district, followed by selection of villages (second stage) from the selected block and selection of respondent farmers (third stage) from the selected villages to make sample of 72 farmers.

Selection of Blocks: Each district has selected randomly two blocks. Rudraprayag district has three blocks; *viz;* Jakholi, Augstyamuni and Ukhimath. Out of these three blocks two blocks were selected randomly for the study. Uttarkashi district has six blocks; *viz;* Badkot, Bhatwari, Chiniyasaud, Dunda, Purola and Mori. Out of these two blocks were selected randomly for the study, *i.e.,* Purola and Dunda.

Selection of villages: Each block has randomly selected one village. Study was concentrated on identification of the trees species grown, soil status of homegarden, role of tree species in biological diversity conservation and improving the livelihood of farmers. Here, Kurura village (30° 73′N to 78° 45′ E) in Purola Tehsil and Pacchan gaun village (30° 65′N to 78° 35′ E) in Dunda Tehsil in Uttarkashi district of Uttarakhand. Malkhi village (30° 28' N to 78° 98′ E) in Augustmuni Tehsil and Khumera village (30° 58′N to 78° 68′E) in Ukhimath Tehsil in Rudraprayag district of Uttarakhand.

Selection of the Respondents: Eighteen families of each village were selected on the basis of land holding capacity, *i.e.*, marginal (<1ha), small (1-2 ha), medium (2-5 ha) and large (>5 ha).

Types of trees species

(i) **Name of trees species:** It includes type of trees species grown by the farmers, *i.e.*, Bhemal (*Grewia optiva)*, Khadik (*Celtis australis*), Malta (*Citrus sinensis*) *etc.*

(ii) **Numbers of trees species:** It includes total number of different trees species grown by farmer on their field.

(iii) **Measurements on tree species:** Just to have an idea about the preference of tree species by the farmers in each village a minimum of 12 trees were resulted in 3 categories on the basis girth measurements, *i.e.,* large, medium and small and rate of growth.

(iv) **Frequency of tree species:** Frequency of trees species were calculated by the help of dominant trees species prevalent in the given region. Those tree species which are more prevalent have more frequency.

Uses of trees

- **Fodder and Fuel-wood sources:** It refers to types of homegardens trees species, grasses and shrubs are grown traditionally in farmer's field.
- Marketing products.
- **Forest products:** It includes fuel, fodder, fiber, fruit, furniture, timber, medicinal uses etc. of various trees in the study area.
- **Agriculture products:** It refers to amount of food grain, vegetable, fruits, livestock product etc. which are marketable and sold by farmer to improve its livelihood. It also includes the agency which help in transport and the nearest place distance where farmer sell the products.
- **Amount of fodder use by livestock:** It includes different livestock, *viz*; buffalo, cow, sheep, bullock and horses and also refers to how much amount of fodders was consumed by different livestock in different seasons.

Data collection for biodiversity conservation: Ethnobotanical data were collected by using semi structured interviews, field observations, ranking and scoring methods. Simple preference ranking was calculated for ten multipurpose tree species in order to assess their number in the study site. Based on their personal preference of efficacy, selected informants were asked to assign their preference to Highest score (1), was assigned to most preferred species and followed to subsequently, the lowest score denoted as (10). The numbers are summed for all respondents, giving an overall ranking for the items by the selected group of respondents.

Data analysis: The statistical techniques used for data analysis are as follows:

(i) Frequency: It was calculated to find out the number of respondents in a particular cell.

(ii) Percentage: Percentage values were calculated to make simple comparisons. These were calculated by dividing the frequency of a particular cell by the total number of respondents and then multiplying the result by 100.

$$P = (n / N) * 100$$

where, n = frequency of a particular cell and N = total number of respondents

Results and Discussion

Tropical montane Himalayan forests are characterized by strong gradients related to topography and manifest as differences in elevation, precipitation, humidity, soil type, slope, aspect and radiation. High diversity and low concentration of dominance in different homegarden categories may be due to variations in anthropogenic pressure in different homegardens.

Various trees species grown by farmers in the study area

Historically, the district was covered by dense natural forests, but the distribution of natural forest is declining due to human interference. The potential vegetation is a temperate broad–leaved forest type. Trees dominated by *Grewia optiva*, *Celtis australis*, *Myrica esculenta*, *Pyrus pashia Rhododendron arboreum*, *Ficus subincisa*, *Quercus leucotrichophora* and *Citrus sinensis* are common homegardens trees species.

Land use - land cover types

The landscape is differentiated into three land use-land cover types: **I.** Mixed Forest, **II.** Homegardens and **III))** Cultivated land.

(i) Mixed forest: Natural vegetation in a temperate broad-leaved forest was dominated by *Alnus nepalensis*, *Lyonia ovalifolia*, *Myrica esculenta*, *Pyrus pashia, Rhododendron arboreum* and *Quercus leucotrichophora* tree species. The village community forests were socially valued as fuel wood, fodder, leaf litter and minor forest products. The leaf litter is used as a component of farmyard manure. Thereby these forests were facing high pressure.

(ii) Homegardens: Homegardens includes multi-species trees in small tiny plots located close to dwellings comprising of variety of tree species like citrus, bhimal, walnut, khadik, timala *etc*. vegetables like onion, chillies, brinjal, cauliflower, cucurbits, potato and leafy vegetables, spices, agriculture crops, grasses and shrub like tungla, kilmora, makoi, hinsalu, kala hinsalu etc. Homegarden agroforestry is believed to be more diverse and provide multiple services for households than other monocropping system and this is due to the combination of crops, trees, shrubs and livestock. A total of 35 tree species were reported in the study site. The *Grewia optiva* was observed as dominant tree species and *Citrus sinensis and Celtis australis* as co-dominant species in this region.

A typical agroforestry setup may employ some or all of these types of system. For example, an agroforestry system in the Garhwal Himalaya was measured to be 27.47% simultaneous, 27.47% sequential, 1.1% homegarden and 43.96% village forestland (Nautiyal *et al.,* 1998). Trees have always been associated with agricultural fields. These trees were deliberately enhanced farmers lifestyle by fulfilling their multifarious needs namely fodder, fuel, fibre, fruits, small timber, agricultural implements etc., along with the agricultural product. The agrihortisilviculture was very common practice by the farmers of this region which includes the cultivation of agricultural crops in association of forest and horticultural trees present in the fields (Kumar *et al.,* 2016; Rana *et al.,* 2016).

