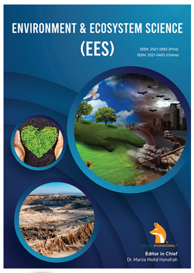
ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN: 2521-0882 (Print)
ISSN: 2521-0483 (Online)
CODEN: EESND2

Environment & Ecosystem Science (EES)

DOI: http://doi.org/10.26480/ees.02.2021.78.84



CrossMark

RESEARCH ARTICLE

ASSESSING LINK BETWEEN ON FARM AGRO-BIODIVERSITY AND FOOD SELF-SUFFICIENCY IN TWO AGRO-ECOLOGICAL REGIONS OF NEPAL

Pradeep Bhusal[a*], Biplav Ghimire[a], Subodh Khanal[b]

[a]Institute of Agriculture and Animal Science, Lamjung Campus, Lamjung Nepal
[b]Institute of Agriculture and Animal Science, Gauradaha Campus, Jhapa Nepal
**Corresponding Author Email: bhusalpradeep98@gmail.com*

ARTICLE DETAILS

Article History:

Received 08 April 2021
Accepted 11 May 2021
Available online 14 June 2021

ABSTRACT

Biodiversity is more recognized as a critical component of food production and food security and an important component of environment conservation. So, the paper tries to address the key research questions about the factors influencing crop diversity on the farm and are the household with high farm diversity more food secure or not? The study thus aimed to assess the on-farm crop diversity and their relation to food self-sufficiency in two different agro-ecological regions of Nepal, i.e. Tulsipur sub-metropolitan (inner terai) and Sundarbazar municipality (mid-hill). For this, a total of 70 households were randomly selected, 35 from each region, and semi-structured interviews, direct observation, and focus group discussion were employed to collect primary data. And the richness, Shannon–wiener, Simpson index, and food self-sufficiency level of households were assessed. The Shannon Wiener index of vegetables, spices were found to be 3.770 and 3.721 and that of fruits was found 2.772 and 2.607 in the home garden of Tulsipur and Sundarbazar respectively. Food self-sufficiency was achieved among 40% of households in the Tulsipur while the figure of the Sundarbazar was only 28.6%. The size of cultivated area and species richness was found moderately positive correlated. Statistical analysis showed that agro-biodiversity across two regions had less difference and finally, the paper showed that biodiversity level has a direct link to household food self-sufficiency level which helps in reducing food insecurity. Our results, therefore, promote to make effective implementation of regional food security strategies and policies to improve.

KEYWORDS

Agro-biodiversity, agriculture, ecological zones, food security, Nepal.

1. INTRODUCTION

By the year 2050, the world population is projected to reach over 9 billion (Kahane et al., 2013). In a world where over 900 million (some 16 % of the world population) are already malnourished, this continuing growth presents a serious challenge to achieving food and nutrition security (Kahane et al., 2013). Meeting the needs of this increasing population, overcoming shortfalls in food production, and ensuring that available produce reaches people in need are major challenges to global agriculture (FAO, 2010). These challenges must be met in ways in which are sustainable and make sure the availability of resources for future generations. At the same time, agriculture needs to confront the consequences of global climate change, increasing competition for water, loss of productive land and competition for available land, continued migration from rural to urban areas and therefore the growing social concerns about the character of the food production system.

In light of these multiple challenges to food security, maintaining and increasing agro biodiversity is recognized as an agro ecological approach to enhancing food security as it stabilizes food systems and improves the dietary diversity of those who depend on local and regional food production (Esquinas-Alcázar, 2005; Thrupp and Thrupp, n.d.; , Ng'Endo et al., 2015). The logic of increasing agro biodiversity is that if farmers diversify their crops or crop varieties, they will increase the probability of at least partial harvest success if they encounter a problem, like a drought or a pest outbreak. However, stable and diverse agro ecosystems are not necessarily economically efficient. By contrast, industrial agriculture, which is based on highly specialized monocultures of starchy staples, is extremely productive, but harvests could also be fragile when produced on the type of marginal lands traditionally (Fraser, 2006).

While the tensions between promoting biologically diverse food systems or promoting specialized monoculture for better food security strategies continue within the twenty-first century, much about the relationship between crop diversity and food security remains unknown and is a matter of widespread controversy. For instance, despite a range of empirical studies that explore the relationship between food security, food system resilience, and on-farm biodiversity there is still the need for a study to better analyze the agro ecological conditions under which crop diversity enhances different aspect of food security (Abson et al., 2013a;

Quick Response Code	Access this article online	
	Website: www. environecosystem.com	**DOI:** 10.26480/ees.02.2021.78.84

Cite the Article: Pradeep Bhusal, Biplav Ghimire, Subodh Khanal (2021). Assessing Link Between on Farm Agro-Biodiversity and Food Self- Sufficiency in Two Agro-Ecological Regions of Nepal. *Environment & Ecosystem Science, 5(2): 78-84.*

Gartaula et al., 2017). This point is made by who argue that scholars interested in topics such as sustainable farming, land use patterns, and ecosystem services need ''to take a more sophisticated and comparative approach to understanding the management of biodiversity" (Lockie et al., 2012).

