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Changing pattern of plant species utilization in relation to altitude and their relative prevalence in homegardens of Kumaun Himalaya, India

Vibhuti [1], Kiran Bargali [1], Surendra Singh Bargali [1,*]

[1]Department of Botany, D.S.B. Campus, Kumaun University, Nainital-263001(Uttarakhand), India

ABSTRACT: The aim of the present study was to analyse the species utilization pattern and their relative prevalence in homegardens varying in size and altitude. Four sites were selected along an altitudinal gradient viz., very low (up to 350 m), low (350-700 m), mid (700-1500 m) and high altitudes (above 2000 m) in Kumaun Himalaya, India. At each altitude, homegardens were categorized into three size classes viz., large (above 0.007 ha), medium (0.004-0.006 ha) and small homegardens (up to 0.003 ha). Maximum species richness was recorded in large sized homegarden at all altitudes except mid altitude where maximum species was observed in medium sized homegardens. Across altitudes, maximum plant species (39) was recorded at mid altitude whereas minimum species (24) were present in high altitude homegardens. Amaryllidaceae was the most important family followed by Oxalidaceae across all the altitudes. In case of plant utilization pattern, maximum species were utilized as a medicine (44.23 %) followed by vegetables (26.66 %), fodder (18.1 %), miscellaneous (15.97 %), spices (13.97 %) and fruits (12.34 %). Among the species, *A. cepa* (1380) and *C. annuum* (1026) showed most prevalence whereas *S. cumini* (278) was the least prevalent species. Across the altitudinal gradient, mid altitude showed most (2341, 1330) relative prevalence whereas high altitude showed least (876, 0) relative prevalence for *A. cepa* and *M. indica*, respectively. Management practices and conventional activity could show a higher effect on species composition and their utilization pattern to improve food security and conserving plant genetic diversity in altitudes.

1. INTRODUCTION

Homegarden is smallholder farming system which combines trees with herb species and sometimes domestic animals around the homestead area. This system has wide socio-economic characteristics features with high species diversity (Pandey et al., 2002, 2006; Udofia et al., 2012), provide crop productivity and avoidance of environment risks (Galhena et al., 2013; Shoo, 2009). Food production and other products such as; timber, feedstuff, spices, medicinal purpose plants, ornamentals etc. increased resource availability, improve productivity, control disease risk, yield over the year for household member and also serve as sources of genetic diversity (Amberber et al., 2014; Vibhuti et al., 2017).

In India, many studies defined the role of homegardens in the human life of rural society, especially in terms of livelihood and economic significance (Das & Das, 2005; Gariya et al., 2016; Tangjang & Arunachalam, 2009). In the rural areas, farmers are mostly depend on their own homegarden product for livelihood. The effective integrated homegarden systems have a high potential to improve the crop productivity, maintain stable supply of socio-economic products (Kahiluoto et al., 2014; Karki et al., 2021) and its contribution to household economic status in several ways (K. Bargali et al., 2018; Tynsong & Tiwari, 2010). Integration of trees with crops also plays important role in enhancing the farm productivity and resilience of households through provision of diversified products for sustaining livelihoods (S.S. Bargali et al., 2019; Lasco et al., 2014; Mbow et al., 2014).

Traditional homegardens support multilayered species strata like; trees, shrubs and herbs near household (B.M. Kumar & Nair, 2004), which provide the edible food, fodder, fuelwood, ornamental and other products (Chandrashekara & Bajju, 2010; Vibhuti et al., 2018). In addition, this system enhances the biodiversity, preserve the environmental and ecological benefits, nutritional security, soil conservation potential, mitigation of carbon dioxide emissions and job opportunity (V. Kumar & Tiwari, 2017; Padalia et al., 2022; Vibhuti et al., 2020). Ecological and socioeconomic factors including geographic area, weather, water accessibility, homegarden size, agricultural policy, market needs and household aspects are determining factors influencing the diversity

* Corresponding author.
E-mail address: surendrakiran@rediffmail.com (Surendra Singh Bargali)

and utilization of products obtained from the traditional homegardens (K. Bargali, 2016; Tesfaye & Desta, 2017).

In Kumaun Himalaya, farmers maintain conventional homegardens for subsistence production and income generation (Parihaar et al., 2014, 2015). It has a multifaceted flora with occupant plant species and produced useful outputs due to high species diversity (Padalia et al., 2015; Subba et al., 2017). Cultivation of plant species in homestead homegardens differed from place to place depending on the socioeconomic conditions of the farmers (Mendez et al., 2001). Therefore, a comparative study of different sized homegardens along an altitudinal gradient has been attempted in terms of species diversity, plant utilization pattern and their relative prevalence.