Table 1: Floristic diversity and composition of homegardens in different altitude of Rudraprayag district of Uttarakhand

Survey report					
Name of district – Rudraprayag	**Name of the Block - Augstyamuni**	**Total frequency**	**Name of district – Rudraprayag**	**Name of the Block - Ukhimath**	**Total frequency**
Name of the village – Malkhi	**Altitude- 1800-2000m**		**Name of the village – Khumera**	**Altitude- 1600-1800m**	
Scientific name	**Local name**		**Scientific name**	**Local name**	
Slow Growing Trees			**Slow Growing Trees**		
Myrica esculenta	Kafal	34	*Melia azedarach*	Bakain	6
Juglans regia	Akhrot	102	*Quercus glauca*	Harinj	25
Ficus religiosa	Peepal	2	*Juglans regia*	Akhrot	40
Grewia optiva	Bhimal	875	*Ficus religiosa*	Peepal	1
Medium Growing Trees			*Grewia optiva*	Bhimal	586
			Medium Growing Trees		
Ficus glomerata	Timla	77	*Ficus glomerata*	Timla	67
Pinus roxburghii	Chir	22	*Rhododendron arboreum*	Buransh	98
Citrus pseudolemon	Badanimbu	75	*Pinus roxburghii*	Chir	15
Ficus subincisa	Chanchru	55	*Citrus reticulata*	Orange	200
Punica grantum	Anar	13	*Ficus subincisa*	Chancharu	18
Celtis australis	Khadikk	548	Celtis australis	Khadik	300
Quercus leucotrichophora	Oak	148	*Quercus leucotrichophora*	Banj	201
Ficus virens	Phelka	78	*Ficus virens*	Phelka	148
Rhododendron arboretum	Buransh	25	*Dendrobenthemia capitata*	Bhamor	16
Fast Growing Trees			*Thamocalamus falconeri*	Ringal	46
Alnus nepalensis	Usth	50	*Erythrina indica*	Pangra	10
Lyonia ovalifolia	Anyar	15	**Fast Growing Trees**		
Musa paradisiaca	Banana	20	*Citrus sinensis*	Malta	115
Citrus sinensis	Malta	280	*Punica granatum*	Almond	3
Prunus communis	Pear	4	Prunus armeniaca	Plum	23
Prunus armeniaca	Chuli	30	*Prunus domestica*	Apple	52
Prunus domestica	Apple	55	*Prunus persia*	Aadu	50
Prunus persia	Aadu	58	*Citrus limon*	Badanimbu	44
Toona ciliate	Toon	15	*Toona ciliata*	Toon	34
Eucalyptus spp	Eucalyptus	3	*Morus alba*	Mulerry	12
Citrus aurantifolia	Nimbu	45	*Lyonia ovalifolia*	Anyar	14
Pyrus pashia	Mole	38	*Citrus aurantifolia*	Nimbu	38
Total		2667	Total		2162

Measurements on Tree species: Just to have an idea about the preference of tree species by the farmers in each village a minimum of 12 trees were resulted in 3 categories on the basis girth measurements, *i.e.*, large, medium, small and rate of growth. By the study report, in Malkhi village a total of all kind of tree species major contribution, *i.e.*, 64% was from the agroforestry trees and the remaining 36% was from horticulture tress (Table 1). Due to higher elevation easily availability of fodder trees species. So there is no scarcity of fodder at higher elevations. The villagers meet their requirement of fodder and fuel wood from the forest area. In Khumera village the major contribution, *i.e.*, 53.84% was from agroforestry tree species and remaining 46.16% was from horticulture trees (Table 1). In this village percentage of fruit was higher than other village because it was near to market where they can sell fruits due to presence of facilities for making juice, jelly, pickle, jam etc and transport. There was a little scarcity of fodder.

In Kurura village the major contribution, *i.e.,* 62.5% was from agroforestry trees and remaining 37.5% was from the horticulture trees (Table 2). There was no scarcity of fodder trees species. In Panchan gaun village the major contribution, *i.e.,* 66.7% was from agroforestry trees and remaining 33.3% was from the horticulture trees (Table 2). The villagers met their requirements of fodder and fuel wood from the nearby forest area. The *Citrus sinensis* fruit tree species frequently found in all villages was an indicator of how farmers were highly depended in homegardens agroforestry system for food in addition to their cash income revenue. This was due to the fact that urban people use the processed juice from the fruit tree species. Fruit trees not only provide food during their life span

Table 2: Floristic diversity and composition of homegardens in different altitude of Uttarkashi district of Uttarakhand

Survey report					
Name of district – Uttarkashi	**Name of the Block - Purola**	**Total frequency**	**Name of district – Uttarkashi**	**Name of the Block - Dunda**	**Total frequency**
Name of the village – Kurura	**Altitude- 1300-1500m**		**Name of the village – Panchan gaun**	Altitude- **1300-1400m**	
Scientific name	**Local name**		**Scientific name**	**Local name**	
Slow Growing Trees			**Slow Growing Trees**		
Juglans regia	Akhrot	35	*Juglans regia*	Akhrot	40
Ficus religiosa	Peepal	5	*Grewia optiva*	Bhimal	400
Grewia optiva	Bhimal	356	**Medium Growing Trees**		
Medium Growing Trees			*Celtis australis*	Khadik	297
Celtis australis	Khadik	367	*Dendrobenthemia capitata*	Bhamor	15
Dendrobenthemia capitata	Bhamor	20	*Ficus glomerata*	Timla	90
Ficus glomerata	Timla	38	*Pinus roxburghii*	Chir	166
Pinus roxburghii	Chir	131	*Ficus subincisa*	Chanchuru	32
Ficus subincisa	Chanchuru	25	*Cedrus deodara*	Deodar	12
Cedrus deodara	Deodar	67	*Quercus leucotrichophora*	Oak	30
Quercus leucotrichophora	Oak	25	*Ficus virens*	Phelka	40
Ficus virens	Phelka	10	*Ficus subincisa*	Chanchuru	37
Rhododendron arboreum	Buransh	80	*Rhododendron arboreum*	Buransh	57
Lyonia ovalifolia	Anyar	20	**Fast Growing Trees**		
Fast Growing Trees			*Citrus sinensis*	Malta	90
Citrus sinensis	Malta	58	*Prunus americana*	Chuli	13
Prunus americana	Chuli	15	*Prunusn persia*	Aadu	29
Prunus domestica	Apple	98	*Toona ciliata*	Toon	27
Prunus persia	Aadu	35	*Thamocalamus falconeri*	Ringal	7
Pyrus communis	Pear	60	*Bombex ceiba*	Semal	13
Toona ciliate	Toon	23	*Citrus limon*	Badanimbu	40
Thamocalamus falconeri	Ringal	35	*Citrus aurantifolia*	Nimbu	50
Musa paradisiaca	Banana	30	*Morus alba*	Mulberry	28
Citrus limon	Badanimbu	40	**Total**		**1513**
Citrus aurantifolia	Nimbu	50			
Pyrus pashia	Mole	36			
Total		**1659**			

