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ASSESSMENT OF PLANT DIVERSITY IN HOMEGARDENS OF THREE ECOLOGICAL ZONES OF NEPAL

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ABSTRACT

Homegardens in Nepal have long been regarded as one of the most important multi-propose agro-forestry systems with complex structure. The aim of the study was to assess the species diversity and richness in three different ecological regions, i.e., Mountain (Sub-alpine), Mid-hill (Temperate) and Terai (Tropical) of Nepal. In total 45 homegardens were randomly selected and examined from three different villages representing one from each ecological regions and the Shannon–wiener, Simpson index and evenness were assessed. Overall 147 species were identified mainly vegetable, fruit, fodder, spices or medicinal plants. The average size of homegardens were found to be bigger in Mid-hill (0.12 ha), however, the species number and diversity was found to be high in the Terai region (102). More similarity between plant species composition was between Terai and Mid-hill. The Shannon-wiener index was found to be 1.316, 1.84 and 1.90 in the homegarden of Mountain, Mid-hill and Terai respectively. Simpson index was 0.052, 0.014 and 0.01 in homegarden of Mountain, Mid hill and Terai region, respectively. Similarly, evenness percentage was 56.29, 65.55 and 65.93 in homegarden of Mountain, Mid-hill and Terai region, respectively. Properly managed homegardens have high productivity and increased sustainability which helps in conserving agro-biodiversity, food sufficiency and economic supports including other ecological functions.

Key words: Homegardes, Ecological zones, Agro-biodiversity and Nepal.

INTRODUCTION

Homegardens are multispecies agro-ecosystems where different herbaceous and tree crops as well as trees are managed in integration (Kumar and Nair 2006). They are typically cultivated with a mixture of annual and perennial plants that can be harvested on a daily or seasonal basis (Sthapit *et al. 20*04). The homegarden is an important source of food security (Vogl *et al.* 2002, Pokhrel *et al. 20*15) and livelihoods (Michon and Mary 1994, Linger 2014) as it supplies diversified vegetables and fruits rich in micronutrients, spices herbs and medicines (Soemarwoto 1987, Kumar and Nair 2006). It meets cultural requirements enhancing source of income and provides ecosystem services at local, regional and global levels by maintenaning microclimate, moisture and conservation of soil at large (Sthapit *et al. 20*04, Linger 2014).

Species diversity is one of the most intuitive and widely adopted measures of biodiversity at both ecological and biogeographic scales (Bardhan

2012). It is a combination of species richness and evenness (Chiarucci *et al.* 2011). Biodiversity conservation and the maintenance of associated ecosystem services are vital for human well-being (Beaumont *et al.* 2011). As a subset of biodiversity, agricultural biodiversity is one of the most important forms of functional diversity currently used by humans and on which all farming and global food security depends (Subedi *et al.* 2009, Khanal *et al.* 2013). However, over 75% of Earth's terrestrial biomes have shown alteration as a result of anthropogenic activities, and homegarden systems are not exception. These are characterized by different vegetation strata composed of trees, shrubs and herbs in association with annual and perennial agriculture crops and small livestock within house compounds (Nair 1985, Fernandez and Nair 1986).

Nepal, unique in its geographical attributes and climatic variation, has been recognized as a biodiversity hotspot. Homegardens, a typical agro-ecosystem, have traditionally been managed in Nepal in the three major ecological zones of the country viz. Tarai, Mid-hills, and Mountains. Despite their ecological, socio-economic and environmental significance, there is an inadequacy in scientific study and information on the homegardens in different ecological regions of Nepal. Therefore, the study was focused on homegarden structure, species diversity and their uses.

