# ASSESSING THE STRUCTURE AND FACTORS AFFECTING AGROBIODIVERSITY OF HOME GARDEN AT KATAHARI RURAL MUNICIPALITY, PROVINCE 1, NEPAL

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## ABSTRACT

*This study was focused to assess the structure and factors affecting agrobiodiversity in home garden of Katahari rural municipality, Morang. 106 species were recorded in the home garden but the effective number was only 30. The diversity was the highest in vegetables followed by fruits and medicinal plants. Shannon diversity index of 2.99 indicated the high diversity of species. Evenness is more for commercial crops and less for fodder and trees. High crop diversity in home garden is dependent on proximity to market, gender and education. Agrobiodiversity increases with the increase in functional diversity of species. Significant correlation were observed between Shannon diversity index and education level (0.29), farm years (0.21) and farm size (0.23). Therefore, while planning for agrobiodiversity management in home garden, prime focus is needed on the production systems and various socio-economic factors prevailing within the farming community.*

**Keywords:** Agro-biodiversity, effective number of species, gender, home garden, proximity

## INTRODUCTION

Home gardens are agro-ecosystems composed of multi-species, multi-storied and multi-purpose plants from herbaceous to shrubs as well as trees and are managed closed to the homestead. It is defined as *gharbagaicha* in Nepal meaning traditional land use system around a homestead, where several species of plants are grown and maintained by household members and their products are primarily intended for the family consumption (Shrestha *et al.*,2002). Home gardens are rich in biodiversity and are vital for food and livelihood security as it provides diversified and nutritious products and, income at local, regional and global level and also conserve soil (Linger, 2014). Species diversity is the intuitive and widely adopted measures of biodiversity at ecological and bio-geographic scales (Bardhan *et al.*, 2012). Home garden has been practiced in Nepal since immortal time and they have ecological,

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socio-economic and environmental significance in our context. Home garden has been a subject of study with respect to agro-ecology and ethnobotany which has given a better insight in understanding biological and physical aspects of home garden with prime focus in terms of sustainability. Homegardens are established next to homestead since prehistoric time (Soemarowoto, 1987). However, home gardening today are managed according to our needs. It is defined as a micro-environment with multi-species, multi-storied and multi-purpose garden situated close to the homestead by (Quat, 1996) and further elaborated by (Watson and Eyzaguirre, 2001; Hodgkin, 2002). This type of farming is being practiced for a long time by farmers; however, it is often overlooked as an important source of food and nutrition.

For sedentary peasant farmers crop varieties and cultivars adapted to local niches around are most accessible resources for a secured livelihood. Majority of households maintain biodiversity close to the homestead as they are used for multiple purposes and are imbued with cultural and spiritual value. Due to this reason, home gardens are to be celebrated, supported and conserved (Eyzaguirre and Linares, 2004). Although home gardens cover only 2–11% of the total land holdings of the family in Nepal, they can supply 60% of the family requirements for fruits, spices and vegetables (Gautam *et al.,* 2009). Structure of home garden refers to the spatial organization of all the home garden components. Since plants represent the most complexand are spatially predominant, the structure refers the plant assemblages in the home garden. The definition requires an understanding of plant assemblages or strata or the way in which plants are distributed across the terrain (Alzina and Howard, 2012). Home garden differs from kitchen garden in terms of function where home garden fulfills need at subsistence level, are multipurpose, variable in size determined by choice of species, interspecies, possess multi-layer canopy structure where annuals and perennials supply diverse foods and are not in priority area for research and development (Shrestha *et al.,* 2002). The effective number of species refers to the number of equally abundant species needed to obtain the same mean proportional species abundance as that observed in the dataset of interest, where all species may not be equally abundant (Tuomisto, 2010). This is an important tool in assessment of number of key species present in the home garden. The role of homegarden in conserving biodiversity and role in livelihood are often out looked in Nepal In this context, the study was focused on assessing the structure, diversity and factors affecting the diversity in the home garden of Katahari rural municipality located in Morang district of Province no. 1, Nepal.

