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Traditional Homegardens as a Sustainable Ecosystem for Maintenance of Biodiversity: A Case Study from Kumaun Himalaya, India

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ABSTRACT Homegardens with trees are one of the agroforestry practices known to be ecologically sustainable and diversifies livelihood of local community. The main objective of this study is to understand the home gardening systems as practiced by rural people in the region, and to provide a base for further scientific studies. The study sites were selected in *Okhalkanda* block of district Nainital in *Kumaun* Himalayan region of Uttarakhand state, India. After primary survey, ten villages involved in homegarden agroforestry were randomly selected and in each village ten households were randomly selected for the collection of data. The total number of species encountered in the homegardens was 86, with vegetables as the dominant use-component. Fodder, fuel wood, fruits, medicinal, miscellaneous, ornamental, pulses, spices and religious were the major plant use categories. As the highest biodiversity and complexity among man-made agro systems homegarden show diversity of production system and diversity of species, both of which are key aspects that determine ecological sustainability.

INTRODUCTION

Homegardens can be defined as 'land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop animal unit being intensively managed by family labour'(Kumar and Nair 2004).They are frequently identified as traditional agroforestry system with complex structure and multiple functions. The most important feature of homegarden is the species diversity that is of immediate use of household (Bargali 2015).The high and maintained diversity of both cultivated and wild plant species makes homegarden suitable for in-situ conservation of plant genetic resources (Bargali et al. 2015). The cultivation of different crops round year is regarded as a strategy of household to fulfill their subsistence and cash needs. Diversification of crops also helps to stabilize yield or income in case of crop failure and fluctuation in market price (Sahoo and Rocky 2015). In addition, diversification also helps in conservation of plant diversity, both wild and cultivated, due to their continuous use by households (Abdoellah et al. 2006). The intimate association between the herbaceous and woody components enhances nutrient recycling and reduces vulnerability to soil erosion.

A diverse and stable supply of socio-economic products and benefits has been provided by homegardens to the families that maintain them (Amberber et al. 2013). In many developing countries homestead agroforestry in the form of homegardens has a long tradition and are an intimate mixture of diversified agricultural crops and multipurpose trees planted and maintained by members of the household (Rahman et al. 2013). The main attributes of these systems, have been identified as their contribution to conservation and livelihoods, high levels of biological diversity, efficient nutrient cycling offered by multi species and multi strata composition, low dependence on external input, improvement of household income as well as nonmarket values of products and services and social and cultural values including the opportunity for gender equality in managing the systems (Kumar and Nair 2004; Bargali 2015; Putri et al. 2016).

In terms of genetics and species, homegardens are the sites of *in-situ* conservation of biodiversity as it provides a sufficient breeding bed for the diverse community of plants (Idohou et al. 2014). Its high production diversity and non-completed harvesting practice has accommodated year-round demand of the household for environmental, economic or social purposes. According to Wiersum (2006) a diverse range of useful plant species in a system enables its

effective adjustment to changing socio-economic condition and demands of current and future generation without negatively affecting the resource bases.

In India, most of the inventory of homegardens has been concentrated in Kerala (Kumar et al. 1994), Assam (Saikia et al. 2012), Karnataka (Shastri et al. 2002) and North East India (Das and Das 2005). However, few studies have been done on the inventory of traditional homegardening systems of *Kumaun* Himalayan region (Agnihotri et al. 2004). To fill this gap, in the present study, an attempt was made to analyse the species composition and utilization patterns of the traditional homegardens in hills of *Kumaun* Himalaya, Uttarakhand, India.

Objectives

The main aim of this study was to analyse the role of homegardening system in maintenance and conservation of biodiversity in the *Kumaun* Himalayan region.

MATERIAL AND METHODS

Study Area

The study area *Okhalkanda* is a village *panchayat* located in the Nainital district ((between 29° 21' – 29° 24' N latitude and 79° 25' – 79° 29' E longitude) of Uttarakhand State, India. The latitude 29.3959469 and longitude 79.6754694 are the geocoordinate of *Okhalkanda*. The block is spread in 192.18 square kilometer area with 65 villages (Fig. 1). Total rural population of block is 48,337 of which 24,427 are males and 23,910 are females (based on Census 2011).

Research Methods

For collection of data, 10 villages were randomly selected in *Okhalkanda* block. The study was based on the primary data collected directly from the field during May 2014 to April 2015 through physical measurement. During study, multistage random sampling method was adopted for data collection. Interviews were conducted targeting primarily old-aged or local experienced persons (usually aged between 30 to 70 years). A total of 100 households, that is, 10 households (PSU, primary sampling unit) from each village were selected for interviewing. A semi structured questionnaire was used for data collection based on the information collected through reconnaissance and pilot survey. All the species found in each household had been accounted for botanical survey. Responses were collected on a variety of demographic and socioeconomic indicators: household species composition, uses of homegarden species, choice of species, cultural activities practices in homestead garden, perceived importance for conservation of species, market access of homestead garden products, and so forth.