2. MATERIALS AND METHODS

2.1. Study area

The study was conducted in Kumaun Himalaya in Uttarakhand State of India. The study sites were selected in Nainital district between 300-2000 m above mean sea level (29°19'-29°28' N and 79°22'-79°38' E). Four sites were selected along an altitudinal gradient viz., very low altitude (up to 350 m), low altitude (350-700 m), mid altitude (700-1500 m) and high altitude (above 2000 m) (**Figure S 1, Appendix A**). At each altitude, homegardens were categorized into three size classes viz., large (above 0.007 ha), medium (0.004-0.006 ha) and small homegardens (up to 0.003 ha) and three replicates for each size class at each altitude were selected. Climatically the study area falls within sub-tropical to temperate zones.

2.2. Sampling Method

We have selected thirty-six homegardens from four altitudes (three homegardens of each size) on the basis of stratified random sampling. For phytosociology analysis, quadrat method was used and random quadrats of 10m × 10m size were laid for trees, 5m × 5m quadrat for shrubs and 1m × 1m quadrats for herbs in the selected sites (Curtis & Mcintosh, 1950). Plant species were identified with the help of vernacular name, flora, some relevant literatures and research papers (Gupta, 1968; Pande et al., 2016; Samant & Palni, 2000). Information regarding use of plants was collected through semi- structured questionnaire/interview from homegarden owners (**Supplementary file 1, Appendix A**). Utilization of the plant species were categoried on the basis of their primary uses.

2.3. Family Importance Value (FIV Index)

Family Importance Value (FIV) index is combination of richness, density and dominance. The FIV index was used to estimate the floristic composition at the species family level (Mori et al., 1983).

2.4. Relative prevalence (RP)

Relative prevalence (RP) of plant species was calculated following Zaman et al. (2010) as:

Relative prevalence (RP) = ni/A × fi/F

Where, ni = Number of specimen species i in homegarden, A = Area of homegarden, fi = Number of homegardens in which species i is present, F = Total number of homegardens.

2.5. Statistical Analysis

Data and samples were collected from study sites. The data was complied with help Microsoft Excel and for statistical treatment using the STATISTICA and SPSS software to prove the statistical significance of the results obtained.

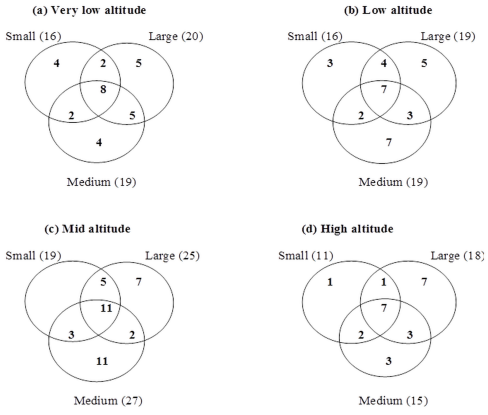

Figure 1. Average species richness in homegardens of Kumaun Himalaya.

3. RESULTS

3.1. Species composition and family importance value

A total number of 57 plant species belonging to 27 families were recorded. The homegardens of mid altitude (MA) supported maximum number of plant species (39) of which, medium sized homegardens (MHGs) shared 27 plant species followed by the large (25) and small (19) sized homegardens (LHGs, SHGs). At this altitude, 11 and 7 species present exclusively in MHGs and LHGs, respectively while 21 species were common in all sized homegardens (Figure 1). The high altitude homegardens (HA) supported lowest number of species (24 sp.) of which, LHGs contributed maximum (18 sp.) followed by MHGs (15 sp.) and SHGs (11 sp.). At this altitude, 1, 3 and 7 species were reported exclusively in SHGs, MHGs and LHGs, respectively while 13 species were common in all sized homegardens (Figure 1). The family importance value was recorded highest for family Amaryllidaceae (FIV=55.12). This family represented maximum number of species in all sized homegardens at all the altitudes followed by family Caryophyllaceae (FIV=27.71) in LHGs at low altitude (LA) and family Asteraceae (FIV =24.07) in LHGs at high altitude.

Family Ebenaceae recorded lowest family importance value (FIV=3.97) in MHGs at mid altitude (Table 1).

Table 1
Family Importance Value of homegarden species along the altitudinal gradient.

