GRASSROOTS JOURNALS
ISSN 2564-4653 | 03(01) June 2023

AGROBIODIVERSITY & AGROECOLOGY | 03(01) JUNE 2023

Published by The Grassroots Institute (Canada) in partnership with University "Lucian Blaga" from Sibiu (Romania) and Fondacija Alica Banja Luka (Bosnia i Herzegovina). Website: https://grassrootsjournals.org/aa

M – 00347 | Research Article

# The Drivers of Changes in the State of Agrobiodiversity

**Bal Krishna Joshi*[1], Devendra Gauchan[2], Pashupati Chaudhary[3], Kamal Aryal[4], Ram Krishna Shrestha[5]**
[1]National Agriculture Genetic Resources Center, Nepal Agricultural Research Council (NARC), Khumaltar, Nepal.
Email: joshibalak@yahoo.com | ORCID: http://orcid.org/0000-0002-7848-5824
[2]Alliance of Bioversity International and CIAT, Khumaltar, Nepal.
Email: d.gauchan@cgiar.org | ORCID: https://orcid.org/0000-0002-3607-8841
[3]Asian Disaster Preparedness Center (ADPC), Phyathai Bangkok 10400, Thailand.
Email: pashupati.nature@gmail.com, | ORCID: https://orcid.org/0009-0003-3162-8415
[4]International Center for Integrated Mountain Development (ICIMOD), Khumaltar, Nepal.
Email: kamal.aryal@icimod.org | ORCID: https://orcid.org/0000-0001-6154-8844
[5]Crop Development and Agrobiodiversity Conservation Center, Kathmandu, Nepal.
Email: rksathi05@gmail.com | ORCID: https://orcid.org/0009-0009-3718-8442
* *Corresponding author*

**How to cite this paper:** Joshi, B.K., Gauchan, D., Chaudhary, P., Aryal, K. and Shrestha, R.K. (2023). The Drivers of Changes in the State of Agrobiodiversity. *Agrobiodiversity & Agroecology*, 03(01): 28-53. Doi: https://doi.org/10.33002/aa030102

**Received:** 14 April 2023
**Reviewed:** 20 May 2023
**Accepted:** 21 May 2023
**Published:** 30 June 2023
Copyright © 2023 by author(s)

**Publisher's Note:** We stay neutral with regard to jurisdictional claims in published maps, permissions taken by authors and institutional affiliations.

**License:** This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/

Open Access

*Editor-in-Chief*
Vacant
*Deputy Editors-in-Chief:*
Prof. Dr. habil. Maria-Mihaela Antofie; Prof. Dr. Gordana Đurić
*Technical & Managing Editor:*
Dr. Hasrat Arjjumend
*Associate Editor*
Dr. G. Prabhakara Rao (India)

## Abstract
The diversity of agricultural genetic resources is decreasing over the years and sites across the world. With the objectives of determining the drivers and their impact on agrobiodiversity particularly in Nepal, different methods e.g., focus group discussion, transact walk, key informant survey, and literature survey were used. Among the 16 broad categories of drivers, the most 5 important drivers in terms of negative impact on agrobiodiversity were the: 1) advancements and innovations in science and technology, 2) changes in land and water use and management, 3) alternative business and information flow, 4) population growth and urbanization, and 5) markets and trade. The most important specific driver is exotic varieties and breeds among 90 specific drivers. The earthquake of 2015 was a major disaster having damaged much local agricultural diversity in more than 14 districts of Nepal. Expansion of area for agricultural production, the establishment of a new settlement and various types of developmental activities have caused a loss of many wild relatives of agricultural species and wild edible species. Threat to crop diversity is high in rice, banana, cucumber, and tomato due to replacement of old cultivars by modern varieties. Threat to rice bean, horse bean, and foxtail millet is due to low priority given by growers and consumers. Invasive alien species like *Parthenium, Eupatorium* spp. and *Lantana camara* have had a significant effect on diversity and ecosystem services. The least affected agrobiodiversity components are microbial genetic resources. The important drivers e.g., exotic genotypes, external inputs, monogenotype-based monoculture policy and climate changes, should be given due attention to control and manage for better management of agrobiodiversity.

## Keywords
Agrobiodiversity; Genetic diversity; Drivers of changes; Genetic resources

## 1. Introduction

Estimate of the total species in the world is 8.7 million (BBC, 2011). Among them, about 30% species are agriculture-related. However, only 12 plant and 5 animal species provide 75% of the world's food (FAO, 1999). Out of 50,000 edible plants from the 320,000 plant species, only 150 to 200 are used by humans. Only 3 plants - rice, maize, and wheat - contribute nearly 60% of

calories and proteins obtained by humans from plants. Animals provide some 30% of human requirements for food and agriculture, and 12% of the world's population lives entirely on products from ruminants (FAO, 1999). Thus, agrobiodiversity is the most important sector of biodiversity fulfilling needs of human welfare and environmental security. In general, agrobiodiversity is divided into 6 components namely crop, forage, livestock, agro-insect, agro-microbial, and aquatic agri-genetic resources (Joshi *et al.*, 2019, 2020). Each component is further divided into 4 sub-components and they are domesticated/cultivated, semi-domesticated, wild relatives, and wild edible species. There are about 6,618 species related to agriculture in Nepal (Joshi *et al.*, 2008, 2017a, 2017b, 2020; Joshi, Ghimire and Singh, 2018; MoFSC, 2014). Diversity is being maintained at ecosystem, species, varietal/ breed/ strain, genotypic and allelic levels. Three agroecozones i.e., mountain, temperate and tropical agricultural zones along with 18 agroecosystems, are the major factors for creating and maintaining diversity in Nepal. This diversity has been conserved and promoted through different conservation initiatives (Joshi *et al.*, 2008; 2017a). However, this life-sustaining native agrobiodiversity pool is under threat of loss owing to different factors and reasons.

FAO (2019) has estimated the loss of 75% of plant genetic diversity is attributed to the farmers worldwide who have replaced their local varieties and landraces by genetically-uniform and high-yielding varieties. Similarly, 30% of livestock breeds are at risk of extinction, meaning that 6 breeds are lost each month. In Nepal, the estimated loss in different components of agricultural biodiversity is 50% in crop genetic resources, 40% in forage genetic resources, 40% in livestock genetic resources, 30% in aquatic genetic resources, 20% in insect genetic resources, and 20% in microbial genetic resources (Joshi *et al.*, 2020). Such loss is higher at the genotypic level.

Agrobiodiversity is under threat due to the use of high-yielding varieties, destruction of natural habitat, overgrazing, land fragmentation, commercialization of agriculture, indiscriminate use of pesticides, population growth and urbanization, and changes in farmers' priorities (Joshi *et al.,* 2017b; MoFSC, 2000). The most important drivers affecting the extent and distribution of agricultural biodiversity have been the commercialization of agriculture, weak policy and regulatory framework and climate change, population growth, and technological advancements (Ghale, 1999; Shrestha and Shrestha, 1999; Upreti and Upreti, 2002). There have been rapid changes and losses in genetic diversity because of the cumulative effects of various factors, which are also termed as "drivers of change" (Chaudhary *et al.*, 2006; Sthapit *et al.*, 2012). To manage agrobiodiversity properly over a long period, the drivers of changes in agrobiodiversity are very important to know. Therefore, this study was carried out to assess the drivers of changes that could help adopt effective measures, good practices, and strategies towards the management of agrobiodiversity.