MATERIALS AND METHODS

Study sites

Representing three ecological regions, three districts, namely Kapilvastu, Kaski and Mustang were purposively selected. One VDC (Village Development Committee) from each district was selected for data collection. They are Gajehada from Kapilvast district, Hemja from Kaski district and Tukuche from Mustang district. Gajehada VDC represents Terai region (tropical climate), Hemja VDC represents Mid-hilly region (temperate climate) and Tukuche VDC represents mountain region (Sub-Alpine climate). Tukucha VDC is characterized by bush type of vegetation, desert like landscape, steep and snowcapped mountains whereas Hemja VDC has both steep to moderate slops as well as flat lands and rivers. Species such as *Schima wallichii*, *Castanopsis indica* and *Myrica esculenta* are the dominant trees. Similarly Gajehada VDC has a plain land with abundance of *Shorea robusta* as the dominant tree. People from all the cultures practice traditional homegardining. The sample fields were widely distributed throughout the villages and were of variable sizes. The basic bio-physical and cultural information of the study sites and demographic and soci-economic characters of respondents are presented in Tables 1 and 2.

Table 1. Basic biophysical and soci-cultural information of the study sites.

Study sites (VDCs)	District	Ecological region	Altitude (masl)	Major dweller (by cast)
Gajehada	Kapilvastu	Tropical /Terai	90-120	Tharu, Brahmin, Chettri and Magar
Hemja	Kaski	Mid-hill	840-1471	Brahmin, Chettri, Magar, Gurung, Newar, kami, Damai and Sarki
Tukuche	Mustang	Mountain	1372-8167	Thakali, Gurung, Magar, Sherpa, Kami and Damai

Table 2. Demographic and socio-economic characters of the respondents.

Demographic and Socio-economic characters of the respondents	Mountain (Tukuche) n=15	Mid-hill (Hemja) n=15	Terai (Gajehada) n=15
Total land holding in hectare	0.61±0.34	0.42±0.11	2.53±2.28
Homegardens size in hectare	0.034±0.013	0.12±0.03	0.055±0.031
Average family size	4.26±1.27	6.66±2.31	7.26 ±2.89
Family members involved in Homegardens (%)	45.31±24.74	47±37.47	45.87±41.71
Education (%)			
Illiterate	46.67	6.67	6.67
Schooling	26.67	73.33	73.33
Higher Education	26.67	20	20
Farming systems	Subsistence	Commercial	Subsistence to Commercial
Average number of livestock's	4.66±1.99	4.73±1.94	5.26±2.78
Market accessibility	Low	High	Medium

Data collection and analysis

Forty five households were surveyed, fifteen households from each VDC representing ecological region and district. The households were randomly selected. Semi structured questionnaires were used during the households survey. Besides, key informant interviews were applied during the collection of data and direct observation method was also used during the study of homegardens. Focus group discussions were also conducted with representation of 10-12 local people in each VDC. A detail survey of composition and management practices of the homegardens of each household was made. The survey consisted of an inventory of tree, shrub and herbaceous species including vegetable species. The plant species in the homegarden were broadly categories into four different groups such as vegetable and spices including others, fruits, trees and fodder, and medicinal. The recorded plant species were analyzed by using different indices. Additional information concerning the homegardens size, socioeconomic information of household, home gardens orientation (subsistence and commercial) and management practices were recorded during the household survey.

The Shannon-wiener index, Eveneness, Simpson's index and Sorensen-coefficient of similarity were calculated (Wezel and Bender 2003).

Plant species were identified on the basis of vernacular names, published field inventories, flora and in consultation with the herbarium of Central Department of Botany, Tribhuvan University, Kathmandu (TUCH). The data were analyzed using the Microsoft Excel. On the basis of different ecological zones, the structural, functional, management and dynamics characteristics of homegarden types were also documented.

RESULTS

The average size of homegardens in Terai, (Gajehada VDC) Mid-hill (Hemja VDC) and Mountain (Tukuche VDC) were 0.055 ha, 0.12 ha and 0.034 ha, respectively. Within the 45 studied homegardens, a total number of 147 plant species were recorded (Table 3). the number of plants recorded in Gajehada, Hemja and Tukuche VDCs were 102, 89 and 25, respectively.

Table 3. Plant species in homegarden of three village of western Nepal.

