

Contribution of Homegarden Agroforestry to Livelihood of Rural Farmers in Nainital, Uttarakhand

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Introduction

Homegardens are commonly defined as: A piece of land with a definite boundary surrounding a homestead, being cultivated with a diverse mixture of perennial and annual plant species, arranged in a multilayered vertical structure, often in combination with raising livestock, and managed mainly by household members for subsistence production (Fernandes and Nair 1986; Christanty, 1990; Kumar and Nair, 2004). Nair and Kumar (2006) emphasised that the multi-layered vegetation structure as well as the intimate combination of trees, shrubs, and annual crops are essential for the concept of homegardens, whereas physical proximity to the homestead is, in some situations, not crucial. 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. 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). A diverse and stable supply of socio-economic products and benefits has been provided by homegardens to the families that maintain them (Christanty 1990).

In rural region of Uttarakhand state, homegarden is a traditional land use system practiced around a homestead where several species of plants are grown and maintained by the members of household and the products are intended primarily for household consumption. Homegarden cultivation was estimated to be the better economic option for such landowners, even considering the opportunity costs for land and labor. These gardens have proven to be highly diverse systems, with a wide variety of plants designed to provide a wide range of benefits. Although homegardens have been extensively described, there is a lack of quantitative data about their benefits. In general, these studies confirm that people in households with productive homegardens do consume more nutritious fruits and vegetables, though most studies do not quantify the amounts consumed.

In rural areas of Nainital district, farmers have small land holdings therefore, they largely depend on natural resources for meeting diverse subsistence needs which has led to over-exploitation. Agroforestry as a science and practice has the potential to contribute to the improvement of rural livelihood, due to capacity of its various forms to offer multiple alternative

and opportunities to the rural farmers to enhance farm production and income while protecting the agricultural environment. Homegarden agroforestry system, with its intensive and multiple uses provide a safety net for households when food is in scarce. Because of high plant diversity in the homegardens, a wide spectrum of multiple use plant products can be generated with relatively low labour, cash or other inputs. Homegarden also supplement family income through sale of surplus produce in the market specially vegetables, fruits, species and herbs etc. The review of literature showed that homegarden are an important element of rural landscape of many countries and they play a vital role in bioresource based economy of the region. However, there is a lack of research on plant diversity and economic value of homegardens in rural areas of Nainital district. Keeping this gap in consideration, an attempt would be made in the present study to provide valuable information on different aspects of homegardens and their role in rural livelihoods in Nainital district of Uttarakhand state.

Objectives:

- i. To analyse plant species diversity in homegardens of rural areas in Nainital district.
- ii. To analyse socio-economic importance of homegardens in rural area Nainital district.
- iii. To investigate the contribution of homegardens towards income generation of the rural people.
- iv. To determine the constraints in management of homegardens.
- v. To develop policy recommendation and management strategies for homegarden management.

Material and Methods

2.1 Study site

Uttarakhand state forms a part of Western Himalaya and is predominantly hilly and mountainous. The study sites were selected between 350-2400 m above mean sea level (at 29°19'-29°28' N and 79°22'-79°38' E) in Nainital district of Uttarakhand state (Fig.2.1). The study area falls in sub-tropical to temperate climate. The maximum temperature was 40.2° C and minimum temperature was – 5.4° C. The average rainfall was 2100 mm. Mostly subsistence and crop based farming is prevailed in the area. In hilly regions cultivation is done on varying degree of slopes and terrace farming is most common. Cultivated soil grows crops like rice, wheat, corn, mustard, potato, ginger, garlic, onion and varieties of pulses and vegetables. Main fruits are mango, jackfruit, banana, litchi, papaya, citrus, peach, plum, etc. In homegarden area, different types of perennial fruits, timber, fuel wood, fodder and annual vegetable plants prevailed.

2.2 Data collection

Different villages practicing homegarden agroforestry were randomly selected in hill and bhabhar region of Nainital district. Three complementary approaches were adopted, namely; (a) formal interview with the village headmen (pradhan) and secretary, (b) direct observation, (c) interaction with the head of the selected households through questionnaires (Fig. 2.2). The survey was administered to a random sample of 30 households in each village. For plant species inventory, whole homegarden was used as sample plot. The plant species were recorded with the help of homegarden owner and identified with the help of vernacular names and floras of the region. The information on the uses and importance of plant species were collected by using questionnaires and focus group discussion. Durations of sedentary, moderate or heavy works by males and females in various activities and bullock power use were noted.

2.3 Vegetation analysis

In Bhabhar and Hill belt of Nainital district, 15 villages actively engaged in homegardened agroforestry were randomly selected at three altitudes viz. very low (upto 500 m), mid (500-1500 m) and high (above 1500 m). In each village 10 homegardens were selected purposively as ultimate

sampling unit for data collection. Homegardens were classified into three categories depending upon the size of homegarden holdings: large, medium and small homegardens.

For the collection of phytosociological data the quadrat method was used. Trees and saplings were sampled in 10x10 m quadrat, shrubs in 5x5 m quadrat and seedlings and herbs in 1x1m quadrat within each plot (Curtis and McIntosh, 1950; Phillips, 1959). Circumference at breast height (cbh at 1.37m from the ground) of individual tree and sapling was measured in each quadrat. Density, frequency, abundance and basal area and Importance value index (IVI) were calculated following Cottam and Curtis, (1956). Species richness (Margalef 1958), Shannon diversity Index (Shannon and Weiner, 1963) and Simpson dominance Index, (Simpson 1949) were also computed based on phytosociological data.

Index of similarity (IS) between forests was calculated following (Muller–Dombois and Ellenberg, 1974) using species richness in different forests as:

$$\text{Index of similarity (IS)} = \frac{2C}{A + B} \times 100$$

Where C is the common species in comparison sites,

A is the total number of species in site A and B in site B.

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).

2.3 Economic contribution of homegarden

2.3.1 Energy budget

Standard energy values of various inputs and outputs used for budgeting are given in Table5. Hours spent by males and females for sedentary, moderate and heavy works were multiplied by per hour energetic value of a given type of work and the products summed up to obtain total human labour input per year in a given land use system. Similarly, duration of bullock power use was multiplied by energetic value of bullock power to computed total energy of this input. Energy inputs through seeds and manure and outputs through edible yields, fuel wood, fodder and litter were calculated by multiplying the amount of an input/output related to its standard energetic value.

2.3.2 Monetary budget

Household income from homegarden was calculated by asking the respondents the amount of homegarden products they sold and consumed. In order to computed the contribution of the homegardens towards farmers' income, gross income was calculated by adding the amount of money earned from all the products collected from homegardens including those used for self consumption and sale. From this gross income the cost of expenditures in maintenance of the homegardens and marketing of plant products was deducted to get net benefits.

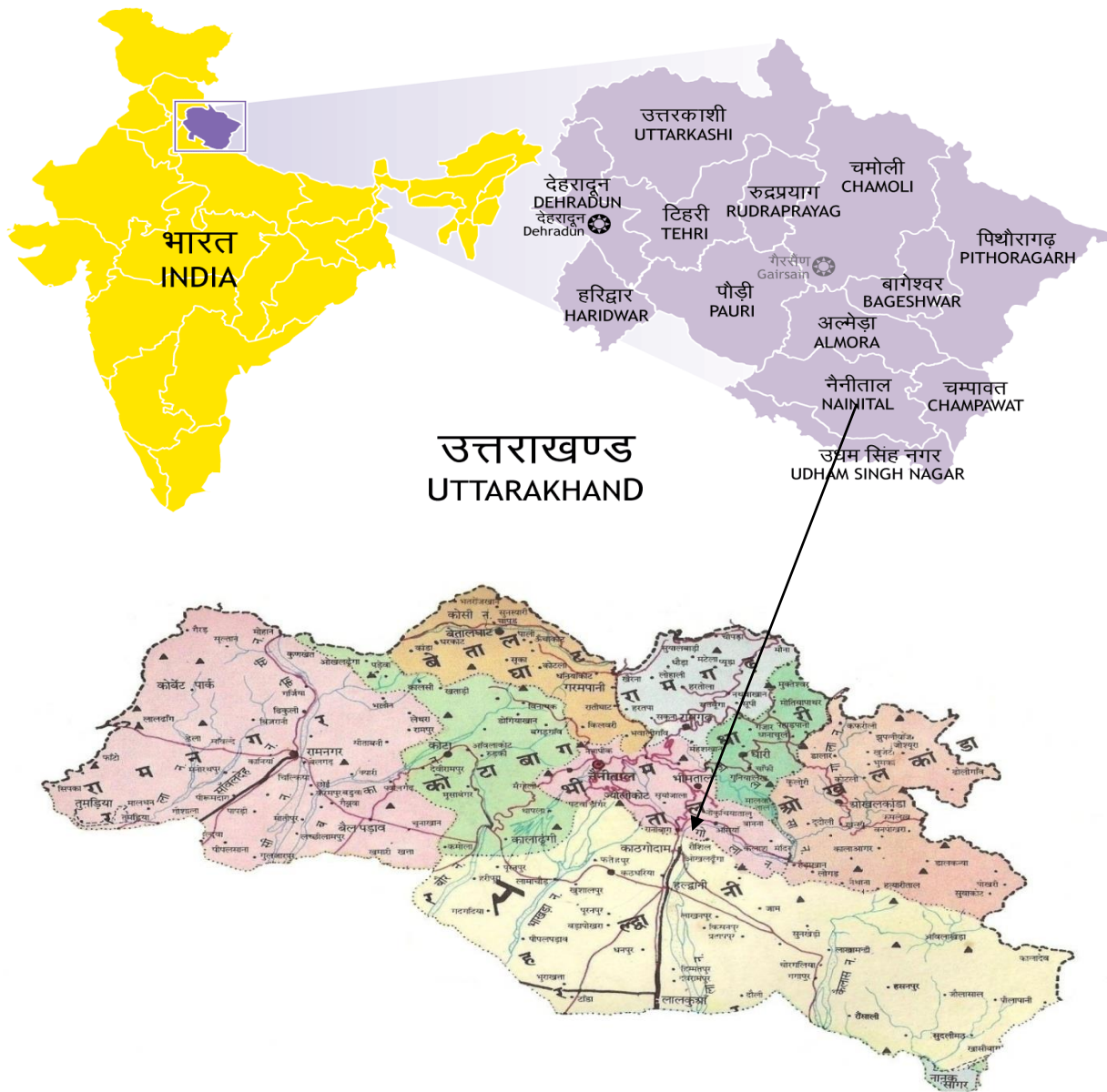


Fig. 2.1. Location map of the study area



Fig 2.2. Data Collection through participatory interview and direct observation method

OBJECTIVE 1: PLANT SPECIES DIVERSITY IN HOMEGARDENS

Maintaining homegardens was a quite common practice in the study villages of Nainital district 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. Out of 120 studied homegardens 51 were categorised as large (>0.004 ha), 42 as medium (0.001-0.004 ha) and 27 as small (<0.001 ha) (Table 3. 1). Plants were usually planted in the front, back and surrounding the houses. A general pattern of spatial arrangement of plant species in homegardens was identified. Ornamental plants such *Tagetes* sp. *Canna indica*, *Biota orientalis* etc. and major fruits tree species for example *Mangifera indica*, *Citrus* sp. *Carica papaya*, etc were grown in frontyard 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. The homegardens showed four distinct strata (Fig 3.1). Strata A or canopy (9.23%) layer was composed of big tree (>10 m height), sub canopy layer or B strata (16.92%) was composed of middle size tree (5m to 10m height), under canopy was or C strata (3.08%) 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 (69.23%) (Fig. 3.2). The common tree species in the A strata were: *Mangifera indica*, B strata were composed of *Carica papaya*, *Ficus hispida*, *Cinnamomum tamala*, *Citrus limetta*, *Musa* sp. and *Punica granatum*. C strata were composed of *Psidium gujavaja* and *Prunus persica*. The shrub layer composed of *Citrus* sp. and the dominated plants in herbs layer were *Ageratum conyzoides*, *Cynodon dactylon*, *Curcuma longa*, *Galinsoga parviflora*, and *Zinger officinale* etc.