Altitudes	Family Importance Value											
	VLA			LA			MA			HA		
HG sizes	SHGs	MHGs	LHGs	SHGs	MHGs	LHGs	SHGs	MHGs	LHGs	SHGs	MHGs	LHGs
Amaryllidaceae	44.10 (93)	46 (98)	45.14 (100)	48.36 (91)	52.98 (75)	55.12 (98)	53.43 (77)	26.78 (73)	41.47 (93)	50.07 (31)	30.13(27)	49.06 (59)
Amaranthaceae	-	-	10.08 (14)	8.35 (5)	7.33 (4)	-	-	5.83 (08)	-	-	-	-
Anacardiaceae	6.69 (01)	5.80 (01)	5.35 (01)	6.64 (01)	6.40 (02)	5.72 (01)	8.66 (03)	3.97 (01)	4.36 (01)	-	-	-
Apiaceae	12.69 (19)	-	-	-	-	-	-	6.89 (12)	-	12.68 (3)	33.71 (44)	-
Asteraceae	9.69 (10)	9.11 (11)	11.54 (19)	23.55 (28)	22.41 (21)	20.70 (22)	24.07 (24)	13.64 (23)	9.76 (16)	-	-	9.04 (6)
Annonaceae	-	5.62 (01)	-	-	-	-	-	-	-	-	-	-
Equisetaceae	-	-	-	-	-	-	-	-	4.96 (05)	-	-	-
Brassicaceae	-	-	-	-	-	-	-	8.73 (05)	6.88 (08)	-	-	23.19 (12)
Caricaceae	6.58 (01)	5.46 (01)	5.35 (01)	-	-	-	-	-	-	-	-	-
Caryophyllaceae	-	13.92 (24)	10.96 (17)	12.96 (17)	10.36 (09)	12.22 (15)	18.22 (22)	22.37 (70)	11.32 (20)	17.63 (18)	18.07 (18)	27.71 (39)
Cucurbitaceae	7.25 (03)	12.33 (05)	17.10 (06)	-	18.04 (04)	12.34 (04)	7.65 (01)	4.23 (02)	4.72 (02)	22.28 (04)	23.69 (06)	11.26 (02)
Euphorbiaceae	-	5.62 (01)	-	-	-	7.08 (04)	-	-	4.36 (01)	-	-	-
Ebenaceae	-	-	-	-	-	-	-	3.97 (01)	-	-	-	-
Fabaceae	27.30 (44)	12.84 (21)	5.35 (01)	33.49 (53)	-	-	9.67 (05)	6.62 (11)	11 (08)	20.36 (20)	17.93 (18)	-
Malvaceae	12.13 (17)	10.73 (15)	9.67 (13)	15.66 (08)	-	8.59 (08)	-	5.38 (06)	9.16 (14)	-	-	-
Myrtaceae	-	-	10.35 (01)	-	6.40 (02)	-	-	-	-	-	-	-
Oxalidaceae	8.41 (06)	10.73 (15)	11.17 (17)	12.96 (17)	18.77 (24)	10.79 (14)	11.53 (12)	8.30 (17)	9.56 (15)	29.93 (20)	15.89 (15)	18.50 (23)
Plantaginaceae	-	-	-	9.41 (08)	-	6.73 (04)	6.92 (11)	11.22 (28)	9.64 (16)	-	-	
Poaceae	50.37 (95)	27.31 (47)	32.60 (64)	12.96 (17)	8.47 (06)	31.75 (35)	15.24 (16)	15.19 (29)	19.08 (19)	-	13.83 (12)	26.94 (19)
Rosaceae	-	-	-	-	-	-	-	7.94 (02)	-	11.14 (02)	15.18 (03)	14.97 (07)
Polygonaceae	-	-	-	-	8.85 (06)	8.14 (06)	-	5.87 (08)	8.48 (12	17.60 (20)	9.33 (04)	10.69 (09)
Rutaceae	-	-	-	-	-	-	-	3.97 (01)	8.72 (02)	-	-	-
Solanaceae	8.21 (05)	11.27 (17)	10.78 (64)	-	16.28 (10)	-	12.88 (11)	9.42 (21)	10.16 (06)	18.32 (08)	11.48 (08)	9.14 (06)
Sapindaceae	6.58 (01)	5.62 (01)	5.35 (01)	6.64 (01)	-	5.72 (01)	-	-	-	-	-	-
Tiliaceae	-	-	-	-	-	-	-	-	4.36 (01)	-	-	-
Violaceae	-	-	-	-	-	-	14.06 (14)	14.85 (42)	14.67 (30)	-	-	-
Zingiberaceae	-	17.62 (13)	9.21 (12)	9.01 (07)	23.71 (14)	14.16 (08)	10.69 (07)	5.83 (08)	12.32 (12)	-	10.76 (07)	-

SHGs, MHGs, LHGs=small, medium, large homegardens,VLA, LA, MA, HA= very low, low, mid altitude, high altitude (individual numberof species in each family is given in parenthesis)