	Species abundance			Local name	Family
	Tukucha VDC n=15	Hemja n=15	Gajehada n=15		
Vegetable, spices and others					
Brassica oleraceae L. Var. cpitata L.	H	H	H	Bandagobi	Cucriferrae
Brassica oleracea var. *botrytis* L	H	H	H	Cauli	Curciferae
Solanum tuberosum L.	H	H	H	Alu	Solanaceae
Lycopersicum esculentum Mill	M	H	M	Golbheda	Solanaceae
Cucurbita pepo L.	L	L	L	Pharsi	Cucurbitaceae
Brassica juncea (L.) Czem	H	M	M	Rayo	Curciferae
Coriandrum sativum L.	M	L	L	Dhaniya	Umbelliferae
Allium cepa L.	M	L	L	Pyaj	Amaryllidaceae
Fagopyrum esculentum Moench.	H	-	-	Phaphar	Polygonaceae
Phaseolus vulgaris L.	H	L	-	Dalo simi	Leguminosae
Raphanus sativus L.	M	M	M	Mula	Curciferae
Daucas carota L. var. sativa DC	L	L	L	Gajar	Umbelliferae
Allium sativum L.	L	L	L	Lasun	Amaryllidaceae
Alllium ascalonicum L.	M	-	-	Chyapi	Amaryllidaceae
Lagenaria siceraria (Molina) Standl.		L	L	Lauka	Cucurbitaceae
Vicia faba L.		L	M	Bakula	Cucurbitaceae
Spinacia oleraceae L.		L	L	Palungo	Chenopodiaceae
Lablab purpureus L.		L	L	Hiude simi	Leguminosae
Trichosanthes anguina L.		M	M	Ghiraula	Cucurbitaceae
Luffa acutangula (L.) Roxb.		-	L	Toraya	Cucurbitaceae
Trigonella foenum-graecum L.		-	L	Methi	Leguminosae
Brassica oleracea L. var. accephala DC.		M	L	Bro cauli	Curciferae
Amaranthus viridis L.		-	H	Lunde	Amaranthaceae
Chenopodium album L.		L	H	Betha	Chenopodiaceae
Lactuca sativa L.		-	L	Chinies sag	Asteraceae
Dioscorea sagittata Royle		L	L	Tarul	Dioscoreaceae
Cucumis sativus L.		-	L	Kakro	Cucurbitaceae
Vigna unguiculata (L.) Walp.		-	L	Bodi	Leguminosae
Phaseolus vulgaris L.		-	M	Rajma	
Elsholtzia flava (Benth.) Benth		L	L	Sampu (sopsop)	Labiatae
Perilla frutescens (L.) Britton		-	L	Silam	Labiatae
Sesamum orientale L.		-	L	Til	Pedaliaceae
Trichosanthes anguina L.		-	L	Cicindo	Cucurbitaceae
Momordica charantia L.		-	L	Karela	Cucurbitaceae
Colocasia antiquorum Schott. Var. esculenta		L	L	Pidalu (Karkalo)	Araceae
Capsicum annuum L.		-	L	Khursani	Solanaceae
Lycopersicum esculentum Mill		H	L	Golbheda	Solanaceae
Lepidium sativum L.		L	L	Camsur	Cruciferae
Pisum sativum L.		L	M	Kerau	Leguminosae
Basella alba L.		-	L	Poi saag	Basellaceae