## 2. Methodology

The impact of drivers of change depends on the types and components of agrobiodiversity. In this study, agrobiodiversity was divided into 5 components: food plant genetic resources (FPGR), forage genetic resources (FGR), animal genetic resources (AnGR), aquatic genetic resources (AqGR), and insect-microbial genetic resources (IMGR) (Joshi *et al.*, 2020).

Food plant genetic resources (FPGR) encompass domesticated and wild plant species and varieties that hold direct value for humans. Forage genetic resources (FGR) include all plant species used for livestock feeding, while aquatic genetic resources (AqGR) comprise edible plant and animal species existing in aquatic environments. Animal genetic resources (AnGR) consist of edible animal species, and insect-microbial genetic resources (IMGR) encompass beneficial and economically significant species of insects and microbes.

General drivers of change in these components (Table 1) were compiled based on existing literature (Chaudhary *et al.*, 2020; Chaudhary, Uprety and Rimal, 2016; FAO, 2019). Specific drivers were identified through authors' experiences, literature review, and interactions with key individuals. The list of potential specific drivers (Table 1) was shared and discussed with the respondents. The effects of these drivers on the six components of agrobiodiversity were assessed through focus group discussions and key informant surveys conducted in 2018 and 2019. Focus group discussions took place in three locations (Palpa, Kathmandu, and Parwanipur), involving over 200 participants. Additionally, 25 key individuals were interviewed. A survey format developed by using Google Forms was also distributed through online channels. Noteworthy cases were documented during the focus group discussions. For each driver, the trend on agrobiodiversity was assessed during the survey as strongly increasing (2), increasing (1), stable (0), decreasing (-1), or strongly decreasing (-2). In cases where information was unavailable or unknown, it was recorded as "NK" (not known) or "NA" (not applicable). The impacts of specific drivers were also evaluated during the survey and supplemented with insights from the existing literature.

## 3. Findings and Discussion

All participants reported the loss of landraces in all the studied sites. Key informants also shared their experiences regarding the impact of different drivers at various sites and time periods. The participants demonstrated a good understanding of specific drivers and their role and contribution to agrobiodiversity. Any factor that directly or indirectly affects agrobiodiversity in a particular area over time and space is referred to as a driver. Drivers can be categorized as direct or indirect. Direct drivers, such as the promotion of modern varieties, play a significant role in replacing native crop diversity. Conversely, efforts are required to minimize the impact of indirect drivers on diversity. For instance, climate change is an indirect driver influenced by human activities, making it challenging to mitigate its impact on agrobiodiversity. Drivers can be further grouped into broad categories and specific drivers (refer to Table 1). Analyzing specific drivers within the context of broad category drivers is crucial and effective in controlling the negative impact on agrobiodiversity. Drivers can also be classified as natural or anthropogenic (refer to Figure 1). Specific drivers are listed across three levels of diversity: ecosystem, species, and genetic.

Table 1: General and specific drivers along with their impact on agrobiodiversity based on the focus group discussion and literature review

| *SN* | *General drivers* | *Specific drivers* | *Some cases/impact* |
|---|---|---|---|
| 1. | Advancements and innovations | Improved and hybrid varieties and breeds, breeding and | • Masuli rice variety had replaced about 60% of rice landraces in the Tarai region |

| *SN* | *General drivers* | *Specific drivers* | *Some cases/impact* |
|---|---|---|---|
| | in science and technology | artificial selection, improved technology, extension strategy, mechanization, formal seed system, widely adopted variety/ breed promotion, recommendation of single variety for larger areas, introduction, commercial agriculture, protected farming | • 80% of Tarai goats got adulterated by Jamunapari goat<br>• Murrah buffalo, a single breed occupied about 40% of buffalo-rearing households |
| 2. | Changes in land and water use and management | The settlement, dam construction, road construction, hydropower, abandonment of land, monogentyping, water use in non-agriculture, encroachment | • Converting land to the city, the road in Biratnagar, Lothar, and Kailali resulted in the complete loss of wild rice<br>• About 60% of agricultural land in the majority of city areas was converted to other business |
| 3. | Pollution and external inputs | Toxic effects, chemicals, exotic seeds and breeds, dust, industrial and sewage, solid waste, plastic, air pollution | • 100% aquatic diversity lost in some areas due to chemical pollution<br>• 100% native diversity of crops, bees, fish, and animals lost due to exotic genotypes in some areas |
| 4. | Climate change | Temperature rise, drought, erratic rainfall, change in snowfall | • Many tropical crop species are now possible to grow in mountain areas<br>• 100% native diversity of some crop species lost in some areas due to drought<br>• Complete crop failure was observed in some species in some areas due to high temperature |
| 5. | Natural disasters | Earthquakes, flooding, landslides, pandemic diseases, hailstone, cyclones, hurricanes, thunderstorms, and lightning | • About 10% of crop diversity was lost due to earthquake in 10 districts<br>• 100% farming land along with native genetic resources were lost in some localities |
| 6. | Alternative livelihood options and information flow | Non-farm business (hotel, tourism, job, industry, trade), media, traditional knowledge, education, non-native language | • 80 to 100% of households shifted their business from agriculture to non-agriculture in some localities<br>• Only 5% of educated people engaged in agriculture<br>• All households near *Yarssagummba* growing areas prefer to collect this species rather than cultivating native crops and breed diversity |
| 7. | Pests, diseases, alien invasive species | Armyworm, blast, late blight, foot and mouth disease, bird flu, swine flu, citrus decline, banana wilt, parthenium, lantana camera, Gandi bug | • The population of different bee species was reduced by 15%<br>• 80% of soil biodiversity lost in some areas<br>• 90% of native diversity lost due to alien invasive species in some areas |
| 8. | Natural selection | Different domains for seed production and cultivation, pollinators, mutation, habitat degradation | • About 60% of seeds/ saplings are from other than cultivating areas<br>• Natural selection did not get a chance to favor almost all domesticated species |