but also the final harvest of timber generates a cash income. Fentahun (2008) also reported that fruit trees from homegardens agroforestry have significant role during environmental crisis of households in Indonesia. While family/especially children's consume fruit trees, it was possible to avoid (buffer) frequency of hunger and decreases number of meals/ day. So dependency on other cereal food crops becomes minimal.

The orchards were having native cultivars of apple, plum, peach, apricot, walnut, orange, lemon, malta, pomegranate with low potential. The status of natural regeneration of tree crop was very poor in the existing systems due to the deliberate removal of seedlings from the field during cultural and other operations. The average number of species per garden did not differ significantly among the homegardens categories, but, density and frequency of species increased with decreasing homegardens size. It considered that owners maintain diversity of plants to fulfill their regular needs regardless of the homegardens size. A study in Zambia showed that some products from homegardens, particularly fruit and cabbage were mostly preferred during drought years (Alfred, 2009). The earlier studies have also demonstrated that, the aspect had a marked effect on the structure and diversity of forest ecosystems (Kusumlata and Bisht, 1991; Bijalwan, 2002; Dhanai and Panwar, 1999; Sharma and Baduni, 2000; Das and Das, 2005; Sahoo *et al.,* 2010; Devi and Das, 2012; Saikia *et al.,* 2012; Kunhamu *et al.,* 2015) had reported that phyto-sociological status was visible among homegardens across the tropics.

(iii) Cultivating lands: About 57.25% of the total area of the villages belonged to this land use group. The cultivation was practiced in well maintained terraces especially in valley and extended to steep slope (30-50%) in narrow terraces. Cropping intensity was low having three crops in two year using traditional varieties with low yield potential. Home state plots have an average contribution to household dietary needs and a food cost was relatively low, on an average 9.9%. Agriculture was the mainstay of livelihood of this region and about 85% of the villagers were engaged in agricultural interventions that is low productive.

Crops grown in the study site: The hill agro-ecosystem was characterised by a distinctly cold winter season, terraced farm plots on steep hill slopes and complex farming systems consisting of agriculture, horticulture, animal husbandry and poultry. The cultivation was practiced on poorly maintained terraces on steep slopes where erosion is the major problem. Some of the important crops are paddy (irrigated), maize, ragi (finger millet), jhangora (Barnyard millet), urd, pea, amaranthus, rajmah, horse gram, ricebean in Kharif and wheat, mustard, toria, lentil peas in Rabi. Vegetable crops like potato, capsicum, radish, vegetable pea, onion, tomato, turnip, coriander and chili in summer (Table 3). The area under vegetable was low. Alfred (2009) explained that some households gave some homegardens products (like fruits, vegetables and sugarcane) to neighbours and relatives, which strengths neighbour and family relationship called social capital.

Table 3: Types of cereals crops preferred in Uttarakhand

Scientific name	English name	Local name	Sowing date	Harvesting date
		Cereals		
Hordeum vulgare	Barley	Jau	Oct-Nov	April-May
Oryza sativa	Paddy	Satti	April-May	Sept-Oct
Triticum aestivum	Wheat	Gehun	Oct-Nov	April-May
		Millet		
Echinochloa frumentacea	Barnyard millet	Jhangora	April-May	Sep-Oct
Eleusine coracana	Finger millet	Mandwa	June	Oct
Setaria italica	Foxtail millet	Koni	April-May	Sep-Oct
		Pulses		
Cajanus cajan	Pigeon Pea	Tor	April-May	Oct-Nov
Glycine max	Soybean	Soyabean	May-June	Sep-Oct
Glycine soja	Soybean	Bhat	May-June	Sep-Oct
Macrotyloma uniflorum	Horse Gram	Gahet	June-July	Sep-Oct
Vigna angularis	Adzuki Bean	Rayans	June-July	Sep-Oct
Vigna mungo	Black Gram	Urd (Kali)	June-July	Sep-Oct
Vigna radiata	Green Gram	Moong	June-July	Sep-Oct

Vigna unguiculata	Cowpea	Sontha	June-July	Sep-Oct
Oils crop				
Brassica campestris	Mustard	Gharia	Oct-Nov	Feb-Mar
Sesamum indicum	Sesame	Til	Apr-May	Sep-Oct
Spices/Condiments				
Cleome viscosa	Unknown	Jakhya	—	Aug-Sep
Perilla frutescens	Perilla	Bhangjeera	—	Sep-Oct

Crops grown in rainfed agriculture in selected Villages: Traditionally agroforestry played a fundamental role in livelihood support for the farmers of Garhwal Himalaya. Rainfed agriculture on terraced slopes was common in Garhwal Himalaya. Traditionally massive amount of leaf litter collected from community forests was allowed to decompose along with livestock excreta and the farmyard manure was transferred to crop fields and incorporated at the time of ploughing. Crop rotation of such three crops was harvested over a period of 2 years. In the first year, during 'Rabi', winter crops like wheat and mustard were grown. In 'Kharif', crops like finger-millet, foxtail, black gram, green gram, pigeon pea, etc were grown. In the second year, during 'Rabi', the land is left fallow and in 'Kharif', upland paddy was grown in rain-fed areas, whereas, in valley irrigated condition pre-sprouting paddy was broadcasted (Table 4).