Dolichos spp.		-	L	Laure semi	Leguminosae
Dolichos spp.		-	L	Vatte simi	Leguminosae
Brassica oleraceae L. var. *gongylodes* L.		-	L	Gyath gobhi	Cruciferae
Solanum melongena L.		-	L	Bhenta	Solanaceae
Brassica rapa L.		M	L	Tori saag	Cruciferae
Benicasa hispada (Thunb.)		L	L	Kuvindo	Cucurbitaceae
Abelmoschus esculentus (L.) Moench		-	L	Cipali bhindi	Malvaceae
Coccinea grandis (L.) Voigt		-	L	Kundaru	Cucurbitaceae
Dolichos lablab L.		-	L	Simi	Leguminosae
Cajanus cajan (L.) Huth		-	L	Rahar	Leguminosae
Sechium edule (Jacq.) Sw.		L		Skush	Cucurbitaceae
Dioscorea bulbifera L.		L		Gittha	Dioscoreaceae
Fruits					
Pyrus malus L.	M	-	-	Syau	Rosaceae
Punica granatum L.	L	L	L	Anar	Punicaceae
Prunus persica (L.) Batsch	L	L	-	Aru	Rosaceae
Prunus amygdealus Batshc	L	-	-	Badam	Rosaceae
Juglans regia L.	L	-	-	Okhara	Juglandaceae
Pyrus communis L.	L	L	L	Naspati	Rosaceae
Purnus domestica L.	L	L	-	Aru bakhara	Rosaceae
Musa paradisiaca L.		L	L	Kera	Musaceae
Mangifera indica L.		L	L	Aap	Anacardiaceae
Psidium guajava L.		L	L	Amba	Myrtaceae
Carica papaya L.		L	L	Meva	Caricaceae
Annona squamosa L.		-	L	Saripha	Annoneceae
Citrus aurantifolia (Christ.) Swingle		L	L	Kagati	Ruteaceae
Citrus limon (L.) Burn f.		L	L	Nibuva	Ruteaceae
Tamarindus indica L.		-	L	Imili	Leguminosae
Zizyphus mauritiana Lam.		-	L	Bayar	Rhamnaceae
Litchi chinensis Sonner		L	L	Litchi	Sapindaceae
Artocarpus integra (Thunb.) Merr.		L	L	Rukh katahar	Moraceae
Saccharum officinarum L.		L	L	Ukhu	Gramineae
Citrus spp.		-	L	Amilo	Rutaceae
Syzygium cumini (L.) Skeels		-	L	Jaamun	Myrtaceae
Phyllanthus emblica L.		-	L	Amala	Euphorbiaceae
Spondias pinnata (L. f.) Kurz		-	L	Amaro	Anacardiaceae
Areca catechu L.		-	L	Supari	Palmae
Cocos nucifera L.		-	L	Narival	Palmae
Vitis vinifera L.		L	L	Angur	Vitaceae
Citrus aurantium L.		L	-	Suntola	Ruteaceae
Choerospondias axillaris (Roxb.) B.L.Brutt. & A.W. Hill.		L	-	Lapsi	Anacardiaceae
Aesandra butyracea (Roxb.) Baehni		L	-	Churi	Sapotaceae
Citrus sinensis (L.) Osbeck		L	-	Mausami	Rutaceae

Trees and fodder

Pinus wallichiana A.B. Jackson	L	-	-	Gobre salla	Pinaceae
Juniperus indica Bertol.	L	-	-	Dhupi	Cupressaceae
Salix babylonica L.	L	-	-	Tissi	Salicaceae
Dalbergia sisso O. Roxb.		-	L	Sisham	Leguminosae
Anthocephalus chinensis (Lam.) A. Rich. ex Walp.		-	L	Kadam	Rubiaceae
Melia azederach L.		L	L	Bakenu	Meliacee
Ficus lacor Buch-Ham		L	L	Kabhro	Moraceae
Euphorbia hispida L.f.		L	L	Tote	Moraceae
Ficus religiosa L.			L	Pipal	Moraceae
Leucaena leucocephala (Lam.) de Wit		-	L	Ipilipil	Fabaceae
Artocarpus lakoocha Wall.		L	L	Badahar	Moraceae
Callistemon citrines (Curtis) Skeels		-	L	Kalaki	Myrtaceae
Lawsonia inermis L.		-	L	Mehandi	Lythraceae
Morus bombycis Koidzumi.		L	L	Kimbu	Moraceae
Bombax ceiba L.		L	L	Simal	Bombacaceae
Crateva unilocularis Buch. Ham.		L	L	Sipligan	Capparaceae
Gossypium arboreum L.			L	Kapas	Malvaceae
Populous euro-americana		-	L	Lahare thulo papal	Salicaceae
Dendrocalamus hamiltonii Nees & Arn. ex Munro		L	L	Tama bans	Gramineae
Schima wallichii (DC.) Korth.		L		Cilaune	Theaceae
Castanopsis indica (Roxb.) Miq.		L		Katus	Fagaceae
Streblus asper Lour.		L		Bedula	Moraceae
Ficus semicordata Buch. Ham ex Sm		L		Khanyu	Moraceae
Erythrina stricta Roxb.		L		Phaledo	Leguminosae
Ficus glaberrima Blume		L		Pakhuri	Moraceae
***Bambusa balcooa* Roxb**		L		Dhanu bans	Gramineae
Persea odoratissima (Ness) Kosterm.		L		Kaulo	Lauraceae
Ficus roxburghii Wall. ex Miq		L		Newaro	Moraceae
Litsea monopelata (Roxb.) Pers.		L		Kutmero	Lauraceae
Brassaiopsis hainla (Bach. Ham. ex D. Don) Seem		L		Seto Chuletro	Araliaceae
Brassaiopsis polyacantha (Wall.) Banerjee		L		Kalo chuletro	Araliaceae
Thysanolaena maxima (Roxb.) O. Kuntze		L		Amriso	Gramineae
Arundinaria maling		L		Nigalo	Gramineae
Michelia champaca L.		L		Chanp	Magnoliaceae
Cinnamomum zeylanicum Breyn.		L		Dalchini	Lauraceae
Euphorbia pulcherrima Wild. ex Kletzsch		L		Lalupate	Euphorbiaceae
Sapium insigne (Royle) Benth. ex Hook. f.		L		Khirro	Euphorbiaceae
Prunus cerasoides D. Don.		L		Painyu	Rosaceae