## MATERIALS AND METHODS

Katahari Rural Municiplality was taken for the study based on the criteria given by (Suwal *et al.,* 2005). Primary criteria such as species diversity, unique species and importance as well as secondary criteria like accessibility, community interest and subsistence farms was taken into consideration. The brief information about the Katahari RM is shown in Table 1. The study was conducted through cross sectional survey in the selected wards. This type of design gathers information from selected population and it is useful in assessing practices, attitudes, knowledge and beliefs of a population in relation to a particular event (Kipkeu, 2014).120 households were randomly sampled from ward no 4 and 6 and data were collected through survey, field observation, inventory preparation and focused group discussion. Open-ended questionnaire with subsequent coding was used to elicit the response of respondents with agriculture as primary occupation. Moreover, nodal farmers were identified using a snowball sampling method as suggested by (Handcock and Gile, 2011). The study was carried out from November 2016 to February 2017. Key species present in the home garden were identified based on criteria given by Watson and Eyzaguirre (2002). Preliminary list of representative species were identified that met the five agreed criteria for the key species as given by (Suwal *et al.,* 2005). Two focus group discussions were done, one in each ward involving a maximum number of twelve and a minimum of eight to supplement and verify the data gathered from the interviews. Data were obtained regarding socio-economic status, characteristics, changes, status and factors affecting the agro-biodiversity.

Table 1: Basic information of Katahari Rural Municiplity (RM), Morang

| **Parameters** | **Values** | **Sources** |
|---|---|---|
| Latitude/longitude/altitude | 26.4710N | (Google Map, 2019) |
| | 87.3165°E | |
| Area | 51.59km$^2$ | (MOFLD, 2017). |
| Population of Katahari RM | 39,775 | (MOFLD, 2017). |
| Population of ward 4 and 6 | 14,282 | (MOFLD, 2017). |
| Number of households | 2763 | (CBS, 2011). |

Shannon diversity index was used to identify agrobiodiversity status of home garden (Wezel & Bender, 2003). Shannon Wiener index and Evenness measure

(E), are commonly, used tools for the purpose of recording the biodiversity at a given locality (Huston, 1995).

Shannon Diversity Index $H = -_{s}\sum_{i=1}(Pi * lnPi)$

Where,

H = Shannon diversity index

Pi = fraction of the crop area composed of species i.

S = numbers of species encountered ∑ = sum from species 1 to species S

The measure of Evenness (E) is the ratio of observed diversity to maximum diversity and it is calculated as,

E = H/Hmax,

E = H /lnS (Magurran, 1988)

The effective number of species was calculated by taking the exponential value of Shannon Diversity Index as mentioned by (Peet, 2003).

Both descriptive and inferential statistics was used during analysis. For descriptive analysis, frequency and percentage as well as descriptive (mean and standard errors) were used. Moreover, in case of inferential analysis one sample t test, independent sample t test, Pearson's Chi square test, one way ANOVA and correlation (Pearson's and Spearman's) was used as and where needed. The unit of analysis was at household level. Data collected from different sources was summarized and presented using frequency tables and charts.

## RESULTS AND DISCUSSION

### GENERAL INFORMATION OF RESPONDENTS

Among total respondents 57.5% were male whereas 42.5% were female. Similarly, 24.1% were illiterate, 55.2% were able to read/write and 20.7% had secondary or higher level of education. The respondents were dominated by Yadav (31%), Terai-Dalits (21%), Rajbansi (22%) and Tharu (17%) whereas Bhramins/Chhetris were only 5.3%. 43.5% of respondents were from age group of 28-45 years. Similarly the average land holding of respondents was 2.64±1.24 ha which was significantly higher ($P<0.01$) than that of average landholding of 0.694 ha in selected ward (CBS, 2011). Also, the average family size was recorded to be 5.3 (Table 2). According to (CBS, 2011), the total population of the selected wards was 14,252 out of which Bhramin/Chhetri were 4.49%, Terai-dalits (44.47%), Hill ethnic groups (1.9%), Terai Backward ethnic groups (25.59%) and others (23.5%) as presented in Table 2.

Most of the women (about 80 %) were engaged only in household activities. Approximately 20% of the women were engaged in both household maintenance and income generating activities (i.e., poultry rearing, vegetable cultivation, sewing, fruit species cultivation). The study further revealed that only 25% of women earned some money through wages, while the rest of the women did not earn money independently of their husbands and families.