Relative frequency of citation (RFC) is used to find out probability between number of respondent who gave citation to each species and number of all respondent. The result describes the local importance of each species. RFC was calculated by following formula (Ghosh 2003; Sharma and Mujumdar 2003):

$$RFC = \frac{NF}{N}$$

Where NF: Number of respondent who gave citation at each species and

N: total of respondent (in this study 100 respondent)

Cultural Important Index (CI) can be used to compare the plant knowledge among different cultures; this also can be used to know diversity information within each species if collaborated with diversity indexes. CI was calculated by following formula (Sharma and Mujumdar 2003; Tardio et al. 2008):

$$CI_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}/N$$

Where, NC=total number of different categories of uses, UR= total number of use reports for each species total and N=number of respondent (100 in this study).

RESULTS

Maintaining homegardens was a quite common practice in the study villages of *Kumaun* Himalaya and almost every household had a homegarden. In the study area, the homegarden size falls within the range of 0.002–0.04 ha with an average of 0. 011 ha. A variety of plant species were grown and maintained in the homegardens and in the present study, 86 plant species distributed in 37 families were recorded growing naturally or cultivated in the homegardens. List of plant species cultivated or maintained in the surveyed homegardens is given in Table 1.The

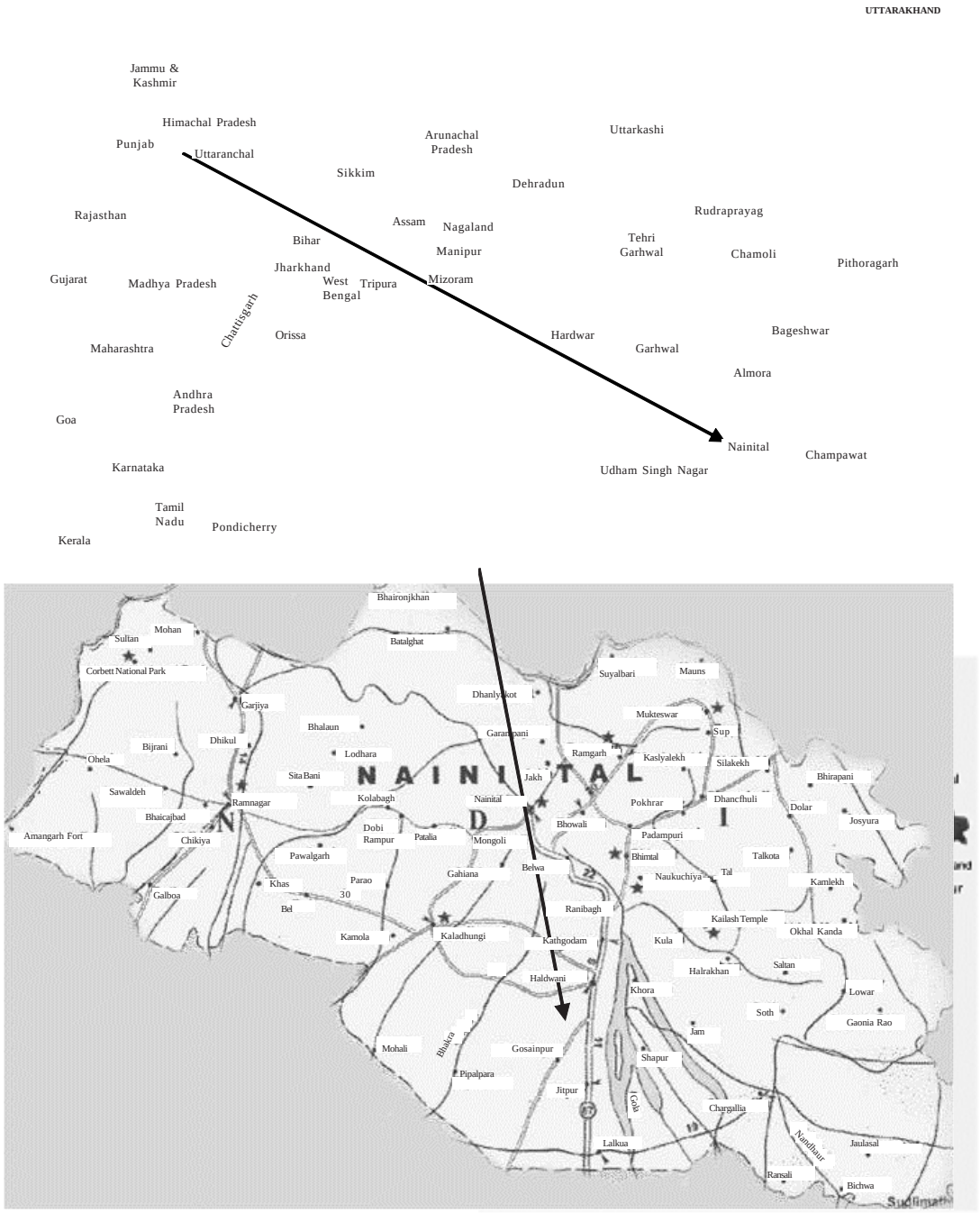

Fig.1. Location map of the study area

Table 1: Plant species growing in the studied homegardens with their habit and traditional uses