| *SN* | *General drivers* | *Specific drivers* | *Some cases/impact* |
|---|---|---|---|
| 9. | Over-exploitation and overharvesting | Overexploitation, over-harvesting, poaching, grazing | • The amount of edible ferns was reduced by 25%<br>• Availability of wild edible fruits and vegetables was reduced by 40% |
| 10. | Human-wildlife conflict | Crop and livestock-fish depredation | • Monkeys, wild boars, wild elephants, tigers, porcupines, squirrels, and bear affected about 10-50% of total agrobiodiversity |
| 11. | Population Growth and Urbanization | Development activities, human-made disturbance, hydropower plants, roads, buildings, industry, dam, human-made sound, lighting in the night, vehicle | • About 60% of native crop diversity lost due to Budhi Gandaki hydropower<br>• 50% of farmers depend on an agro-vet for their seeds requirement |
| 12. | Markets and trade | Market demand, value chain, access to markets, illegal trade, cost of production | • Only about 10% of native products get to market<br>• The majority of the native products are not well-processed, labeled, and packed |
| 13. | Changing economic, socio-political, and cultural factors | Changes in food choice, preferences, labor shortage, migration, land fragmentation, political instability, increased remittance | • 95% of items in farmer's fields, kitchens, research stations, and supermarkets are from outside the country<br>• More than 50% of city dwellers ignore native food cultures and prefer exotic products |
| 14. | Migration | Outmigration, temporary migration to the city, shifting to city/plain areas, girl migration after marriage | • About 50% of native genetic resources were lost due to migration in some areas<br>• In some location, 50% of agricultural land remain barren |
| 15. | Incentives | Subsidy, training and visit, free distribution, cash reward, materials rewards | • The incentive is only for improved variety and breed<br>• Native agrobiodiversity never includes in training and education program |
| 16. | Policies | Commercialization, agriculture fair, promotional activities, single variety promotion | • Only uniform variety has been entered into the formal seed system<br>• The awarding system is only for improved variety and breed |

Multiple factors and actions are driving agrobiodiversity loss in Nepal, leading to various impacts. Several cases highlight the impact of drivers on agrobiodiversity. For instance, following the introduction of the Masuli rice variety in the Tarai region of Nepal in 1973, approximately 60% of rice landraces were lost within a decade. Similarly, the introduction of the Jamunapari goat in the Tarai region resulted in 80% of Tarai goats being crossbred with this exotic breed. Ajaya Chaudhary, a farmer from Rupandehi, observed a complete loss of aquatic animals (gogee, sutuahi, native fishes, earthworms, etc.) and native weeds due to the use of herbicides and pesticides. Heavy machinery for soil preparation, along with chemical fertilizers and pesticides, has led to the loss of soil biodiversity, rendering the soil lifeless. Construction of an irrigation channel from Chepe River to Rainas in Lamjung

district resulted in the loss of two dozen upland rice landraces (Ghaiya) from Rainas. Similarly, Palungtar, Gorkha witnessed a 90% loss of native rice landraces due to the factors like outmigration, urbanization, and the adoption of improved varieties (KH Ghimire, personal communication). Additionally, the use of pesticides has led to the scarcity of local mushrooms (Govrechayu, jharichayu, kalodungechayu, padkechayu) in many areas of Nepal.

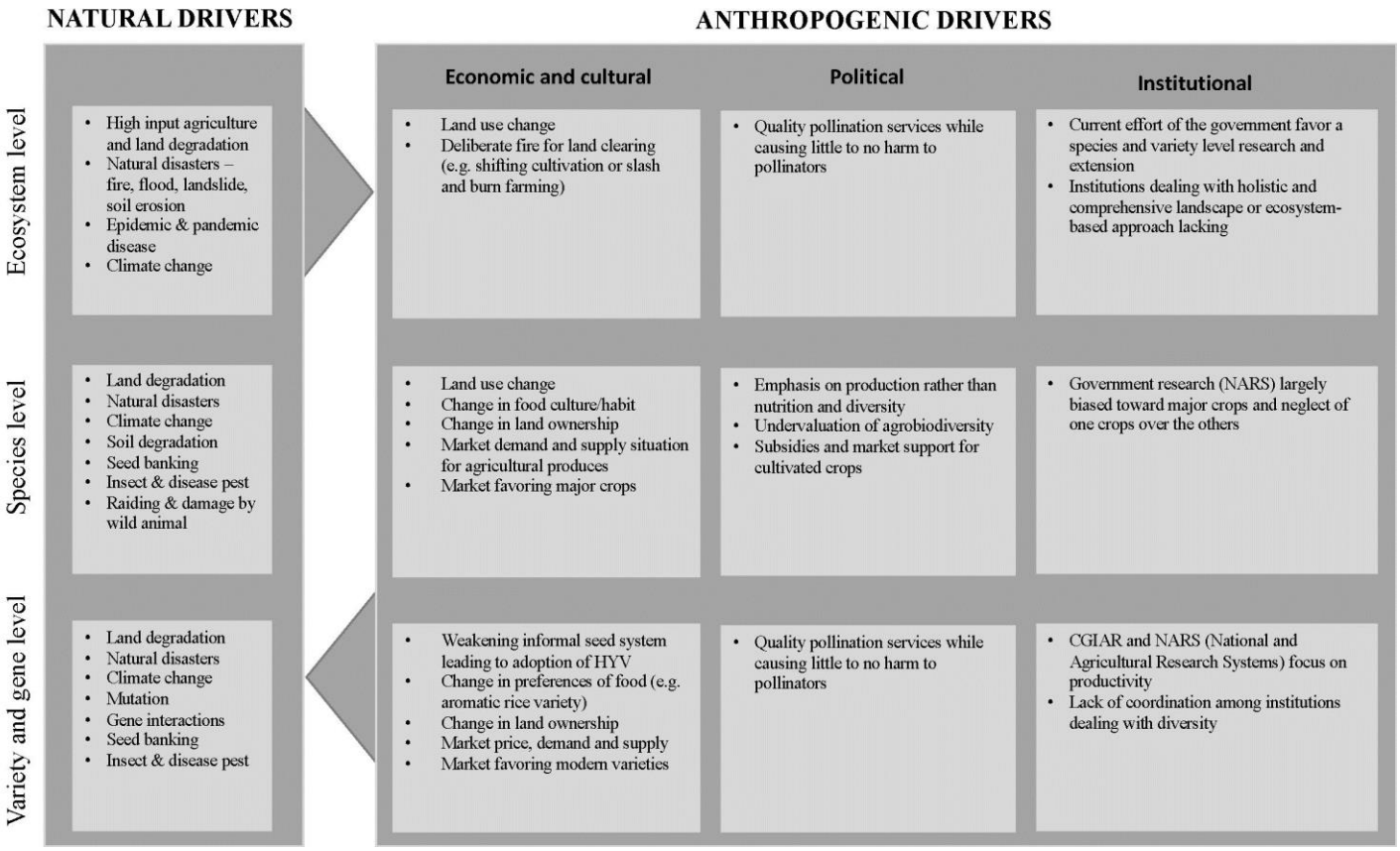


Figure 1: Different types of drivers over ecosystem, species, and genotype levels.