Table 2: Demographic and socio-economic characteristics of respondents of Katari RM, Morang, 2017

| | |
|---|---|
| **Gender (%)** | |
| Male | 57.5 |
| Female | 42.5 |
| **Education (%)** | |
| Illiterate | 24.1 |
| Read and write | 55.2 |
| Secondary and higher | 20.7 |
| **Ethnicity (%)** | |
| Bhramins/Chhetri | 5.3 |
| Terai-dalits | 21 |
| Yadav | 31 |
| Rajbanshi | 22 |
| Tharu | 17 |
| Others | 3.7 |
| **Age group (%)** | |
| Below 28 years | 13.33 |
| 28-45 years | 42.5 |
| 45-60 years | 23.33 |
| Above 60 years | 20.83 |
| **Total land holding (ha)** | **2.64±1.24** |
| **Home garden size (ha)** | **0.074±0.021** |
| **Average family size** | **5.30±2.23** |

*Size of home garden, structure and species richness*

The average size of home garden ranged from 80 to 1508 $m^2$. This finding agrees with the previous report of average 402-434 $m^2$(Sunwar *et al.,* 2006) and indicates sufficient home garden area for family needs and conservation of key species.

The average number of crops plant species in each garden was $5.17 \pm 0.29$. Total of 106 species belonging to 38 families were recorded in the home garden in the study area. During the observation, 3 species of commercial crops, 7 species of food/cereals, 19 species of fruits, 21 species of medicinal plants, 5 species of spices, 11 species of trees/fodder and 42 species of vegetables were recorded. Out of which, 23 species were highly abundant, 25 species has medium abundance and 60 species has low abundance. Varieties of species were recorded in the home garden of study area comprising from annual to perennial crops. Home garden in the study area comprised of high levels of species diversity with a mixture of annual and perennial plants in line with the study. 123 species was recorded in home garden of Rupandehi and 131 species was recorded in Gulmi district of Nepal (Sunwar,2006).

As home garden consists of large number of species, it is difficult to carry out scientific studies. So, for that purpose identification of key species is pivotal for understanding complex integrated system. Based on the focused group discussion and effective number of species, key species are identified. Key species refers to a portfolio of locally important plant species that are frequently and extensively grown in home garden in the context of specific sociocultural and agroecology, primarily intended for HH consumption and food culture. Table 3 shows the list of key species present in home garden of Katahari RM.

Table 3: Criteria for identification of key species in home garden of Katahari RM

| Criteria | Plants |
|---|---|
| Traditional plant species | Amaranth, Elephant foot yam, orchid tree, neem, wax gourd, Coccinea, Colocasia, Finger millet, buckwheat, yam, calotropis, basil |
| Species grown frequently in home garden | Okra, Areca nut, neem, Artimesia, wax gourd, chilly, Cabbage, cauliflower, pigeon pea, fababean, pumpkin. mango |

| | |
|---|---|
| Species grown frequently from each trophic groups | 2-5 species/varieties of fruits, vegetables, cereals, medicinal plants, fodders and commercial crops |
| Comparative richness | Hyacinth bean, chilly, sponge gourd, wax gourd, drumstick |
| Unique or specific ethnic food culture | Coccinia, elephant foot yam, cassava, tamarind, water cress, spine gourd, lacor, |
| Religious value | Basil, peepal, Calotropis, Cynodon |
| Commercial value | Jute, tobacco, sugarcane, lemongrass, areca nut |
| Availability (multiple harvest, low production cost, use of multiple parts) | Cauliflower, winter beans, drumstick, tomato, lemongrass, basil |
| Integrated with holistic farming system | Mango, litchi, citrus, kadam, kabro, Ecucalyptus, areca nut |

*Criteria adapted from (Gautam *et al.*, 2009).

*Species diversity Indices of home garden*

Based on the information at Table 4, it can be said that the effective number of species is equivalent to 30 which meant that out of 106 species, only 30 species are common. Moreover, there are 5 common species of vegetables and spices, 4 species of fruits, 3 species of medicinal plants and fodder/trees and 2 species of commercial crops. Moreover, 63.24% of species are evenly distributed. The population of fodder is least even (56.64%) whereas commercial crops are highly even (76.56%). That means high variation was observed in fruit trees and least in case of commercial crops.