Table 4: Crops grown in rain-fed agriculture in Uttarakhand

Scientific name	English name	Local name
Rainy crops		
Allium sativum	Garlic	Lassun
Capsicum annum	Chilli	Mirch
Colocasia esculenta	Arum	Arvi
Winter crops		
Amaranthus polygamus	Amaranth	Chulai
Brassica rugosa	Musturd	Rai
Cucrbita pepo	Pumpkin	Kaddu
Lagenaria siceraria	Bottle Gourd	Lauki
Momordica charantia	Bitter Gourd	Karela
Pisum sativum	Pea	Mattar
Solanum tuberosum	Potato	Aalu
Trigonella foenum-graecum	Fenugreek	Methi
Summer crops		
Abelmoschus esculentus	Lady's finger	Bhindi
Glycine max	Soyabean	Soya
Llycopersicum esculentum	Tomato	Tamatar
Solanum melongena	Brinjal	Baigan

Irrigated agricultural land: Irrigated land was confined in valleys along streams. Here, two crops were harvested in a year: rice being the major crop of summer season and wheat in winter season.

Pasture land: About 8.5% (42.21 ha) of the total area of selected villages were under pasture and waste lands particularly on steep slopes. There were many local and introduced fodder species that can be grown successfully in the hill areas. The area within the farm that can be set aside for fodder production being small, nutritive value of grasses was an important consideration. The common grasses were *Agropyron semicostatum, Setaria, Alpuda, Heteropogon* and *etc.* (Table 5).

Table 5: Floristic diversity (Grasses and Shrubs) found in traditional homegardens of Uttarakhand

S. No.	Scientific name	Common name	Family
Grass species			
1	*Andropogon munroi*	Musliya ghas	Poaceae
2	*Chrysopogon fulvus*	Gurla	Poaceae
3	*Cynodon dactylon*	Dubla/Doob	Poaceae
4	*Saccharum narenga*	Kans	Poaceae
5	*Apluda mutica*	Tachula	Poaceae
6	*Heteropogon contortus*	Kumrya ghas	Poaceae
7	*Setaria glauca*	Bandra	Poaceae
8	*Arthraxon ciliaris*	Kandlya	Poaceae
Shrubs species			
1	*Rhus parviflora*	Tungla	Anacardiaceae
2	*Coraria nepalensis*	Makola/ Coriaria	Coriariaceae
3	*Artemisia vulgaris*	Kurinja	Asteraceae
4	*Lantana camara*	Lantana/kuri	Verbenaceae
5	*Eupatorium adenophorum*	Kalabansa	Asteraceae
6	*Berberis asiatica*	Kilmora	Berberidaceae

7	*Solanum khasianum*	Kantili/Kantkari	Solanaceae
8	*Solanum nigrum*	Makoi	Solanaceae
9	*Zanthoxylum alatum*	Timru	Rutaceae
10	*Rubus ellipticus*	Hinsalu	Rosaceae
11	*Rubus niveus*	Kala Hinsalu	Rosaceae
12	*Rosa brunonii*	Kunja	Rosaceae
13	*Murraya koenigii*	Kurry patta	Rutaceae

Continuous exploration for fodder crops in different altitudes and seasons was a crucial focus area for livestock rearing in hills. Fodder requirements were high during the winter months, it is necessary to identify species of low temperature tolerance. Additionally, fodder storage practices have to be promoted among farmers. The existing opportunity to produce and supply high quality fodder to farmers through Van Panchayats in an organised manner has not been fully taken up.

Uses of various trees species grown by farmer in the study area: Homegardens agroforestry play an important role for agro-ecosystem service mainly through providing raw material for compost production.

Farmer grows trees to fulfill their domestic needs and commercial targets. It is worthwhile, that in hilly regions the existence without agroforestry was difficult because trees not only supplement the fodder, fuel, fibre, fruits etc. but also reduces the pace of land sliding in the fields, protect crops to adverse wind and climatic conditions, conserve the moisture, improve the soil quality through nitrogen fixation and organic matter in terms of litter fall etc. The status of natural regeneration of tree crop is very poor in the existing systems due to the deliberate removal of seedlings from the field during cultural and other operations (Saroj and Dadhwal, 1997). The Selection of intercrops depends mainly on edapho-climatic conditions of the area, farmer's need/traditions and resource availability (Bijalwan, 2012). The recorded a total of seven primal used categories like fruit, timber, fuel-wood, fencing, religious, ornamental, medicinal and miscellaneous, with fruit trees as a dominant trees species. At least three of all the plant use categories were found in 70% homegardens - fruits, timber and fencing.

Many of the timber and fruit trees grown in homegardens were also used for fuel-wood purpose. A high percentage of fruit species was linked with multipurpose usage of fruit trees as food, fodder, fuel wood and timber. In the timber category, the most dominant were *Quercus leucotrichophora* and *Cedrus deodara.* In addition to providing food, some fruit trees were multipurpose and played an important role during festivals and in rituals. *Ficus religosa*, *Musa paradisiaca*, *Ficus roxburghii* were found to be a common religious plant in all homegardens. Although farmers grew some species like bhimal in the corner for shade management and protection from storms but they did not followed any definite spacing or planting design for species grown, due to lack of technical knowledge.

Table 6: Floristic diversity (Trees) found in traditional homegardens of Uttarakhand

Domestic trees	Family	Uses
Grewia optiva	Tiliaceae	Fuel-wood, Fodder, Fiber, Shade tree, Fruit
Celtis australis	Ulmaceae	Fuel-wood, Fodder, Fuel wood, Fruit
Ficus clavata	Moraceae	Fuel-wood, Fodder
Cedrus deodara	Pinaceae	Furniture, Fuel-wood, Timber
Quercus leucotrichophora	Fagaceae	Fodder, Fuel-wood, Agriculture implement, Timber
Ficus memoralis	Moraceae	Fodder, Fuel-wood, Fruit
Toona ciliata	Meliaceae	Timber, Fuel-wood, Fuel-wood, Agriculture implement
Quercus glauca	Fagaceae	Fodder, Fuel-wood, Agriculture implement
Lyonia ovalifolia	Ericaceae	Fuel-wood
Myrica esculenta	Myricaceae	Fuel-wood, Fruit, Medicinal
Melia azedarach	Meliaceae	Fuel-wood, Timber
Commercial trees		
Pinus roxburghii	Pinaceae	Fuel-wood, Timber
Juglans regia	Juglandaceae	Fuel-wood, Fruit, Twigs use as toothbrush
Quercus leucotrichophora	Fagaceae	Fuel-wood, Fodder, Timber, Agriculture implement, Soil conservation
Rhododendron arboreum	Ericaceae	Fuel-wood, Juice, Soil conservation
Malus domestica	Rosaceae	Fruit, Fuel-wood