As mentioned in table 2, the top five drivers with the most negative impact on agrobiodiversity, in order, are: advancements and innovations in science and technology, changes in land and water use and management, alternative business and information flow, population growth and urbanization, and markets and trade. Almost all drivers have a detrimental effect on all five components of agrobiodiversity. A study conducted by the Ministry of Agriculture and Livestock Development (Joshi et al., 2017b) identified pollution and external inputs as an important driver affecting the extent and distribution of associated biodiversity in Nepal over the past 10 years. Unplanned and unregulated rural roads emerged as a significant threat to agrobiodiversity across all seven provinces of Nepal (refer to Table 3). However, the threat of overexploitation of plant species was relatively low in Lumbini province compared to other provinces. The impacts of different drivers are described below.

Table 2: Effect of drivers on components of agrobiodiversity in Nepal

| *SN* | *Driver* | *Effect of drivers on agrobiodiversity components* | | | | |
|---|---|---|---|---|---|---|
| | | FPGR | FGR | AnGR | AqGR | IMGR |
| 1. | Advancements and innovations in science and technology | -2 | 0 | -1 | 1 | -1 |
| 2. | Changes in land and water use and management | -2 | -1 | -1 | -2 | -1 |
| 3. | Pollution and external inputs | -2 | 0 | -1 | -1 | -2 |
| 4. | Climate change | -2 | -1 | 1 | -1 | -1 |
| 5. | Natural disasters | -2 | -1 | -2 | -1 | -1 |
| 6. | Alternative business and information flow | -1 | 0 | -1 | 0 | 0 |
| 7. | Pests, diseases, alien invasive species | -1 | -1 | -1 | -1 | 0 |
| 8. | Natural selection | -1 | 0 | -1 | 0 | 0 |
| 9. | Over-exploitation and overharvesting | -1 | -2 | -2 | -1 | 0 |
| 10. | Human-wildlife conflict | -1 | 0 | -1 | -1 | 0 |
| 11. | Population growth and urbanization | -2 | -2 | -1 | -1 | -1 |
| 12. | Markets and trade | -2 | -1 | 1 | 1 | 1 |
| 13. | Changing economic, socio-political, and cultural factors | -1 | 0 | 1 | 1 | 1 |
| 14. | Migration | -2 | 1 | -1 | 1 | 0 |
| 15. | Incentives | -1 | 0 | -1 | 0 | 0 |
| 16. | Policies | -1 | 2 | 0 | 0 | 0 |

Code description: Trends are strongly increasing (2), increasing (1), stable (0), decreasing (-1), or strongly decreasing (-2), no information available, not known (NK), and not applicable, (NA). FPGR, food plant genetic resources; FGR, forage genetic resources; AnGr, animal genetic resources; AqGR, aquatic genetic resources; and IMGR, insect-microbial genetic resources.

Table 3: Threat assessment of agrobiodiversity in different states of Nepal

| *Threat* | *Province* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Koshi* | *Madesh* | *Bagmati* | *Gandaki* | *Lumbini* | *Karnali* | *Sudur-paschim* |
| Loss of agrobiodiversity | High | High | High | High | High | High | High |
| Improper use of pesticides | High | High | Very High | High | High | High | Moderate |
| Urbanization | High | High | High | High | Moderate | High | High |
| Lack of incentives to conserve local landraces | Moderate | High | Moderate | High | High | High | High |
| Overharvesting of plant species | Moderate | High | High | High | NA | Very High | Moderate |
| Climate change | High | Moderate | High | High | Moderate | High | High |
| Unplanned and unregulated rural roads | Very High | Very High | Very High | High | High | Very High | Very High |
| Overexploitation of plant species | High | High | Moderate | High | Low | High | High |
| Alien Invasive Plant species | Moderate | Moderate | Moderate | Moderate | High | High | High |
| Loss of local landraces | Moderate | Moderate | High | High | Very High | Moderate | High |
| Loss of wild relatives | Moderate | High | High | Moderate | Very High | Moderate | High |
| Increased vulnerability to pests and diseases | Moderate | High | High | High | High | High | Moderate |

NA = is not available. *Source*: MoFE (2018)

### 3.1 Advancements and Innovations in Science and Technology

The participants expressed that modern uniform varieties have replaced their traditional landraces. Dependency on external stakeholders for inputs has further accelerated the loss of genetic diversity and traditional knowledge. The commercialization of agriculture promotes monoculture and the use of modern and hybrid varieties, which are major contributors to genetic erosion, as they replace local and diverse landraces (Shrestha and Shrestha, 1999; Joshi *et al.*, 2020; Chaudhary *et al.*, 2006). This trend has resulted in a narrow genetic base and increased vulnerability among resource-poor farmers, as well as the loss of native agrobiodiversity. For example, out of 1,800 indigenous and wild species of rice, only one variety is commonly cultivated in the Tarai region (Shrestha and Upadhyay, 1999). Several indigenous vegetable varieties are on the brink of extinction due to the widespread use of hybrid seeds (Shrestha and Shrestha, 1999).

The use of hybrid varieties in Nepal since 1995 has shown a significant rise: 620% in tomato, 123% in cauliflower, 260% in carrot, 447% in brinjal, 146% in okra, and 100% in cabbage. A study conducted in six districts representing three agroecological domains (Mountain, Hill, and Tarai) indicated the introduction of 29 varieties of cereals, 10 varieties of legumes, 14 varieties of fruits, and 56 varieties of vegetables within a span of 20 years. Varietal diversities of indigenous vegetables (particularly bitter gourd, snake gourd, broadleaf mustard, pumpkin, sponge gourd, and radish) and cereals (rice and finger millet) are at high risk of extinction. Many landraces have been reported as endangered in crops such as rice, maize, buckwheat, finger millet, legumes, fruits, vegetables, and medicinal plants (Sthapit *et al.*, 2012; Upreti and Ghale, 2000). Similarly, the introduction of exotic forage varieties has led to genetic erosion in forage species. Native oat and vetch species were previously cultivated by farmers, but with the introduction of high-yielding oat and vetch cultivars, the native species have been replaced and lost. A similar situation exists with tree fodders.

In recent years, the adoption of bee foraging practices by commercial bee farms, which involve exotic bee species, has positively affected the pollination of crops such as rapeseed, mustard, and others in Chitwan, Dang, Surkhet, as well as apple in Jumla districts. However, the promotion of exotic bees has led to a reduction in the population of native bee species. Similar cases can be observed in livestock and fish commercialization. The populations of pure Yak and Nak have drastically declined, making Yak a rare animal in the northern Himalayan ranges.

While certain technologies, such as biotechnology, have a positive effect on creating and maintaining diversity in animal and plant genetic resources (AnGR and PGR), the indiscriminate introduction of exotic breeding animals and varieties has resulted in cross-breeding with local animals and landraces, leading to under-utilization of native resources and ultimately their loss. The recent expansion of artificial insemination has also shifted attention away from animal biodiversity.

### 3.2 Changes in Land and Water Use and Management

Many participants have shared their own experiences regarding changes in land use. They have expressed an interest in converting agricultural land to other businesses if it proves to be more suitable and profitable. In peri-urban areas, farmers are more profit-oriented, which has led to the gradual replacement of

traditional farming systems with commercial vegetable cultivation. As a result, the area under traditional crops, as well as their varieties and landraces, has decreased. Land fragmentation has also contributed to farmers opting for food crops instead of forage, leading to a decline in forage diversity. Furthermore, both land and human resources have shifted from agricultural activities to non-agricultural businesses.