Table 4: Shannon Weiner Index, effective number of species and evenness of species present in home garden at Katahari RM, 2017

| | **Shannon Weiner Index** | **Effective number of species** | **Evenness in percentage** |
|---|---|---|---|
| All species | 2.998 | 30.045 | 63.24 |
| Cereals | 0.942 | 2.56 | 64.56 |
| Fruits | 1.304 | 3.684 | 57.72 |
| Medicinal plants | 1.243 | 3.465 | 65.34 |
| Vegetables and spices | 1.592 | 4.913 | 58.62 |
| Fodder and trees | 1.045 | 2.843 | 56.64 |
| Commercial crops | 0.843 | 2.323 | 76.56 |

Typical values of Shannon Diversity Index are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4 (Kerrhoff, 2010). So, in our case overall diversity of 2.99 seems to be on higher side i.e. it pertain high biodiversity among species. The structure of home garden in diverse. In comparison to different species, commercial crops are less diverse whereas vegetable species are highly diverse. The vegetable species constitute the major component followed by fruits and medicinal plant species that also contributed to the species diversity. Thus, it can be said that the home garden are viable option in conserving on farm biodiversity.

*Relation between plant species richness and socioeconomic factors*

Higher diversity of crops was observed in the home garden distant to market (6.15 ± 0.20) and the lowest diversity observed in the home garden nearer to market (4.2 ± 0.180). The finding was significantly different ($P<0.05$). It showed that the increase in proximity to market decreases the biodiversity in home garden.

Higher diversity of crops was observed in home gardens owned by women (6.22 ± 0.15) while men had in average 4.12 ± 0.16 crops. The finding was significantly different ($P<0.05$). Female tended to cultivate more crops as compared to male.

Higher diversity of crops was recorded in home gardens of people with higher level education (4.42 ± 0.24) while uneducated gardeners and gardeners with only basic education were found to have an average of respectively 3.95 ± 0.14 and 2.97 ± 0.19 crops respectively. The finding was significantly different ($P<0.05$). Education helped respondents to conserve more species in their home garden.

High wild plant diversity occurred in home gardens with primarily for medicinal plant production (6.54 ± 0.34). Few wild plant species were observed in home gardens with primarily for both food and medicinal purposes (2.54 ± 0.36) and in home gardens with primarily for food production (1.12 ± 0.18). Significant difference was observed ($P<0.05$). This showed that the medicinal plants in home garden are linked to wilderness.

Higher values of wild plant species were observed in the home garden distant to market (6.6 ± 0.24) and lowest on gardens nearer to market (3.54 ± 0.13) and the finding was significantly different ($P<0.01$). Diversity of wild plant species in home garden decreases as the proximity to market increases.

*Relationship between functional diversity of home gardens and agrobiodiversity*

The analysis of the relationship between the whole plant diversity of home gardens and the spectrum of uses indicated positive and significant, although low correlation for medicinal use ($r = 0.34$, $p$ value $< 0.01$), ornamental use ($r = 0.28$, $p$ value $< 0.05$), and miscellaneous use ($r = 0.24$, $p$ value $< 0.05$). It showed that the home garden in the study area support homestead in diverse ways Table 5. Food and plant protection uses were not significantly correlated to the global plant diversity ($r = -0.15$ for food use, $r = -0.23$ for protection/delimitation, $p$ value $> 0.05$). Thus, it can be said that the home gardens with high interest for medicinal, ornamental, and miscellaneous uses were likely to be more diversified than home gardens with high interest for food and plant protection purposes. And are likely to conserve more species and more support to livelihood.

Table 5: Correlation between diversity level and spectrum of plant use in home garden at Katahari RM, 2017

| Diversity level | | Spectrum of plant uses | | | | |
|---|---|---|---|---|---|---|
| | | **Food** | **Medicine** | **Ornamental** | **Plant protection** | **Miscellaneous** |
| Cultivated plant | *R* | − 0.15 | 0.34 | 0.28 | − 0.23 | 0.24 |
| | *P* value | 0.115 | < *0.01* | < *0.05* | 0.765 | *0.05* |
| Wild plant | *R* | −0.34 | 0.55 | 0.16 | 0.15 | 0.33 |
| | *P* value | <*0.01* | < *0.001* | <*0.05* | 0.124 | *0.34* |

Positive and significant correlation was observed between medicinal ($r = 0.55$, $P < 0.001$) and ornamental ($r = 0.16$, $P < 0.05$) uses of wild plant species but negative and significant correlation between food use ($r = -0.34$, $P < 0.01$) and diversity of wild plant species. No significant correlation was observed in case of plant protection and miscellaneous uses of wild plant species.