Species	*Family*	*Common name*	*Local name*	*Habit*	*Part used*	*Uses*
Abelmoschus esculentus (Linn.) Moench	Malvaceae	Lady's finger	Bhindi	Herb	Fruits	Edible
Ageratum conyzoides Linn.	Asteraceae	Podina jad	Ujawa jad	Herb	Whole plant	Fodder, Medicine
Allium cepa Linn.	Alliaceae	Onion	Piyaz	Herb	Bulb, Leaves	Edible, Medicine
Allium sativum Linn	Alliaceae	Garlic	Lasan	Herb	Bulb, Leaves	Spice, Medicine, Miscellaneous
Amaranthus blitum var. *oleracea* Hook.	Amaranthaceae	Amaranth	Chaulai	Herb	Leaves, Tender twigs	Edible
Amaranthus caudatus Linn.	Amaranthaceae	Ramdana	Chua	Herb	Tender twigs, Seeds	Edible, Medicine
Arachis hypogaea Linn.	Fabaceae	Pea nut	Mungphali	Herb	Seeds	Edible
Bauhinia variegata Linn.	Fabaceae	Variegated bauhinia	Kachnar	Tree	Leaves, Flower buds, Bark	Fodder, Edible, Medicine
Biota orientalis	Cupressaceae	Thuja	Morpankhi	Tree	Whole plant	Ornamental
Bohermaria olerosa Wedd.	Urticaceae	Khagasi	Gethi	Tree	Leaves, Bark	Fodder, Miscellaneous
Brassica compestris Linn.	Brassicaceae	Yellow mustard	Sarson	Herb	Young shoots, Seeds	Edible, Cultural
Brassica juncea (Linn.) Czernajew. & Cosson	Brassicaceae	Black mustard	Layi	Herb	Leaves, seeds	Edible, Miscellaneous
Brassica oleracea var. *botrytis*Linn.	Brassicaceae	Cauliflower	Phulgobhi	Herb	Inflorescence	Edible
Brassica oleracea var. *capitata* Linn.	Brassicaceae	Cabbage	Bandgobhi	Herb	Head	Edible
Cajanus cajan (L.) Millsp.	Fabaceae	Pigeon pea	Arhar	Perennial Herb	Seeds, Whole plant	Edible, Fodder
Canna indica Linn.	Cannaceae	Cana/ Kali haldi	Kwel	Perennial Herb	Whole plant	Ornamental
Cannabis sativa Linn.	Cannabinaceae	Hemp	Bhang	Herb	Stem, seeds	Edible, Fibre, Cultural
Capsicum annum Linn.	Solanaceae	Chilly	Mirch	Herb	Fruits	Edible, Spice, Miscellaneous
Cardemine impatients Linn.	Brassicaceae	-	Ban laiyya	Herb	Whole plant	Fodder
Carica papaya Linn.	Caricaceae	Papaya	Papita	Tree	Fruit	Edible, Medicine
Celtis australis	Ulmaceae	European nettle tree	Karik	Tree	Branches	Fuel
Chenopodium album Linn.	Chenopodiaceae	Pigweed	Bathua	Herb	Leaves	Edible, Medicine
Cinnamomum tamala Nees	Lauraceae	Tejpat	Kikar	Tree	Leaves, Bark	Spice, Medicine
Citrus aurantifolia (Christm) Swing	Rutaceae	Citrus	Kagi nimbu	Tree	Fruits	Edible, Medicine
Citrus aurantium Linn.	Rutaceae	Sweat orange	Narangi	Tree	Fruits	Edible
Citrus limon (Linn.) Burm.f.	Rutaceae	Lemon	Bara nimbu	Shrub	Fruits	Edible, Medicine
Citrus grandis (Linn.) Osbeck	Rutaceae	Grape fruit	Chakotara	Tree	Fruits	Edible
Citrus medica Linn.	Rutaceae	Citron	Galgal	Tree	Fruits	Edible
Citrus sinensis Linn.	Rutaceae	Sour orange	Malta	Tree	Fruits	Edible
Colocasia esculenta Schott	Araceae	Taro	Arbi/ pinalu	Herb	Rhizome	Edible
Coriandrum sativum Linn.	Apiaceae	Coriander	Dhania	Herb	Leaves, Seeds	Edible, Spice, Medicine
Cucumis sativus Linn.	Cucurbitaceae	Cucumber	Kakri	Trailing Herb	Fruits	Edible

Table 1: Contd...