The scarcity of water sources significantly drives the utilization of agrobiodiversity. The aquatic environment in the mid-hills is primarily affected by river damming for hydropower, while in the southern plains, the encroachment of wetlands, lakes, and swamps for irrigation purposes is a major factor. Continuous deforestation poses a significant threat to forest biodiversity. Nepal experienced a 1.4% loss in forest area between 1990 and 2000 (FAO, 2010). The factors driving the loss of forest habitats and agricultural land include encroachment for settlements, expansion of cultivation using exotic breeds/varieties, and the development of infrastructure such as schools, hospitals, temples, and water storage tanks (DOR, 2010).

### 3.3 Pollution and External Inputs

Participants reached a consensus that pollution of soil, water, and air, primarily caused by chemicals, poses a significant risk to numerous genetic resources, placing them at the brink of extinction. The use of external inputs, including exotic genetic resources, has emerged as a major driver contributing to the loss of native genetic diversity. This driver has a particularly pronounced impact on crop and insect-microbial genetic resources. In Panauti of Kavreplanchok, for instance, local farmers have reported a scarcity of native bees, which they attribute to the heavy use of pesticides. Furthermore, they estimate that approximately 70% of soil biodiversity has been lost as a result of these practices.

### 3.4 Climate Change

Climate change is a widely discussed issue, and many participants have shared their experiences on this topic. The increasing annual temperatures have adversely affected crop growth cycles, resulting in reduced yield and productivity. Precipitation plays a crucial role in determining the success of crop production (Thomas *et al.*, 2007; Viglizzo *et al.*, 1997). The existing plant varieties in various regions may not be well adapted to the new production conditions. Alarming signs of a sharp and sustained decline in food security have already emerged in Nepal, such as a significant decrease in winter food crop harvests across all regions in 2009. The crop sector has also faced major challenges due to outbreaks and spread of minor diseases, pests, and unwanted weeds (Chaudhary *et al.,* 2011; Tiwari *et al.*, 2010). Farmers have reported the extinction of plant species, with the Seti River Valley of the Kaski district witnessing a reduction from 77 rice landraces to only 11 (Rijal *et al.*, 1998).

Changes in soil, temperature, humidity, sunshine, and water availability are altering the ability of certain species, varieties, and breeds to survive in their respective environments. Tree lines and species are migrating to higher elevations, while species already residing at the highest elevations face the challenge of having nowhere else to go.

Farmers in the Mustang and Manang districts have experienced improved apple sizes and have been able to grow cauliflower, cabbage, chilli, tomato, and cucumber due to climate shifts (Dahal, 2005). There have been reports of better sizes and tastes of local fruits (Dahal, 2005). Rice cultivation is now possible at altitudes up to 2,400 meters in Murza VDC of Myagdi district in Western Nepal (Dahal, 2006). The delayed monsoon has disrupted cropping patterns, maturity periods, and planting and harvesting times, resulting in thousands of hectares of fallow farmland (Regmi and Adhikari, 2007). In 2006, drought in the Eastern region of Nepal caused a 30% decrease in rice production, while heavy flooding in 2006 and 2008 destroyed crops in several places in Western Nepal (Paudel *et al.*, 2006). Farmers have also observed the effects of climate change on beekeeping, insect and pest intensity, and other impacts on rain-fed agriculture, such as changes in the timing of fruit tree and coffee flowering, decline in local grass species, and reduced size of some fodder trees (Regmi *et al.*, 2009). Changes in snowfall patterns, including duration and reduced amounts during winter, have also affected vegetation, including crops and animal genetic resources. Animals kept under the transhumant migratory system, such as sheep and yak, are particularly vulnerable to climate change, resulting in declining numbers and increased mortality.

The emergence of tropical insect pests and diseases at higher altitudes has become a common occurrence. For instance, *Citrus psylla*, whitefly, and armyworm are becoming problematic in these areas. Additionally, common cockroaches and mosquitoes are now being observed in high hill and mountainous regions where they were not previously seen. Outbreaks of snails and slugs have also been frequently reported. Abundant populations of *Lissachatina fulica* were found in Biratnagar, Jaleshwor, and Birgunj, and in recent years, it has spread to the western limits of the Western Development Region of the Terai and extended north across the Siwalik Hills to Makwanpur, Chitwan, and Tanahun (Budha and Fred, 2008).

Long-duration droughts have led to the drying up of ponds and wetlands, while heavy rainfall has caused flooding, resulting in the loss of fish and sweeping away of pond and wetland waters. Rainfall-induced landslides, degradation, and filling of wetlands and lakes have devastating effects on various types of biodiversity, including associated biodiversity. According to the Millennium Ecosystem Assessment (2005), changing climatic conditions are likely to become the leading direct driver of biodiversity loss by the end of this century. The Intergovernmental Panel on Climate Change has estimated that a temperature increases greater than 1.5 degrees Celsius could put 20-30% of species at a higher risk of extinction, with the risk increasing with further temperature rise (IPCC, 2007).

### 3.5 Natural Disasters

Participants recounted the devastating earthquake of 2015 and its profound impact on human survival, as well as the scarcity of genetic resources. Natural disasters, such as earthquakes, flooding, and landslides, have had a significant impact on agrobiodiversity (Joshi and Gauchan, 2017). The mid-hills, which are known for their rich agrobiodiversity, have been among the most affected areas by such disasters. The earthquake of 2015 resulted in the loss of a large number of livestock and the depletion of native crop diversities, leading to

the erosion of soil biodiversity and the disruption of the seed system. According to Joshi and Gauchan (2017), approximately 10% of the total local crop diversity, based on landraces, was lost in 10 districts of Nepal as a result of the devastating earthquake in 2015.

### 3.6 Alternative Livelihood Options and Information Flow

Many farmers have opted to pursue alternative businesses such as hotels, jobs, or other entrepreneurial ventures instead of engaging in agricultural activities. As a consequence, numerous genetic resources possessed by these farmers have lost, and agricultural land has been left barren. The influence of advertisements and promotional information also plays a crucial role in determining the choice of genotypes for cultivation and other purposes.

### 3.7 Insect Pests, Diseases, and Alien Invasive Species

In all studied sites, there have been reports of new pests, diseases, and invasive species. This phenomenon is commonly observed in Nepal (Tiwari *et al.*, 2010; Chaudhary *et al.*, 2011). These newly introduced or unintentionally introduced insect pests and diseases have had a significant impact on native genetic resources. Farmers often face challenges from common problematic pests such as aphids, caterpillars, cutworms, blight, *Alternaria* spp. of fungus, blast, and others, which prompt them to seek alternative solutions. Furthermore, emerging and re-emerging animal diseases like foot and mouth disease, hemorrhagic septicemia, black quarter in cattle and buffaloes, Peste des petits in Ruminants (PPR) in goats and sheep, and bird flu in poultry cause substantial damage to livestock diversity. Many native breeds are not typically vaccinated or provided with medicines against parasites, leading to reduced productivity. In addition, several alien invasive species such as *Lantana camara*, *Mikania micrantha*, *Chromolaena odorata*, and *Eichhornia crassipes* pose a threat to native genetic resources in both forested and cultivated areas (Tiwari *et al.*, 2010; Chaudhary *et al.*, 2011).