FACTORS AFFECTING BIODIVERSITY IN HOME GARDEN

Farming years positively influenced Shannon diversity index ($H'$) of the total crop species present in the home garden (Table 6), indicating that species diversity increased depending on the number of years the farm had been cultivated. Moreover, the age of the household head had a positive influence on species diversity, showing that those who had been farming for many years registered relatively higher diverse crop species. There was a significant and a weak negative correlation between the level of education of the household head and crop diversity ($r = -0.29$, $p < 0.05$) (Table 6). Similarly, farming years was significantly correlated with total farm size.

Table 6: Pearson's correlation coefficient (*r*) between demographic factors and biodiversity in home garden at Katahari RM, 2017

| Factors | Age of household head | Education level | Farm years | Total farm size (ha) | Shannon diversity index (*H'*) |
|---|---|---|---|---|---|
| Age of household head | 1 | | | | |
| Education level | −0.42** | 1 | | | |
| Farm years | 0.45** | 0.38** | 1 | | |
| Total farm size (ha) | 0.54** | −0.12 | 0.66** | 1 | |
| Shannon diversity index (*H'*) | 0.34 | 0.29* | 0.21* | 0.231* | 1 |

* Correlation is significant at the 0.05 level (two-tailed)

** Correlation is significant at the 0.01 level (two-tailed)

## FACTORS DETERMINING POSSESSION OF A FUNCTIONAL TYPE OF HOME GARDEN FOR FOOD AND MEDICINAL PURPOSE

Gender seems to be significantly factor associated to possession of different garden type (chi-square = 28.05, *p* value < 0.05). Women owned 63.16% of home gardens primarily for food production and owned 45.12% gardens with both food and medicinal purposes. Men owned 69.12% of home gardens primarily for medicinal plant production, more than the half (54.88%) of for both food and medicinal home gardens and 59% of home gardens with non-specific function.

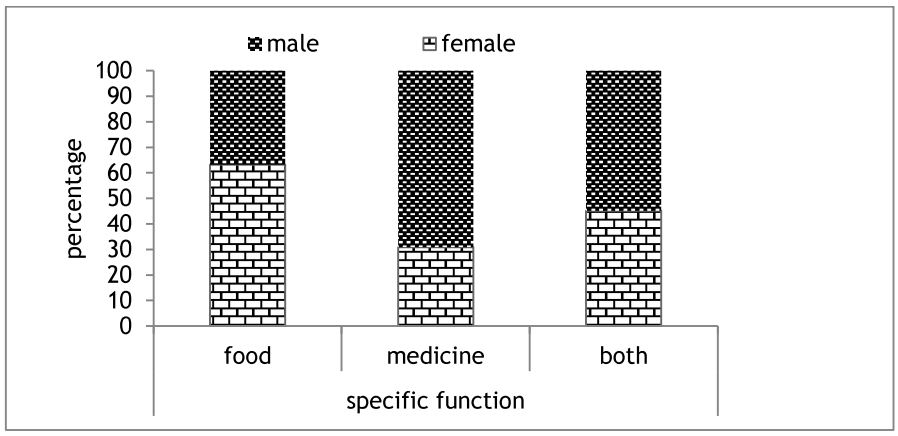


Figure 1.Specific function of home garden with respect to gender of respondents at Katahar RM, 2017.

People with secondary or higher education owned most of the home garden with specific function for food (43%) and 40% for both food and medicine,

whereas 55% of people with basic education dominated for medicinal purpose. Similarly, uneducated people and at large extent people with at most basic education owned most of home gardens (75.81%) with non-specific function.

Education level and age of gardeners were not significantly associated to the possession of a functional home garden (chi-square = 12.19 for education level, chi-square = 18.61for age of gardener, *p* value > 0.05).