In this context, this paper presents household-level data from Nepal that help explore the connection between crop diversity and household food self-sufficiency. Species diversity of plants are present in the household cultivated areas in ecological different areas and properly controlled of such cultivated area have high productivity and increased sustainability that helps contributes to the conservation of agro-biodiversity, food self-sufficiency and economic supports including others ecological functions (KC et al., 2016; Pokhrel, 2016). Home gardens maintains the highest number of farmers planting interest crops in home garden that act as an individual household output test area (Pandey, 2015). Also the crop diversity depends not only on production domains and household landholding, but also on factors like ethnicity, interaction between resource richness, and others demographic, cultural and economic factors of the farms households (Gauchan et al., 2020a). Assessing household food self-sufficiency throughout the year is relevant in the developing world where many small-scale farmers depend on the food they produce locally as their main strategy in achieving food security (Rana et al., 2007; Pandey, 2015; Floyd et al., 2003; Belsky and Siebert, 2003). Hence, data that show the extent to which families in various agro ecosystems are food self-sufficient during the year are important in assessing food security and provide insights into the stability of a small-scale farming family's food supply.

As a result, we hypothesize that families with higher levels of agro biodiversity will have greater levels of food self-sufficiency but that this relation may be contingent on factors such as agro ecological region, market access, education. If proven correct, this argument might provide one indication that biologically diverse food and agricultural systems are more stable.

We explore this issue in two contrasting agro ecological regions in the South Asian nation of Nepal, a country in which nearly 50 % of the population suffers from hunger and malnutrition and the majority of citizens depend on subsistence farming as their livelihood (Commission, n.d.; Division et al., 2011). Food self-sufficiency in terai region of Nepal is 72% and that of mountains is 11% and Terai have lesser food non-sufficient than hills and mountains that may be due to availability of more cultivated area and others inputs and about 10% of households, suffer chronic food insecurity and more than 50% farmers are food non-sufficient even for 6 months (Joshi and Maharjan, 2007; Maharjan and Joshi, 2011; Bohle and Adhikari, 1998).

This highlights that how these areas are more vulnerable to food insecurity. The positive consequences of food security are shown by evidence that households with nonfarm income have higher food sufficiency, absorption capacity, nutritional quality and food stability and the major contributing factors to food insecurity are limited access to resources due to absence of capable male members, illiteracy, large size of family, higher dependency ratio, depending on the subsistence agriculture with small landholdings, limited access to irrigation and fertilizer (Maharjan and Joshi, 2011). The paper also suggests, farmers need to start thinking as a collective and take concerted action through farming cooperatives to increase agriculture production, farm income, boost agricultural sustainability and food self-sufficiency while fostering socio-economic growth in country like Nepal (Poudel, 2007; Gautam et al, 2020a; (Karki et al., 2015).

So, this study not only documents on-farm crop diversity in two agro-ecological regions, but also utilizes statistical analysis to test the hypothesis that food plant diversity in on farms is positively associated to food self-sufficiency of household. Finally, the key research questions guiding this study were:

i) How does food plant diversity vary in different farms in two agro-ecological regions?

ii) What are the biophysical and socio-economic factors influencing the crop diversity in the farms?

iii) Are households with high on-farm food plant richness and diversity more food secure?

2. Methodology

This research draws on data collected in two districts in Nepal, to explore the relationship between crop diversity and food self-sufficiency in a range of two agro-ecological regions. These districts represent agro ecosystems regions from tropical to temperate with different levels of market access. One municipality from each district was selected for data collection. They were Tulsipur sub-metropolitan from Dang district and Sundarbazar municipality from Lamjung district. First one, Tulsipur Dang represents inner terai region (tropical to subtropical region) and second one Sundarbazar Lamjung represents mid hills region (subtropical to temperate). The population density in dang and lamjung district is at about 187 and 99 inhabitants/sq.km, respectively (Nepal census 2011). Brahman, Kshetri and Tharus are the predominant ethnic group community in dang while Kstheri, Gurung, Magar, Brahman are dominant in Lamjung district (Nepal census 2011). The selection of Tulsipur and Sundarbazar municipality as study sites was with an aim to represent to two different agro-ecological zones and thus most likely a different level of agro-biodiversity, with an added advantage of geographical closeness to each other.

Table 1: Shows details on geographical, climatic and socio-cultural characteristics of the two regions (CBS, 2015).

Study sites	Districts	Ecological region	Altitude(masl)	Major dweller (by cast)
Tulsipur	Dang	Inner terai	300-1100 m	Tharus, Chhetris, Brahmins
Sundarbazar	lamjung	Mid hills	450-1800 m	Gurung, Chhetris, Tamang, Brahmins

2.1 Data Collection

The present study purposively selected fourteen villages in order to cover the above-mentioned different climatic zones, seven villages in Tulsipur, dang and rest seven villages in Sundarbazar, Lamjung. Five households were randomly selected from each village. A total of 70 households, 35 in Tulsipur (seven households per each village) and 35 in Sundarbazar (seven households per each village) were recorded during surveyed. The households were randomly selected. This sample size was calculated according to feasibility where the aim of the study was to gain insights into the biophysical and socio-economic factors influencing food plant diversity, rather than to estimate sample representativeness among smallholder farming households. Semi structured questionnaires were used during the household survey. Such questionnaires were prepared and pretested and final face to face survey was conducted using mWater Surveyor from December 2019 to February 2020.