Medicinal					
Hippophae salicifolia D. Don	L	-		Ashuk	Elaeagnaceae
Aloe vera (L.) Burm. f.		L	L	Ghui kumari	Liliaceae
Ocimum sanctum L.		L	L	Tulasi	Labiateae
Azadirachta indica A. Juss.		-	L	Nim	Meliaceae
Cuscuta reflexa Roxb.		L	L	Akasveli	Convolvulaceae
Nyctanthes arbor-tristis L.		L	L	Parijat	Oleaceae
Curcuma angustifolia Roxb.		L	L	Haledo	Zingiberaceae
Acorus calamus L.		-	L	Bojho	Araceae
Tinospora cordifolia (Willd.) Miers.		-	L	Gurjo	Menispermaceae
Achyranthes aspera L.		-	L	Apamarg	Amaranthaceae
Centella asiatica L. Urban		L	M	Ghod tapre	Umbelliferae
Cynodon dactylon (L.) Pers.		-	M	Dubo	Gramineae
Calotropis gigantea (L.) Dryand.		L	L	Ank	Asclepiadaceae
Artemesia indica Willd.		L	L	Titepati	Compositae
Spilanthes paniculata Wall. ex. DC		L	L	Marati	Compositae
Boerhavia diffusa L.		-	L	Punarva	Nycteginaceae
Mentha viridis (L). L.		L	L	Pudina	Labiatae
Zingiber officinale Rosc.		L	L	Aduva	Zingiberaceae
Cinnamomum tamala (Buch-Ham.) Ness & Eberm.		-		Tejpat	Lauraceae
Mimosa pudica L.		-	L	Lajjvati	Leguminosae
Justicia adhathoda L.		L		Asuro	Acanthaceae
Zanthoxylum armatum DC.		L		Timur	Rutaceae
Conyza japonica (Thunb) Less ex DC.		L		Salaha jhar	Compositae
Mussaenda macrophylla Wll.		L		Dhovini	Rubiaceae
Cereus peruvianus (L.) Mill.		L		Siuli	Cactaceae
Oxalis corniculata L.		L		Cari amilo	Oxalidaceae
Mentha arvensis L.		-	L	Bavari	Labiatae