Species	*Family*	*Common name*	*Local name*	*Habit*	*Part used*	*Uses*
Curcuma longa Linn.	Zingiberaceae	Turmeric	Haldi	Herb	Rhizome	Spice, Medicine
Curcurbita maxima Duch. Ex Lam.	Cucurbitaceae	Pumpkin	Kaddu	Herb	Fruits	Edible
Cynodon dactylon (Linn.) Pearsoon	Poaceae	Bermuda grass	Doob	Herb	Whole plant	Cultural, Medicine
Dolichos lablab Linn.	Fabaceae	Lablab	Simi	Herb	Fruits	Edible
Dioscorea bulbifera Linn.	Dioscoreaceae	Potato yam	Gaithi	Climbing vine	Tubers	Edible, Medicine
Dioscorea deltoidea Kunth.	Dioscoreaceae	Tarud	Torh	Climbing vine	Rhizome	Edible, Medicine
Diospyros kaki Linn.	Ebenaceae	Japanese persimmon	Kaku	Tree	Fruits	Edible
Fagopyrum esculentum Moench	Polygonaceae	Buckwheat	Ugal	Herb	Leaves, flour of grains	Edible
Ficus auriculata Lour.	Moraceae	Timil	Timla	Tree	Leaves	Fodder, Cultural
Ficus hispida	Moraceae	Totmila	Totmila	Tree	Leaves	Fodder
Ficus palmata Forssk.	Moraceae	Bedu	Bedu	Tree	Leaves, Latax	Fodder, Medicine
Fragaria nubicola Lindl. Ex Lacaita	Rosaceae	Wild Strawberry	Bhee-kaphal	Herb	Whole plant, Fruits	Fodder, Edible
Galinsoga parviflora Cav.	Asteraceae	-	Khursani gha	Herb	Whole plant	Fodder
Grevia optiva J.R. Drumm.ex Burrett	Tiliaceae	Grewia	Bhemal	Tree	Leaves, Branches	Fodder, Fibre
Hordeum vulgare Linn.	Poaceae	Barley	Jau	Herb	Leaves,Seeds	Fodder, Cultural
Lagenaria siceraria (Mol.) Standl.	Cucurbitaceae	Bottle gourd	Lauki	Large vine	Fruits	Edible
Litsea polyantha Juss.	Lauraceae	Mango Laurel	Katmara	Tree	Leaves	Fodder
Luffa acutangula (Linn.) Roxb.	Cucurbitaceae	Vegetable sponge	Torai	Trailing herb	Fruits	Edible
Lycopersicon lycopersicum (Linn.) Karsten.	Solanaceae	Tomato	Tamater	Herb	Fruits	Edible, Medicine, Miscellaneous
Mangifera indica Linn.	Anacardiaceae	Mango	Aam	Tree	Fruits, Leaves, Small branches	Edible, Cultural, Miscellaneous
Mentha longifolia (Linn.) Huds	Lamiaceae	Mint	Pudina	Herb	Leaves	Medicine, Miscellaneous
Momordica charantia Linn.	Cucurbitaceae	Bitter gourd	Karela	Trailing Herb	Fruits	Edible, Medicine
Mirabilis jalapa Linn.	Nyctaginaceae	Gulabans	Gadgham	Herb	Whole plant	Ornamental
Musa paradisiaca Linn.	Musaceae	Banana	Kela	Perennial Herb	Fruits, Leaves, Whole plant	Edible, Cultural
Nicotiana tabacum Linn.	Solanaceae	Tambaku	Tamakh	Herb	Leaves	Miscellaneous
Ocimum sanctum Linn.	Lamiaceae	Holy Basil	Tulsi	Herb	Leaves, Inflorescence	Cultural, Medicine
Oxalis corniculata Linn.	Oxalidaceae	Indian sorrel	Tipatia	Herb	Whole plant	Fodder, Medicine
Phaseolus vulgaris Linn.	Fabaceae	Kidney Bean	Rajma	Herb	Seeds	Edible
Pisum sativum Linn.	Fabaceae	Pea	Matar	Herb	Seeds	Edible
Prunus cerasoides D.Don	Rosaceae	Padam	Paya/Padam	Tree	Leaves, Branches	Cultural, Miscellaneous

Table 1: Contd...

Species	*Family*	*Common name*	*Local name*	*Habit*	*Part used*	*Uses*
Prunus domestica Linn.	Rosaceae	Plum	Pulam	Tree	Fruits	Edible
Prunus persica (Linn.) Batsch	Rosaceae	Peach	Aaru	Tree	Fruits	Edible
Psidium guajava Linn.	Myrtaceae	Guava	Amrud	Tree	Fruits, Leaves	Edible, Medicine
Punica granatum Linn.	Punicaceae	Pomegranate	Anar/ Darim	Shrub	Fruits	Edible, Cultural, Miscellaneous
Pyrus communis Linn.	Rosaceae	Pear	Nashpati	Tree	Fruits	Edible
Raphanus sativus Linn.	Brassicaceae	Radish	Muli	Herb	Roots, Young leaves	Edible, Medicine
Rosa multiflora Thumb.	Rosaceae	Rose	Gulab	Shrub	Flower	Ornamental, Cultural
Rumex hastatus D.Don	Polygonaceae	Bilmora	Chalmora	Under shrub	Shoots, Leaves	Fodder, Medicine
Saccharum officinarum Linn.	Poaceae	Sugarcane	Ganna	Herb	Stem	Edible, Cultural
Salvia officinalis Linn.	Lamiaceae	Garden sage	Salvia	Shrub	Whole plant	Ornamental
Sesamum indicum Linn.	Pedaliaceae	Sesame	Til	Herb	Seeds	Edible, Cultural
*Solanum melongena*Linn.	Solanaceae	Brinjal	Baigan	Herb	Fruits	Edible
Solanum tuberosum Linn.	Solanaceae	Potato	Alu	Herb	Tubers	Edible
Spinacea oleracea Linn.	Chenopodiaceae	Spinach	Palak	Herb	Leaves	Edible
Tagetes erecta Linn.	Asteraceae	Merigold	Genda/Hajari	Herb	Flowers, Leaves	Ornamental, Cultural, Medicine
Tinospora cordifolia (Willd)Miers ex Hook.	Menispermaceae	Giloe	Gurg	Fleshy Climber	Stem	Medicinal, Cultural
Trichosanthes anguina Linn.	Cucurbitacea	Snake gourd	Chichenda	Trailing Herb	Fruits	Edible
Trigonella foenum-graecum Linn.	Fabaceae	Fenugreek	Methi	Herb	Leaves, Seeds	Edible, Medicine
Urtica dioica Linn.	Urticaceae	Common Nettle	Shisoon	Shrub	Young shoots	Fodder, Edible
Vicia faba Linn.	Fabaceae	Broad bean	Bakla	Herb	Young pods	Edible
Vigna unguiculata (Linn.) Walp.	Fabaceae	Cow pea	Lobia	Herb	Seeds	Edible
Vitis vinifera Linn.	Vitaceae	Grape	Angur	Vine	Wine	Edible
Zea mays Linn.	Poaceae	Maize	Makka	Herb	Seeds, Whole plant	Edible, Fodder, Cultural
Zingiber officinale Roscoe	Zingiberaceae	Zingiber	Adrak	Herb	Rhizome	Spice, Medicine