For each of the 35 farms, exact geographic location and altitude as well as whole farm areas (including non-crop areas such as homestead area) and cropped farm areas were each measured with a Global Positioning System (GPS). On each farm the head of the household or his/her representative was interviewed by using a semi-structured questionnaire to collect data on: (1) Basic demographic (age, sex, education of household members, numbers of active family members) and socio-economic household characteristics (religion, ethnicity of household, income of family) (2) farm size, details and production on food plant and livestock species/varieties produced on the farm, and (3) status of food sufficiency from the farm in each household. Each survey took about half an hour to complete. Besides survey, some direct observation method was also used during collection of data and some secondary data were also collected from their respective municipality.

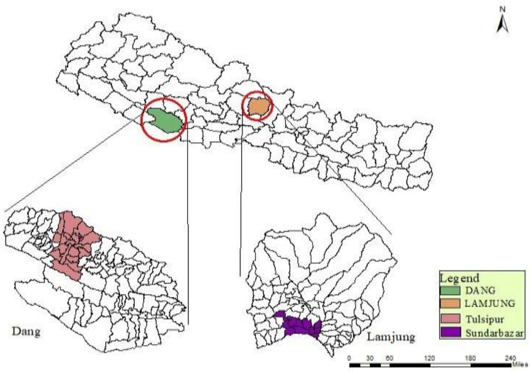


Figure 1: Ecological map of Nepal showing two study area

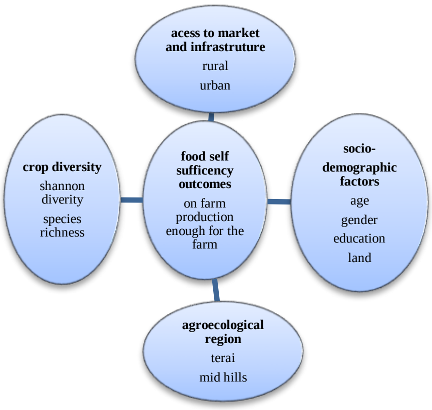


Figure 2: Conceptual framework of Research

2.2 Preparation of Variables

Household food self-sufficiency was measured by the question ''please mention the number of the months for which food from your own production is sufficient to meet the requirements of your family.'' Respondents were asked to provide their response as a number of months they were able to provide for themselves. Those who responded ''more than 12 months'' were classified as food self-sufficient, and those who responded ''<12 months'' were classified as not food self-sufficient. In terms of explanatory or independent variables, while some of the covariates are intuitive, others, such as species richness, Shannon diversity index for each crop of households, age dependency, and education level were transformed into indices using the procedures outlined below.

First, household-level agro-biodiversity was calculated using three different indices(KC et al., 2016).:
(1) Species richness, summing up the total number of crops present on each farm;
(2) Shannon diversity index for on farm crop. The Shannon diversity index for crop was calculated using the following equation (Eq. 1):

$$H = -\sum_{i=o}^{n} Pi * lnPi$$

Where, Pi = fraction of the entire population made up of species i. And
n = number of crop species encountered.

To calculate the Shannon diversity of crop area, we have used Pi as the fraction of the total cropland made up of a crop i.

(3) Simpson index of diversity was calculated using following equation (Eq.2):

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where, n= numbers of individuals of each species. And
N=total number of individuals of all species.

Simpson index of diversity ranges from 0 to 1.
High scores (close to 1) indicates high diversity.
Low scores (close to 0) indicates low diversity.

Second, for each household we developed an age dependency ratio that is defined as the ratio of household members who were least likely to work due to their age (defined as those aged 0–15 and those aged over 60) relative to the number of people aged 16–60 years in the family (KC et al., 2016).

2.3 Data Analysis

According to the conceptual framework, our approach was to test the relationship between crop diversity and food self-sufficiency. Drawing on the literature cited above, we hypothesize that (1) agro-biodiversity is positively associated with food self-sufficiency and its food security impacts; but that (2) the agro biodiversity does not vary in different agro-ecological regions. To test this hypothesis, we used the following two steps. First, we summarized the data using descriptive summary statistics. These results are presented in ''Summary statistics'' section below. Simple descriptive statistics such as means or medians (for normally distributed or skewed variables, respectively), frequency counts and percentages were done to characterize farms according to species richness and abundance. The cultivation frequency of crops was calculated and compared across the agro-ecological region. Second, we used independent sample t test to evaluate the hypothesis of agro-biodiversity is significantly different over food sufficient and non-sufficient household and also to evaluate the hypothesis of agro biodiversity across two regions is similar.

These results are presented in ''Comparisons of agricultural biodiversity across agro-ecological regions and socio-demographic groups'' and ''Diversity levels for food self-sufficient households versus non-self-sufficient households'' sections. Two diversity indices, Shannon diversity index and Simpson diversity indices were computed by above formula using Ms excel 2013. Statistical Package for Social Sciences (SPSS Version 22.0) was used for all other analyses. Before SPSS analysis, the data from mWater portal surveyor and Ms excel were coded and tabulated. To determine bivariate relationships between food plant species richness or diversity variables and biophysical or socio-economic variables, Pearson's correlation coefficient was also computed. The independent variables included in the analysis were: (i) number of a family members (ii) type of household (iii) age of family members (iv) main income source of household (v) walking distance to nearest market, (vi) cropped farm area, (viii) household head's age, (ix) education of household members (x)religion of family household (xi) ethnicity of respondent.