Abundance of the plant species in homegardens: L= Low, M=Medium, H=High

The studied homegardens were stratified into three different layers according to plant height. The highest layers is 3- 20 m whose composition was dissimilar in all three study sites and consisted of trees, fodder plants and fruits. The major species were *Pinus wallichiana, Juniperus indica*; *Salix babylonica, Pyrus malus, Prunus persica* and *Juglans regia* in Tukuche VDC (Table 3). Similarly, the major species were *Artocarpus lakoocha, Schima wallichii, Castonopsis indica, streblus asper, Ficus semicordata, Ficus glaberrima, Persea odoratissima* etc. in Hemja VDC and *Dalbergia sisso, Anthocephalus chinensis, Leucaena leucocephala, Artocarpus lakoocha, Populous euro-americana, Melia azederach* etc in Gajehada VDC. The middle layers was 1 to 3 m whose composition includes species like *Lycopersicum esculentum, Fagopyrum esculentum, Phaseolus vulgaris* in the Tukuche VDC, *Lycopersicum esculentum, Vicia faba, Vigna unguiculata, Colocasia antiquorum, Pisum sativum, Punica granatum, Musa paradisiaca, Carica papaya, Citrus aurantifolia, Citrus limon, Morus bombycis, Thysanolaena maxima, Drepanostachyum intermedium, Calotropis gigantea, Artemesia indica* and *Justicia adhathoda* species in Hemja VDC and species like *Lycopersicum esculentum, Cucumis sativus, Vigna*

unguiculata, Perilla frutescens, Momordica charantia, Pisum sativum, Basella alba, Abelmoschus esculentus, Musa paradisiaca, Carica papaya, Citrus aurantifolia, Citrus limon, Lawsonia inermis and *Gossypium arboreum* in the Gajehada VDC. The lower most region of homegardens includes species like *Brassica oleraceae, Solanum tuberosum, Brassica juncea, Coriandrum sativum, Allium cepa, Phaseolus vulgaris, Alllium ascalonicum* and *Raphanus sativus* which are common in all three ecological zones.

Table 4. Species diversity indices of homegardens in three study sites.

Ecological zones	Shannon-Wiener Index	Simpson Index	Evenness in Percentage
Tukuche (Mountain)			
n=15			
All species	1.316	0.052	56.29
Vegetables, spices and others	1.119	0.079	51.25
Fruits	0.681	0.255	42.54
Trees and fodder	0.434	0.185	31.07
Medicinal	-	-	-
Hemja (Mid-hill)			
n=15			
All species	1.84	0.014	65.55
Vegetables, spices and others	1.33	0.45	56.48
Fruits	1.178	0.083	58.78
Trees and fodder	1.34	0.46	58.47
Medicinal	1.07	0.061	53.05
Gajehada (Terai)			
n=15			
All species	1.90	0.01	65.93
Vegetables, spices and others	1.59	0.023	59.99
Fruits	1.205	0.062	56.51
Trees and fodder	1.091	0.095	57.68
Medicinal	1.29	0.73	63.04

The Shannon-wiener index was found to be 1.316, 1.84 and 1.90 in homegarden of Mountain, Mid-hill and Terai region respectively (Table 4). Shannon-wiener index of vegetable, spices and others categories was 1.119, 1.33 and 1.59 in Mountain, Mid-hill and Terai region respectively. Shannon-wiener index in homegarden of mountain region of categories fruits was 0.681 and that of trees and fodder was 0.434 which are the least value among three ecological regions. Similarly, Shannon wiener-index of mid hill of categories; vegetables, spices and others was 1.33 of fruits was 1.178, of trees and fodder was 1.34 and that of medicinal plants was 1.07. And that of Terai region highest Shannon-wiener index was of vegetables, spices and others while least was of trees and fodder categories. Simpson's index was 0.052, 0.014 and 0.01 in homegarden of Mountain, Mid hill and Terai region, respectively. The evenness percentage was 56.29, 65.55 and 65.93 in homegarden of Mountain, Mid hill and Terai region respectively (Table 4). In homegarden of Mountain region the plant used for medicinal purpose was found to be only one i.e. *Hippophae salicifolia*. The highest similarity index was recorded between the homegardens of Terai and Mid hill (57.59%), while least was between Terai and Mountain (20.63%) (Table 5).

Table 5. Sorensen coefficient of similarities in percentage of used plant species in homegardens of three study sites.