Table 3. 1. Homegarden category (Size range) and total area of sampled homegarden

Homegarden size (ha)	Small (<0.001)	Medium (0.001-0.004)	Large (>0.004)
No. of HGs	27	42	51
Total area of HGs	0.017	0.09	0.94

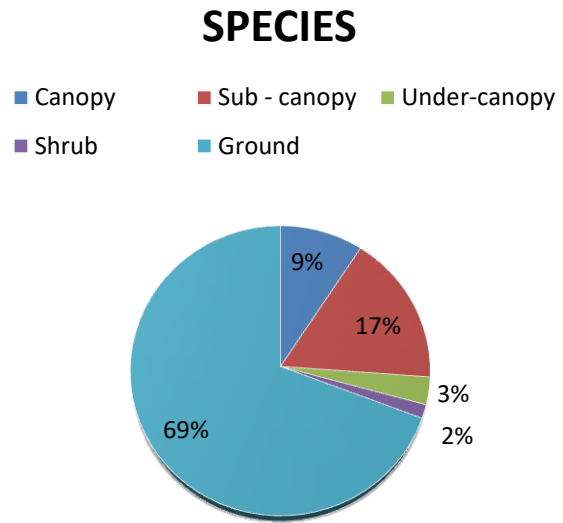


Fig. 3.1 Homegarden showing distribution and contribution of plant species in different strata.

Floristic composition

A variety of plant species were grown and maintained in the homegardens and in the present study, 88 plant species distributed in 51 families were recorded growing naturally or cultivated in the homegardens. The family having the highest number of species was Fabaceae (with 9 species) followed by Brassicaceae, Rosaceae and Rutaceae (each with 6 species), while most of the families were represented by one or two species (Fig.3.2). Majority of species showing high density were vegetable crops and fruits plants and there was a remarkable similarity with respect to species composition among different homegardens.

The homegardens appear to be assorted mixture of tree, shrub, herb, climber and epiphytes. Of the total 88 species recorded in the present study, 49.37%, 29.11%, 8.86%, 7.59% and 5.63% were herbs, trees, tubers, climbers and shrubs, respectively (Fig 3.3). 44 species from 23 families were recorded in large sized homegarden, 32 species from 23 families in medium sized homegarden while, 62 species from 32 families were recorded in small sized homegarden system.

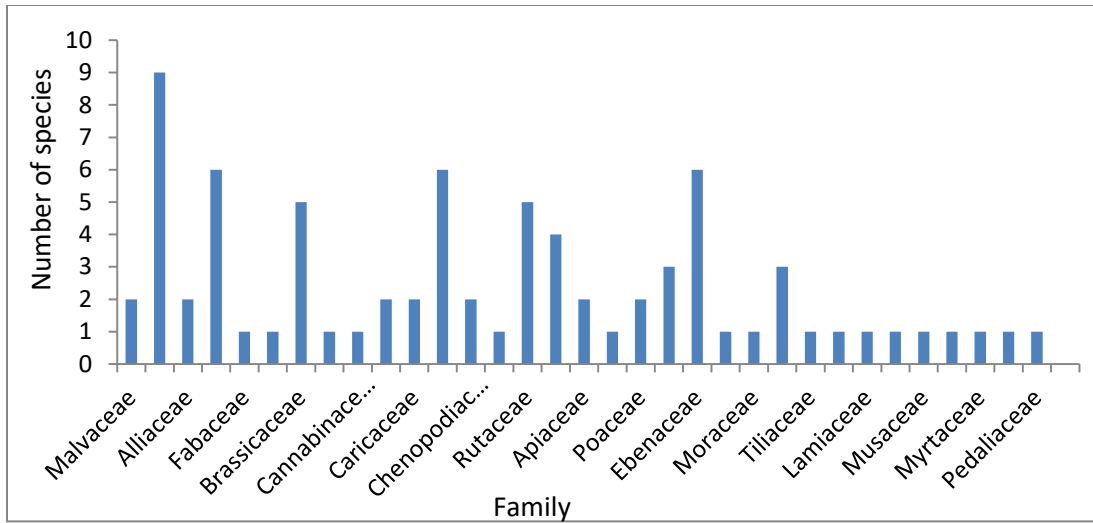


Fig. 3.2. Distribution of homegarden species in different families.

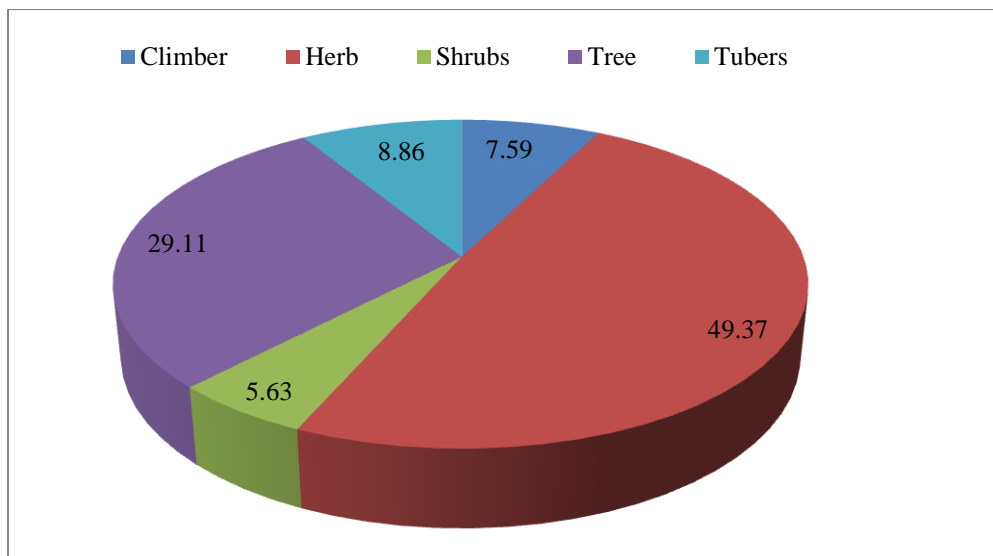


Fig. 3.3. Plant species contribution (%) in studied homegardens.

Vegetation structure

Herb density was maximum in small sized homegarden (23.15 ind m⁻²) followed by medium (21.00 ind m⁻²) and large-sized (16.22 ind m⁻²) homegardens. Maximum diversity (3.84) was observed in small homegardens, while minimum (2.84) in medium sized homegardens. In contrast to it, concentration of dominance was maximum (0.19) in medium sized homegardens while, minimum in small homegardens. Equitability was similar (1.18) in small as well as medium sized homegardens, while it was highest (1.30) in large sized homegardens. Seedlings

were observed only in small sized homegardens and density was 18 ind ha⁻¹. Seedling diversity was 1.69. Concentration of dominance was 0.51. Equitability was 2.44.

Sapling density was highest (400 ind ha⁻¹) in medium sized homegardens followed by small sized homegardens (336 ind ha⁻¹) and large sized homegardens (286 ind ha⁻¹). Maximum sapling diversity (3.30 ind ha⁻¹) was observed in small sized homegarden while, minimum (2.40 ind ha⁻¹) in large sized homegarden. Concentration of dominance of sapling layer was maximum (0.21) in large while, minimum (0.12) in small sized homegarden. Tree density was maximum in large (143 ind ha⁻¹) followed by medium (100 ind ha⁻¹) and small-sized (82 ind ha⁻¹) homegardens. Similarly, tree diversity was maximum (2.52) in large followed by medium (1.50) and small (1.44) sized homegardens. Concentration of dominance was highest (0.48) in small followed by medium (0.38) and large sized (0.18) homegarden (Table3. 2).

Table 3. 2: Vegetation structure in surveyed homegardens.

Homegarden size/Parameters	D	H'	Cd	E
Herb (ind m ⁻²)				
Small	23.53	3.84	0.11	1.18
Medium	21.00	2.84	0.19	1.18
Large	16.22	3.32	0.12	1.30
Seedling (ind. ha ⁻¹)				
Small	18	1.69	0.51	2.44
Medium	-	-	-	-
Large	-	-	-	-
Sapling(ind. ha ⁻¹)				
Small	336	3.30	0.12	1.25
Medium	400	2.73	0.18	1.31
Large	286	2.40	0.21	1.34
Tree(ind. ha ⁻¹)				
Small	82	1.44	0.48	1.04
Medium	100	1.50	0.38	1.37
Large	143	2.52	0.18	1.41

Where D= density, H'= diversity, Cd= concentration of dominance and E=equitability

Maximum similarity (57.45%) was reported between small and medium sized homegardens followed by small and large sized homegardens (56.60%) while minimum similarity was reported between medium and large homegardens (Table 3.3).

Table 3.3: Similarity Index (%) for different homegarden (HG) categories

	Small HGs	Medium HGs	Large HGs
Small HGs	0.00	-	-
Medium HGs	57.45	0.00	-
Large HGs	56.60	50.00	0.00

Utilization pattern

Foods from home gardens varied from horticultural crops to roots to palm and animal products; further plants from the gardens are also used as fodder, medicine, spice, miscellaneous, cultural, ornamental, fibre, and fuel. In the present study, 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 was edible followed by medicine, fodder, cultural/ritual, other uses, spice, ornamental, fibre and fuel (Fig.3.3). Leaves and fruits were most frequently used plant parts while some parts like flowers and flour were rarely used (Fig 3.4).