3. Result

3.1 Summary statistics

The average cultivated farm area in seven villages of dang was 0.404 ha (range=0-1.55), being significantly higher than cultivated farm area of Lamjung, which as 0.148 ha (range=0-0.406) .Majority of family depends on agriculture, either for primary source or secondary source of income. Besides this, people were engaged in business, services and the most important one was remittance for the source of their income. Each household mainly comprised of a nuclear family an average household size of 6.49 ± 0.508(range 3-17) in dang and 5.26 ± 0.282 (range=2-11 in lamjung table). Among them, dependent family members were 43.67% (age dependency ratio) and 44.88% in dang and Lamjung respectively. The average age dependency ratio shows that families have more or less the same number of adults and dependent members throughout the sample. Out of 35 respondents from each agro-ecological region, 91.4 % were male headed and 8.6% were female headed type of household in dang. Similarly, 68% were male headed and 31.4% female headed household in Lamjung. Most of the samples were Hindus (around 88.6%) and then Muslim (8.6%) and Christian (2.9%) in Dang whereas in Lamjung, after Hindus (71.4%) most of them were Buddhist (22.9%) and finally (5.7%) Muslims. About 8.6 and 11.4 percent were marginalized an untouchable type of sample recorded respectively in dang and Lamjung.

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

Variable	Dang high market access (n=35)	Lamjung medium market access (n=35)
Land holding	0.54012 ±0.92 ha	0.39446 ± 0.69 ha
Total cultivated area	0.404 ±0.071 ha	0.148 ± 0.021 ha
Dependency ratio	43.67%	44.88%
Market distance	2.043±0.3882 km	4.14 ± 0.372 km
Farming system	Subsistence to commercial	Subsistence to semi-commercial
Average family size	6.49 ± 0.508	5.26 ± 0.282
	percent	percent
Education level		
<5 years of schooling	35.8	27.2
6-8 years of schooling	14.1	20.1
9-10years of schooling	16	24
>10 years of schooling	30.1	28.7
Food self-sufficiency level		
self-sufficient	40	28.6
non self-sufficient	60	71.4
Farming system		
No farming	11.4	11.4
Subsistence	48.6	77.1
Semi-commercial	28.6	8.6
commercial	11.4	2.9
Household type		
Male headed	91.4	68.6
Female headed	8.6	31.4
Ethnicity		
Elite group	40	31.4
Marginalized and touchable	51.4	57.1
Marginalized and untouchable	8.6	11.4

Source: field survey 2020

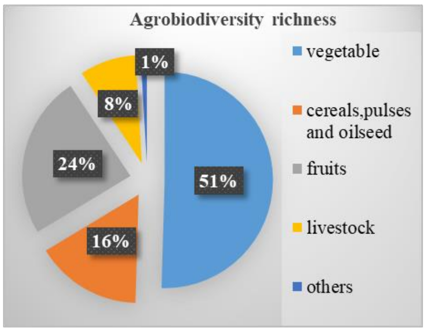


Figure 3: On Farm Biodiversity Richness of Respondents

3.2 Food self-sufficiency level and farming system of households

Taking about food self-sufficiency, only few percentage was self-sufficient in both of the ecological region. Most of samples were non-sufficient around 60% and 71.4% respectively in dang and Lamjung as shown in the table, while remaining 40 % and 28.6% were food self-sufficiency in dang and Lamjung respectively. Most of the farmers of both areas had higher subsistence level of farming system followed by semi-commercial and others. Only few of them were engaged in commercial farming. In dang with higher market and road access people are involved more in commercial farming and semi-commercial farming system in comparison to Lamjung where market access is moderate.

3.3 Crop Diversity level in two agro ecological regions

Species richness of vegetables category was higher than rest. Highest number of vegetables species were found followed by fruit species and then cereal, pulses and oilseeds and livestock finally. Vegetables like radish, bean, potato, cabbage, cauliflower, broadleaf mustard, coriander, bitter-gourd, sponge -gourd have higher cultivation frequency followed by Onion, okra, bottle-gourd and others. Among them vegetables like Knolknol, Seesem-seed, ash-gourd, kidney bean, mushroom are more cultivated in dang than Lamjung. While vegetables like chayote and some spices like large cardamom, black-pepper, pepper are only present in Lamjung area. Other's vegetables have more or less same frequency in both areas (table3).