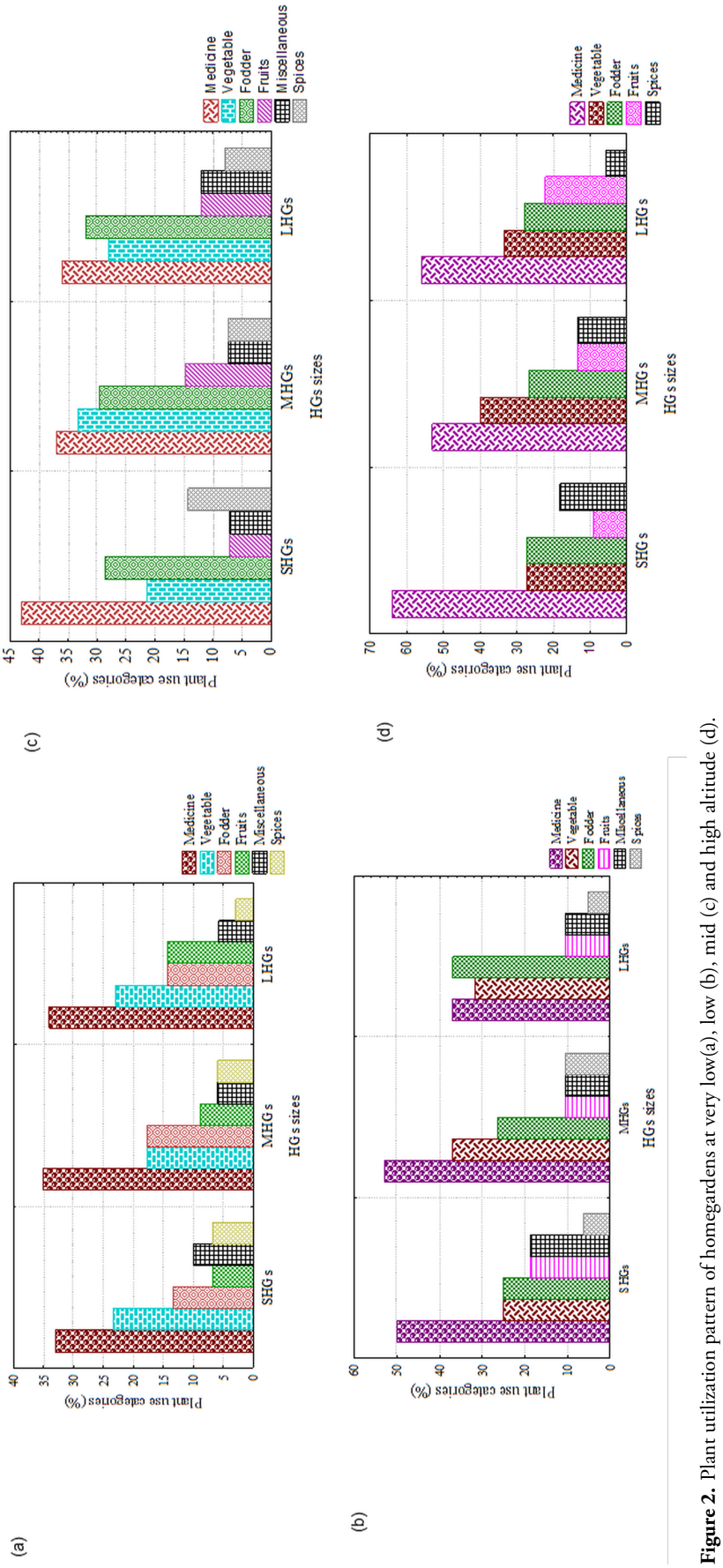

Figure 2. Plant utilization pattern of homegardens at very low(a), low (b), mid (c) and high altitude (d).

3.2. Utilization pattern of homegardens species and their relative prevalence

There were six different utilization categories on the basis of primary important needs viz fruit, vegetable, spice, medicinal, fodder and other miscellaneous product (oil yielding, building purpose materials and religious values). Plants of medicinal and edible (vegetables) categories were the most frequent component followed by fodder, fruits, spices and miscellaneous categories in different sized homegardens (Figure 2). At very low altitude, medicinal plant contributed maximum in MHGs while vegetable was maximum in SHGs. At low altitude, contribution of medicine and vegetable was higher in MHGs. At mid and high altitudes, contribution of medicine was maximum in SHGs while vegetables contributed maximum in MHGs (Figure 2).

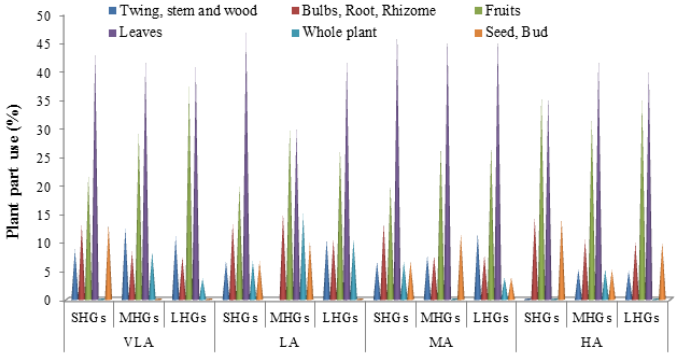

Figure 3. Plant part used in homegardens at different altitudes. (SHGs,MHGs, LHGs=small, medium, large homegardens, VLA, LA, MA, HA= very low, low, mid, high altitude)

Fruit species cultivation was highest in LHGs at high altitude (22.22 %) whereas least fruit species cultivation (6.67) was recorded in SHGs at very low altitude. In an average percentage of plant species were used as spices, in which maximum contribution was recorded in SHGs at mid altitude (14.29 %) and minimum contribution was observed in LHGs at very low altitude (6.67 %). Among the different spice crops, *C. sativum*, *C. longa* and *C. annuum* were frequently cultivated species. Other miscellaneous plant species like *C. dactylon*, *O. sanctum* and *M. indica* were considered important religious plants and used in various rituals (Figure 2).