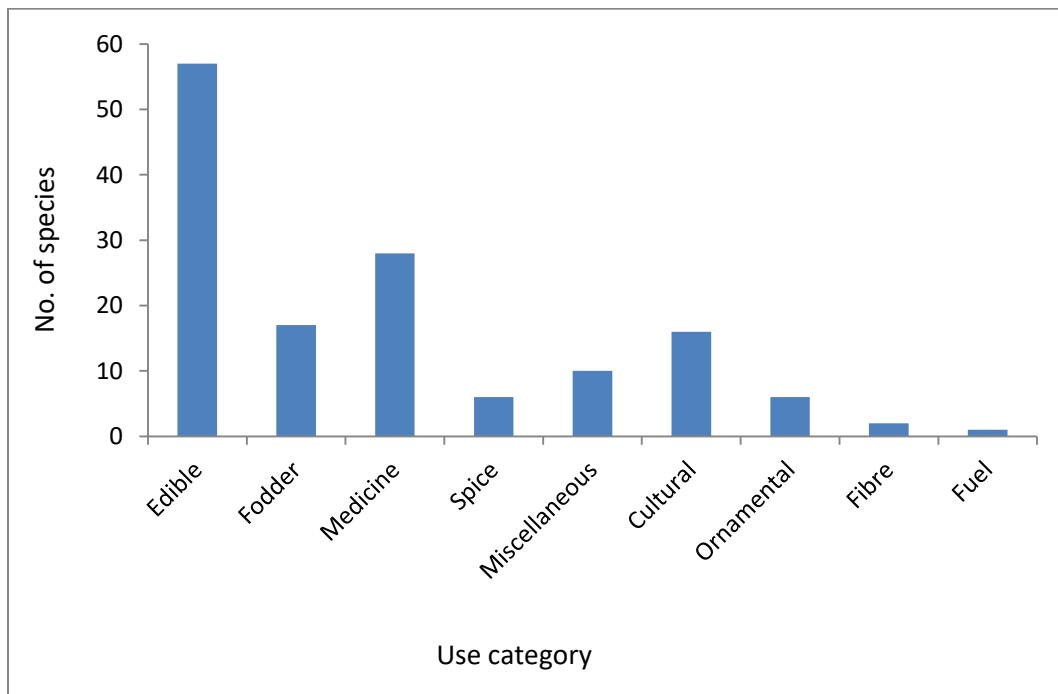


Fig 3.3 Mean number of species per use category per homegarden

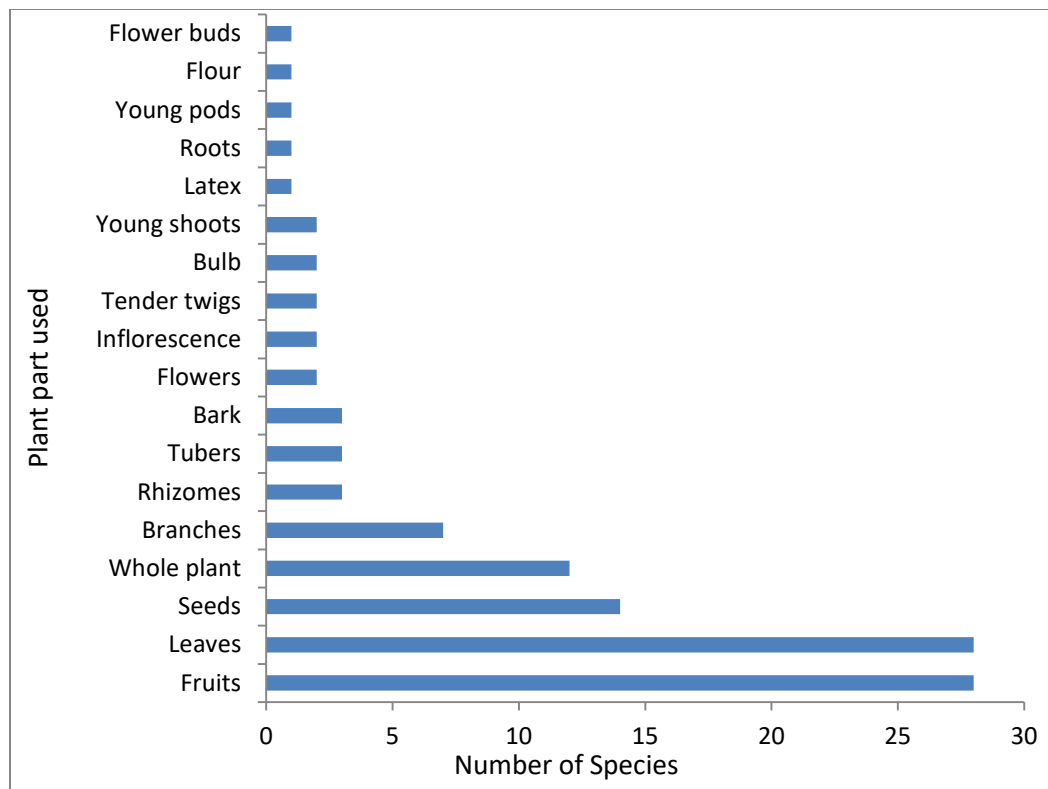


Fig 3.4. Plant parts utilized for various purposes.

OBJECTIVE 2: SOCIO-ECONOMIC IMPORTANCE OF HOMEGARDENS

In this category, two major groups of variables can be distinguished; local (external) environment and household environment (household's resource levels). Among the local environment, commercialization and access to market, reliance on off-farm income, access to inputs and access to off-farm resources are believed to influence species diversity of farms. Commercialization and access to market often causes a decline in the diversity of species. Homegardens close to market towns, particularly in well-off households, tend to emphasize on high-value cash crops instead of staple foods. On the other hand, farmers tend to compensate their lack of access to markets and resources by producing as much of their consumption from home production as possible.

Tradition homegardens of study area were rich in biological diversity harbouring 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 (Fernandes and Nair 1990). 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 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. The vegetables, crops and trees planted in a

homegarden are carefully arranged to provide for specific functions and benefits, which are primarily economic in nature. Rural farmers which are totally depends on farming for their livelihood, they commonly grow seasonal vegetables such as radish, green leafy vegetables, cabbage, potato etc. Commonly apple, orange, plum, peach etc. are the economically important fruits in hilly areas while mango, guava, litchi etc. are in Bhabhar region. Some social and economic benefits of homegardens recorded in the study area are given in Table 4.1.

Table 4.1. Rural farmer’s perception of social and economic benefits in maintaining homegarden.

<i>Benefits</i>	<i>Percentage</i> *
Social	
Food/food security	86
Health Improvement	57
Uplifting of women	62
Preservation of indigenous knowledge	58
Reduce pressure on women	54
Economic	
Easy source of fresh vegetables	75
Reduce pressure on forest	52
Alternative source of income generation	65
Reduce family food budget	80
Biodiversity conservation	62

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

Social benefits

Reviews of studies from various countries reveal that the degree and combination socio-cultural impacts on societies engaged in home gardening vary across the board. Multiple social benefits of home gardens include enhancing food and nutritional security in many socio-economic and political situations, improving family health and human capacity, empowering women, promoting social justice and equity, and preserving indigenous knowledge and culture (Mitchell and Hanstad 2004).

i. Enhancing food and nutritional security

The home gardens included a diverse set of plants that are locally preferred and adapted to local conditions. Large homegardens provide a sufficient number of tubers or cereals; they can also provide the household's basic food supply. Along with the nutritional benefits, homegardens provide potential food security to the householder. Since the diverse mixture of crops is harvested at different times, a constant supply of food in some form or the other is available from these homegardens, at all times of the year. Rural farmers continue to rely on their homegardens to enhance household food security against the risks presented by monocropping systems.

The most fundamental social benefit of home gardens stems from their direct contributions to household food security by increasing availability, accessibility, and utilization of food products. Home gardens provide easy day-to-day access to an assortment of fresh and nutritious foods for the household and accordingly those homes obtained more than 50% of the vegetables, fruits, tubers, and yams from their garden. Supporting this premise, present study concluded that, while adding to the caloric quantity, home gardens supplement staple-based diet with a significant portion of proteins, vitamins, and minerals, lead to an enriched and balanced diet particularly for growing children and mothers. Additionally, plants from the gardens – especially spices and herbs - are used as flavor enhancers, teas, and condiments.

The results of the present study indicated that 30% of the total households grow vegetables only for household consumption while 70% grow for both home consumption and commercial purposes. With regard to support from governmental and non-governmental organization on vegetable production, 65% answered that they do not get any support from any organization while 35% responded that they get some services or support. The type of support received included training, planting material/ cutting and technical support.

ii. Improving health

Plants are an important source of medicine for humans and livestock and are used as biological pesticides to protect crops from diseases and pest infestations. Herbs and medicinal plants are grown in home gardens all over the world, and in developing countries nearly 80% of the people

use them to treat various illnesses, diseases, and also to improve their health conditions (Rao and Rao 2006). A generous portion of the plants found in home gardens have some medicinal value and they can be used to treat many common health problems in a cost-effective manner.

Though growing plants in homegardens primarily for curing diseases was not the major objective of the local rural people in the study villages of Nainital district. However, even today, a large number of rural households utilize many plants as medicine in home remedies (Padliya et al. 2015; Parihaar et al. 2015). A total of 28 plant species were used in curing various ailments by the local people. *Citrus* fruits 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 conyzoides* was used in healing 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.

iii. Uplifting the status of women

Women's participation and responsibilities in home gardening varies across cultures, including land preparation, planting, weeding, harvesting, and marketing (Bargali 2015). Through home gardening women have developed proficiency related to plants and garden practices that helps them become better home and environment managers. Their labor is indispensable to maintain the garden and to help keep production cost low. As home managers, women have useful knowledge of numerous domestic needs. By their involvement in the production process, they are able to meet family needs more easily and economically. While home gardens provide a respectable path for women to contribute to household subsistence, eminence, and character, they hold a greater socio-cultural and spiritual importance for women.

iv. Preserving indigenous knowledge

Homegardens consist of a variety of components and species that represent social and traditional aspects of different societies. This rich indigenous culture and communal knowledge base is expressed through home gardening by the selection of plants and animal species as well as the farming practices used by the local community Home gardens serve as a valuable repository for

preserving and transferring indigenous crops and livestock species, production knowledge and the skills from one generation to another. The sources of seeds/planting materials for home gardens are largely through self maintenance, local market, office of agriculture and rural development, neighbours and relatives. The highest percentage of household (60-75%) uses their own stock. This indicates that local people still have indigenous experiences in preserving genetic diversity of traditionally known vegetables.

Interactions in and around the home garden create and reinforce social status and ties between the household and the community. Home gardeners habitually exchange or gift planting materials, vegetables, fruits, leaves, herbals and medicinal plants for social, cultural, and religious purposes. Such interactions are essential for social integration and building social capital.

Economic benefits

The economic benefits of home gardens go beyond food and nutritional security and subsistence, especially for resource-poor families. Home gardens can contribute to household economic well-being in several ways: garden products can be sold to earn additional income gardening activities can be developed into a small cottage industry; and earnings from the sale of home garden products and the savings from consuming home-grown food products can lead to more disposable income that can be used for other domestic purposes. Although home gardens are viewed as subsistence-low production systems, they can be structured to be more efficient commercial enterprises by growing high-value crops and animal husbandry. The fact that home production is less cost-intensive and requires fewer inputs and investment is extremely important for resource-poor families that have limited access to production inputs.

In the present study, from the economic point of view, rural farmers were motivated to involve in home gardening because of better nutrition, easy accessing fresh food and a reduction in family food budget. However, some were interested to reduce pressure on forests (52%) and biodiversity conservation(62%).

