Livelihood Options and Agrobiodiversity in Mountain Settlements of Manang District

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Abstract

Mountain ecosystems are experiencing rapid changes in natural environmental conditions and human activities including tourism and development activities. And such factors have substantial impacts on the livelihood of mountain people. Increasing road networks towards the rural settlements have increased the availability of goods and services from the nearby markets, thereby contributing to shifting away from traditional agricultural practices in the rural mountain settlements in Nepal. In this study, we sought to analyze the impact of tourism on agrobiodiversity and livelihood strategies in different villages of Manang with different level of tourist flow; low at Naar, moderate at Ngawal/Khangsar and high at Manang Nysyang. We used semi-quantitative field inventory data to compare diversity on agricultural plant species and livelihood options in these valleys. The study involved 72 households including 16 in Naar village, 26 in Ngawal/Khangsar and 30 in Upper Manang (Nysyang). We have confirmed a total of 60 species of agrobiodiversity in these mountain settlements (excluding microorganisms), with the minimum diversity at Naar Village with 28 species, and with maximum diversity in Upper Manang (51 species). The total number of species under agrobiodiversity is very poor in the mountain settlements of Manang which forms less than 1% of total agricultural species (60/6618) in Nepal. The poor agrobiodiversity in Manang is highly threatened due to various natural and anthropogenic drivers. We believe that our findings will be highly instrumental while making plans and policies for conservation of regional agrobiodiversity in context of changing climate and intensified human activities.

Keywords: agrobiodiversity, livelihood, Manang, mountain, tourism

Introduction

Mountains cover about 22% (32 million km^2) of the global land surface and accommodate about 1,010 million people (67% rural), and most of them (63%) are in developing countries (FAO, 2015). It is estimated that 40% of mountain people are vulnerable to food insecurity (FAO, 2019). Globally, only three crops, namely, wheat, rice, and maize, account for more than half of the dietary energy supply for humans, and the production diversity is declining rapidly (Adhikari et al., 2017; Mannar et al., 2020). In Nepal, the decline in agrobiodiversity is high, with the gradual disappearance of traditional nutritious food crops such as buckwheat, barley, millets, sorghum, oat, and beans from our food systems (Adhikari et al., 2017).

More than 60 percent people in Nepal rely on agriculture directly for their livelihood (GON, 2023). Agricultural activities in harsh climatic zones are highly critical in mountain landscapes such as Manang, where 6-10 persons per hectare land ratio in 1981 that has been increased to more than 10 persons per hectare by 2001 (Subedi, 2003). However, studies in recent years found decreasing pressure on agricultural land due to switching off from agricultural activities

to trade, tourism, and other livelihood options. This resulted in widespread migration and agricultural land abandonment in the valley, thereby the loss in local verities of agricultural crops. Agrobiodiversity holds significant importance within the broader spectrum of biodiversity, particularly in Nepal, where it is categorized into six primary components (cereals, legumes, vegetables, fruits, livestock, and fodder) and four subcomponents (value insects, aquatic animals, pest and disease) as representative species in each category (Joshi et al., 2020).

A total of 1,506 species of agricultural crop and forage genetic resources have been documented in Nepal (Joshi et al., 2020). This includes 93 introduced species, 670 wild edible plants, 224 crop wild relatives, 35 semi-domesticated species, and 484 cultivated native species. Among the cultivated native species, 64 are agronomic, 145 are horticultural, and 275 are forage species. Cultivated ornamental plant species consist of 100 exotic and 200 native varieties. In the realm of medicinal plants, out of 700 species, 120 native species are under cultivation, and 60 are exotic (Joshi et al., 2020). The existing crop genotypes exhibit a wide range, including landraces, modern, released, registered, de-notified, hybrid, inbred, open-pollinated variety (OPV), exotic, native, bulk, mixture, partial hybrid, breeding line, mutant, organ transplant organism (OTO), multiline, near-isogenic line (NIL), double haploid (DH), synthetic, clonal, and genetically modified organisms (GMO) (Joshi et al., 2020).

Manang in the Annapurna region of central Nepal has attracted trekkers from many countries since the late 1980s (Subedi & Chapagain, 2013). Upper Manang was not accessible to foreigners until early decades of the 20th (Kawakita, 2011), it was only notable to tourists after 1970. Tourism flourished in Annapurna Circuit and especially after the initiation of the Annapurna Conservation Area Project (ACAP) in 1986. However, in recent years the soaring number of visitors in Annapurna region has already created environmental problems including loss of biodiversity along with diversification in livelihood options. The agricultural production in the areas of extreme environment hardly supports local farmers to manage their livelihood. Hence, they are bound to seek alternative livelihood options for their survival (Van Spengen, 2000), with one of the highest rates of household out-migration in Nepal (Subedi, 2007). Different settlements of Manang were visited by tourists, and we could broadly categorize three types of settlements; most frequently visited by tourists and have a medium and low tourist flow. These differences impacted the livelihood options and agricultural practice in the region differently, and there are very few studies on the impact of tourism associated with infrastructure development in existing agricultural practices including agrobiodiversity.