Thamocalamus falconeri	Poacea	Fodder, Ornamental, Construction work, Construction work
Pyrus communis	Rosaceae	Fruit, Fuel-wood
Prunus Persia	Rosaceae	Fruit, Fuel-wood
Prunus domestica	Rosaceae	Fruit, Fuel-wood
Prunus armeniaca	Rosaceae	Fruit, Fuel-wood
Citrus aurantifolia	Rutaceae	Fruit, Medicinal

Gaur (1999) considered that the village community forests were socially valued as fuel- wood, fodder and leaf litter and minor forest products. The leaf litter was used as a component of farmyard manure. Wood of *Alnus nepalensis* was used for carpentry and construction. *Lyonia ovalifolia* was useful for fuelwood, seed paste applied on wounds and boils. *Myrica esculenta* fruit was edible, raw or made into refreshing drinks and its wood was used as fuel and implements. *Pyrus pashia* leaves and twigs were used as fodder, ripe fruits are edible; it was believed to check soil erosion in landslide zones. Wood of *Rhododendron arboreum* used for fuel-wood, charcoal, flowers eaten raw or made into sauce, jellies, jams, refreshing drinks and flowers useful as bee forage.

Fodder and fuel sources: Farmers meet their average daily requirements for animals from agriculture lands, forest area and van panchayat land during different seasons of the year. The farmers use green as well as dry fodder for their animals. The fuel consumption was much higher by farmer during winter season as compare to summer season. The contribution of forest and van panchayat for fuel-wood were 13.5 and 5 kg, 11.5 and 6.5 and 2.6 and 6.2 kg/day for group of farmers during rainy, winter and summer seasons, respectively (Fig. 3).

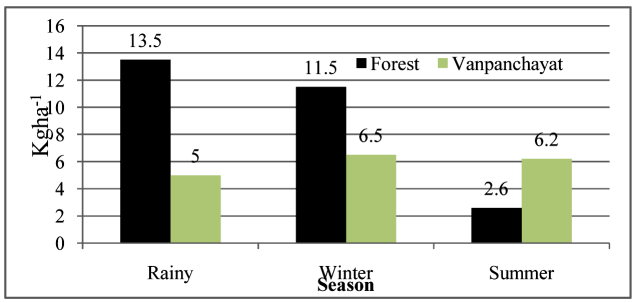

Fig. 3: Amount of fodder use in different season (kgha^{-1})

Fodder scarcity, particularly during winter months was a recurring problem faced by farmers. This issue often tends to get ignored in livestock development programmes, resulting in outcomes far below expectations. Returns from animal-based activities were generally low because of low productivity of animals and the absence of organised marketing channels. This was a reason for the lack of motivation among farmers to invest in livestock.

Table 7: Floristic diversity (Fodder and fuel) found in traditional homegardens of Uttarakhand

Fodder Trees	Local name	Fuel Trees	Local name
Grewia optiva	Bhimal	*Cedrus deodara*	Deodar
Celtis australis	Khadik	*Toona ciliate*	Toon
Ficus subincisa	Chanchru	*Myrica esculenta*	Kafal
Quercus leucotrichophora	Banj	*Quercus leucotrichophora*	Banj
Ficus virens	Phelka	*Lyonia ovalifolia*	Anyar
Quercus glauca	Harinj	*Pinus roxburghii*	Chir
Thamocalamus falconeri	Ringal	*Juglans regia*	Akhrot
Morus alba	Sahtoot	*Rhododendron arboreum*	Buransh
Ficus glomerata	Timla	*Melia azedarach*	Bakain

There are various multipurpose trees that are deliberately retained by the farmers on their agricultural fields, yet *Grewia optiva* being a multipurpose species is widely preferred in agroforestry systems in Garhwal Himalayan regions. This species provides the fodder during the lean period (winter) and therefore, deliberately cultivated by farmers on the bunds of the agriculture fields. The fodder of this species is preferred by the animals and therefore, used for stall feeding, which is believed to enhance the milching property of animals (Bijalwan and Dobriyal, 2014). According to Sehgal *et al.* (2003) *Grewia optiva* is one of the most important fodder trees of north-western and central Himalaya and is found distributed throughout the Sub-Himalayan tracts.

The species is considered to be a boon for the Himalayan regions (Bhatt and Pathak, 2003). *Celtis australis*, *Melia azedarach* and *Ficus roxburghii* are among the preferred trees by the farmers under agroforestry system for the multipurpose benefits in terms of fuel, fodder, fibre etc. along with agricultural crop.

Amount of fodder use by different Livestock: It was revealed that majority of fodder was consumed by horse, *i.e.*, 16.2 kg/day/animal, followed by buffalo 13.5%, bullock 11.8%, cow 7% and sheep 4.5% kg/day/animal (Figure 4). The farmer use green as well as dry fodder for their animals. The dependency on dry fodder is more during winter and summer season as there is a scarcity of green fodder during winter and summer. For dry fodder the farmers collect it from pasture lands or forest lands or crop residue of kharif crop mainly mandua. The amount of fodder collected is totally depends upon the size of family. The farmer does not purchase the fodder from market. Toky *et al*. (1989) reported that the total above ground biomass in agrihortisilvicultural or agrihorticultural system was around 48 t/ha and it was about two fold higher than agrisilviculturtal systems. In fodder tress significant percentage of annual production up to 48% was allocated in current twigs, while in horticultural trees a major portion up to 63% was partitioned in fruits. Trees and shrubs are found ubiquitously but fodder availability for livestock production is limited.