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 homegardens of studied village was calculated (Table 4.2). *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).

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.

Table 4.2. RFC and CI of homegarden tree and shrub species.

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

OBJECTIVE 3: CONTRIBUTION OF HOME GARDENS IN RURAL LIVELIHOOD AND INCOME GENERATION

Home gardens have been an integral part of the local food systems since ancient times and have been practiced in most developing countries all over the world as a supplemental source of food. Homegardens plays a vital role in contributing to peoples livelihoods (Table 5.1). Maroyi (2009) and Guuroh et al. (2011) reported that homegardens improves the family's nutritional status, health, and food security. Agroforestry homegardens therefore, is part of a household livelihood strategy and has gained prominence as a natural asset through which sustainable use of resources, particularly for the livelihoods of the poor, may be achieved. Homestead gardening provide an important contribution to sustainable agricultural production because of their potential to meet economic, social, ecological, and institutional conditions for sustainable livelihoods (Nair, 2006).

Some of the cultivated species of homegardens were also marketed. They sold some vegetables fruits and other surplus products to the nearby market for monetary benefits (Fig 5.1). 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. Homegardens often allow for the setup of small source of income to the household. For example, the traditional art of pickling mangos and other fruits and also by making different fruit jams.

Contribution of homegarden products to rural livelihoods

Cereals and pulses

Nutrition and food supply are major aspects of homegardens. Food crops are not only widely prevalent (Caron, 1995; Mendez et al., 2001; Vogl et al., 2002), but they also provide a significant portion of the household nutritional requirement in many homegardens around the world. Total five cereals and nine pulses were cultivated which belongs to 2 families (Poaceae and Fabaceae, respectively) (Table 5.2). At low altitude homegardens *O. sativa* and *Z. mays*

were cultivated as major cereal crops which contributes 33.33% whereas, *C. arietinum*, *G. max* and *V. unguiculata* were grown as pulse crops which contributes 50% of total pulse crops. At mid altitude site, *E. frumentaceae*, *E. coracana*, *T. aestivum* and *Z. mays* were cultivated as cereal crops which contributes 83.33% whereas, *G. max*, *G. soja*, *M. uniflourm* and *V. mungo* as pulse crops which contributes 66.66%. At high altitude *T. aestivum* and *Z. mays* were cultivated as cereal crops which contributes 33.33% whereas, *C. arietinum*, *G. max* and *G. soja* as pulse crops, which contributes 50 % of total pulse crop.

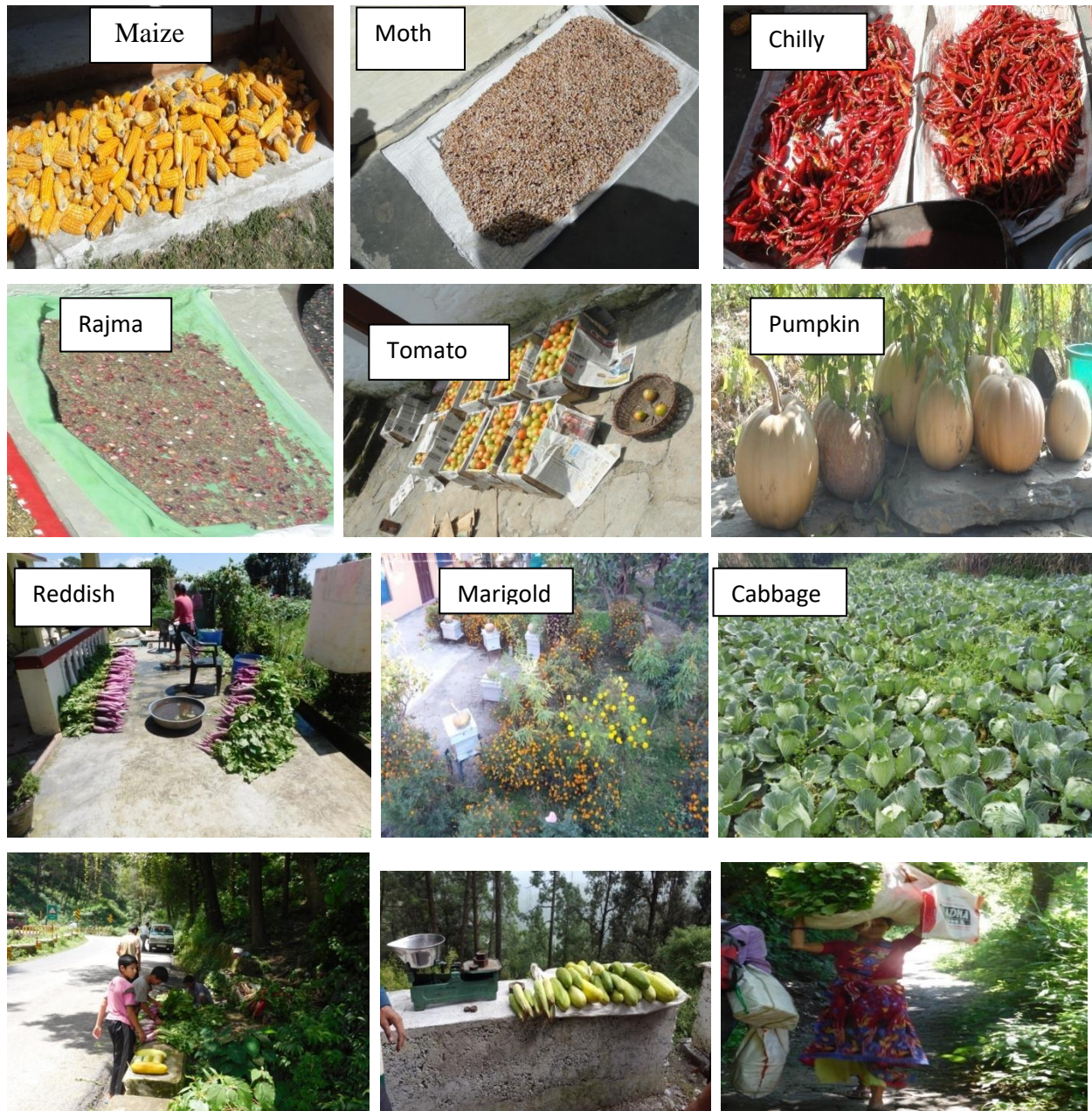


Fig. 5.1. Some home garden products being used for income generation in the study area.

Table 5.1. Main functions of homegardens (modified after Kehlenbeck et al.,2007)

Homegarden's Contribution			
Livelihood		Services	
Subsistence	Economic	Social	Ecological
Fruits Vegetables Spices Medicine Staple food Timber Fodder Fuel wood	Cash income Employment	Pleasure Food Security Health Improvement Aesthetics Women empowerment	Habitat for wild flora + fauna Pest + disease Control Nutrient cycling Microclimate Soil erosion Control

Table 5.2 Cereals and pulses crops produced by the local communities

S.N.	Botanical name	English name	Local name	Family
Cereals_crops				
1	<i>Eleusine coracana</i> (L.) Gaertn.	Finger millet	Manduwa	Poaceae
2	<i>Hordeum vulgare</i>	Barley	Jau	Poaceae
3	<i>Oryza sativa</i> L.	Rice	Dhan	Poaceae
4	<i>Triticum aestivum</i> L.	Wheat	Gehu	Poaceae
5	<i>Zea mays</i> L.	Maize	Makka	Poaceae
Pulses Crops				
6	<i>Cicer arietinum</i> L.	Gram	Chana	Papilionaceae
7	<i>Glycine max</i> (L.) Merr.	Soya	Soyabean	Papilionaceae
8	<i>Glycine soja</i> Siebold & Zucc.	Soybean	Bhatt	Papilionaceae
9	<i>Lens esculenta</i>	Lentil	Masoor	Papilionaceae
10	<i>Macrotyloma uniflorum</i>	Horsegram	Gahat	Papilionaceae
11	<i>Phaseolus lunatus</i> L.	Lobia	Lobia	Papilionaceae
12	<i>Phaseolus vulgaris</i> L.	Kidney bean	Sem	Papilionaceae
13	<i>Pisum sativum</i> L.	Garden Pea	Mater	Papilionaceae
14	<i>Vigna mungo</i>	Black gram	Urd	Papilionaceae

Vegetable crops

Homegarden is the dwelling place and it is the centre where all the vegetables and quick growing fruits are cultivated (Bargali et al 2015). A variety of vegetable crops are being grown in homegardens of Nainital district (Fig. 5.3). In rural areas of Nainital district, farmers have successfully integrated food crops like potato, leafy vegetables like spinach and fruit vegetables like pumpkin along with fruit and fodder tree in their homegarden area. Some of the cultivated vegetable species are given in Table 5.3. They have successfully maintained many introduced species in homegarden along with indigenous ones, leading to their integration and acquired cultural significance in the region's diverse and unique food preparation and eating habits (Pande et al 2016).

Major food products were divided in four classes in which maximum contribution was recorded for vegetables at low and high altitude homegardens while at mid altitude maximum contribution was recorded for pulses (Fig 5.2). At all the altitudes by products

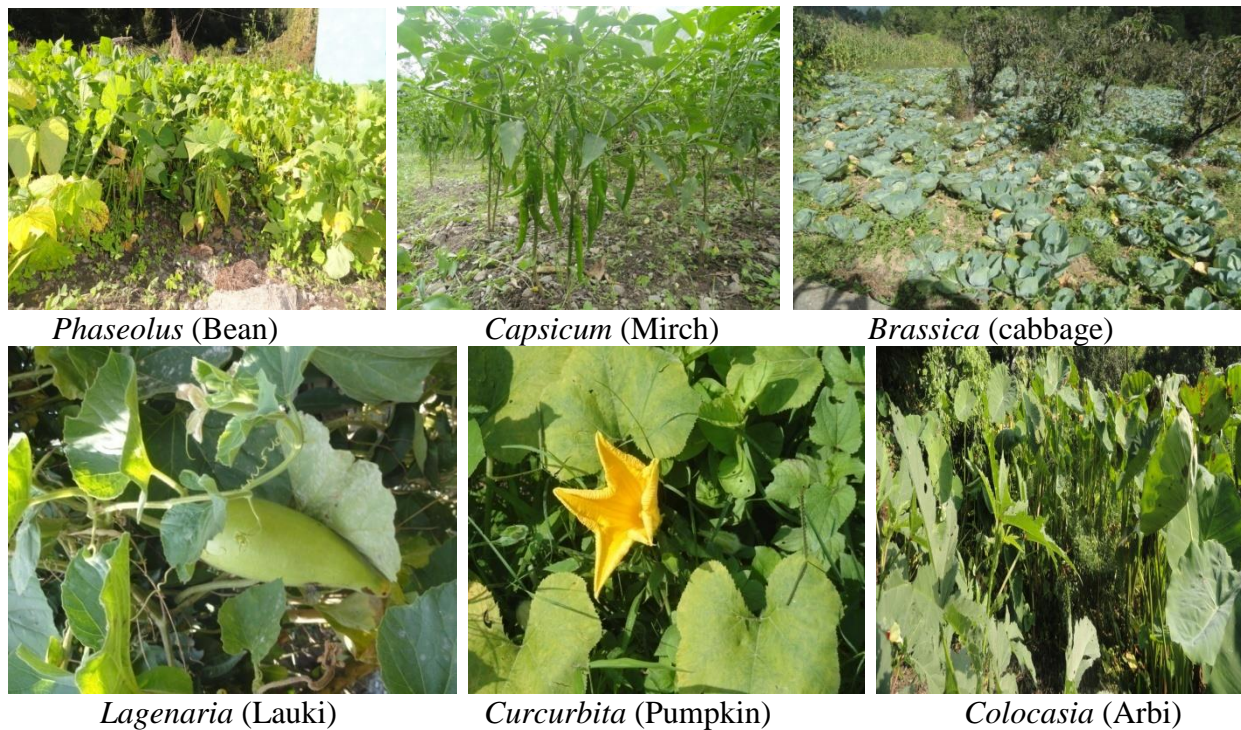


Fig.5.2. Some common vegetables growing in homegardens

Table 5.3. List of vegetables cultivated in homegardens.