family having the highest number of species was Fabaceae (with 09 species) followed by Brassicaceae, Rosaceaeand Rutaceae (each with 06 species), while most of the families were represented by one or two species (Table 2).Plants were usually planted in the front, back and surrounding the houses. Ornamental plants such *Tagetus* sp. *Canna indica*, *Biota orientalis* etc. and major fruits tree species like *Mangifera indica*, *Citrus* sp. *Carica papaya*, etc were grown in front yard at distance from the house because according to inhabitants these species have extended roots that may affect the house and their eventual falling down may destroy the house. Farmer generally collects planting materials from homegarden wilding (species that were grown/ collected from outsides homegardens premises), friends and families, relatives, government and NGO nurseries. In *Kumaun* Himalaya, there is no specific management practiced for homegardens which are being traditionally managed by the household owners. No specific spacing is followed in planting of species in homegarden.

Table 2: Distribution of homegarden species in different families

Family	*Number of species*
Alliaceae	2
Amaranthaceae	2
Anacardiaceae	1
Apiaceae	1
Araceae	1
Asteraceae	3
Brassicaceae	6
Cannabinaceae	1
Cannaceae	1
Caricaceae	1
Chenopodiaceae	2
Cucurbitaceae	6
Cupressaceae	1
Dioscoreaceae	2
Ebenaceae	1
Fabaceae	9
Lamiaceae	3
Lauraceae	2
Malvaceae	1
Menispermaceae	1
Moraceae	3
Musaceae	1
Myrtaceae	1
Nyctaginaceae	1
Oxalidaceae	1
Pedaliaceae	1
Poaceae	4
Polygonaceae	2
Punicaceae	1
Rosaceae	6
Rutaceae	6
Solanaceae	5
Tiliaceae	1
Ulmaceae	1
Urticaceae	2
Vitaceae	1
Zingiberaceae	2

Most of the homegardens in the study area showed four strata. A or canopy layer was composed of big tree, sub canopy layer or B strata was composed of middle size tree (5m to 10m height), under canopy or C strata was composed of shrubs and saplings (1 to 5m height) and ground vegetation (<1 m height) included herbs, seedlings of both tree and shrub species. The common tree species in the A strata was *Mangifera indica*, B strata was composed of *Carica papya, Ficus hispida, Cinnamomum tamala, Citrus limetta, Musa* sp. *and Punica granatum.* C strata was composed of *Psidium gujavaja* and *Prunus persica*. The shrub layer composed of *Citrus* sp. and the dominated plants in herbs layer were *Ageratum conycoides, Cynodon dactylon,Curcuma longa, Galinsoga parviflora,* and *Zinger officinale* etc.

Species Composition and Their Use Categories

According to perception of local people, homegarden provide the following benefits viz.food, fodder, medicine, spice, miscellaneous, cultural, ornamental, fibre, and fuel. A total of 39 species have one use type, 38 species have two use types and 8 species were with three use types. The maximum number of species were edible followed by medicine, fodder, cultural/ritual, spice, ornamental, fibre, fuel and other uses (Table 3). Leaves and fruits were most frequently used plant parts while some parts like flowers and flour were rarely used (Table 4).

Edible

Of the total recorded plant species as grown in the homegarden, 67 percent were edible (Table 1). Most of the species were used as vegeta-

Table 3: Mean number of species per use category in surveyed homegardens of Kumaun Himalaya

Use category	*Number of species*
Edible	57
Fodder	17
Medicine	28
Spice	6
Miscellaneous	10
Cultural	16
Ornamental	6
Fibre	2
Fuel	1

Table 4: List of plant parts utilized for various purposes in surveyed homegardens of Kumaun Himalaya

Plant part used	*Number of species*
Flower bud	1
Flour	1
Young pods	1
Roots	1
Latex	1
Young shoots	2
Bulb	2
Tender twigs	2
Inflorescence	2
Flower	2
Bark	3
Tubers	3
Rhizomes	3
Branches	7
Whole plant	12
Seeds	14
Leaves	28
Fruits	28

ble and fruits. The edible fruit yielding plants such as *Musa* sp., *Citrus* spp. etc. were considered as nutrition species. Major seasonal vegetables common in all the studied homegardens were *Capsicum annum*, *Brassica* sp. *Solanum melongena*, *Dolichos lablab* etc. Different parts of plants growing in homegarden were utilized as edibles. The young shoots of *Urtica dioca* were used as vegetable during winter season. The local people were well aware of the nutritious properties of some important plant species; therefore, they cultivate and maintain these species in their homegardens. Some local vegetables such as sweet gourd, reddish, pumpkin etc. were cut into pieces, dried and stored for use during offseason.