Relative prevalence provides the importance of individual species in a particular area. Among the cultivated herbs, *A. cepa* was the most prevalent species in SHGs at mid altitude (RP=4666) whereas *A. esculentus*, *A. sativum*, *C. sativum* and *P. sativum* showed least relative prevalence value in LHGs at mid altitude (Table 2). For wild herb species, relative prevalence was maximally shared by *A. conyzoides* in MHGs and minimum (RP=1800) by *V. serpens* (RP=277) in LHGs at mid attitude. For cultivated trees species, *C. sinensis* was most prevalent (RP=1200) in MHGs while *C. limon* and *M. indica* were the least prevalent species in LHGs at mid altitude (RP=277) (Table 2). Mid altitudes showed the most relative prevalence with a most utilizable species (Table 3). In the homestead homegarden, leaves were used in maximum by household member for own consumption followed by fruits,root, rhizomes, twig, stem, and seed at all the altitudes (Figure 3).

4. DISCUSSION

4.1. Status of homegardens plant species

According to Senanayake et al. (2009) species richness is influenced by homegarden size, managed by owners to fulfill their regular needs and for this they grow multipurpose plant species utilized for the different purposes. Yirefu et al. (2019) stated that utilization of homegarden product and their management can secure food productivity which determined by environmental factors and dietary habits as well as the socio-economic and market demands. In this study, the species richness showed significant positive correlation with homegarden size (Figure 4) at all the altitudes except mid altitude. In contrast, homegardens of Mexico (Rico-Gray et al., 1990) and Indonesia (Abdoellah et al., 2006) the numbers of species or individuals were not related to homegarden size. In the present study the mean species richness per homegarden ranged from 11 to 27. Martin et al. (2019) estimates 64 species/garden in the Southwest region of Sri Lanka and Kebebew (2018) observed 10 to 45 species in Arba Minch town, Southern Ethiopia. Across the homegarden sizes, species richness increased with increasing homegarden size except mid altitude homegardens where species richness was maximum in medium sized homegardens similar to the findings of Das and Das (2005). Family Importance Value indicated that across the altitudinal gradient, Amaryllidaceae was the most important family followed by Oxalidaceae (Table 1). These variabilities may be due to the changes in the procedure, plant life forms, topography and ecological factor.

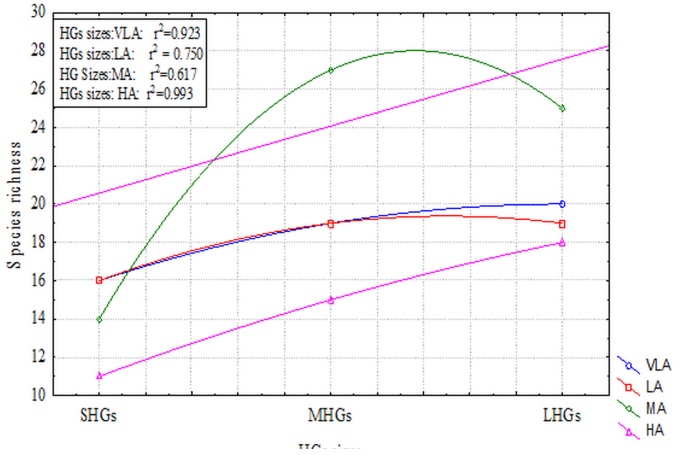

Figure 4. Regression equation showing relationship between species richness and homegardensize at different altitudes.

Table 2
Relative prevalence of different plant species in homegardens across altitudinal gradient.