### 3.8 Natural Selection

Farmers typically do not practice seed selection for future plantations but instead rely on purchasing seeds each year from commercial farms and shops. This practice suggests that natural selection does not play a significant role in the selection of seeds for the next planting season. In the field of agriculture, particularly in breeding programs, nature's influence in selecting genetic resources is almost non-existent. The selection made by farmers and breeders may not always result in successful outcomes in the subsequent season's planting. It is common for seeds to be produced in locations other than the actual production sites, which can lead to genotypes experiencing complete failure in their performance due to environmental shocks or mismatches.

### 3.9 Overexploitation, Overgrazing, and Overharvesting

The overexploitation of high-value species has emerged as a significant threat to their survival in their natural habitats. The excessive commercial

harvesting of medicinal plants, both legally and illegally, poses a direct danger to high-value species such as yarchagumba (*Ophiocordyceps sinensis*), jatamasi (*Valeriana jatamansi*), sarpagandha (*Rauvolfia serpentina*), and many others. Uncontrolled forest fires present a serious hazard, particularly in the Siwalik region and high-altitude areas. Many of these fires are intentionally set by local communities to clear land for agriculture or to promote the early growth of grass for livestock grazing. Recurrent forest fires cause significant damage, hindering the regeneration and growth of seedlings, destroying non-timber forest products, harming ground flora and fauna, and inhibiting the development of understory vegetation. This ultimately leads to the transformation of forests into open areas with relatively low biodiversity. Overgrazing in forests has had detrimental effects on seedling regeneration and growth, resulting in forest degradation in various locations. Additionally, the over-harvesting of many wild foods such as bamboo shoots (Tusa), ferns (Niuro/Daunde), certain medicinal plants, and wild animals has put them at risk of extinction.

### 3.10 Human-Wildlife Conflict

Due to the persistent issue of wildlife disturbances, such as monkeys, boars, and wild elephants, many farmers have been compelled to make changes either in the choice of agricultural species or in their agri-businesses altogether. The presence of wildlife poses a significant threat as they often destroy crop fields and consume or damage planted seeds. In order to mitigate these challenges and minimize losses, farmers have resorted to altering their agricultural practices or exploring alternative income-generating activities. The need to protect crops from wildlife encroachment has driven farmers to adapt and seek solutions that are more compatible with the local wildlife dynamics.

### 3.11 Population Growth and Urbanization

The farmers who participated in the study appeared to be less informed about one particular driver of biodiversity loss. However, based on the available literature and insights from key informants, it is evident that increased population pressure, widespread poverty, and environmental degradation are the major severe threats to flora and fauna diversity in Nepal (Upreti, 2000; Yonzon, 2000). The population growth rate is estimated at 0.61% per year, with a corresponding growth rate of 2.3% per year for principal agriculture production. The combination of small landholdings and mounting population pressure has resulted in challenges in maintaining existing agrobiodiversity.

Unplanned rapid urbanization, the absence of appropriate land use policies, and weak institutional arrangements have placed enormous pressure on land resources, leading to the loss of agrobiodiversity. The rapid migration from rural to urban areas is posing significant socio-economic and conservation-related threats (NPC, 1998). In the Tarai region, such as Chitwan, Banke, and Kanchanpur, the loss of agrobiodiversity is attributable to swift urbanization, the expansion of feeder roads, construction of buildings and industrial facilities (Upreti and Upreti, 2002). Additionally, wetland sites, which are important habitats for indigenous crop species, are degrading and being lost due to encroachment, conversion into rice fields, fish ponds, extended settlements, and sedimentation (Siwakoti and Tiwari, 2007).

The changes in demand for livestock products, driven by population growth, urbanization, and higher income, have also had an impact on the diversity of livestock, poultry, and fish species. Urbanization and industrialization have further contributed to the reduction of grazing lands, negatively affecting animal genetic resources (AnGR) and forage diversity.

### 3.12 Markets and Trade

Market access and options play a crucial role in ensuring the sustainability of native genetic resources in agricultural production. The promotion of supermarkets and the availability of frozen food items have become an emerging trend, with a significant portion of the market consisting of imported goods, often overlooking local products. This can undermine the demand for and market opportunities of indigenous agricultural products.

However, on a smaller scale, certain native agricultural products hold high market value, leading to the continued cultivation of specific landraces, breeds, or strains. These products enjoy a niche market and are often sought after due to their unique characteristics or cultural significance. Examples of such native products that are exported include yak cheese, chyangra meat, large cardamom, Jumli bean, Jumli marshi (a type of rice), wool, and pashmina. The export value of these products incentivizes their continued production and contributes to their conservation.

In this way, the market plays a dual role, both posing challenges to local products through the dominance of imported goods but also providing opportunities for the conservation and preservation of native genetic resources when there is a high market demand and value for specific indigenous products.

### 3.13 Economic, Socio-Political, and Cultural Factors

The participants in the study acknowledged that as household economies improve, there is a tendency for individuals to move away from agriculture. Engaging in other non-agricultural businesses or occupations is often associated with higher social status. These values and reputations attached to non-agribusiness pursuits have significantly contributed to the loss of agrobiodiversity. Socio-cultural diversity, including food cultures and dietary habits, is closely intertwined with agrobiodiversity.

In many cases, women play a crucial role in determining the continued growth and preservation of genetic resources. Women are primarily responsible for growing local crops, managing wild relative plants, and maintaining their cultivation (Howard, 2003). However, changing socio-cultural dynamics and shifting dietary patterns in rural communities have led to the erosion of traditional food habits. The easy availability and appeal of fast foods with different tastes have influenced dietary choices. As a result, there has been a decline in women's knowledge of processing, preparation, and storage techniques associated with traditional foods. This erosion of knowledge, along with changing dietary habits, has had adverse effects on genetic diversity, family food security, and overall health.

It is important to recognize the role of women in agricultural practices and the preservation of agrobiodiversity. Empowering women and promoting their active participation and leadership in decision-making processes related to

agriculture and food systems can contribute to the conservation and promotion of genetic resources, food security, and sustainable agricultural practices.

### 3.14 Migration

Land abandonment in the studied sites is a growing concern, primarily driven by migration and labor shortage. This trend has had a direct impact on the gradual decline of local genetic resources. For instance, in the Panchase region (Kaski, Parbat, and Syngja districts), approximately 20-25% of cultivable land has been left uncultivated due to the migration of entire households to urban areas. In Samibhanjyang, Lamjung, around 50% of farming households have migrated to urban and plain areas, resulting in 50% of the land being left barren. This pattern of migration has led to the loss of almost 80% of traditional agricultural genetic resources in the area.