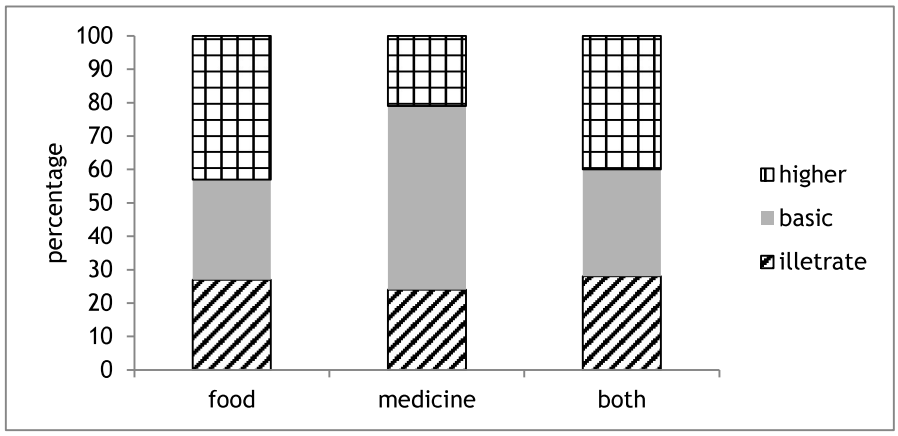


Figure 2.Specific function of home garden with respect to education of respondents at Katahar RM, 2017.

With regards to the age of the home gardeners, and regardless of the function, most of home gardens were owned by old people. Primarily for food, medicinal and for both medicinal and food purposes, home gardens were almost exclusively owned by old people; 60%, 54% and 61% respectively.

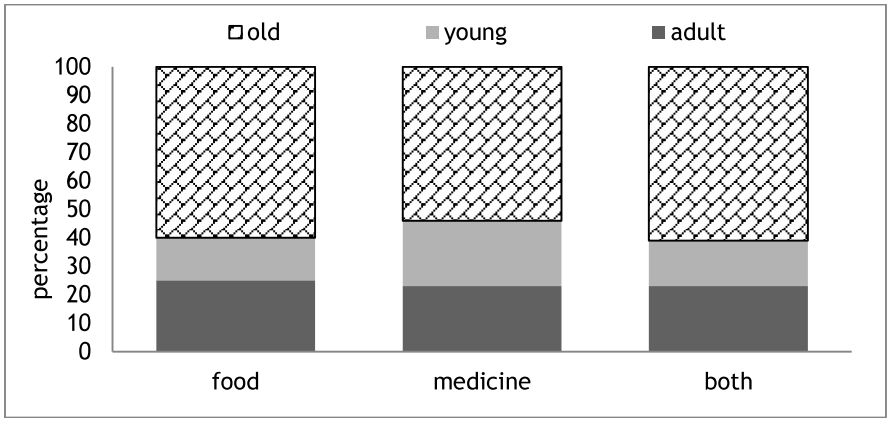


Figure 3.Specific function of home garden with respect to age of respondents at Katahar RM, 2017.

The possession of functional types of home garden was found to be significantly associated to distance to market (chi-square = 78.16; *p* value < 0.001). Home gardens with primarily for food production were mostly found in the nearer to market within 2 km (68.58%) while home gardens primarily for medicinal purpose were mostly encountered in home garden 2 km distance (62.19%). Home gardens with primarily for both food and medicinal purposes were found in home garden within 2 km to market.

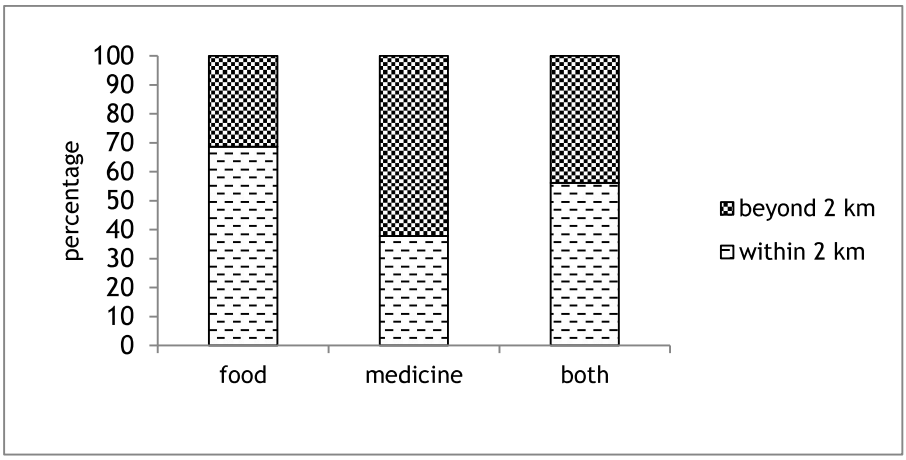


Figure 4.Specific function of home garden with respect to distance to market at Katahar RM, 2017.