Plant species	VLA			LA			MA			HA		
	SHGs	MHGs	LHG	SHGs	MHGs	LHG	SHGs	MHGs	LHG	SHGs	MHGs	LHG
Cultivated herb species												
Abelmoschus esculentus (Linn.) Moench	1185	1056	833	-	-	527.77	-	600	277.77	-	-	-
Allium stracyes Linn.	-	-	-	-	-	-	-	-	-	-	-	285.71
Allium cepa Linn.	1778	1056	833	1185.18	1266.67	791.66	4666.67	1800	555.55	1222	833.33	571.43
Allium sativum Linn.	1185	704	556	592.59	844.44		1555.56	1200	277.77	1833.33	833.33	571.43
Amaranthus blitum var. oleracea Hook.	-	-	278	592.59	-	-	-	600	-	-	-	-
Brassica juncea (Linn.)	-	-	-	-	-	-	-	-	-	-	600	-
Brassica oleracea var. botrytis Linn.	-	-	-	-	-	-	-	-	-	-	-	600
Brassica oleracea var. capitata Linn.	-	-	-	-	-	-	-	600	277.77	-	-	571.43
Capsicum annuum Linn.	-	704	556	-	422.22		3111.11	-	833.33	1833.33	833.33	571.43
Colocasia esculenta Schott	-	352	278	-	422.22	527.77	1555.56	-	277.77	-	416.67	-
Coriandrum sativum Linn.	593	-	-	-	-	-	-	600	-	611.11	416.67	-
Cucurbita maxima Duch. ex Lam.	-	-	-	-	-	263.88	-	600	-	611.11	416.67	285.71
Cucumis sativus Linn.	-	-	278	-	422.22	-	1555.56	-	277.77	-	833.33	285.71
Curcuma longa Linn.	-	352	-	592.59	422.22	263.88	1555.56	-	277.77	-	-	-
Glycine max (L.) Merr.	1185		-	592.59	-		-	-	-	-	-	-
Lagenaria siceraria (Mol.) Standl.	-	352	556	-	-	263.88	-	-	-	611.11	416.67	-
Luffa acutangula (Linn.) roxb.	593	352	-	-	422.22	-	-	-	-	-	-	-
Momordica charantia Linn.	-	-	-	-	422.22	-	-	-	-	-	-	-
Pisum sativum Linn.	-	-	-	1185.59		-	-	-	-	611.11	-	-
Solanum tuberosum Linn.	-	-	-		422.22	-	-	-	277.77	-	-	-
Spinacea oleracea Linn.	593	-	-	-	-	-	-	-	-	-	-	-
Trigonella foenumgraecum Linn.	593	-	-	-	-	-	-	-	-	-	416.67	-
Zingiber officinale Roscoe		-	-	-	422.22	527.77	-	-	-	-	-	-
Vicia faba L.	-	-	-				1555.56		277.77	-	-	-
Wild herb species												
Achyranthes aspera Linn.	-	-	-	-	422.22	263.88	-	-	-	-	-	-
Ageratum conyzoides Linn.	-	-	-	1185.18	844.44	791.66	-	1800	-	-	-	-
Arabidopsis stricta (Cambess.) Busch.	-	-	-	-	-	-	-	-	-	-	-	285.71
Arthraxon hispidus (Thunb.) Makino	-	1056	556	-	844.44	527.77	-	-	-	-	-	
Commelina benghalensis L.	593	-	556	-	-	-	-	-	-	-	-	

Continued on next page

Table 2 continued

Cynodon dactylon (L.) Pers.	3556	2815	1944	592.59	-	-	-	-	277.77	-	-	285.71
Cyperus rotundus L.	593	704	-	-	-	-	-	-	555.55	-		-
Eleusine indica (L.) Gaertn.	-	-	-	-	-	-	1555.56	600	277.77	-	416.67	-
Equisetum debile Roxb. ex Vaucher	-	-	-	-	-	-	-	600	-	-		-
Euphorbia hirta L.	-	-	-	-	-	263.88	-	-	-	-	-	-
Galinsoga parviflora Cav.	593	352	278	1185.18	1266.67	1055.5	3111.11	2400	1111.1	-	-	285.71
Oxalis corniculata Linn.	2370	1056	1111	2962.96	2111.11	1055.5	6222.22	2400	-	611.11	1250	1142.8
Poa annua Linn.	-	-	-	-	-	26388	-	600	-			
Polygonum nepalensis Meissn	-	-	-	-	422.22	527.77	-	1200	833.33	611.11	416.67	571.43
Stellaria media L.	-	352	278	1185.18	844.44	791.66	4666.67	1200	833.33	1222.22	2083.3	1428.5
Trifolium pretense L.	-	352	-	592.59	-	-		1200	277.77	-	-	-
Veronica anagallis aquatica Linn.	-	-	-	592.59	-	263.88	1555.56	600	277.77	-	-	-
Viola serpens Wall. Ex. Roxb.,	-	-	-	-	-	-	3111.11	-	277.77	-	-	-
Fruit tree species												
Achras sapota L.	-	352	-	-	-	-	-	-	-	-	-	-
Carica papaya Linn.	593		278	-	-	-	-	-	-	-	-	-
Citrus limon (Linn.) Burm.f.	-	-	-	-	-	-	-	600	277.78	-	-	-
Citrus sinensis Linn.	-	-	-	-	-	-	-		277.77	-	-	-
Diospyros kaki Linn.	-	-	-	-	-	-	-	1200		-	-	-
Litchi chinensis Sonn.	593	704	278	592.59	-	263.88	-	-	-	-	-	-
Malus domestica Borkh.	-	-	-	-	-	-	-	-	-	-	-	285.71
Mangifera indica L.	1778	1056	556	592.59	844.44	263.88	3111.11	600	277.77	-	-	-
Prunus persica Linn.	-	-	-	-	-	-	-	600	-	-	416.67	285.71
Prunus armeniaca L.	-	-	-	-	-	-	-		-	-	416.67	285.71
Prunus domestica Linn.	-	-	-	-	-	-	-	600	-	611.11	-	285.71
Psidium guajava Linn.	-	-	556	-	422.22	-	-	-	-	-	-	-
Syzygium cumini (L.) Skeels	-	-	278	-	-	-	-	-	-	-	-	-
Fodder tree species												
Ficus auriculata Lour.	-	352	-	-	-	-	-	-	277.77	-	-	-
Grewia optiva J. R. Drumm. ex Burrett	-		-	-	-	-	-	1200	277.77	-	-	-

(SHGs,MHGs, LHGs=small, medium, large homegardens, VLA, LA, MA, HA= very low, low,mid altitude, high altitude)

Table 3
Relative prevalence of homegardenspecies in different altitudes.