Table 3: Plant diversity in cultivated area of two agro ecological region of Nepal

Biodiversity	Species abundance Dang (n=35)	Lamjung (n=35)	Local name	Family
1.vegetables, spices and others				
Brassica oleraceae L. Var capitata	H	H	Bandagobi	Curciferae
Brassica oleracea var. botrytis	H	H	Cauli	Curciferrae
Solanum tuberosum	H	H	Alu	Solanaceae
Lycopersicum esculentum	M	M	Golbheda	Solanaceae
Cucurbita pepo L.	M	M	Fharsi	Cucurbitaceae
Brassica juncea Czem	H	H	Rayo	Curciferae
Coriandrum sativum	H	H	Dhaniya	Umbelliferae
Allium cepa	H	H	Pyaj	Amaryllidaceae
Raphanus sativus	H	H	Mula	Curciferae
Daucas carota L. var. sativa	L	L	Gajar	Umbelliferae
Allium sativum	H	H	Lasun	Amaryllidaceae
Lagenaria siceraria	H	M	Lauka	Cucurbitaceae
Vicia faba.	H	M	Bakula	Cucurbitaaceae
Lablab purpureus	M	M	Hiude simi	Leguminosae
Trichosanthes anguina	H	H	Ghiraula	Cucurbitaceae
Trigonella foenum-graecum	M	L	Methi	Leguminosae
Brassica oleracea var accephala	M	H	Broccoli	Curciferae
Brassica oleraceae L. var. gongylodes	L	-	Ghadgobi	Curciferae
Vigna unguiculata	M	M	Bodi	Leguminosae
Phaseolus vulgaris	M	M	Rajma	Leguminosae
Elsholtzia flava	M	M	Sampu	Labiatae
Sesamum orientale.	L	L	Til	Pedaliaceae
Trichosanthes anguina	H	M	Chicindo	Cucurbitaceae
Momordica charantia	H	H	Karela	Cucurbitaceae

Colocasia antiquorum Schott. Var. esculenta	M	M	Pidalu	Araceae
Capsicum annuum	H	H	Khursani	Solanaceae
Lepidium sativum	L	L	Camsur	Cruciferae
Pisum sativum	L	L	Kerau	Leguminosae
Basella alba	M	L	Poisaag	Basellaceae
Abelmoschus esculentus	H	H	Bhindi	Malvaceae
Brassica rapa	H	H	Tori saag	Cruciferae
Solanum melongena	M	M	Bhenta	Solanaceae
Dolichos lablab	H	H	Simi	Leguminosae
Benicasa hispada	M	L	Kuvindo	Cucurbitaceae
Sechium edule	L	L	Skush	Cucurbitaceae
Capsicum annuum	L	L	Bhede khursani	Solanaceae
Cucumins sativas	H	H	Karko	Cucurbitaceae
Zingiber officinale	M	H	Aduwa	Zingiberaceae
Curcuma longa	M	M	Besar	Zingiberaceae
Amaranthus spp	H	M	Bethe	Amaranthaceae
Glycine max	L	M	Bhatta	Leguminosae
Dioscorea alata	L	L	Tarul	Dioscoreaceae
Agaricus spp.	L	L	Mushroom	Agaricaceae
Menthe L.	M	L	Pudina	Lamiaceae
Ipomoea batatas	L	L	Sweetpotato	Convolvulaceae
Dendrocalamus hamiltonii	L	L	Bashko tama	Poaceae
Zanthoxylum piperitum	-	L	Timmur	Rutaceae
Cicer arietinum	M	L	Chana	Fabaceae
Piper nigrum	-	L	Marich	Piperaceae
Elettaria cardamomum	-	L	Alaichi	Zingiberaceae
Beta vulgaris	L	L	Chukunder	Amaranthaceae
Sechium edule	-	L	Chayote	Cucurbitaceae
Dolichos spp.	L	M	Vatte simi	Leguminosae
2.Cereals, pulses and oilseeds				
Oryza sativa	H	H	Dhan	Graminaeae
Zea mays	H	H	Makai	Graminaeae
Triticum aestivum	M	L	Gahu	Graminaeae
Lens culinaris	M	L	Masuro	Leguminosae
Brassica nigra	M	L	Tori	Brassicaceae
Hordeum vulgaris	L	M	Jahu	Graminaecae
Vigna mungo	M	L	Maas	Fabaceae
Vigna radiate	L	-	Mung	Fabaceae
Cajanus cajan	L	-	Arhar	Fabaceae
Eleusine coracana	-	M	Kodo	Gramineae
Macrotyloma unifloru,	L	-	Gahat	Fabaceae
Fagopyrum esculentum	-	L	Phaapar	Polygonaceae
Helianthus annuus	L	-	Suryamukhi	Asteraceae
Glysine max.	L	M	Bhatta	Leguminosae
Cicer arietinum	M	L	Chana	Fabaceae
Arachis hypogaea	L	L	Groundnut	Fabaceae
3.Fruits				
Mangifera indica L	M	L	Aap	Anacardiacea
Musa paradisiaca	M	M	Kera	Musaceae
Punica granatum	M	L	Anar	Punicaceae
Prunus persica	L	M	Aaru	Rosaceae
Pyrus communis	L	M	Naspati	Rosaceae
Psidium guajava	M	M	Amba	Mytraceae
Carica papaya	M	M	Meva	Carciaceae
Annona squamosa	L	-	Saripha	Annonecceae
Citrus aurantifola	M	M	Kagati	Ruteaceae
Citrus lemon	-	L	Nibuwa	Ruteaceae
Tamarindus indica	L	-	Imili	Leguminosae
Litchi chinensis	M	L	Litchi	Sapindaceae
Artocarpus integra	L	M	Rukh katahar	Moraceae
Saccharum officinarum	L	L	Ukhu	Gramineae
Syzygium cumini	L	-	Jaamun	Myrtaceae
Phyllanthus emblica	L	L	Amala	Euphorbiaceae
Vitis vinifera	L	L	Angur	Viticeae
Citrus aurantium	-	M	Suntola	Ruteaceae
Citrus spp.	L	M	Amilo	Ruteaceae
Purnus domestica	L	L	Aru bakhara	Rosaceae
Ananas comosus	L	L	Pineapple	Bromeliaceae
*Fragaria *ananassa*	L	-	Strawberry	Rosaceae
Hylocereus undatus	L	-	Dragonfruit	Cactaceae
Morus bombycis	L	-	Kimbu	Moraceae
Citrus spp.	-	L	Junar	Rutaeaceae