Vegetable	Local Name	Botanical Name	Family
Amaranthus	Chua	<i>Amaranthus cruentus</i>	Amaranthaceae
Arbi	Gaderi/ Pinalu	<i>Colocasia esculenta</i>	Araceae
Bean	Bean	<i>Phaseolus vulgaris</i>	Fabaceae
Bitter gourd	Karela	<i>Momordica charantia</i>	Cucurbitaceae
Bottle gourd	Lauki	<i>Lagenaria siceraria</i>	Cucurbitaceae
Brassica	Rai	<i>Brassica juncea</i>	Brassicaceae
Buckwheat	Ugal	<i>Fagopyrum esculentum</i>	Polygonaceae
Chayote	Ascus	<i>Sechium edule</i>	Cucurbitaceae
Chenopodium	Bathua	<i>Chenopodium album</i>	Chenopodiaceae
Chilly	Mirch	<i>Capsicum annum</i>	Solanaceae
Coriander	Dhania	<i>Coriandrum sativum</i>	Apiaceae
Egg plant	Baigan	<i>Solanum melongena</i>	Solanaceae
Faba bean	Bakula	<i>Vicia faba</i>	Fabaceae
Fenugreek	Methi	<i>Trigonella foenum-graecum</i>	Fabaceae
Garlic	Lahsun	<i>Allium sativum</i>	Alliaceae
Head cabbage	Band gobhi	<i>Brassica oleracea</i> var. <i>capitata</i>	Brassicaceae
Lady's finger	Bhindi	<i>Abelmoschus esculentus</i>	Malvaceae
Loose cabbage/ Cauli flower	Phool gobhi	<i>Brassica oleracea</i> var. <i>botrytis</i>	Brassicaceae
Luffa	Torai	<i>Luffa acutangula</i>	Cucurbitaceae
Onion	Piyaz	<i>Allium cepa</i>	Alliaceae
Pea	Matar	<i>Pisum sativum</i>	Fabaceae
Potato	Aalu	<i>Solanum tuberosum</i>	Solanaceae
Potato yam	Gethi	<i>Dioscorea bulbifera</i>	Dioscoraceae
Pumpkin	Kaddu	<i>Curcubita pepo</i>	Cucurbitaceae
Redish	Mulli	<i>Raphanus sativus</i>	Brassicaceae
Snake gourd	Chichinda	<i>Trichosanthes anguina</i>	Cucurbitaceae
Spinch	Palak	<i>Spinacea oleracea</i>	Amaranthaceae
Sweet gourd	Ramkerala/ kerala Meetha	<i>Cyclanthra pedata</i>	Cucurbitaceae
Tomato	Tamater	<i>Lycopersicon lycopersicum</i>	Solanaceae

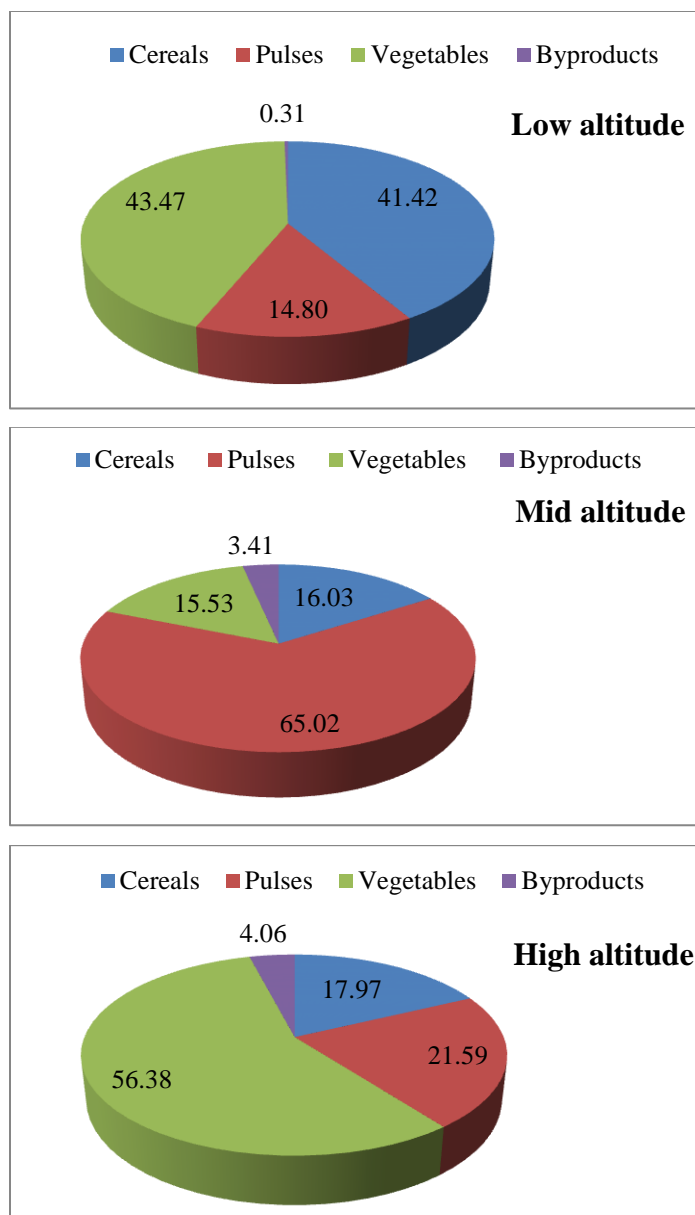


Fig.5.3 Contribution of different homegarden agroforestry products in livelihood of rural farmers

Energetic values of different inputs and outputs

Concerning socio-economic conditions, a sustainable agricultural system should be able to maintain its productive capacity by continuously yielding adequate amounts of diverse and valuable crops suitable for meeting both subsistence and cash needs of the farmer's household. Inputs such as labour investment, planting material, fertiliser, and pesticides etc and outputs were calculated according to energetic values of different inputs and outputs in the agroforestry systems in Himalaya, India (Source: Mitchell 1979, (Table 5.4)). Gross per hectare annual

energy input was 8742.28 MJ in homegarden system. Maximum energy input was accounted for manure in low (576.7 MJ) and high altitude homegarden agroforestry system (1569.5 MJ), while it was maximum for seeds in mid altitude site (2114.8 MJ). Labour inputs were small, well spread over the year and flexibly allocated. As a tendency, labour input seemed to increase with increasing altitude (19.68 MJ at low altitude to 49 MJ at high altitude) possibly due to better available at low altitude. Annual energy output from homegarden system was 27490.6 MJ per hectare. Output from food grains was highest at mid altitude (16812 MJ) followed by high and low altitude (781 MJ and 579 MJ, respectively). Pinnacle of fuel wood collection was maximum at mid altitude site (295.5 MJ) followed by high and low altitude site (98.5 MJ and 24.7 MJ, respectively). High altitude site (4050 MJ) had vegetables as top energy output shareholder while low altitudinal site (3320 MJ), and mid altitude site (804 MJ) followed it. Acme of fodder collection was recorded maximum (165.6 MJ) at mid altitude region. Byproducts obtained from mid; high and low altitude site was 176.6 MJ, 147 MJ and 12 MJ, respectively. Maximum net return was obtained from mid altitudinal site (13805.3 MJ) whereas, minimum from high altitudinal site (1888.7 MJ). Output/Input Ratio was bordered between 4.14-1.57 MJ along the altitudinal gradient and was maximum for low altitude homegarden agroforestry systems (Table 5.5).

Table 5.4: Energetic values of different inputs and outputs in the agroforestry systems in Himalaya, India (Source: Mitchell 1979)

Category	Energy
Grains	16.2 MJ kg ⁻¹
Pulses	17.0 MJ kg ⁻¹
Oilseeds	23.07 MJ kg ⁻¹
Potato	03.9 MJ kg ⁻¹
Leafy vegetables	02.8 MJ kg ⁻¹
Other vegetables	02.4 MJ kg ⁻¹
Milk	04.2 MJ kg ⁻¹
Green fodder	03.9 MJ kg ⁻¹
Hay	14.5 MJ kg ⁻¹
Straw	13.9 MJ kg ⁻¹
Fuel wood	19.7 MJ kg ⁻¹
Farmyard manure/compost	07.3 MJ kg ⁻¹
Human labour	

Male Sedentary work	00.418 MJ h ⁻¹
Moderate work	00.488 MJ h ⁻¹
Heavy work	00.679 MJ h ⁻¹
Human labour	
Female Sedentary work	00.331 MJ h ⁻¹
Moderate work	00.383 MJ h ⁻¹
Heavy work	00.523 MJ h ⁻¹
One bullock-day	72.7 MJ day ⁻¹

Table 5.5: The energy inputs and outputs in surveyed homegardens

Input/Output*	Low altitude	Mid altitude	High altitude
INPUT			
Human Power**	19.68	45.0	49.0
Drought Power**	290.8	872.4	581
Seeds	86.2	2114.8	1121
Manure	576.7	1416.2	1569.5
Total Input	973.38	4448.4	3320.5
OUTPUT			
Food Grains	579	16812	781
Vegetables	3320	804	4050
Byproducts	12	176.6	147
Fuel wood	24.7	295.5	98.5
Fodder	92	165.6	132.7
Total output	4027.7	18253.7	5209.2
Net Return	3054.32	13805.3	1888.7

Output/Input Ratio 4.14

4.10

1.57

*Energy in (MJ ha⁻¹ y⁻¹), **Energy in (MJ ha⁻¹ day⁻¹)

Monetary budget

The average annual gross monetary input per homegarden was Rs. 27691 in homegardens of Nainital. Maximum input was accounted for manure/fertilizers at mid (Rs. 5120) altitude while minimum input was recorded for seeds (Rs. 300) at low altitude homegardens. Total input was maximum at mid altitude homegardens and minimum for the low altitude homegardens. Total output followed same pattern as described for input. Food grains contributed maximum for the livelihood of rural farmers at low and mid altitude, while at high altitude it was contributed by vegetables (Table 5.6). Output input ratio increased with decreasing altitudinal range. This may be due to the better facilities and proper maintenance of homegardens.