Agrobiodiversity is very important as their insurance against pests, diseases, and climatic changes and as a coping mechanism in extreme conditions (Bahadur et al., 2016). They form an integral part of our food systems and maintain crop diversity, crop habitat diversity, and the assemblage of varieties of crops and livestock breeds (Negi et al., 2012). It is therefore highly important to improve diversity in agriculture with the revival of traditional food crops to improve both agricultural and environmental sustainability. The national data from Nepal showed that only a slight decline in the share of traditional crops, but there has been significant decline of agrobiodiversity in the country's high-altitude mountain districts (e.g., Humla and Jumla) (Gautam et al., 2019), and such decline has also been reported from Manang District, central Nepal. However, the causes and consequences about loss of agricultural crop diversity due to anthropogenic activities such as tourism and livelihood changes are not well explored in mountain settlements of Nepal such as Manang District. In this study, we compared the

diversity of agricultural plant species and livelihood options in Manang which is exposed to similar climatic conditions but different tourism and development activities. Specifically, we asked, (a) is there any difference in agrobiodiversity species richness among different settlements of Manang? (b) does agrobiodiversity richness in different settlements vary with different intensity of tourist flow?

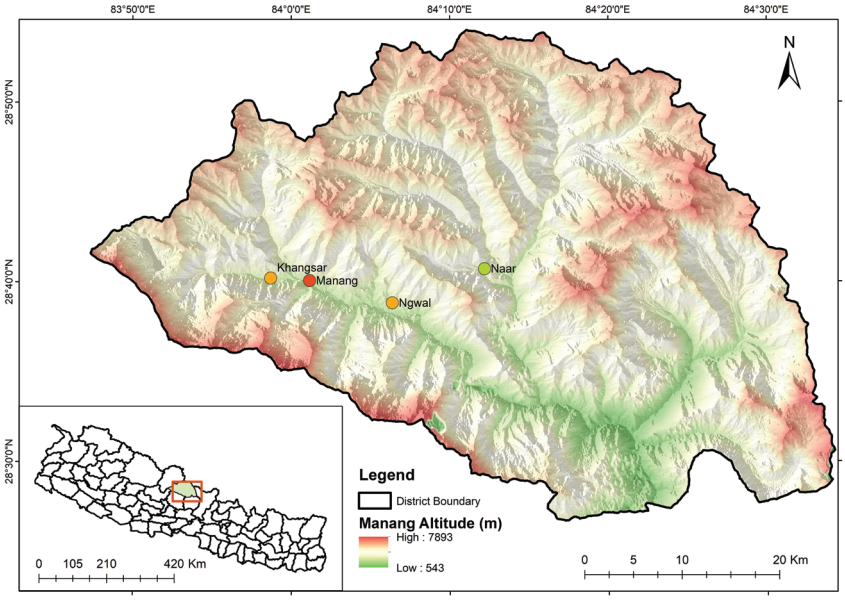
Materials and methods

Study area

The study was carried out in Manang District in central Nepal which is located behind the Annapurna Mountain range in the Nepal Himalayas (28° 27' to 28° 54' N latitudes to 83° 49' to 84° 34' E longitudes) (Figure 1). Manang District comprises three different regions such as the Upper Manang valley (Nyeshang Valley) in the west, the Lower Manang (Gasamdo) in the east and Naar-Pho Village in the north. The Upper Manang valley (Nyeshang) is extended from the lowermost settlement at Pisang (3100 m asl), to the uppermost settlement at Khangsar (3750 m asl). The Upper Manang valley is mainly formed with moraine deposited by Marsyangdi River and many glaciers from north and south. Manang Valley is a relatively cold and arid region with extreme cold winters (up to -5°C) and mild cool summers (up to 22°C) (DHM, 2017).