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

3.4 Agro Biodiversity Richness, Shannon wiener and Simpson Index Over Agro-ecological Region

The Shannon-wiener index was found to be 1.100223 and 2.40746 in cultivated area of Inner terai and mid-hill region respectively (Table 4). Shannon-wiener index of vegetable, was 3.770 and 3.721 in Terai and mid hills region respectively. Shannon-wiener index in cultivated area of mid-hills region of categories fruits was 2.607 and that of cereals, legumes and oilseeds was 2.073 while Shannon wiener of fruits and cereals, legumes and oilseeds of terai region were 2.772 and 2.216 respectively. Simpson's index was 0.7545 and 0.5501 in cultivated area of Mid-hill and Terai region, respectively. The Simpson index found in mid hills of vegetables, fruits, cereal and oilseeds and livestock were 0.974, 0.924, 0.846 and 0.508 respectively. While Simpson index in Terai region was found 0.976 in vegetables, 0.930 in fruits, 0.874 in cereals, legumes and oilseeds and last one 0.504 in livestock. (table 4). The richness of inner-terai is 94 whereas it is 92 in Lamjung (Table 4).

3.5 Agro-Diversity level for food self-sufficient household versus food non- sufficient household

We conducted an independent sample t test to evaluate the hypothesis of agro-biodiversity is significantly different over food sufficient and non-sufficient household. When we analyzed the differences in agro biodiversity between food self-sufficient and non-sufficient households, we found that self-sufficient groups had significantly ($p<0.005$) higher agriculture biodiversity. More precisely:

significant differences were observed form the independent t test between agro-biodiversity richness between food sufficient households (M=42.67, SD=11.427) and non-sufficient households (M=34.13, SD=13.141), conditions [t (68) =2.693, p=0.09]. The richness of food sufficient household is significantly higher than non-sufficient households. Food sufficient households planted more number of diverse crop in comparison to non-sufficient households.

This study found that food sufficient households had statistically significantly higher Shannon wiener (0.11078±0.20486) compare to nonsufficient households (0.09371 ± 0.02902), [t(68)=2.564,p=0.013]

Table 4: Agro Biodiversity Richness, Shannon wiener and Simpson Index Over Agro-ecological Region

Ecological zones	Richness	Shannon-wiener index	Simpson index
Dang (inner-terai) n=35			
All species	94	1.1002	0.550134
Vegetables and spices	49	3.770	0.976
Cereals, legumes and oilseeds	14	2.216	0.874
Fruits	22	2.772	0.930
Livestock	9	0.742	0.5034
Lamjung(mid-hill) n=35			
All species	92	2.4074	0.7545
Vegetables and spices	53	3.721	0.974
Cereals, legumes and oilseeds	12	2.073	0.846
Fruits	19	2.607	0.924
Livestock	8	0.832	0.508

This result showed that Simpson indices of biodiversity of food non-sufficient household is statistically higher than sufficient households, condition [t (68) =-2.630, p=0.011].

In summary, the data suggest that food self-sufficiency and agro biodiversity are related, with self-sufficient households planting a higher diversity of crops (KC et al., 2016). These results broadly verify points raised in the literature that diversity is a key aspect of food sufficiency which is one of the aspects of food security. It is importance to consider that there are other factors that could also make a positive role to food self-sufficiency, such as level of education of household members, income of family, size of cultivated land.

3.6 Relation of Cultivated Area to food self-sufficiency and richness, Shannon and Simpson

An independent t test was conducted to found the role of cultivated area in food sufficiency level. We consider a null hypothesis as cultivated area between food sufficient households and non-sufficient household is similar. From the t test analysis, we came to found that there is statistically significant differences between food sufficient (0.475± 0.458) and non-sufficient households (M=0.173 ± 0.1748), conditions [t(26.553)=3.115 ,p=0.004]. This told us that cultivated area determine the food sufficiency level. Greater the cultivated area, households will greater lead towards food sufficiency and vice-versa. Also, correlation analysis was done to evaluate the hypothesis that there is no association between cultivated area and richness, Shannon and Simpson index (Table 5). From the test we found that there was moderate positive correlation between cultivated area and species richness. It means that increase in area will definitely increase species richness. Similarly, there was small positive correlation between cultivated area and Shannon wiener index. However, there was small negative correlation between Simpson index and cultivated area. It means that with increase in one cultivated area, there is decrease in another Simpson index of diversity and vice-versa.