Table 5.6: Monetary budget (Rs.) of surveyed homegardens in Nainital.

Input/Output	Altitude			Average
	Low	Mid	High	
INPUT				
Human Power	3000	3500	3100	3200
Seeds	300	4345	2226	2290
Manure/Fertilizer	2030	5120	4070	3740
Total Input	5330	12965	9396	9230
OUTPUT				
Food Grains	8900	21730	8800	13143
Vegetables	7700	10150	9710	9186
Byproducts	200	1596	1250	1015
Fuel wood	750	1800	400	983
Fodder	120	216	180	172
Total output	17670	35492	20340	24500
Net Return	12340	22527	10944	15270
Output/Input Ratio	3.31	2.73	2.16	2.73

Livelihood Benefits of homegardens

In India, many studies determined the importance and role of homegardens in the life of local people, especially in terms of livelihood and economic significance (Tynsong and Tiwari 2010, Bargali et al 2015). They are a vital source of income for subsistence economy and contribute to the self sufficiency of many rural households in remote places often secluded from markets and modern production centers. Most of the homegarden plants were edible and make significant contributions to the nutritional well being. Because of high plant diversity in the homegardens (Kala 2010), a wide spectrum of multiple-use plant products can be generated with relatively low labour, cash or other inputs. In seasons of scarcity homegardens with their diverse products available year round, contribute towards food security (Tynsong and Tiwari 2010). Traditional vegetables are often cited as having and providing vitamins such as B, C and even higher amounts of some minerals such as iron and calcium as well as proteins (Bargali 2016). In the study area, the people were aware of the nutritious properties of some important plant species; hence they have cultivated these plants in their homegardens such as *Musa Spp.*, *Mangifera indica*, *Lycopersicon esculentum*, *Coriandrum sativum* etc.

Homegardens have shown to provide a diverse and stable supply of socio-economic product and benefits to the families in the rural areas. During the survey it was observed that villagers cultivate and maintain plants in their homegardens mainly for household consumption and surplus vegetables and fruits were sold in the nearby market for monetary benefits. The most marketed vegetables were chilly (*Capsicum* sp.), tomato (*Lycopersicon esculentum*), beans (*Phaseolus* sp.) cabbage (*Brassica oleracea*) etc. Some household give homegardens products like fruits, vegetable and milk products to their neighbours and relatives that give strength to neighbor and family relationship called social capital. Plants grown in the home gardens were also used in various cultural practices. Mango (*Mangifera indica*) and banana (*Musa paradisiaca*) are the important religious plants and their leaves and fruits are used for religious ceremonies of Hindu religion.

The average annual gross income generated by homegardens in Nainital district was Rs.15270 which was much higher than the Kandyan Gardens in Sri Lanka (Rs.1621) and much lower than homegardens in South Meghalaya (Tynsong and Tiwari 2010) (Rs.44,241) homegardens of South Africa (High and Shakleton 2000) (Rs.16520). The percentage contribution of homegardens

towards peoples' average annual gross income was 10 to 20 %, which was lesser than the contribution of homegardens in Indonesia (21.1%) and higher than the homegardens in South West and North-east Bangladesh (15.9% and 11.8%, respectively) and South Meghalaya (7%) (Tynsong and Tiwari 2010). In terms of energy and monetary budget, low altitude homegardens were more efficient as compared to mid and high altitude homegardens as indicated by high output/input ratios.

OBJECTIVE 4: CONSTRAINTS IN HOMEGARDEN MANAGEMENT

The most notable cause behind the poor status of rural area of hilly region is the lack of constant source of income. The life of people living in hilly area is very indurations because they have to go through several painstaking tasks to fulfill their daily needs which in contrast to the luxurious living standard of people living in plain areas because of accessibility to all forms of resources. However, Homegarden agroforestry systems contribute an additional source of income for rural people. Causes behind low income from homegarden are shared by many factors such as natural hazards, non-scientific management of homegarden systems and lack of professional training. Scarcity of proper communication between owner and consumer and shortage of medium or roads to reach nearby market is also play a major hurdle in their low income. Some common constraints face in homegarden management are listed in Table 6.1.

Table 6.1. Common constraint faced in homegarden management (source: field survey)

Constraint category				
Biophysical	Economic	Social	Ecological	External support services
Shortage of land	Inability to purchase planting material,pesticide etc	Boundary conflits	Weather uncertainty	Financial
Lack of planting material	Marketing of products	Theft of products	Destruction by wildlife and domestic animals	Logistic
Lack of pesticides			Weed, pest, parasite and disease attack	Technical
Shortage of organic manure			Soil erosion	
Shortage of				

labour				
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During the management of homegarden, rural people confronted so many problems such as crop destruction by animals (*e.g.* by monkeys, baboons, pigs, sometimes grazing domestic animals also), lack of transportation facilities, unavailability of market etc. Some common constraints faced by rural farmers in the study area are listed in Table 6.1 and shown in Fig. 6.1. Presence of forests around villages is a quite common in hilly areas which is a natural house for much diversified fauna. During quite periods; either in day or night, they usually entered in to the villages in search of food. In these animals mainly herbivorous attacked fruit trees and vegetables growing in homegardens. It is very vital for the homegarden owners to look after their gardens on regular intervals otherwise animals like monkeys, baboons, boars etc. can readily destroy those homgarden products.

Unemployment or deficiency of financial security forced rural people to go nearby towns or cities to fulfill their economical needs for life. Income from homgardens only provides slight support to daily life needs because there are so many needs except food in everyones life. Hilly areas are prone to natural calamities that interrupt their regular income and challenge food security, so the rural people have to go for alternative source to speed up with the requirements of life. Landslides, cloud bursting, unapproachable places and several natural drawbacks made it very tedious to provide fluent travelling medium. People living in rural areas faced too many problems to achieve things for their daily needs.

Generally nature trails were used by people for travelling from one place to another place. Principal transportation medium for rural areas includes mules, asses, horses for long and short distances both. Transportation through animals needs too much physical endurance and strength but still it is not capable of transporting products in bulk with swift speed. People usually spent their whole day in transporting their products. If they have proper roads then they could be able to use motor vehicles, as a result they can cover long distance in short time and use their rest of the day in other productive stuffs and increasing their livelihood.

Few people in hilly rural areas are generally well educated and they commonly join any service sector where they get a fix amount monthly or annually. Homegardens failed to provide this kind

of security to people depend on this. Those people who have to live their life in their respective villages lack proper knowledge and training about farming. Genetically modified seeds are sometimes unaffordable for homegarden owners or they had no clue about such seeds are available in their nearby areas. They were kept on farming in their fields with old means and mediums. If this kind of information or knowledge could reach these kinds of farmers it would be a blessing for them and their family. This problem is usually faced by farmers at high altitude areas because they lack easily accessible resources.

Farmers casted compost and/or chemical fertilizer in their fields to provide a boost for their seeds to grow faster in a healthy manner. Generally along with the crop, unutilized plants tend to grow faster than them in form of weeds by using nutrients that were provided by farmers for their product. Weeds such as *Stellaria media*, *Ageratum*, *Arthraxon*, *Erigeron*, *Galinsoga* and *Oxalis* etc. mainly grow with crop plants. Different insects also damage their fields vigorously sometimes. They mostly work as vectors for many pathogens.

One of the major problems for maintaining homegardens in summer was the availability of an adequate amount of water for irrigation. Hilly areas did not have irrigation facilities that are generally available at low altitude or at plains such as tubewells, canals etc. They were mostly dependent on rain water or resources that they have saved or developed during rainy time.

Major constraints in the homegarden management

Low altitude Homegardens

The biggest constraint faced by homegarden owners at low altitude was lack of time (76%) for the management of homegardens because they tend to give their major portion of day time in getting livelihood from other resources. They mainly tried to look after their homegardens on weekdays or on holidays. Migration reached its rock bottom level at the low altitudinal region because at this altitude all major resources are easily accessible or approachable. So it was not a constraint in low altitudinal homegardens. Weed infestation (38%) is the second biggest problem, closely followed by destruction by animals (32%), insect attack as well as adverse environmental conditions (26%), availability of water for irrigation (22%), transportation (14%) and unavailability of seeds of good quality (6%) (Fig. 6.1).

Mid altitude Homegardens

Homegardens at mid altitude encountered 82% weed infestation and 78% destruction by animals as their major constraints. Destruction of crops by animals experienced by many of rural farmers in this region is expected because villages are in the vicinity of forests and wild animals get easy access. In addition, sometimes domestic animals also destroy the crops. These constraints are closely followed by adverse environmental conditions as well as unavailability of water for proper irrigation (68%). One major positive outcome of the survey revealed that migration (14%) is less at mid altitude than the high altitude (74%). Transportation unavailability (32%) was higher than the low altitude (14%) (Fig. 6.1).

High altitude Homegardens

It was prominently manifested from survey that the destruction by animals had the major impact on the management of homegarden agroforestry systems. It was patrimonial in hilly rural areas to suckle domestic animals in houses. Domestic animals peregrinate in a confined area and that's why they usually reach to the homgarden systems also. Weed infestation (78%) and migration (74%) to earn more for good life closely followed the former constraints. Besides the above mentioned constraints, unavailability of good quality seed (62%), lack of transportation facilities (58%) for interior villages were also responsible for inferior income (Fig 6.1). Due to the involvement of women in various domestic stuffs such as household works, fuel wood and fodder collection from nearby forest, they did not able to give ample time for the management of homegarden systems. Other constraints like lack of constant availability of irrigation especially in summers, adverse weather and insect attack were also the duress in proper management of homegardens.



Fig. 6.2: Some constraints recorded in surveyed homegardens. a,-c: lack of transportation facilities; d: insect attack; e- f: weed infestation; g-h: lack of irrigation facilities; i: destruction by animals.