Figure 1

Map of Manang district showing study sites



Methods

Social survey on tourism and livelihood options

Household surveys were conducted in each village with the help of a semi-structured questionnaire for accessing local people's livelihood options. A field visit was carried out in

June 2023 at Manang. Altogether 72 respondents were interviewed regarding their livelihood options and agrobiodiversity practice in the villages. Among them 16 respondents were interviewed in Naar Village (low tourist flow), 26 respondents were interviewed from Nagwal and Khangsar villages (with moderate tourist flow) and 30 respondents were interviewed from Humde and Upper Manang (with the higher tourist flow). The households were selected by snowball method as per the respondents' hint, the households surveyed are 16 and 56 in Naar (13% of total households) and Manang Ngisyang (10 % of total household) rural municipality respectively. Rapid biodiversity survey was carried out with the help of semi-structured questionnaire for enumeration of plant species harvested for agricultural purposes in each village. The plant species were collected with the help of respondents. Plant enumeration data was tabulated into local names, scientific name, family, life form, plant habitat and their use potential and production volume (semi-quantitative) in the excel sheet.

An enumeration list of agricultural plants with their local names was produced. Plants were identified with the help of local people and comparing published literature and photographs (Shrestha, 1998; Joshi & Joshi, 2006; DPR, 2016). We followed Nomenclature by using the catalogue of life (https://www.catalogueoflife.org/col/search/). The unidentified plant specimens were collected, dried, and pressed for the herbarium preparation (Lawrence, 1951), they were given the Accession codes (CHG) and processed for identification. Further key informant interviews were also conducted with the hotel owners and villagers separately, who depend on agriculture for their livelihood.

Data analysis

Field inventory data were collected, compiled, categorized using computer software EXCEL and R 4.0.3.). (R Development Core Team 2020). Descriptive analysis (bar graph, and tables) was performed, in MS Excel 2021. Redundancy Analysis (RDA) was performed as a direct extension of multiple regression, as it models the effect of an explanatory matrix X (n x p) on a response matrix Y (n x m). Pearsons's correlation coefficients were computed between total agrobiodiversity richness and the livelihood options, and their relationship was analyzed by simple regression equations. The field interview questionnaire survey was conducted with the prior consent of the local people. Herbarium specimens and seeds were collected only for the identification purposes.

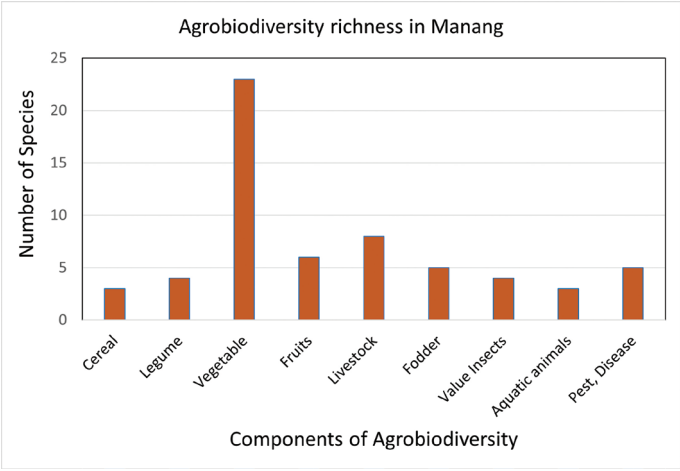
Results and discussion

Species in agrobiodiversity

We have confirmed a total of 63 species of agrobiodiversity in these mountain settlements (excluding microorganisms) (Figure 2). The minimum diversity was found in Naar Village (4200 m asl) with 28 species, and the maximum diversity was recorded in Upper Manang (51 species). The redundancy analysis showed that the species composition is oppositely seen in between Naar (low tourist flow) and Humde and Tankimanang (high tourist flow) (Figure 3). Among different components of agrobiodiversity, vegetable crops were the richest whereas the minimum diversity was found for main crops and aquatic animals (Figure 2). The total number of species under agrobiodiversity is very poor in the mountain settlements of Manang which forms less than 1% of total agricultural species (60/6618). The already poor agrobiodiversity in Manang is highly threatened due to various direct and indirect drivers of agrobiodiversity.