Table 5: Relation of Cultivated Area to Richness, Shannon and Simpson:

		Cultivated	richness	H	1-d
cultivated	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	73			
richness	Pearson Correlation	.406**	1		
	Sig. (2-tailed)	.000			
	N	70	70		
H	Pearson Correlation	.319**	.976**	1	
	Sig. (2-tailed)	.007	.000		
	N	70	70	70	
1-d	Pearson Correlation	-.350**	-.953**	-.922**	1
	Sig. (2-tailed)	.003	.000	.000	
	N	70	70	70	70

4. Discussion

The findings from this study suggests that there are more similarities in between biodiversity of mid-hill (Lamjung) and inner-terai (Dang) region of Nepal. Only few species of vegetables, fruits and cereals, legumes and oilseeds are difference in between two agro-ecological zones. More similarity in species composition between dang and Lamjung may be due to similar feature and less difference of altitude, rainfall pattern, light intensity and temperature. The most common plant grown among biodiversity of dang and lamjung is vegetable, spices. This may be due to convenience of farmer to grow in small cultivated area like kitchen garden and may be due to commonly daily consumption pattern of people. Other factors like cultivated area, dependency ratio, literacy rate also have some role in food self- sufficiency. Another key finding of this paper is that crop diversity serves as a strategy to improve food self- sufficiency of house hold (Gauchan et al., 2020b). This results build on existing evidence of probability of house hold being food self-sufficient increase with increase in richness and diversity of cultivated area of house hold that support food security (KC et al., 2016). The increase in cultivated area of household increase the probability of higher species richness.

5. Conclusion

A survey was carried out in Tulsipur, Dang and Sundarbazar, Lamjung during November 2019 to Feburary 2020 to evaluate the link between on farm agro-biodiversity and food self-sufficiency in agro-ecological region of Nepal. Shannon wiener diversity index, species richness and food sufficiency level of farm is calculated of each farm and others data were obtained by semi-structured interview.

From the above research survey, we conclude that the agro-biodiversity of two agro-ecological region of Nepal is moreover similar and such biodiversity level have direct link to household food self-sufficiency level which helps in food security. Furthermore, we conclude that promoting crop diversity is an affordable strategy for reducing food insecurity in Nepal. Our results therefore promote to make effective implementation of regional food security strategies and polices to improve.

To close, while the central findings of this paper is that food self-sufficiency helps food security and itself is influenced by agro biodiversity, it is important to note that these are not simple relations. For instance, agricultural biodiversity and food security are influenced by other factors such as resource entitlement and market access. Therefore, it is important to recognize that the connection between on-farm diversity and food self-sufficiency are complex, and this study only provides a preliminary evaluation of one aspect of these complex relations.

Acknowledgement

I would like to express my deepest and sincere gratitude to my major research advisor Mr. Subodh Khanal, Assistant Professor Department of Soil Science, Environment Science and Agri-engineering, Paklihawa Campus Nepal for his constant encouragement, immense support, supervision and guidance, feedback and motivation and his amiable attitude despite his demanding calendar. His dynamism, vision, sincerity and motivation have deeply inspired me. He taught me the methodology to carry out research and to present the research works as a clearly as possible and I could not have imagined having a better advisor and mentor for my research. Similarly, I owe my profound gratitude to Institute of Agriculture and Animal Science, Lamjung Campus for their administrative and technical help which facilitated my research work. I am really grateful and express my heartfelt thanks to all respondents of Tulsipur municipality and Sundarbazar municipality Nepal who provide me sufficient information and their valuable time to conduct this research possible. Also my cordial thanks to those unmentioned persons who helped me directly and indirectly. Lastly, thank you my family for your incessant support and well guidance.

References

Abson, D.J., Fraser, E.D.G., Benton, T.G., 2013. Landscape diversity and the resilience of agricultural returns: a portfolio analysis of land- use patterns and economic returns from lowland agriculture.

Abson, D.J., Fraser, E.D.G., Benton, T.G., 2013. Landscape diversity and the resilience of agricultural returns: A portfolio analysis of land-use patterns and economic returns from lowland agriculture. Agriculture and Food Security, 2 (1). https://doi.org/10.1186/2048-7010-2-2

Belsky, J.M., Siebert, S.F., 2003. Cultivating cacao: Implications of sun-grown cacao on local food security and environmental sustainability, Pp. 277–285.

Bohle, H.G., Adhikari, J., 1998. Rural livelihoods at risk how Nepalese farmers cope with food insecurity. Mountain Research and Development, 18 (4), Pp. 321–332. https://doi.org/10.2307/3674097

CBS. 2015. Population Census in Nepal. Ministry of Population and Environment, 111 (3), Pp. 51–57.

Commission, N. P., (n.d.). The Food Security Government of Nepal.

Division, P., Health, M., Era, N., International, I.C.F., 2011. Nepal.

Esquinas-Alcázar, J., 2005. Protecting crop genetic diversity for food security: Political, ethical and technical challenges. Nature Reviews Genetics, 6 (12), Pp. 946–953. https://doi.org/10.1038/nrg1729

Esquinas-Alcázar, J., 2005. Protecting crop genetic diversity for food security: Political, ethical and technical challenges. Nature Reviews Genetics, 6 (12), Pp. 946–953. https://doi.org/10.1038/nrg1729

Floyd, C., Harding, A., Paudel, K.C., Rasali, D.P., Subedi, K., Subedi, P.P., 2003. Household adoption and the associated impact of multiple agricultural technologies in the western hills of Nepal, 76, Pp. 715–738.