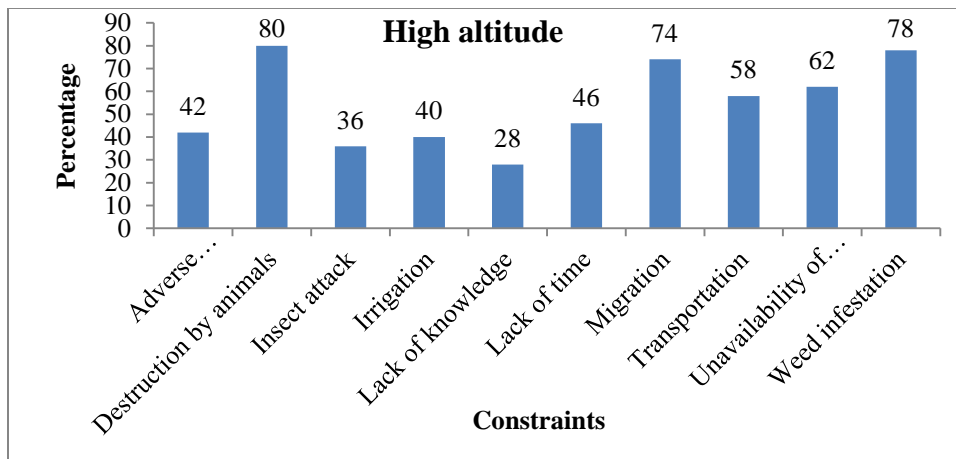
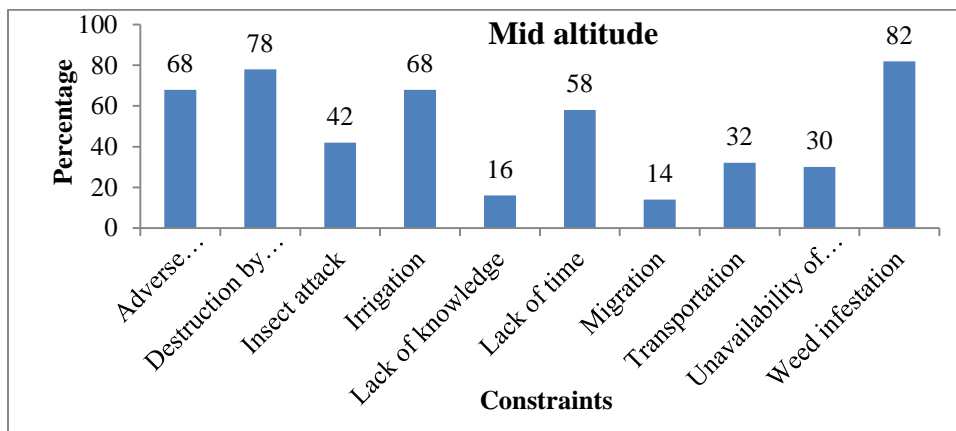
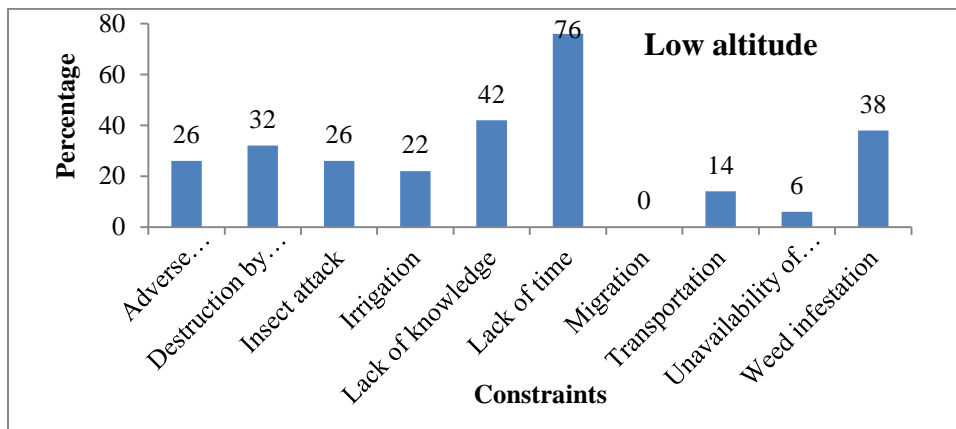


Fig.6.1: Constraints faced in Homegarden management at different altitudes.

OBJECTIVE 5: POLICY RECOMENDATION AND MANAGEMENT STRATEGIES

Homegardens upgrade the work of the rural population by giving nourishment, food, security and contribute fundamentally to the gross yearly salary of the family. The wage from homegardens relies upon their size, number of attractive yields and administration. Homegarden likewise guarantees accessibility of items inside the residence which is especially vital in hilly regions. Till now, there is no particular administration plan of estate plants everywhere throughout the nation in spite of the fact that it has huge commitment to greening the nature. Considering the current situation with the homegarden of the rustic regions of Kumaun locale, the results of this study revealed that effective development and management of homegardens is essential for sustainable growth and poverty reduction. Sustainable management of homegardens must be balanced with the short-term needs of the people for social and economic development and protection of the natural resource base. On the basis of their requirement farmers in the study area have adopted/developed some technologies to enhance production (Fig. 7.1). Drip irrigation kits contribute in improving livelihoods and well-being of poor rural people by saving time and water consumption, but a ready source of water is needed during the dry periods to maintain crop growth. Where there is no source of water close to the garden, it is important to capture and store rainwater as well as household grey water. But for poor rural households with little ready cash to invest, what are the cost-effective ways of obtaining and applying water to gardens? These systems have prevailed with intensive cultivation for hundreds of years, yet the production remains consistent.

Suggested Models of homegarden agroforestry based Integrated Farming Systems for the Rural farmers of Nainital:

This study demonstrated how homegardens are used to advance important livelihood objectives. It considered the potential benefits of homegardening as part of the farming system, with the capability of raising income and thus improving livelihoods of the poor. For home gardening to be sustainable and continue to benefit poor families following models have been suggested:

i. Livelihood Security Model (based on Fruit/vegetable/fodder/fiber/cereals, oil seeds & pulses etc.)

- i. Horticultural trees (Guava/Mango/Litchi/Citrus/ Jackfruit etc.) + Agricultural crops (Pea/Beans/Tomato/ Garlic/ Onion/ Cauliflower/Chilli, etc.)
- ii. Nitrogen fixing tree (Kachnar/ Shisham) + Agricultural crops (Groundnut/ pulses etc.)
- iii. Fuel wood tree (Oaks/ Celtis) + Agricultural crops (Groundnut/Pulses etc.)
- iv. Trees on bunds (Ficus/Shisham/Pinus) + Agricultural crops/fodder crops

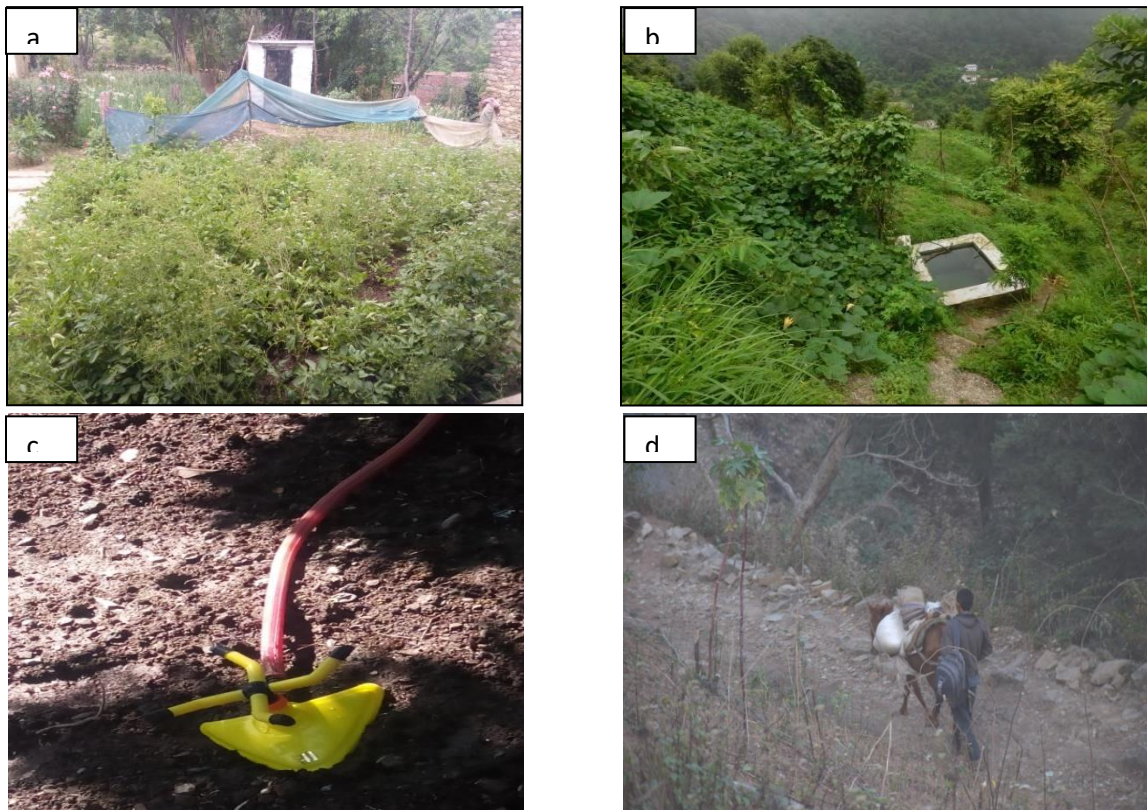


Fig.7.1. Some management strategies opted by rural people in the study area. a. Cloth fence for protection from wildlife; b. Rain water harvesting; c. Drip irrigation; d. Transportation by horse.

Under this model multiple cropping (double/inter cropping) could be adopted to ensure production in adverse situation of draught, flood etc. It will also provide foodgrains (cereals, pulse, oilseed etc.), fodder (green pasture, forage, leaf), fuel (Twigs, branches), homestead use (leaf, rhizomes, organic matter) etc. Adoption of this model will insure production of crops,

vegetables, etc. under multiple cropping farming system and cropping intensity is expected to increase.

ii. Employment & Income Generation Model:

(Based on Cash crops/Medicinal crops/ Aromatic crops/Horticultural crops /livestock etc)

- i. Cash crops (Capsicum/ Brinjal/ Tomato/Peas/ Cabbage/ Reddish/ Beans Groundnut etc.)+ Fruit trees (Banana/ Citrus/Mango/Litchi etc.)/ Fuel trees (Ficus/ Bhimal etc.)/ Timber trees (Teak/Shisham etc.)
- ii. Agricultural crops (Maize/Groundnut/Pulses etc.) + Floriculture crops (Marigold/Gladulai/Roses/ Guldawari etc.)Horticultural crops (Banana/ Citrus/Mango/Litchi etc)
- iii. Medicinal/ Aromatic (Lemon grass/Tulsi/Stevia /Giloe etc.) + Timber tree (Teak/Shisham etc.) Floriculture (Marigold/Gladulai/Roses etc)
- iv. Livestock rearing (Milk, egg & meat production model) Rearing of Goat /Poultry/Cow/Buffalo etc.
- v. Value addition components (Apiculture/Sericulture/Mushroom cultivation/Bamboo cultivation etc)

These models will provide employment to the farmers throughout the year. Meat, Egg, Flower, Fruit, Vegetable, Poultry and other produces will generate income. The system will also generate extra income through Apiculture, Sericulture, and Post Harvest Technology etc. In addition to the abovementioned outcomes, these models will be helpful in improving Cultivation practices, Biodiversity conservation and maintaining Ecological balance.