Figure 2

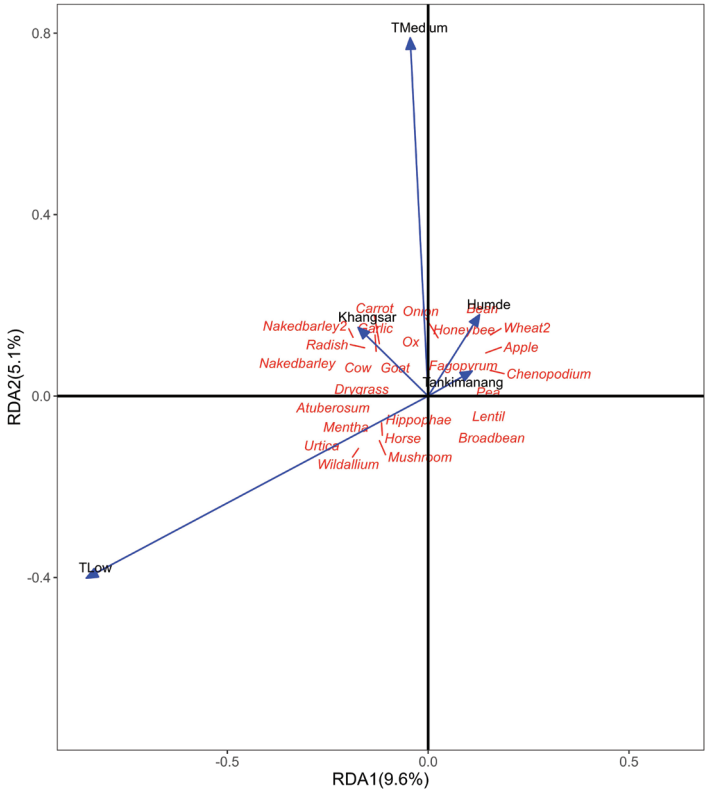
Agrobiodiversity in Manang District



Note: Cases of Naar, Ngawal, Khangsar and Upper Manang.

Figure 3

RDA plot shows the agrobiodiversity species in different settlements and the tourist flow (low and medium) of Manang district

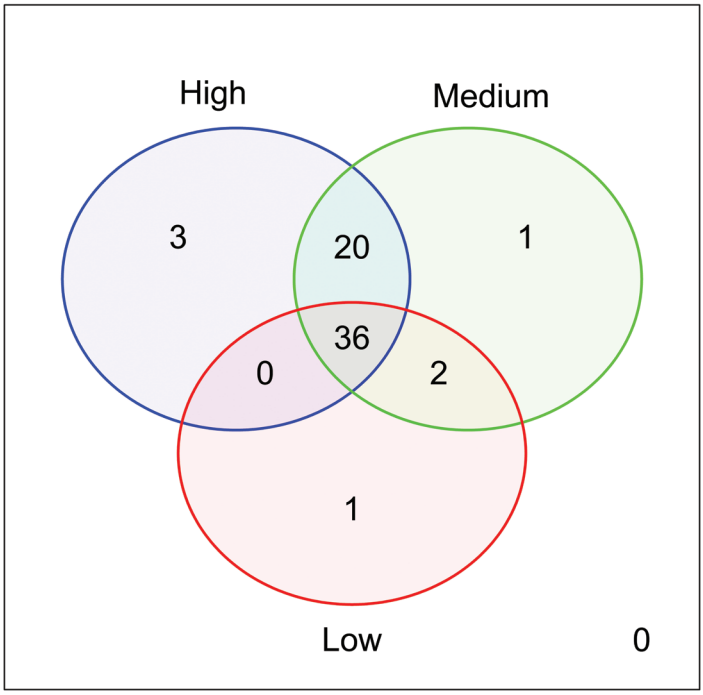


Analysis on agrobiodiversity richness

The total number of species (63) of agrobiodiversity components across the different settlements of Manang is relatively small, which is of course due to the harsh climate of the region and is also due to the exclusion of microorganisms. While observing the total species richness pattern, the species richness is common at different settlements categorized by the low, medium and high flow of tourists in the villages (Figure 4). The results showed that there are equal number of species at the locations with high and medium level of tourist flow, indicating that agrobiodiversity richness is high in the areas having high flow to tourist than the settlement having very low flow of tourists.

Figure 4

Vein diagram shows number of agrobiodiversity species



Note: Categorized by tourist flow (Low: Naar, Medium: Khangsar, Nagwal, High: Manang, Humde, Tankimanang).

The biodiversity in Nepal is extensive, encompassing a reported total of 24,300 biological species. Of these, 28% (6,618 species) are agricultural, excluding 27 exotic ornamental fish species. Agricultural fauna exhibits greater species richness (3,785 species) compared to agricultural flora (2,833 species) (Joshi et al., 2020). The insect component leads with the highest number of agricultural species (3,500), followed by the crop component (1,026 species) and the microorganism component (800 species) (Joshi et al., 2020). The livestock component has the lowest species richness among the six components of agrobiodiversity.