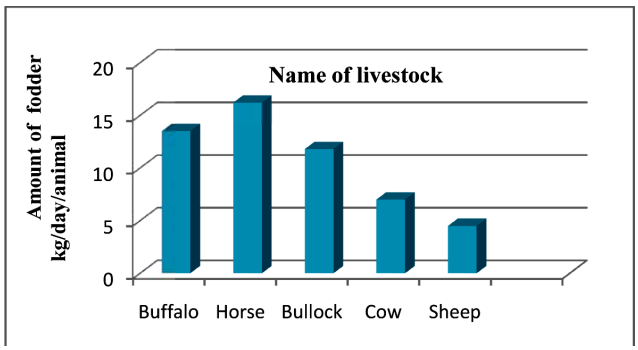

Fig. 4: Amount of fodder consumption in kg/day by different animals

To access the potential of homestead garden in biodiversity conservations and livelihood: Homegardens has high potential for in situ conservation of genetic resources (Kumar, 2011; Kunhamu *et al.*, 2015). It assumed that *In situ* domestication has taken place in homegardens and similar patterns of domestication have happened for other plant species in homegardens around the world, especially in those with long history as in South and Southeast Asia (Wiersum, 2004). A total of 35 species of trees (forest trees+ fruit trees), 18 species of agriculture crops, 13 species of vegetable crops, 9 species of grasses and 13 species of shrub were identified and documented from the study area (Figure 5). *Grewia optiva* was observed as dominant tree species and *Celtis australis* and *Citrus sinensis* as co-dominant species in the study site. *Grewia optiva* (36%) was the most preferred species, followed by *Celtis australis* (33%). These results indicated that homegardens play a vital role in *in situ* conservation of agribiodiversity (Lamprecht, 1989). The commonly represented families of trees species were Tiliaceae Rutaceae, Ulmaceae and *etc.*

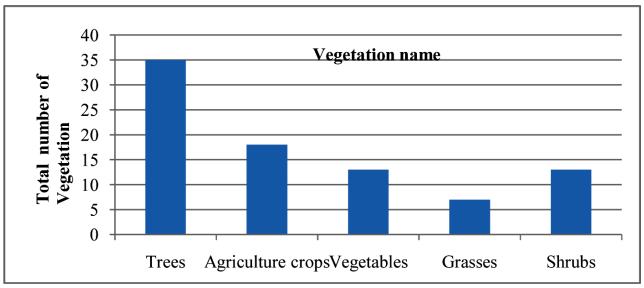

Fig. 5: Total number of vegetation in existing homegardens

Homegardens exhibit complex structure, both vertically and horizontally. The vertical structure of homegardens was composed of 3-4 canopy layers. In the present study, four to five vertical canopy layers were identified in homegardens, the emergent layer, the canopy, the understory, the shrub and the herb layer. The emergent layer had a height of 15 m or more and was composed of multipurpose tree species represented in the canopy layer such as *Quercus leucotrichophora, Toona ciliata, Bombex ceiba and Celtis australis.* The canopy layer was between 10-15m with species such as *Juglans regia, Pinus roxburghii, Cedrus deodara etc.* The understory layer was between 5 and 10 m with species such as *Grewia optiva, Citrus sinensis, Ficus spp, Melia azedarach, etc.* The shrub layer had the height of 1-5 m and was composed of shrubs like *Rhus oarviflora, Rosa brunonii, Rubus niveus* and *Berberis asiatica*. Whereas the herb layer was less than 1 m and was mainly composed of vegetables and grass species like *Lycopersicum esculentum, Allium sativum, Andropogon munroi* and *Cynodon dactylon.*

All the five layers were not present in all homegardens. The canopy, shrub and herb layers were common in all homegardens. The shade provided by the upper layers supports a large number of shade-loving plants like *Colocasia esculenta and Curcuma longa.* It found that there was no separate zone for fruit trees, these trees species were usually grown scattered in the

boundary of the homegarden or grown mixed. Also majority of the trees with multipurpose uses such as timber, fuelwood, *etc.* were usually grown in the forest zones. The multi-layered, forest like vegetation structure of the studied homegarden in the area contributes substantially to the agro-ecological sustainability through reducing soil erosion. Research findings from homegardens of Meghalaya, North-east India also confirms that, multilayered vegetation structure prevents soil erosion, provides habitat to soil micro-organisms and promote a favourable microclimate for the household (Tynsong and Tiwari 2010).

To access the role of Homegardens in livelihood of the farmer: Homegarden have shown to provide a diverse and stable supply of socio-economic product and benefits to the families in the villages. It was noted that the food production was directly increased through edible fruits, nuts, grain etc. During the interview it was clearly noticed that villagers plant trees mainly for household consumption and income in their farm. During the survey of the villages the average income per family was found Rs 1000-4000 in the four study sites. Net income generated by farmers from homegarden from sale of fruits (*Citrus sinensis, Musa paradisiaca, Prunus communis, Prunus armeniaca, Prunus domestica, Citrus aurantifolia)* and vegetable include *Lycopersicum esculentum, Amaranthus polygamus, Cucurbita pepo)* was 6.15%.

Similarly, only 28% of such products were sold in South African homegardens, the remainder being used for household consumption (High and Shackleton, 2000). The net income generated from homegardens was also correspondingly variable. For example, in Indonesia it ranged from 6.6% to 55.7% of total income with an average of 21.1% depending on the size of the gardens, family needs and species composition (Soemarwoto, 1987). It is estimated that about 50% of the total number of homegardens contribute less than 25% of the total income of the household (Sankar and Chandrashekara, 2002). On the other hand, about 32% and 20% of total number of homegardens studied contributed about 25% - 50% and > 50% of the household income respectively.

However, the contribution of homegardens for the state economy of wood and bamboo is significant. For instance, according to Krishnankutty (1990) homesteads provide 74% to 84% of wood requirements in Kerala.

Plant diversity and composition of homegarden in study site: The diversity and species composition of homegardens depend on requirements of the families, preferences and knowledge about use of the species. The homegardens flora are composed of both food and non-food plants. Among the food crops 32%, 19% were fruit species, 7% species were vegetables and 6% pulses & cereals ranked 1st in that order. On the other hand, non-food components of the garden grown include fuel, fodder and medicinal plants. Total number of trees recorded in the study area of Malkhi, khumera, Kurura and Panchan gaun villages were 2667, 2162, 1659 and 1513 (Fig. 6). Average number of species per homegarden varies with the size of the homegardens. The high diversity and complexity in the structure of homegardens fulfil a range of social, economic and ecological functions.