Summary

Homegardens are generally regarded as a very complex, species-rich agro-ecosystem managed in a sustainable manner over decades or even centuries. The main objective of this study was to assess the contribution of homegardens in rural livelihoods in Nainital district of Uttarakhand state, India. The study sites were selected between 350-2400 m above mean sea level (at 29°19'-29°28' N and 79°22'-79°38' E) in Nainital district of Uttarakhand state. Three complementary approaches were adopted, namely; (a) formal interview with the village headmen (pradhan) and secretary, (b) direct observation, (c) interaction with the head of the selected households through questionnaires. The plant species were recorded with the help of homegarden owner and identified with the help of vernacular names and floras of the region. The information on the uses and importance of plant species were collected by using questionnaires and focus group discussion. Standard energy values of various inputs and outputs were used for calculating energy budget while to calculate monetary budget the cost of expenditures in maintenance of the homegardens and marketing of plant products was deducted from the gross income to get net benefits.

In the study area, the homegarden size falls within the range of 0.002–0.04 ha with an average of 0.011 ha. In the present study, 88 plant species distributed in 51 families were recorded growing naturally or cultivated in the homegardens. Species richness was higher for bhabhar region as compared to hill region while along the size gradient species richness increased with increasing homegarden size. Herb density was maximum in large homegarden (1153-1904 ind m⁻²) followed by medium (377-583 ind m⁻²) and small-sized (292-630 ind m⁻²) homegardens. Tree density was maximum in large (2600-3600 ind ha⁻¹) followed by medium (800-2100 ind ha⁻¹) and small-sized (200-433 ind ha⁻¹) homegardens. Multiple social benefits of home gardens include enhancing food and nutritional security in many socio-economic and political situations, improving family health and human capacity, empowering women, promoting social justice and equity, and preserving indigenous knowledge and culture. In the present study, from the economic point of view, rural farmers were motivated to involve in home gardening because of better nutrition, easy accessing fresh food and a reduction in family food budget. However, some were interested to reduce pressure on forests (52%) and biodiversity conservation (62%).

In homegardens gross per hectare annual energy input was 8742.28 MJ while energy output was 27490.6 MJ. Output/Input Ratio was bordered between 4.14-1.57 MJ along the altitudinal gradient and was maximum for low altitude homegardens. In terms of money total input was maximum at mid altitude homegardens and minimum for the low altitude homegardens. Output input ratio increased with decreasing altitudinal range. This may be due to the better facilities and proper maintenance of homegardens. The percentage contribution of homegardens towards peoples' average annual gross income was 10 to 20 %. During the management of homegarden, rural people confronted so many problems such as crop destruction by animals (*e.g.* by monkeys, baboons, pigs, sometimes grazing domestic animals also), lack of transportation facilities, unavailability of market etc. Biggest constraint faced by homegarden owners was lack of time (76%) at low altitude, weed infestation at mid altitude (82%) and destruction by wild animals (80%) at high altitude homegardens.

This study demonstrated how homegardens are used to advance important livelihood objectives. It considered the potential benefits of homegardening as part of the farming system, with the capability of raising income and thus improving livelihoods of the poor. By adopting better Livelihood Security Models and Employment and Income Generation Models rural farmers can generate employment throughout the year. In addition, these models will be helpful in improving Cultivation practices, Biodiversity conservation and maintaining Ecological balance.

References

- Abdoellah OS, Hadikusumah HY, Takeuchi K, Okubo S, Parikesit P 2006. Commercialization of homegardens in Indonesian villages: Vegetables composition and functional changes. *Agroforestry Systems*, 68(1): 1-13.
- Bargali K 2015. Comparative Participation of rural women in agroforestry home gardens in Kumaun Himalaya, Uttarakhand, India. *Asian Journal of Agricultural Extension*, 6(1): 16-22.
- Bargali K. 2016. Traditional homegardens as a sustainable ecosystem for maintenance of biodiversity: a case study from Kumaun Himalaya. *Journal of Biodiversity* 7(2):88-100.
- Bargali K, Vibhuti, Shahi C 2015. Contribution of rural women in vegetable cultivation in homegardens of Nainital District, Kumaun Himalaya, India. *Current Agriculture Research Journal*, 3(2): 90-100.
- Buchmann C 2009. Cuban homegardens and their role in social-ecological resilience. *Human Ecology*, 37: 705-721.
- Christanty, L. 1990. Homegardens in tropical Asia, with special reference to Indonesia. In *Tropical Home Gardens* (eds Landauer, K. and Brazil, M.), United Nations University Press, Tokyo, Japan, , pp. 9–20.
- Fernandes , E. C. M. and Nair P. K. R. 1986. An evaluation of the structure and function of tropical homegardens. *Agric. Syst.* 21:279–310.
- Ghosh A 2003. Herbal folk remedies of Bankura and Medinipur districts, West Bengal (India). *Indian Journal of Traditional Knowledge*, 2: 393-396.
- High C and Shakleton CM 2000. The comparative value of wild and domestic plants in homegardens of a South African rural village. *Agroforestry Systems*, 48: 141-156
- Kala CP 2010. Homegardens and management of key species in the Pachmarhi Biosphere Reserve of India. *Journal of Biodiversity*, 1(2):111-117.
- Kehlenbeck, K.; Arifin, H.S.; Maass, B.L. (2007). Plant diversity in homegardens in a socio-economic and agro-ecological context. In: Tschardtke, T.; Leuschner, C.; Zeller, M.; Guhardja, E.; Bidin, A. (eds.). *The Stability of Tropical Rainforest Margins: Linking Ecological, Economic and Social Constraints of Land Use and Conservation*. Springer, Berlin, Germany, p. 297-319.
- Kumar BM, Nair PKR 2004. The enigma of tropical homegardens. *Agroforestry Systems*, 61:135-152.
- Mitchell R, Hanstad T 2004. Small Homegarden Plots and Sustainable Livelihoods for the Poor. Rome, Italy: LSP Working Paper 11.
- Mitchell, R. 1979. An analysis of Indian agroecosystems, Interprint, New Delhi.
- Nair PKR and Kumar BM 2006 . Introduction. In: KUMAR, B.M.; NAIR, P.K.R. (eds.). *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry*. Advances in Agroforestry, Vol. 3, Springer, Dordrecht, The Netherlands, p. 1-10.
- Padalia K, Bargali K, Bargali SS 2015. How does traditional homegardens support ethnomedical values in Kumaun Himalayan Bhabhar Belt, India? *African Journal of Traditional Complementary and Alternative Medicines*, 12(6): 100-112.
- Pande PC, Vibhuti, Awasthi P, Bargali K, Bargali SS 2016. Agro-biodiversity of Kumaun Himalaya, India: A review. *Current Agriculture Research Journal*, 4(1): 16-34.

- Parihaar RS, Bargali K, Bargali SS 2014. Diversity and uses of Ethno-medicinal plants associated with traditional agroforestry systems in Kumaun Himalaya. *Indian Journal of Agricultural Sciences*, 84(12): 1470-1476.
- Rao MR, Rao BR 2006. Medicinal plants in tropical homegardens. In *Tropical Homegardens: A Time-tested Example of Sustainable Agroforestry*. Edited by Kumar BM, Nair PKR. Dordrecht, The Netherlands: Springer Science.
- Rowe WC 2009. Kitchen garden in Tajikistan: The economic and cultural importance of small scale private property in post-Soviet society. *Human Ecology*, 37: 691-703.
- Sharma PP, Mujumdar AM 2003. Traditional knowledge on plants from Toranmal Plateau of Maharashtra. *Indian Journal of Traditional Knowledge*, 2: 292-296.
- Singh J.S., Singh S.P., Gupta, S.R. 2010. Ecology, environment and resource conservation. Anamaya Publishers, New Delhi.
- Tardio J, De Santayana P, Santayana M 2008. Cultural importance indices: A comparative analysis based on useful wild plants of Southern Cantabria (Northern Spain). *Economic Botany*, 62:24-39.
- Tynsong H and Tiwari BK. 2010. Plant Diversity in the Homegardens and their Significance in the Livelihoods of War Khasi Community of Meghalaya, North-east India. *Journal of Biodiversity* 1(1): 1-11.

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Paper Published

- Kiran Bargali 2016. Traditional Homegardens as a Sustainable Ecosystem for Maintenance of Biodiversity: A Case Study from Kumaun Himalaya, India. *J Biodiversity*, 7(2): 88-100
- Pande P.C., Vibhuti, Awasthi P., Bargali K. and Bargali S.S. 2016 . Agro-Biodiversity of Kumaun Himalaya, India: A Review. *Current Agriculture Research Journal* 4(1), 16-34.
- Kritika Padalia, Kiran Bargali and S.S. Bargali 2017. Present scenario of agriculture and its allied occupation in a typical hill village of Central Himalaya, India. *Indian Journal of Agricultural Sciences* 87(1): 132-141
- Suman Pantola, Vibhuti, Kiran Bargali and SS Bargali. 2017. Screening of three leguminous crops for drought stress tolerance at germination and seedling growth stage. *Indian Journal of Agricultural Sciences* 87(4): 467-472.
- Vibhuti, Bargali K. and Bargali S.S. 2018. Effects of homegarden size on floristic composition and diversity along an altitudinal gradient in Central Himalaya, India. *Current Science*. 114 (12): 2494-2503.
- Bargali K., Karki H., Vibhuti, and Bargali S.S. 2018. Contribution of homegarden agroforestry in livelihood of rural farmers in Kumaun Himalaya. *Bionature* 38(1): 34-47.
- Vibhuti, Karki H. and Bargali K 2017. Assessment of ecosystem services in homegarden systems in Kumaun Himalaya. In: Ecological ignorance in Development: raising Disastrous Possibilities Edited by Prem Prakash, Narendra Kumar Singh and Amita Prakash.

Paper present in Conference/ Seminar

- Kiran Bargali. Traditional homegardens of Kumaun Himalaya, Uttarakhand: A sustainable ecosystem for maintenance of biodiversity. Paper presented in 103rd Indian Science Congress organized by University of Mysuru, January 3-7, 2016
- Himani Karki, Kiran Bargali and S.S. Bargali 2017. Effects of homegarden size on species composition in Nainital district of Kumaun Himalaya. Paper accepted for presentation in 11th State Science and Technology Congress organized by UCOST, Dehradun 02-04 March 2017.
- Vibhuti, Kiran Bargali and S.S. Bargali 2017. Carbon pool and stability as affected by altitude in homegarden systems of Kumaun Himalaya, India. Paper presented in 11th State Science and Technology Congress organized by UCOST, Dehradun 02-04 March 2017.

- Vibhuti, Kiran Bargali and S.S. Bargali 2017. Indigenous knowledge and conservation aspects of homegardens in Hill region of Kumaun Himalaya, India. Paper accepted for presentation in XIX Commonwealth Forestry Conference organized by FRI, Dehradun 3-7 April 2017.
- Kiran Bargali 2017. Homegardens as an option for improved food security and enhanced livelihood. Paper present in National Seminar on Socio-economic impacts of ecological ignorance in Development: Raising Disastrous possibilities. Organized by the Department of Botany. Post graduate college Dwarahat, Almora. 6-7 May 2017
- Kiran Bargali 2018. Contribution of homegarden agroforestry in livelihood of rural farmers in Kumaun Himalaya. Paper presented in International seminar organized by UPSA. 7-8 October 2017.
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