Agriculture in Nepal is undergoing a process of feminization due to male outmigration. This shift in gender dynamics in agriculture, along with the increased flow of remittances, has had implications for agrobiodiversity. The rising rate of outmigration is a significant driver of change in women's roles in agriculture and the management of agrobiodiversity (Desai and Banerji, 2008; Maharjan, Bauer and Knerr, 2012). The shortage of labor, combined with the availability of remittance money and cheap substitutes in the market, has led to the abandonment of local crops such as Ghaiya rice and Kauno (Bhattari, Beilin and Ford, 2015). The labor-intensive nature of processing Kauno, in particular, has added to the drudgery experienced by women, further contributing to its abandonment.

Addressing the challenges of land abandonment, labor shortage, and gender dynamics in agriculture is crucial for the conservation and preservation of agrobiodiversity. Creating supportive policies, providing access to resources and technologies, and empowering women in agricultural decision-making can help mitigate these threats and ensure the sustainable management of genetic resources.

### 3.15 Incentives

Farmers were initially unaware of the incentives associated with their own genetic resources. Consequently, they were persuaded to adopt modern varieties through the provision of incentives. Both monetary and non-monetary rewards are exclusively applicable to released, registered, and improved uniform varieties and breeds. However, this system promotes uniformity and a single genotype across large areas, leading to the displacement of localized genetic diversity.

### 3.16 Policies

Farmers were initially unaware of the policies regarding the management of agrobiodiversity, leading to a lack of attention towards its conservation in current policies. Native traditional crop landraces and livestock breeds have been significantly affected due to inadequate policy measures, strategies, and institutional support for farmers, as well as poor seed maintenance and exchange practices. In Nepal, the Seed Act 2045 (1988) fails to prioritize the informal "farmers-to-farmers" and non-formal seed management system, which has long

been in existence (Timsina, 2000) and accounts for over 90% of the seed flow (Joshi *et al.*, 2020). The country's agricultural policy leans more towards monoculture and promotes improved varieties and breeds/strains to enhance production and productivity, contradicting conservation policies and neglecting the preservation and utilization of on-farm genetic diversity. Numerous indigenous crop and livestock diversities are disappearing, yet the existing regulatory framework is ineffective in protecting the loss of valuable agrobiodiversity (Joshi *et al.*, 2020; Upreti and Upreti, 2002).

The expansion of tourism areas, particularly in regions abundant in agrobiodiversity, has accelerated the loss of biodiversity (Shrestha and Shrestha, 1999; Yonzon, 2000). National policies, strategies, and action plans do not fully incorporate the provisions of the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Nepal's membership in the World Trade Organization (WTO) limits the effective implementation of CBD (Chaudhary, 1999) as the provisions of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) conflict with the biodiversity conservation goals outlined in the CBD (Adhikari, Belbase, and Ghale, 2000).

## 4. Conclusion

More than 90 specific drivers have been identified as having a negative impact on agrobiodiversity. The effects of these drivers vary over time and across different locations. Among the components of agrobiodiversity, crop biodiversity is particularly affected due to the introduction of exotic varieties. Understanding these drivers is crucial for effectively planning and mitigating their adverse effects on agrobiodiversity. Various good practices have been implemented to ensure the availability of agrobiodiversity. These practices include the development of site-specific polymorphic varieties, evolutionary populations, cultivar mixtures, agro gene sanctuaries, provision of incentives, market guarantees for native genetic resources, geographical indication tags, community gene banks, school field gene banks, agro-insect field gene banks, dedicated structures, and land areas for conservation, among others. It is essential to urgently develop strategies and action plans in the country to minimize the negative impact of these drivers on agrobiodiversity. The aforementioned good practices should be widely and extensively implemented throughout the country to safeguard existing genetic diversity for long-term availability.

## 5. Acknowledgments

The study was supported by the Ministry of Agriculture and Livestock Development and the Nepal Agricultural Research Council. We extend our gratitude to Ajay Chaudhary and Krishna Hari Ghimire for their valuable information and insights. We also express our deep appreciation to the farmers and stakeholders who actively participated in this study from various regions of the country. Their contributions were invaluable to the success of this research.

## 6. References


Adhikari, R., Belbase, N. and Ghale, Y. (2000). Seed of monopoly: Impacts of Trips agreement on Nepal. Nepal: Pro-Public and Action Aid, Nepal, p. 149.

Bhattari, B., Beilin, R. and Ford, R. (2015). Gender, Agrobiodiversity, and Climate Change: A Study of Adaptation Practices in the Nepal Himalayas. *World Development*, 70: 122-132. DOI: https://doi.org/10.1016/j.worlddev.2015.01.003

Budha, P.B. and Fred, N. (2008). The Giant African Land Snail Lissachatina fulica. *The Malacologist*, 50: 19–25.

Chaudhary, P., Bhatta, S., Aryal, K., Joshi, B.K. and Gauchan, D. (2020). Threats, Drivers, and Conservation Imperative of Agrobiodiversity. *The Journal of Agriculture and Environment*, 21: 44–61. DOI: https://doi.org/10.3126/aej.v21i0.38441

Chaudhary, P., Gauchan, D., Rana, R.B., Sthapit, B.R. and Jarvis, D.I. (2006). Potential loss of rice landraces from a Terai community in Nepal: A case study from Kachorwa, Bara. *PGR Newsletter*, 137: 14–21.

Chaudhary, P., Rai, S., Wangdi, S., Mao, A., Rehman, N., Chettri, S. and Bawa, K.S. (2011). Consistency of local perceptions of climate change in the Kangchenjunga Himalaya landscape. *Current Science*, 101(4): 504–513. Available online at: http://www.jstor.org/stable/24078981 (accessed 12 March 2023).

Chaudhary, R.P. (1999). Intellectual Property Rights and Farmers Rights. In: *Proceedings of the National Conference on Wild Relatives of Cultivated Plants in Nepal*. June 2-4. Kathmandu: GEM-Nepal, pp.215–223.

Chaudhary, R.P., Uprety, Y. and Rimal, S. (2016). Deforestation in Nepal: Causes, consequences and responses. In: Shroder, J.F. and Sivanpillai, R. (eds.), *Biological and Environmental hazards, risks, and disasters*. Amsterdam: Elsevier, pp.335–372.

Dahal, N. (2005). Perceptions of climate change in Himalayas. *Tiempo Bulletin*, 26: 19–24. Available online at http://tiempo.sei-international.org/newswatch/feature050910.htm (accessed 7 March 2023).

Dahal, N. (2006). Implications of Climate Change in Nepal: Some Observations and Opportunities. 23rd Warden Seminar, Pokhara. Available online at: https://lib.icimod.org/record/12235 (accessed 7 March 2023).