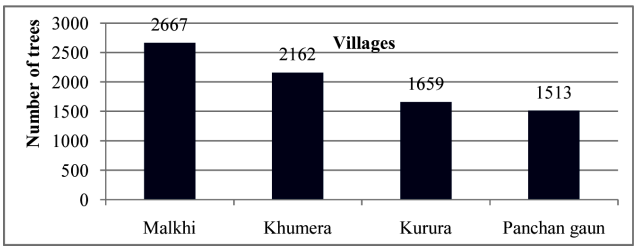

Fig. 6: Total number of trees in selected villages

Out of the total trees in the study site, ten trees were selected according to simple Preference ranking to determine the relative diversity. This technique was employed to rank some selected homegardens species according to their number. Based on their personal preference of efficacy, selected respondents were asked to assign values for each plant. Highest score (1) for maximum diversity and least diversity was given the lowest score (10).

The results of trees diversity using simple preferences ranking in the three study sites showed that tree in Malkhi village have maximum diversity, *i.e.*, 2157 and kurura have lowest diverstity, *i.e.* 1034. The tree species were chosen according to the respondent's consensus. Thus, *Grewia optiva* showed a total number of 2217 trees and ranked first, *Celtis australis* and *Citrus sinensis* with a total of 1512 and 543 ranked second and third positions, respectively (Table 8).

Table 8: Preference ranking for widely used trees in homegardens of Uttarakhand

Scientific name	Study site				Total	Rank
	Malkhi	Khumera	Kurura	Panchan gaun		
Ficus virens	34	67	25	90	216	7
Juglans regia	102	40	35	40	217	6
Grewia optiva	875	586	356	400	2217	**1**
Ficus subincisa	55	18	25	38	136	9
Citrus lemon	75	44	40	40	199	8
Celtis australis	548	300	367	297	1512	**2**
Quercus leucotrichophora	148	201	25	30	404	4
Rhododendron arboreum	25	115	80	57	277	5
Citrus sinensis	280	115	58	90	543	**3**
Toona ciliate	15	34	23	27	99	10
Total	2157	1520	1034	1109	5820	

Factors affecting the homegardens diversity: Homegardeners face a number problem like poor soils, lack of planting material, good infrastructure, transport facilities, inaccessibility of technology, ineffective pest management and improper irrigation facilities in the area. Small and fragmented land holding and low purchase capacity of the farmer also lead to high cost, low return and low income to farmers. Long duration of crops and competition of trees in the same field also cause a lot of problems. Shading effect of planted trees caused low yield of agriculture crop, variation in monsoon, damage of crop due to insect pest, diseases, hailstorm, landslides and other natural calamities affect production. According to the results of semi-structured interviews, the diversity and productivity of homegardens in the study area were mainly affected by lack of agricultural support extension service (83.05%). Disease and pests are the main biological factors of the community sites, which damaged marketable and non- marketable crops.

The same was also found in Holeta Town had high species diversity and a rich floristic composition that is worthy of *in situ* conservation of plant biodiversity, trial sites of new variety of income source vegetables and other species. In addition, homegardens provide significant contributions for the gardener and the society as source of supplementary food, medicinal functions and income. However, insufficient agricultural support, small sized garden and disease and pests affect the diversity of species. If these challenges receive attention by concerned institutions and researchers, the hotspot will maintain its existing biodiversity and traditional management systems on a sustainable basis in the future (Amberber *et al.* 2014).

References

Abdoellah, O.S. 1990. Homegardens in Java and their future development. pp. 69-79. In: K. Landauer and M. Brazil (eds.) Tropical Homegardens. United Nations University Press, Tokyo, Japan.

Alam, M.S. and Masum, K.M. 2005. Status of homestead biodiversity in the offshore Island of Bangladesh. *Research Journal of Agriculture and Biological Sciences* 1: 246-253.

Alfred, M. 2009. Traditional homegardens and rural livelihood in Nhema, Zimbabwe: a sustainable agroforestry system, *International Journal of Sustainable Development World Ecology* **16**: 1–8.

Amberber, M., Argaw, M. and Asfaw, Z. 2014. The role of homegardens for in situ conservation of plant biodiversity in Holeta Town, Oromia National Regional State, Ethiopia. *International Journal of Biodiversity and Conservation* **6**(1): 8-16.

Bhatt, R.K. and Pathak, P.S. 2003. Up scaling quality fodder production in semi-arid tropics by *Grewia optiva*. *ICAR News* **9**(1): 15-19.

Bijalwan, A. 2012. Structure, Composition and Diversity of Horticulture Trees and Agricultural Crops Productivity under Traditional Agri-Horticulture System in Mid Hill Situation of Garhwal Himalaya, India. *American Journal of Plant Sciences* **3**: 480-488.

Bijalwan, A. and Dobriyal, M.J.R. 2012. Productivity of Wheat (*Triticum aestivum*) as Intercrop in Grewia Optiva Based Traditional Agroforestry System along Altitudinal Gradient and Aspect in Mid Hills of Garhwal Himalaya, India. *American Journal of Environmental Protection* **2**(5): 89-94.

Das, T. and Das, A.K. 2005. Inventorying plant biodiversity in homegardens: A case study in Barak Valley, Assam, North East India. *Current Science* **89**: 155-163.

Devi, N.L. and Das, A.K. 2012. Diversity and utilization of tree species in Meitei homegardens of Barak valley, Assam. *Journal of Environmental Biology* **34**: 211-217.

Dhanai, C.S. and Panwar, V.P. 1999. Role of aspect and soil on the structure and composition of *Quercus floribunda* natural stands in Garhwal Himalaya. *Indian Forester* **125**(12): 1204-1213.

Farooquee, N.A. and Saxena, K.G. 1996. Conservation and utilization of medicinal plants in high hills of the central Himalayas. *Environ. Conserv.*, **23**: 75-80.

Fentahun, M. 2008. Fruit Tree Species in the Wild and in Homegarden.

Forest survey of India (FSI). 2015. The state of forest report, Dehradun, FSI, Ministry of environment and forests, Govt of India, New Delhi. pp: 40.

Gaur, R.D. 1999. Flora of the district Garhwal northwest Himalaya (with ethanobotanical notes). Transmedia Publication, Srinagar (Garhwal) India.

High, C. and Shackleton, C.M. 2000. The comparative value of wild and domestic plants in homegardens of a South African rural village. *Agroforest Syst*., **48**: 141-156.

Krishankutty, C.N. 1990. Demand and supply of wood in Kerala and their future trends. KFRI Research Report 67, Kerala Forest Research Institute, Peechi, Kerala.