Manang was opened for tourists after 1977 (Watkins, 1996; Koirala, 1981) and has become one of the popular tourist destinations since the area became a part of Annapurna Conservation Area (ACA) in 1984 (Ives, 2006). Hence, the local people shifted from typical agriculture

and livestock towards tourism businesses such as hotels and trekking and trade. It was in 1980, only 14000 tourists trekked the route which cover Annapurna, Manang and Jomsom, and this number increased up to 110,000 by 2013, showing the highly intense tourist flow in the region (Subedi & Chapagain, 2013). Due to the harsh climate of the region tourism activity is quite seasonal in Manang, one is spring season (March-May) and the other is autumn (October-November). Interestingly, both tourist seasons overlap with the period of major agricultural activities such as ploughing, sowing/planting during spring and the harvesting in the autumn. Hence the local people in Manang have opportunity both tourism, trade and agriculture (Rogers, 2004). Tourism and tourist related business are more common in upper Manang (Manang valley) in comparison to the Naar-Phu village at which hardly receives visitors less than 500 a year (KMTNC, 2005). This strikingly different number of tourists visiting upper Manang and Naar-Phu village has shaped livelihood options in these two distinct settlements.

We followed the government (Government of Nepal) formulated protocol that includes the major six components (cereals, legumes, vegetables, fruits, livestock and fodder) and Four subcomponents (value insects, aquatic animals, pest and disease) of Agrobiodiversity in this study (Joshi et al., 2019, 2020) (Table 1). Notably, the count of wild edible species is higher in all components except forage and livestock components. However, it is noteworthy that in other agrobiodiversity components, there is low intra-specific diversity (different genotypes). Forage species and rangeland are distributed across elevations ranging from 60 m asl to 5000 m asl, with a total of 510 forage species, including 50 exotic varieties (Abington, 1992).

Tourism and livelihood options of local people

We have identified seven different livelihood options as mentioned by the local people. These options included agriculture and livestock, Business including tourism service, agricultural labor, non-agricultural labor, job, medicinal plant collection and remittance. It was observed that the peak season of agriculture and tourism overlap in Manang, that creates labor shortage in Manang (Figure 5). The local people have also mentioned that agriculture labor shortage is one of the important drivers for the loss of agrobiodiversity. The species richness indicated that agrobiodiversity is rich in areas with high and medium level of tourist flow, whereas the relatively poor richness was observed at the site with low flow of tourists. While checking the preference of agricultural species, local people mentioned that they have started growing plant crop species having higher demand from the visitors. Hence the people from areas with a higher flow of tourists are continuing the harvesting of traditional crops as well as the plant products with higher demand by visitors, making their localities rich in agrobiodiversity.

The livelihood options showed variation according to the places; agriculture and livestock is the major subsistence for local people in Naar Village as well as in Ngawal/Khangsar Village whereas tourism businesses were the major source of income in upper Manang (Nysyang) (Figure 6). Medicinal herb collection is more prominent source of income in Naar and Ngawal/Khangsar villages in comparison to upper Manang (Nysyang). However, there is increasing trend in tourist flow in Naar as well as Ngawal/Khangsar villages. There is rapid development of tourism infrastructure at Khangsar Village as it is the gateway of highly famous Tilicho lake trekking, which will create more livelihood options soon. If local people can maintain the traditional agricultural practices, and start growing new plant species as per the demand of visitors, the area can still maintain the richness of agrobiodiversity.

Figure 5

Annual calendar of activity of local people in Manang

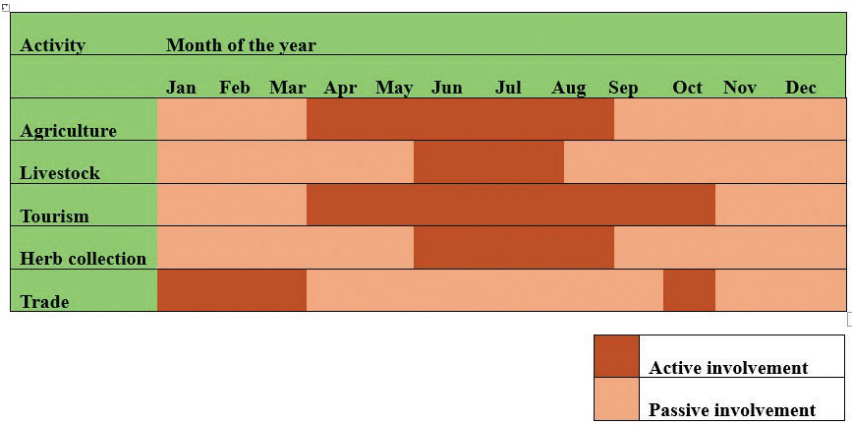
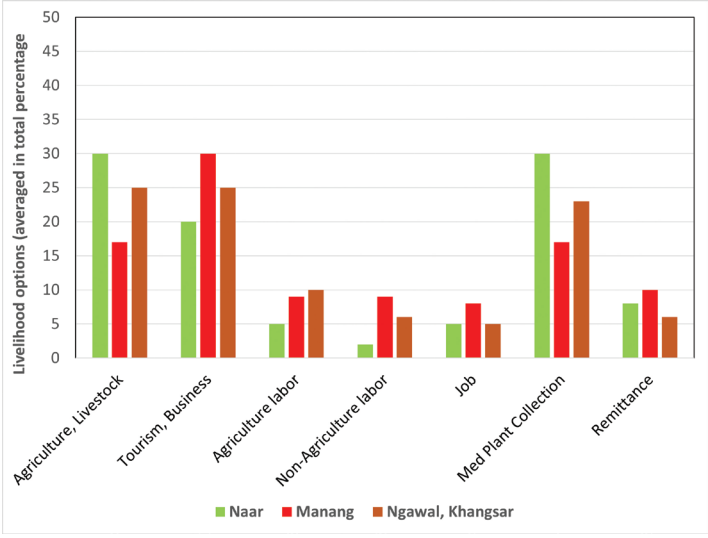