Cultural Uses

Plants grown in homegardens were used in various cultural practices as about 19 percent of total species reported from the studied homegardens was used to perform a range of rituals. Mango leaves *(Mangifera indica)* were used in *kalash sthapana* during *puja* ceremony and also used to prepare festoons for religious and other auspicious festivals, adorning *mandaps* and home. Festoons were intended as a charm to make the house devil proof. *Doob* grass *(Cynodon dactylon)* was widely used by local inhabitants in many religious ceremonies and rituals. The tips of this grass shoot having 3 to 5 blades were collected and offered to Lord *Ganesh* during *puja* ceremony. Banana plant and fruits *(Musa sp.)* are considered very auspicious in all religious and social ceremonies and fruit was a common offering to gods. The banana plant and leaves were widely used to make welcome gate during marriage ceremony. Stem of *gurja/ giloe (Tinospora cordifolia)* and inflorescence (locally known as *manjari*) of *tulsi (Ocimum sanctum)* were used during *shivarchan* (*Parthiv ling puja* ceremony).

Paste of *haldi (Curcuma longa)* and *sarso (Brassica compestris)* along with oil is used in *Haldi* ceremony of bride and groom during marriage ceremony. *Til (Sesamum indicum),* flowers of marigold *(Tagetes erecta)* and *gulab (Rosa multiflora)* form an essential article of religious ceremonies. The leaves of *tulsi (Ocimum sanctum)* make one of the constituents of charnamrit prepared during *puja* ceremony. During an eclipse, *doob* grass leaves were ingested and also placed in cooked food and stored water to ward off psychic pollution and help to avoid any ill effect. *Tulsi* leaves were kept in the mouth and on the breast of the dying person to ensure passage to heaven. The small branches of mango (*Mangifera indica*) and seeds of *til (Sesamum indicum)* were used in *havan* (sacred fire). The seeds of *til (Sesamum indicum), jau* (*Hordeum vulgare*), and leaves of *timil (Ficus articulata)* and marigold *(Tagetes erecta)* were used in *pitritarpana* during *shradh* as an oblation to deceases ancestors.

Sugarcane *(Saccharum officinarum)* pieces with some other fruits were offered to goddess Lakshmi during Diwali festival. In the evening of *Tryodashi* to perform *Pradosh Puja* of Lord Shiva sugarcane juice was offered.

Medicinal Use

Though growing plants in homegardens primarily for curing diseases was not the major objective of the local rural people in the study villages of *Kumaun* Himalaya. However, even today, a large number of rural households utilize many plants as medicine in home remedies (*Padaliya* et al. 2015; Parihaar et al. 2015; Pande et al.2016). A total of 28 plant species were used in curing various ailments by the local people. *Citrus* species *kagni nimbu* were used to cure stomach disorder by making juice and pickle. *Tulsi*

(Ocimum sanctum) was regarded as an extraordinary plant and since ancient times was used to cure cough and cold by mixing with zinger and/ or honey. According to some people tulsi purify and depollute the atmosphere. The extract of *Ageratum conzoides* was used in heeling cuts, and the extract of *Tagetus* sp. was used in curing earache. Unopen buds of *kachnar (Bahunia variegata)* were used as vegetable and pickle to cure various stomach ailments/ disorders. *Tinospora cordifolia* stem is used during fever. The juice of sugarcane was a folk remedy for arthritis, bed sores, boils, cold, cough, fever and jaundice. The latex of *bedu (Ficus palmata)* was used to cure injury in humans as well as animals.

Fodder

Fodder trees growing in homegarden area were utilized as green fodder particularly during winter season when green fodder was not available. In hills, fodder collection is a very important but very tough job, as rural women has to travel a long distance to collect fodder for livestock. In such situation lopping of branches of homegarden fodder trees not only reduce pressure on natural forest but also reduce stress of rural women. In the present study, 17 species were being used as fodder. *Bohermaria olerosa*, *Grewia optiva*, *Ficus* spp. *Bahunia variegata* were most common fodder yielding plants present in almost all homegardens. Besides this, grasses growing on the margins, walls of terraced fields, straw of maize, barley, cow pea and other leguminous crops were dried, stored and used as fodder during lean period.

Miscellaneous/Other Uses

Trees growing in homegarden area were used for various purposes. The miscellaneous uses include shade, ornamental, ceremonial, environmental and aesthetic. The ecological benefits of homegarden include conservation of soil water, nutrients and biodiversity (Masum et al. 2008). Dry grasses (collected from bunds of agricultural fields and fallow lands) straw of wheat and paddy and in some cases fire wood were stored on the trees of homegarden for the use of next year. This method avoided pest attack and kept the grasses and straw dry. Some wild herbs and grasses growing in homegarden were used as fodder. Growing plants mostly for vegetable during different seasons of the year continued greenery of homegardens, which also provided the cultural services, especially in terms of scenic beauty. The branches of *Prunus cerasoides* is used for making handles of agricultural equipments. The dried rachis of fern *(Chilenthus sp.)* was used for making nose and ear studs. The bark of *Bohermaria olerosa* was dried and mixed with flour of *Elucine carcogena (Madua)* to increase nutritive value and decrease roughness. The paste of fresh bark of this species was used in making vegetable of young shoots of *Urtica dioca*.