Fraser, E.D.G., 2006. Crop diversification and trade liberalization: Linking global trade and local management through a regional case study. Pp. 271–281. https://doi.org/10.1007/s10460-006-9005-5

Gartaula, H., Patel, K., Johnson, D., Devkota, R., Khadka, K., Chaudhary, P., 2017. From food security to food wellbeing: examining food security through the lens of food wellbeing in Nepal's rapidly changing agrarian landscape. Agriculture and Human Values, 34 (3), Pp. 573–589. https://doi.org/10.1007/s10460-016-9740-1

Gauchan, D., Joshi, B.K., Sthapit, S., Jarvis, D.I., 2020b. Traditional crops for household food security and factors associated with on-farm diversity in the Mountains of Nepal. The journal of Agriculture and Environment, 21, Pp. 31-43. ISSN:2091-1009 https://hdl.handle.net/10568/109041

Gauchan, E.D., Joshi, B.K., Manandhar, H.K., Jarvis, D.I., 2020a. Traditional Crop Biodiversity for Mountain Food and Nutrition Security in Nepal Tools and Research Results of the Traditional Crop Biodiversity for Mountain Food and Nutrition Security in Nepal (Issue May).

Gautam, R., Sthapit, B., Shrestha, P. (n.d.). Home_Gardens_in_Nepal_1166.pdf.

Joshi, N.P., Maharjan, K.L., 2007. Assessment of Food Self-Sufficiency and Food Security Situation in Nepal. Journal of International Development and Cooperation, 13 (1), Pp. 209–230. https://doi.org/10.15027/28492

Kahane, R., Hodgkin, T., Jaenicke, H., 2013. Agrobiodiversity for food security, health and income. Agron. Sustain. Dev., 33, Pp. 671–693. https://doi.org/10.1007/s13593-013-0147-8

Karki, T.B., Sah, S.K., Thapa, R.B., McDonald, A.J., Davis, A.S., 2015. Identifying pathways for improving household food self-sufficiency outcomes in the hills of Nepal. PLoS ONE, 10 (6), Pp. 1–13. https://doi.org/10.1371/journal.pone.0127513

KC, K.B., Pant, L.P., Fraser, E.D.G., Shrestha, P.K., Shrestha, D., Lama, A., 2016. Assessing links between crop diversity and food self-sufficiency in three agroecological regions of Nepal. Regional Environmental Change, 16 (5), Pp. 1239–1251. https://doi.org/10.1007/s10113-015-0851-9

Lockie, S., Carpenter, D., Piechnik, D.A., 2012. Agriculture, biodiversity, and markets: livelihoods and agroecology in comparative perspective, Pp. 617–619. https://doi.org/10.1007/s10980-011-9690-3

Maharjan, K.L., Joshi, N.P., 2011. Determinants of household food security in Nepal: A binary logistic regression analysis. Journal of Mountain Science, 8 (3), Pp. 403–413. https://doi.org/10.1007/s11629-011-2001-2

Ng'Endo, M., Keding, G.B., Bhagwat, S., Kehlenbeck, K., 2015. Variability of on-farm food plant diversity and its contribution to food security: A case study of smallholder farming households in western Kenya. Agroecology and Sustainable Food Systems, 39 (10), Pp. 1071–1103. https://doi.org/10.1080/21683565.2015.1073206

Pandey, S., 2015. Factors affecting crop diversity in farmers' fields in Nepal. Renewable Agriculture and Food Systems, 30 (2), Pp. 202–209. https://doi.org/10.1017/S1742170513000367

Pokhrel, C.P., 2016. Assessment of plant diversity in homegardens of three ecological zones of Nepal. Ecoprint: An International Journal of Ecology, 22, Pp. 63–74. https://doi.org/10.3126/eco.v22i0.15472

Poudel, D.D., 2007. Farmer Cooperatives for Food Self-sufficiency, Agricultural Commercialization, and the Socio --economic Development of Nepal. Unfolding Futures: Nepalese Economy, Society, and Politics, Pp. 1–11.

Rana, R.B., Garforth, C., Sthapit, B., Jarvis, D., 2007. Influence of socio-economic and cultural factors in rice varietal diversity management on-farm in Nepal. Agriculture and Human Values, 24 (4), Pp. 461–472. https://doi.org/10.1007/s10460-007-9082-0

Sunwar, S., Thornström, C.G., Subedi, A., Bystrom, M., 2006. Home gardens in western Nepal: Opportunities and challenges for on-farm management of agrobiodiversity. Biodiversity and Conservation, 15 (13), Pp. 4211–4238. https://doi.org/10.1007/s10531-005-3576-0

Teixeira, H.M., van den Berg, L., Cardoso, I.M., Vermue, A.J., Bianchi, F.J.J.A., Peña-Claros, M., Tittonell, P., 2018. Understanding farm diversity to promote agroecological transitions. Sustainability (Switzerland), 10 (12). https://doi.org/10.3390/su10124337

Thrupp, L.A.N.N., Thrupp, L.A., (n.d.). Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture, Pp. 265–281.