Plant species	VLA	LA	MA	HA	Mean
Cultivated herb species					
A. cepa	1222	1081	2341	876	1380
A. aspera	-	343	-	-	86
A. blitum var. oleracea	278	593	600	-	368
A. conyzoides	-	940	1800	-	685
A. esculentus	1025	528	439	-	498
A. hispidus	806	686	-	-	373
A. sativum	815	719	1011	1079	906
A. stracyes	-	-	-	286	71
A. stricta	-	-	-	286	71
B. juncea	-	-	-	600	150
B. oleracea var. botrytis	-	-	600	-	150
B. oleracea var. capitata	-	-	439	571	253
C. annuum	630	422	1972	1079	1026
C. esculenta	315	475	917	417	531
C. longa	352	426	917	-	424
C. maxima	-	264	600	438	325
C. sativum	593	-	600	514	427
C. sativus	278	422	917	560	544
G. max	1185	593	-	-	444
L. acutangula	473	422	-	-	224
L. siceraria	454	264	-	514	308
M. charantia	-	422	-	-	106
P. sativum	-	1186	-	611	449
S. oleracea	593	-	-	-	148
S. tuberosum	-	422	278	-	175
T. foenumgraecum	593	-	-	417	252
V. faba	-	-	917	-	229
Z. officinale	-	475	-	-	119
Wild herb species					
C. benghalensis	575	-	-	-	144
C. dactylon	2772	593	278	286	982
C. rotundus	649	-	556	-	602
E. debile	-	-	600	-	150
E. hirta	-	264	-	-	66
E. indica	-	-	811	417	307
G. parviflora	408	1169	2207	286	1017
O. corniculata	1512	2043	4311	1001	2217
P. annua	-	264	600	-	216
P. nepalensis	-	475	1017	533	506
S. media	315	940	2233	1578	1267

Continued on next page

Table 3 continued

T. pratense	352	593	739	-	421
V. anagallis-aquatic	-	428	811	-	310
V. serpens	-	-	1694	-	424
Fruit tree species					
A. sapota	352	-	-	-	88
C. papaya	436	-	-	-	109
C. limon	-	-	439	-	110
C. sinensis	-	-	278	-	69
D. kaki	-	-	1200	-	300
L. chinensis	525	428	-	-	238
M. domestica	-	-	-	286	71
M. indica	1130	567	1330	-	757
P. persica	-	-	600	351	238
P. armeniaca	-	-		351	117
P. domestica	-	-	600	351	238
P. guajava	556	422	-	-	245
S. cumini	278	-	-	-	70
Fodder tree species					
F. auriculata	352	-	278	-	157
G. optiva	-	-	739	-	185

VLA=verylow altitude, LA=low altitude, MA=mid altitude, HA=high altitude

4.2. Plant utilization pattern

In the study area, homegarden species are used for primary and secondary needs of the family members and utilized as fruit, vegetable, medicine, timber, fuelwood, ornamental plant, sacred purposes and other miscellaneous purposes (Figure 5). Albuquerque et al. (2005) Albuquerque et al. (2005) reported the predominance of medicinal plants (26%) in homegardens of North-Eastern Brazil. Cui et al. (2000) also recorded that species of plants in traditional homegardens of China were utilized as: medicines (23%), vegetables (21%), fruits (19%), ornamentals (9%) and spices (7%). Dash & Misra (2001) Dash and Misra (2001) also observed that the vegetables and spices are the most edible cultivated plant in homegardens of Eastern Ghats of Orissa. Whereas Sunwar et al. (2006) reported vegetable and species are the most important utilising products in Nepalese homegardens. Blanckaerta et al. (2004) recorded 65.7 % ornamental, 29.6 % edible and 8.6 % medicinal plants in the homegardens of Mexico. These findings indicated that plant diversity was selected for cultivation in homegardens according to the requirements of the household. In our study, homegarden have a complex plant diversity from herbs to trees. The production of cultivated crops was consumed by family member and the local communities. The community also prefers the wild plants, fodder, wood and other miscellaneous uses from the homegarden system in small amount which is enough to them (Shukla et al., 2017; Vibhuti et al., 2019).