Figure 6

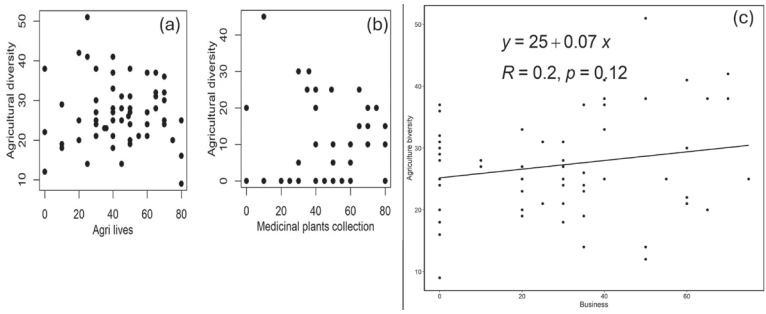
Livelihood options in study locations in Manang



It was found that there was no relationship of agrobiodiversity richness with agriculture and livestock, and medicinal plant collection as livelihood options. However, positive but insignificant relationship was observed between agrobiodiversity richness with tourism business (Figure 7). This is an important relationship to show the positive impact of tourism on agrobiodiversity contrary to our proposed hypothesis. However, commercialization of agriculture promotes monoculture, and the increased use of modern hybrids are the major contributors of genetic erosion on local agrobiodiversity (Shrestha & Shrestha, 1999; Chaudhary et al., 2016; Joshi et al., 2020). Hence, it is likely to happen that Manang will lose indigenous crop varieties if we continuously introduce modern hybrids. It is therefore highly critical to preserve local agrobiodiversity which is not only stress tolerant but also nutrient rich.

Figure 7

Relationship of agrobiodiversity richness with agriculture and livestock, and medicinal plant collection and tourism business as livelihood options