Kumar, V. 2017. Importance of Homegardens Agroforestry System in Tropics Region. In book: Biodiversity, Conservation and sustainable Development (Issues & Approaches). Prithwiraj Jha, New Academic Publishers, New Delhi.

Kumar, V. and Desai, B.S. 2016a. Phytosociological study of Waghai forest range in Dang district, south Gujarat, India. *Environment and Bio-sciences*, **30**(02): 549-553.

Kumar, V. and Desai, B.S. 2016b. Biodiversity and Phyto-sociological Analysis of Plants around the Chikhali Taluka, Navsari District, Gujarat, India. The Ecoscan, Vol. 10 (In press).

Kumar, V. and Tripathi, A.M. 2017. Vegetation Composition and Functional Changes of Tropical Homegardens: Prospects and Challenges. In: Gupta, S.K., Panwar, P. and Kaushal, R. (Eds), Agroforestry for increased production and livelihood security. New India Publishing Agency, New Delhi, pp. 475-505.

Kumar, S., Malik, M.S. and Kumar, V. 2016. Economics and yield performance of Gamhar (Gmelina arborea Roxb.) under agri-silvicultural system in East Singhbhum district in Jhadkhand, India. In: Gaur *et al.* (Eds). Livelihood and Climate Change Mitigation and Adaptation through Agroforestry (In press).

Kumar, B.M. and Nair, P.K.R. 2004. The enigma of tropical homegardens. *Agroforestry Systems* **61**: 135-152. http://dx.doi.org/10.1023/b:agfo.0000028995.13227

Kumar, B.M. 2011. Species richness and aboveground carbon stocks in the homegardens of central Kerala, India. *Agriculture, Ecosystems and Environment* **140**: 430-440. http://dx.doi.org/10.1016/j.agee.2011.01.006

Kunhamu, T.K., Ajeesh, R. and Kumar, V. 2015. Floristic analysis of peri-urban homegardens of southern Kerala, India. *Indian Journal of Ecology* **42**(2): 300-305.

Kusumlata and Bisht, N.S. 1991. Quantitative analysis and regeneration potential of moist temperate forest in Garhwal Himalaya. *Indian J. For.*, **14**(2): 98-106.

Lamprecht, H. 1989. Siliculture in the tropics. Tropical forest ecosys-tems and their tree species possibilities and methods are the long-term utilization. T2-verlagsgeslls chaft, RoBdort, Germany, p. 296.

Magurran, A.E. 1988. Ecological Diversity and Management. Princeton: Princeton University Press.

Muller-Dombois and Ellenberg, D. 1974. Aims and Methods of vegetation Ecology. John Wiley & Sons, p. 547. New York, London, Sydney, Toronto:, John Wiley and Sons, pp. 547.

Nautiyal, S., Maikhuri, R.K., Semwal, R.L., Rao, K.S. and Saxena, K.G. 1998. Agroforestry systems in the rural landscape – a casestudy in Garhwal Himalaya, India. *Agroforestry Systems*, **41**: 151–165.

Ramakrishnan, P.S. 2001. Ecology and Sustainable Development. National Book Trust, New Delhi, India.

Rana, P., Tewari, S.K. and Kumar, V. 2016. Socio-economic Characteristics of Homegardens in Garhwal Region of Uttarakhand. *Indian Journal of Ecology* (in press).

Sahoo, U.K., Rocky, P., Vanlalhriatpuia K. and Upadhyaya, K. 2010. Structural diversity and functional dynamism of traditional homegardens of North-East India. *The Bioscan*, **1**: 159-171.

Saikia, P., Choudhury, B.I. and Khan, M.L. 2012. Floristic composition and plant utilization pattern in homegardens of Upper Assam, India. *Tropical Ecology* **53**: 105-118.

Sankar, S. and Chandrashekara, U.M. 2002. Development and testing of sustainable agroforestry models in different agroclimatic zone of Kerala with emphasis on socio-cultural, economic, technical and institutional factors affecting the Sector. KFRI Research Report 234. Kerala Forest Research Institute, Peechi, Kerala.

Saroj, P.L. and Dadhwal, K.S. 1997. Present Status and Future Scope of Mango Based Agroforestry Systems in India. *Indian Journal of Soil Conservation* **25**(2): 118-127.

Sehgal, R.N., Rathore, A. and Chauhan, S.K. 2003. Divergence studies in selected genotypes of *Grewia optiva*. *Indian Journal of Agroforestry*, **5**(1&2): 99-102.

Sharma, C.M. and Baduni, N.P. 2000. Structural attributes and growing stock variations on different aspects of high Himalayan and Siwalik chirpine forests. *Journal of Tropical Forest Science* **12**(3): 482-492.

Shrestha, P., Gautam, R., Rana, R.B. and Sthapit, B. 2001. Home gardens in Nepal: status and scope for research and development. pp. 105-124. In: J.W. Watson & P.B. Eyzaguirre (eds.) Homegardens and in situ Conservation of Plant Genetic Resources in Farming Systems. Proceedings of the Second Inter- national Home Gardens Workshop, Witzen-hausen, Federal Republic of Germany.

Soemarwoto, O. 1987. Homegardens: a traditional agroforestry system with a promising future. In: Steppler H.A. and Nair P.K.R. (eds), Agroforestry: A decade of development, ICRAF, Nairobi, pp. 157-170.

Suyal, S., Sharma, C.M., Gairola, S., Ghildiyal, S.K., Rana, C.S. and Butola, D.S. 2010. Phytodiversity (Angiosperms and Gymnosperms) in Chaurangikhal forest of Garhwal Himalaya, Uttarakhand, India. *Indian Journal of Science and Technology* **3**(3): 267-275.

Toky, O.P., Kumar, P. and Khosla, P.K. 1989. Structure and function of traditional Agroforestry Systems in the western Himalaya. I. Biomass and productivity. *Agroforestry Systems* **9**(1): 47-70.

Tynsong, H. and Tiwari, K. 2010. Plant diversity in homegardens and their significance in the Livelihoods of War Khasi community of Meghalaya. *North East India Journal of Biodiversity* **1**: 1–11.

Wiersum, K.F. 2004. Forest gardens as an 'intermediate' land use system in the nature-culture continuum: characteristics and future potential. *Agroforestry Systems* **61**: 123-134. http://dx.doi.org/10.1023/b:agfo.0000028994.54710.44