	Gajehada-Hemja	Gajehada-Tukuche	Hemja – Tukuche
All species	57.59	20.63	26.54
Vegetables spices and others	65.75	40	53.64
Fruits	61.53	14.28	32
Trees and fodder	37.20	0	0
Medicinal	61.11	0	0

DISCUSSION

Homegardens play important role for self sufficiency and economic support (Linger 2014), including ecological sustainability. However, degree to which homegardens contribute to the provision of the household food varies a lot (Wezel and Bender 2003, Khanal *et al. 20*14). Homegarden structure may differ from one place to other according to the local physical environment, ecological characteristics, socioeconomic and cultural factors (Abdoellah 1990, Kumar and Nair 2004). Species distribution in the homegardens is determined by environmental factors and dietary habits as well as socio-economic and market demands (Fernandez and Nair 1986). As dual propose homegardens may have higher diversity than subsistence-only (Scales and Marsden 2008). The high diversity of homegarden of Terai region may be due to dual propose (Subsistence and Commercial). However, the least diversity of plant species in Mountain region may be due to small area of homegarden and other climatic stress along with the reason that remote homegardens can have lower biodiversity (Scales and Marsden 2008). The result of present research is consistent with the study of Christanty *et al.* 1986, it was found that garden diversity varies according to ecological characteristics of gardens. For example, species number and diversity were shown to be influenced by altitude of homegardens (Karyono 1990, Quiroz *et al.* 2002), homegardens size (Abdoellah *et al.* 2001) level of production intensity and market access (Michon and Mary 1994).

There is more similarity in between plants of Mid-Hill and Terai region whereas only few species of vegetables are common in between three ecological zones. More similarity in species composition between Terai and Mid-hill may be due similar feature and less differences of altitude, rainfall pattern, light intensity and temperature. On the other hand, less similarity between mountain region and Tarai may be due to differences in those parameters. Species diversity and utilization pattern of plant species is influenced by ecological and socioeconomic factors, including geographic location, climate, water availability, garden size and history, agricultural policy, market needs, food culture and household preferences (Gajaseni and Gajaseni 1999, Trinh *et al.* 2003). Although the proportions of species used for different purposes vary, in general, traditional homegardens contribute substantially towards meeting the basic subsistence needs and services such as food including vegetables and fruits, medicines, forage, shade and ornamentals (Albuquerque *et al. 20*05).

The most common plants group among homegardens of Terai, mid hill and Mountain region is vegetable, spices and others. This may partly be due to common consumption patterns of people and partly due to convenience to grow in homegardens of all three ecological zones. Least similarity was between trees and fodder. This may be due to difference in climate and altitude. There was no any similarity between trees and fodder and medicinal plants of Mountain with Terai and Mid-hill which might have been due to variation in climatic factors.

Among the gender groups women were main participant in managing homegardens. They were mainly active in managing homegardens like sowing, planting, managing, harvesting, trading and storing products and seeds in all ecological zones. Men actively participate in activities like irrigation and fertilization. The same case was also reported by Larios *et al.* (2013) in Tehuacán Valley, Mexico.

If homegardens are managed properly, productivity and sustainability can be increased which will help in conserving agro biodiversity, food sufficiency, economic supports and other ecological functions. Diverse plant species were found in homegardens of different ecological zone. So practice of homegardens can help to conserve genetic diversity of plants. However, most abundant species in homegardens belonged to vegetable and spices groups which indicate

management in homegardens is directed to increase daily basic needs for food sufficiency. Homegarden is also considered as a cost-effective strategy for climate change mitigation because tree-based farming systems store carbon in soils and woody biomass, and may also reduce greenhouse gas emissions from soils (Verchot *et al.* 2007, Smith and Olesen 2010).

The most remarkable similarity among the homegardens from diverse ecological and socio-economic background is with respect to the species composition of the herbaceous components (Fernandes and Nair 1986). In this study also there is much similarity among the herbaceous species like vegetables, spices and others than other groups of plants.

In conclusion, homegardens are complex systems with different structure and large number of components where food production is the main role of most species maintaining almost continuous production throughout the year. Although during favorable climatic and environmental condition the production may be high in homegardens but in general there is something to harvest daily for basic food supply of household. The cultivation of different crops in homegardens is regarded as a strategy to meet subsistence and increase economic status. The production from homegadens is mostly used for home consumption while surplus can be used for monetary propose or can be used during food scarcity. So diversity in homegardens can enhance the livelihood by providing socio-economic and ecological services.

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