Ornamental plants like *Biota orientalis (morpankhi)*, *Canna indica (kwal)*, *Rosa* spp. *(gulab)*, *Tagetus (genda)* etc. were cultivated to increase the scenic beauty of homegardens. Some of the cultivated species of homegardens were also marketed. Some vegetables and fruits were sold in the nearby market for monetary benefits. The most marketed vegetables were chilly (*Capsicum* sp.), tomato *(Lycopersicum lycopersicon)*, beans *(Phaseolus* sp.) and most marketed fruits were *Citrus* spp. *Sesamum indicum* was grown for household consumption and surplus amount was sold.

Maintenance of Homegardens

Women were main managers of homegardens, sowing, planting, maintenance and harvest of most of the homegarden products. Men participate in activities such as tree pruning, weeding, fertilization, action against pests and harvesting of some products mainly those of tall trees (Bargali 2015). In the study area, people use ash from home fire, manure prepared by dung and leaves collected from nearby forests. Sometimes chemical fertilizer was also used particularly for cash crops. Pruning was also practiced to collect fodder and to make easy harvesting of homegarden products. Ornamental plants growing close to houses were irrigated regularly particularly during dry season. Fruit trees were occasionally irrigated as irrigation was a major constraint due to scarcity of water.

DISCUSSION

A total of 86 plant species were recorded from the selected homegardens of the *Kumaun* Hi-

malayan region. Several studies have reported that species diversity in a homegarden ranged from less than five (Ahmed and Rahman 2004; Abdoellah et al. 2006) to more than 100 (Hemp 2006).These homegardens also showed stratification of vegetation with mixture of trees, shrubs and herbs. The overall species diversity was largely based on the traditional ecological knowledge of the local community which is a part of their cultural practices. The species cultivated and maintained in the homegardens ranged from fuel wood *(Ciltis australis)*, fodder *(Bohermaria olerosa*, *Grewia optiva)*, fruits *(Musa paradisiaca*, *Citrus* spp.), medicinal *(Ocimum sanctum*, *Tinospora cordifolia),* spices *(Capsicum annum*), vegetable *(Solanum melongena*, *Dolichos lablab)* religious *(Sesamum indicum)* ornamental (*Tagetes erecta*) etc. Many plant species were multipurpose. In addition to these, contribution of weeds *(Ageratun conjoides)*, grasses *(Cynodon dactylon)*, pteridophytes *(Adiantum* sp. *Selaginella* sp.) and bryophytes *(Funaria* sp.*)* to the floristic diversity of the homegarden cannot be ignored.

Tradition homegardens of study area were rich in biological diversity harboring many local crop species. Associated knowledge, cultural and rituals of local people sustain such diversity. *Colocasia* sp.*, Dioscorea* sp.*, Solanum tuberosum* were the common and subsidiary tuberous food crops while, *Solanum melongena* and *Capsicum* sp. were common vegetable crops. This system was highly diverse and complex with mixed cropping pattern, involving simultaneous growing of as many as 15-20 crops in the same field (though in small quantity). Growing a few individuals of many species in a small area, not only enhance the dietary diversity of the homegarden's owner but also maintain the fertility of soil (Bargali et al. 2015). Given the small size and location of homegarden within the compound of individual household, hiring of labour was generally not required and raising homegarden was dependent on the family labour. However, mutual labour support mechanism with neighbours was reported in some families of studied homegardens. Similar observations were also reported from other part of world (Buchmann 2009; Kala 2010; Rowe 2009). Homegardens are

Table 5: RFC and CI of homegarden tree and shrub species (for detail see methods)

Species	*Basic value*			*Ethnobotanical indexes*		*Rank order*	
	FC	*NC*	*UR*	*RFC*	*CI*	*RFC*	*CI*
Bauhinia variegata	90	150	03	0.90	1.50	3	5
Biota orientalis	05	05	01	0.05	0.05	24	24
Bohermaria olerosa	95	175	02	0.95	1.75	**1**	2
Carica papaya	15	25	02	0.15	0.25	23	23
Celtis australis	67	127	02	0.67	1.27	13	12
Cinnamomum tamala	25	45	02	0.25	0.45	22	21
Citrus aurantifolia	76	146	02	0.76	1.46	9	7
Citrus aurantium	62	62	01	0.62	0.62	15	17
Citrus limon	79	138	02	0.79	1.38	7	10
Citrus grandis	37	37	01	0.37	0.37	21	22
Citrus sinensis	87	87	01	0.87	0.87	5	14
Citrus medica	46	46	01	0.46	0.46	19	20
Diospyros kaki	04	04	01	0.04	0.04	25	25
Ficus auriculata	89	169	02	0.89	1.69	4	3
Ficus hispida	47	47	01	0.47	0.47	18	19
Ficus palmata	78	148	02	0.78	1.48	8	6
Grevia optiva	92	182	02	0.92	1.82	2	**1**
Litsea polyantha	80	145	02	0.80	1.45	6	8
Mangifera indica	60	158	03	0.60	1.58	16	4
Musa paradisiaca	74	144	02	0.74	1.44	10	9
Prunus cerasoides	68	128	02	0.68	1.28	12	11
Prunus domestica	38	38	01	0.38	0.38	20	21
Prunus persica	58	58	01	0.58	0.58	17	18
Psidium guajava	39	68	02	0.39	0.68	20	15
Punica granatum	73	123	03	0.73	1.23	11	13
Pyrus communis	63	63	01	0.63	0.63	14	16