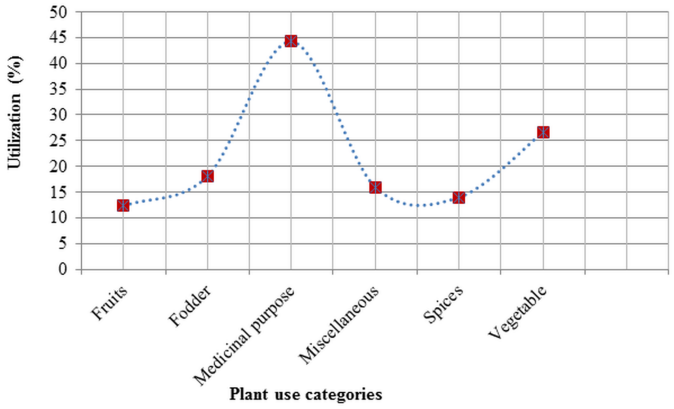

Figure 5. Percent utilization of different use categories of homegarden species.

4.3. Relative Prevalence of homegardens species

Percentage of homegarden comprising with a particular species, represents relative prevalence of that particular species in area. Cluster of homegarden species across the altitudinal gradient on the basis of their relative prevalence is presented in Figure 6. Among the species, *A. cepa* (1380) and *C. annuum* (1026) showed most prevalence whereas *S. cumini* (278) was the least prevalent species. Across the altitudinal gradient, mid altitude showed most (2341, 1330) relative prevalence whereas high altitude showed least (876, 0) relative prevalence for *A. cepa* and *M. indica*, respectively Table 3. Uddin et al. (2002), reported red amaranth (RP=11690) and Indian spinach (RP=4606) as the most prevalent species in the homestead of Southeastern Bangladesh. The homegarden supply food especially for farmers in the rural areas because it could be maintained with low-cost input and diversified with high output.

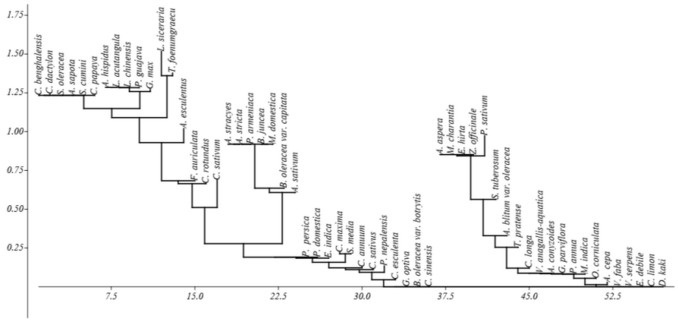

Figure 6. Cluster of homegarden species across the altitudinal gradient on the basis of their relative prevalence.

In this study, traditional homegardens of all villages possessed a multilayered vegetation structure. *M. indica*, *L. chinensis*, *C. papaya* and *F. auriculata* were the most frequent and dominant trees in very low and low altitudes, *Citrus sp.*, *D. kaki* and *G. optiva* trees were most common in mid altitude whereas in high altitude, *P. persica*, *P. armeniaca* and *M. domestica* were most dominant trees. Herb Plants like A. cepa, *A. sativum*, *C. sativum*, *C. maxima*, *L. siceraria*, *A. esculentus* and *C. esculenta* were cultivated as vegetable plants in majority of homegardens at all the altitudes. Medicinal plants have a various therapeutic properties were abundant in all household homegardens. Most wild species like *O. corniculata*, *S. media*, *C. dactylon*, *A. conyzoides* and *G. parviflora* were used as fodder in different altitudes. The presence of fodder trees and grasses has a crucial value, which resulted in increase in the number of livestock and decrease in the livestock forage cost and women drudgery.

5. CONCLUSIONS

In conclusion, home gardens are highly diverse with their utilization pattern in various ways. The socio-economic condition, management practice and the climatic factors were major determinant for farmer to enhance species diversity in homegarden systems. This study suggested that large sized homegardens are more efficient and more diversified than the small and medium sized homegardens at all the altitudes except mid altitude. Amaryllidaceae was the most important family in all the altitudes. High efficiency of utilized homegarden species was shared by medicinal plants and vegetables. Among the species, *A. cepa* and *C. annuum* showed most prevalence whereas *S. cumini* was the least prevalent species. Our study suggested that this traditional system should be recognized as potential unit to improve species composition, conserving plant genetic diversity and requires support to contribute food security in relation to altitude and homegarden size. Since homegardens are multipurpose systems provide important nutritional and health

benefits, therefore, should be encouraged and can be improved by proper management practices, cooperative and extension services.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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ORCID

Vibhuti	0000-0003-2539-2787
Kiran Bargali	0000-0002-8554-8803
Surendra Singh Bargali	0000-0001-6341-0945

A. APPENDIX, SUPPLEMENTARY INFORMATION

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AUTHOR CONTRIBUTIONS

V- Collected the data and prepared the manuscript, KB - Helped in analysis of data and manuscript preparation, SSB- Helped in conceptualization, study design and reviewed the manuscript.

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