The functional type of home gardens was found to be significantly associated to the number of managers (chi-square = 34.62; *p* value < 0.01). Home gardens with primarily for food production were mostly found (65.57%) to have single manager while home gardens with primarily medicinal and/or food purposes were mostly found (63%) to be managed by at least two persons.

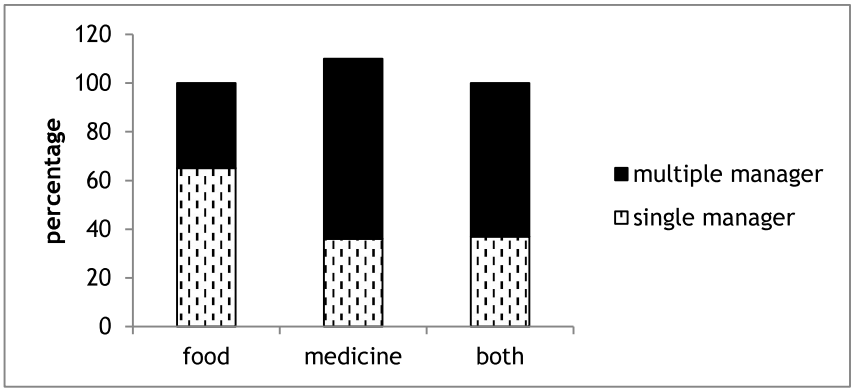


Figure 5.Specific function of home garden with respect to management at Katahari RM, 2017.

*Crops and livestock conservation*

It was evident that the protection of crop diversity has not received enough attention in the study area. Villagers and communities consciously or unconsciously protected crops through two ways, via preserved seeds or via planted crops. Most families had an independent grain house to preserve crop seeds. The survey found that a lot of villagers planted a small land area of traditional crop varieties. Communities close to market access or vehicles, seems to be planting traditional crop varieties. Some villagers established special places to breed and market the local breeds of animals for sale. Chickens were the main source of meat raised by villagers. Local villagers preferred to breed local chicken breeds and Giriraj as well. Almost all families raised but subsequently only a small number of villagers raised a large number of turkey and geese for sale.

## CONCLUSION

The study area is dominated by Terai Castes and mainly by Yadav (31%). Total of 106crop species were recorded in 120 home gardens. The average size of home gardens ranged between 80-1508 $m^2$. The effective number of species was 30 with average of 5.17±0.29 species recorded in each household. The Shannon Diversity Index of 2.99 showed high diversity among the components of home garden; vegetable being most diverse and commercial crops being the least in terms of biodiversity. Commercial crops were evenly distributed (75.56%) whereas fruits being least evenly distributed (57.72%). Higher diversity was associated with female owners, gardens farther from market and higher level of education. Similarly high wild plant diversity was noticed in home gardens done for medicinal plant production and home gardens distant to market. Diversity in home garden increases as the spectrum of use increases. Positive correlation was observed between cultivated crops diversity with respect to medicinal, ornamental and miscellaneous use and positive correlation was observed between wild crops diversity with respect to food, medicinal and miscellaneous use. The farm size of home garden was significantly positively correlated to the age of household head and farming years. Similarly, Shannon diversity index was significantly negatively correlated to education level but positively correlated to farming years and farm size. Though significant difference was not observed, diversity index was positively correlated to age of household head. Gender of household head significantly affected the purpose of home garden for food and or medicinal use. Female household head preferred home garden for food whereas male for medicinal use. Old people owned most of the home garden for food and medicinal purpose. Distance to near market also significantly affected the functionality

of home garden. Food production was mostly found in home garden nearer to market whereas; medicinal plant was main product in home garden that is away from market. Farmers were reluctant to use traditional varieties or breeds and were conserving plant diversity by preserved seed or planted crops. As home garden are small in size but highly diverse, there is a need to undertake policy reforms that target smallholder farmers and create awareness on the significance of agrobiodiversity assisting in conservation

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