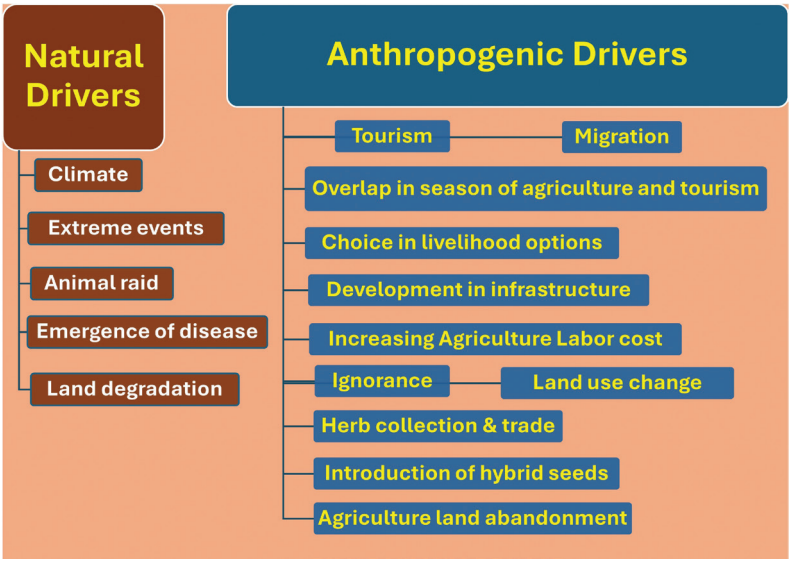


Drivers of agrobiodiversity richness

We have identified the five natural and 11 anthropogenic drivers of changes in agrobiodiversity in study regions, and the factors were as per local people's responses (Figure 8). Among them the anthropogenic drivers appear to be more influential than the natural causes. This indicated that agrobiodiversity in future is highly dependent on human activities although the environmental changes are very rapid and intense in the region. The utilization of agrobiodiversity at higher elevations greatly relies on water resources, the hydroclimatic balance is disrupted both by warming temperatures and by higher uncertainty in precipitation patterns (Thomas et al., 2007; IPCC, 2022) associated with excessive rainfall, snowfall, and drought as well as changing patterns of monsoon. Nepal has already witnessed sharp decline in winter crop harvest in 2009 across all regions. The decline of agrobiodiversity is also due to emerging pests and diseases as well as due to increasing invasive weeds (Tiwari et al., 2005), however, there were no such threats in case of studied sites at Manang at present.

Figure 8

Driving factors for agrobiodiversity richness



As IPCC (2007) indicated the warming temperatures greater than 1.5°C could put 20-30% of species at a higher risk of extinction, and this risk is persistent throughout Nepal. Although few respondents mentioned that the loss of agrobiodiversity in the study area is also due to climate change, other have also observed that they can grow cauliflower, carrot, cabbage, chili, tomato, coriander, spinach and cucumber due to increasing temperature trends in the region. Some farmers also experienced improved size of apple and vegetable crops as well as upward elevation shifting of crops including maize, apple, and others in Manang. Additionally, the local farmers have substantially used plastic tunnels to grow vegetables which have been highly affecting to maintain temperature and save vegetables from frost damage. The local people have already started domestication of wild vegetables such as Jimbu *(Allium hypsistum)*, which has high market value and no chance of being raided by wild animals. One of the underlying causes of loss of crop diversity is due to increasing incidences of extreme climate events in the mountain settlements. These extreme events include hailstorm, drought episodes, untimely snowfall and rainfall instead of snowfall, which severely affect crop yield and crop cycle.

With the commercialization of agriculture, there is an increasing trend of monoculture and hybrid varieties that are continuously replacing local and diverse landraces (Joshi et al., 2020). For instance, there is increasing trend of replacing native agricultural plants with hybrid varieties since 1995, these introduction accounts for more than 620% in tomato, 123% in Cauliflower, 260% in carrot, 447% in brinjal, 146% in Okra and 100% in cabbage.

Crop raids by wild animals have been reported by more than 90% of respondents in the study area. The study area lies within the Annapurna Conservation Area, where killing of wild animal is forbidden and illegal. Hence instead of threating/killing the wild animals the local farmers are gradually shifting from agriculture to other means of livelihood. Manang represents the mountain settlement in Nepal with high outmigration, thereby there is a general trend of population decline and less people to work in farmland. Also, there is a higher trend of agriculture land abandonment causing agrobiodiversity to decline. And there are new livelihood options such as involvement in tourism, herb collection and trade, infrastructure development projects, agriculture as well as non-agriculture labors. Local people mentioned their involvement in non-agriculture sectors for their livelihood which is also responsible for general decline in agrobiodiversity. Interestingly, the present study showed richer agrobiodiversity in the region with diverse livelihood options than the region with higher dependency in agriculture. The results indicated that agrobiodiversity richness is highest in Manang Village of Upper Manang followed by Ngawal/Khangsar and Naar Village, and the richness corresponds to livelihood options in these villages, upper Manang showing more options for livelihood and Naar village with least options. Further it is also highlighted that Naar village lies above 4000 m asl and has low outcome from agriculture with limited opportunity for agriculture thereby showing low richness in agrobiodiversity.

Further, the fair overlapping in the peak season of tourism and agriculture in Manang has created labor shortage to work in farmland, and this is also an important driver for agriculture sustainability in Manang. The labor shortage coupled with outmigration of males and undergoing feminization as well as due to diversification on livelihood options such as availability or remittance money and cheaper substitutes in the market have led to the abandonment of local crops in Nepal (Bhattarai et al., 2015). We have found that people in Manang are gradually shifting from cultivation of Karu (naked barley) to cultivating wheat as the latter is less labor intense. However, the local people in upper Manang are still able to

manage agriculture as well as tourism and showed rich agrobiodiversity in comparison to Ngawal/Khangsar and Naar village of Manang district. In conclusion, there are both natural and anthropogenic drivers of agrobiodiversity in Manang, and these drivers differently influenced agrobiodiversity in the study areas.