not static, but have evolved over centuries as an adaptive ability of farmers in response to changing rural and livelihood conditions (Kumar and Nair 2004). Traditionally, the homegardens mainly served to produce vegetables, fruits and other crops which supplemented the staple food crops produced on open croplands.

Local and Cultural Importance of Plant Species

Based on information provided by local inhabitants, local and cultural importance of tree and shrub species growing in homegadens of studied village was calculated (Table 5).*Bohemaria olerosa* was the most useful species (RFC= 0.95) and *Grewia optiva* was the most culturally significant species (CI=1.82). This is due to the higher use value of *G. optiva*, because each added value is measure of the relative importance of each plant use. As *Diospyros kaki* was least frequently cited fruit tree, it showed lowest value of RFC and CI (0.04). The low citation of species by local informants does not mean that these species were less useful, but it highlighted species with high cultural agreement for the total survey area and for recognizing the shared knowledge of local people (Tardio et al. 2008).

Role of Homegardens in Biodiversity Conservation

Biodiversity has become a growing concern for all over the world and it is linked up with long term health and vigor of the environment and also as a regulator in ecosystem functions (Serrano et al.2016). Due to anthropogenic pressure and land use change the natural forest has been under pressure and decreasing day by day. In this situation, homegardens have been the most effective and under spread measure for biodiversity conservation. In *Kumaun* Himalayan region, rural people have cultivated and planted multipurpose species that can severe as fruits, fodder, fuel, vegetable, species etc. Such kind of choice plays a significant role in conservation of forest since most of the demand of fodder and fuel was fulfilled by homegarden species. These homegarden also attract a number of bird species which play significant roles as pollinators or in the control of insect pest. Rural people were interested in maintaining plant diversity in their homegardens because they use homegarden products such as vegetables, fruits, spices etc. throughout the year and save money. However, many were also interested in conserving the environment (58%) and reducing biotic pressure on forests (Table 6).

Table 6: Reasons for plant diversity conservation in homegardens

Reasons	*Percentage**
Source of food/food security	86
Save money	62
Source of alternative income	57
Ensure progress of their family	38
Soil stabilization	54
Preserve environment	58
Source of fuel wood and fodder	75
Reduce pressure on forest	52

*Note: Due to multiple responses, percentages do not add up to 100%

The low availability of some highly useful plant species in the wild (for example, ritual, edible and medicinal plant species) had also encouraged people to cultivate these plants in the homegardens. This practice not only help in conservation of genetic pool of species which are declining in the wild but also provide a safety net to the local people in case of exigency. Given the valuable Traditional Ecological Knowledge interwoven with homegardens along with their ecological, environmental and economic significance, the farmers may be encouraged to continue the tradition of raising home gardens in view of maintaining the biodiversity as well as the livelihood of local people. The high species richness and evenness of different plant growth from could improve the resistibility of each individual species. This leads to a synergistic ecological process where the ecosystem is allow to functions naturally and each species would inherit the ability to adapt to a changing environment for this long term survival with in a balances and harmonious state (Putri et al. 2016). Moreover, this species rich ecosystem also forms a stable buffer against biotic (such as pests and disease) and abiotic (such as drought) stress (Wiersum 2006). Hence, this attribute is able to reduce the failure if compared with monoculture trend.

CONCLUSION

The present study indicated vital role of homegarden in conservation of biodiversity.

Homegarden as an ecosystem contain multiple levels of diversity, including cultural, genetic and agronomic diversity. They are not only important sources of food, fodder, fuel, medicine, spices and income, but are also important for *in-situ* conservation of a wide range of plant genetic resources. Some studied homegardens mimic the natural structure of forest systems, with the crucial difference that nearly all the species present in the homegarden were used. Thus, a valuable conservation role of homegarden is as a sustainable use system within or around protected forest areas. Homegardens are often the focal point for a household's social interaction within the family, relatives and friends. One of the important functions that homegarden perform is to keep knowledge of varieties and uses of diversity alive from generation to generation. Homegarden also provide ecosystem services to the larger agricultural system and health and well-being of the household. They provide protected and enriched environment for varieties that may have been more susceptible to biotic and abiotic stresses in the fields. The contribution of homegardens to conservation is dynamic and ensures the maintenance of adapted materials which provide direct benefits to the owners and to the users of homegarden products.

RECOMMENDATIONS

The high plant diversity of homegarden fulfills a range of social, economic and ecological functions. Conservation through use approach is a unique conservation strategy adopted in the management of homegarden systems. Therefore, there is urgent need to document such traditional systems of natural resource management for economic viability and ecological sustainability. In view of the fact that traditional homegardens are ecologically sustainable and still rely upon traditional knowledge attempt should be made to revive these systems to conserve biodiversity.

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