The local people would ideally seek direct as well as indirect incentives from the government to conserve their agrobiodiversity resources. Although there has been some support for providing vegetable seeds from the local government and some incentives from Annapurna Conservation Area Project, they are inadequate. And people do not fully rely on these seed sources for their subsistence and manage seeds on their own. This clearly indicated that the policy measures are inadequate for the conservation of native agrobiodiversity resources. It is emphasized that the local farmers should be made aware of the importance of their indigenous biological resources and need supports at policy level to support them conserve agrobiodiversity while diversifying their livelihood options and improve their life in such remote locations with harsh environmental conditions.

Local knowledge on agrobiodiversity

Agricultural Genetic Resources (AGRs) in the mountainous regions of Manang district are relatively poor because of both climatic and topographic extremes in Manang district. Despite most mountain people still relying on agriculture, their knowledge is relatively poor in terms of components of agrobiodiversity. Our results indicated that people of Naar valley showed less knowledge on agrobiodiversity in comparison to the people of Ngawal/Khangsar and upper Manang (Figure 9). Hence, it is highly critical to create awareness among local people about the importance of various components of agrobiodiversity in their region. They may not recognize the importance of value insects for their agriculture and may use insecticides and pesticides to control them.

Figure 9

Semi-quantitative scores of knowledges of agrobiodiversity among local people in Manang

	Components of Agrobiodiversity	Naar	Ngawal	Manang
Main components	Crop	5	5	5
	Forage Crop	3.5	4	5
	Livestock	5	5	5
	Agricultural Insects (Value Insects)	3	3.5	4.5
	Agro-microbes (mushroom, soil microbes, pathogene)	2	3	4
	Aquatic Agricultural Resources (Aquatic fish, frog, wild lice)	1	2	3
Sub components	Domesticated plant/animal	2	2.5	2.5
	Semi-domesticated plants/animals	1.5	1.5	2
	Wild Relatives	1	1	0.5
	Wild Edible fruits	0.5	1.5	1.5
	Total Score	**24.5**	**29**	**33**

*Note: Major components =*5, sub components =*5)*

Nepal, despite being rich in agrobiodiversity, has faced a serious challenge as native genetic resources have not been given sufficient attention in research, education, and development. This neglect has led to genetic erosion, posing a threat to the diversity of native agricultural resources. Addressing this issue requires tackling several major challenges. One critical challenge is halting the ongoing genetic erosion to preserve the unique characteristics of native genetic resources (Joshi et al., 2020). Efforts are needed to enhance the competitiveness

of native Agricultural Genetic Resources (AGRs) and reduce the current heavy dependence, which stands at 95-100%, on foreign germplasm (Joshi et al., 2017). This shift aims to secure food and nutrition by conserving existing agrobiodiversity.

There is a need to replace foreign agricultural products and germplasm with those derived from native AGRs. This involves identifying globally potential native AGRs and promoting them in international markets. Additionally, it is essential to develop site-specific products to cater to diverse agricultural environments. Creating an enabling environment that supports diverse varieties, breeds, and strains is crucial. This involves policies that favor diversity-rich agricultural products and strains. Moreover, efforts should be made to accelerate the evolutionary population to capture diversity from a wide range of agricultural areas.

Conclusions

We found that agrobiodiversity is rich in Upper Manang in comparison to Ngawal/Khangsar and Naar Village of Manang despite its connection to roads leading to lower valleys (Beshisahar) and increasing tourism activities associated with number of tourists. It is found that agrobiodiversity is maintained high due to traditional agriculture practice as well as modern agriculture practice using irrigation, fertilizers, improved seeds, polyhouses etc. Tourism also promoted agriculture practice because local people have also started growing crops as per the demand of tourists. The local people mentioned about environmental changes and anthropogenic activities as important drivers for agrobiodiversity richness. There are some incentives from the level of local municipal and ACAP (Annapurna Conservation Area Project) for the promotion of sustainable agriculture, although it has some counterproductive influence on indigenous agrobiodiversity, because we should be cautious while introducing hybrid seeds as incentives to the local farmers. Rather, we could initiate the production of indigenous crops seeds for sustainability as the indigenous species are stress tolerant and with higher nutritive value. New tools such as livestock insurance, compensation for crop against animal raid and increasing attraction towards local food (domestic tourists). There is huge potential of harvesting high value medicinal plants such as Jimbu *(Allium hypsistum)* which is without risk to wild animals. Moreover, it is found that tourism activities in Manang have positively contributed towards increasing agrobiodiversity in Manang, and it will sustain until the local people shift from cultivating indigenous crops to only hybrid and exotic varieties. However, more precise studies on species introduction and indigenous bioresources are recommended while interpreting results of agrobiodiversity richness in mountain landscape like Manang.

Acknowledgements

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