Desai, S. and Banerji, M. (2008). Negotiated identities: male migration and left-behind wives in India. *Journal of Population Research*, 25: 337–355. DOI: https://doi.org/10.1007/BF03033894

DOR (2010). Statistics of Strategic Road Networks (SSRN 2009/10). *Department of Roads (DOR* [Preprint]. Kathmandu: Department of Roads.

FAO (1999). Women: users, preservers and managers of agrobiodiversity. Available online at: https://www.fao.org/3/x0171e/x0171e03.htm (accessed 7 March 2023)

FAO (2010). *Global Forest Resources Assessment 2010: Main Report.* Food and Agriculture Organization of the United Nations (FAO), Rome. Available online at: https://www.fao.org/publications/card/en/c/e4fa9d60-5207-5a96-976c-cd2e6f3519a5 (accessed 7 March 2023).

FAO (2019). The State of the World's Biodiversity for Food and Agriculture. In: Bélanger, J. and Pilling, D. (eds.), *FAO Commission on Genetic Resources for Food and Agriculture Assessments.* Rome: FAO.

Ghale, U.Y. (1999). Intellectual Property Rights, Bio-diversity and FS. In: *Proceedings of the National Conference on Wild Relatives of Cultivated plants in Nepal*. Green Energy Mission Nepal, pp.229–235.

Howard, P.L. (2003). *Women and plants, gender relations in biodiversity management and conservation*. London, United Kingdom: ZED Books.

IPCC (2007). Climate change 2007: Impacts, adaptation, and vulnerability. In: Parry, M. L., Canziani, O., Palutikof, J.P., van der Linden, P.J., and Hanson, C.E. (eds.), *Climate Change 2007: Impacts, Adaptation, and Vulnerability.* Report of the IPCC. London: Cambridge University Press.

Joshi, B.K. (2013). A brief overview of community seed bank initiatives in Nepal. In: Shrestha, P., Vernooy, R. and Chaudhary, P. (eds.), *Community Seed Banks in Nepal: Past, Present and Future*. Pokhara, Nepal: LI-BIRD/USC Canada Asia/Oxfam/ The Development Fund/ IFAD/Bioversity International, pp.41–46.

Joshi, B.K. and Gauchan, D. (eds.) (2017). Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal. In: *Proceedings of a National Sharingshop*. Kathmandu, Nepal: NAGRC, Bioversity International and Crop Trust. Available online at: https://himalayancrops.org/wp-content/uploads/2019/11/Final-Proce-Sharingshop-germplasm-rescue-2017.pdf (accessed 7 March 2023).

Joshi, B.K., Acharya, A.K., Gauchan, D. and Bhatta, M.R. (2017a). Agrobiodiversity status and conservation options and methods. In: Joshi, B.K., KC, H.B. and Acharya, A.K. (eds.) *Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal*. Dhulikhel; NAGRC, FDD, DoA and MoAD; Kathmandu, Nepal, pp.21–38.

Joshi, B.K., Acharya, A.K., Gauchan, D. and Chaudhary, P. (eds.) (2017b) *The state of Nepal's biodiversity for food and agriculture*. Kathmandu, Nepal: Ministry of Agricultural Development.

Joshi, B.K., Ghimire, K.H. and Singh, D. (2018). National Agriculture Genetic Resources Center'. Kathmandu, Nepal: NAGRC, NARC, Khumaltar.

Joshi, B.K., Gorkhali, N.A., Pradhan, N., Ghimire, K.H., Gotame, T.P., Khatri-Chhetri, P., Mainali, R.P., Karkee, A. and Paneru, R.B. (2020). Agrobiodiversity and its Conservation in Nepal. *Journal of Nepal Agricultural Research Council*, 6:14–33. DOI: https://doi.org/10.3126/jnarc.v6i0.28111

Joshi, B.K., Khatri-Chhetri, H.B., Upadhyay, M.P., Gupta, S.R., Lu, B.R., Mathur, P.N. and Sthapit, B.R. (2008). *Ex situ* and *in situ* management of wild and weedy rice in Nepal using a geographical information system. *Plant Genetic Resources Newsletter*, 155: 69–74.

Joshi, B.K., Shrestha, R., Gautam, I.P., Poudel, A.P. and Gotame, T.P. (2019). *Neglected and Underutilized Species (NUS) and Future Smart Food (FSF) in Nepal*. National Agriculture Genetic Resources Center (NAGRC, National Genebank), NARC, Nepal.

Maharjan, A., Bauer, S. and Knerr, B. (2012). Do rural women who stay behind benefit from male out migration: Case study in the hills of Nepal. *Gender, Technology and Development*, 16: 95–123. DOI: https://doi.org/10.1177/097185241101600105

MoFE (2018). *Nepal's Sixth National Report to The Convention on Biological Diversity*. Kathmandu, Nepal. Available online at: https://mofe.gov.np/old/downloadfile/Final%20Draft%206NR%20CBD%2031Dec2018_1546246223.pdf (accessed 7 March 2023).

MoFSC (2000). *National Biodiversity Action Plan*. Kathmandu: Ministry of Forests and Soil Conservation, HMG of Nepal, Global Environment Forum, UNDP.

MoFSC (2014). *Nepal Biodiversity Strategy and Action Plan 2014-2020*. Kathmandu: Ministry of Forest and Soil Conservation, Government of Nepal. Available online at: https://www.cbd.int/doc/world/np/np-nbsap-v2-en.pdf (accessed 7 March 2023).

NPC (1998). *Ninth Five Year Plan*. Kathmandu, Nepal: National Planning Commission.

Paudel, D., Shrestha, P., Basnet, A., Shrestha, P., Sthapit, B. and Subedi, A. (2006). Stability of social seed networks and nodal farmers in rice seed flow system: Does it matter for on-farm conservation? In: Sthapit, B.R. and Gauchan, D. (eds.), *On-farm management of agrobiodiversity in Nepal: Lessons Learned,* pp. 99–108. Bioversity International, NARC, LI-BIRD and IDRC.

Raut, S.K. (1999). The Giant African land snail, Achatina fulica Bowdich in Nepal and Bhutan. *Journal of the Bombay Natural History Society*, 96: 73. Available online at: https://www.biodiversitylibrary.org/partpdf/155538 (accessed 7 March 2023).

Regmi, B. and Adhikari, A. (2007). *Human development report 2007: Climate change and human development – risk and vulnerability in warming world; Country case study-Nepal*. New York: United Nations Development Program. Available at: https://un.info.np/Net/NeoDocs/View/4633 (accessed 7 March 2023)

Regmi, B.R., Kafle, G., Adhikari, A., Subedi, A., Suwal, R. and Poudel, I. (2009). Towards an *innovative* approach to integrated wetland management in Rupa Lake Area of Nepal. *Journal of Geography and Regional Planning*, *2*(4): 080–085. Available online at: https://www.internationalscholarsjournals.com/articles/towards-an-innovative-approach-to-integrated-wetland-management-in-rupa-lake-area-of-nepal.pdf (accessed 7 March 2023)

Rijal, D.K., Kadayat, K.B., Joshi, K.D. and Sthapit, B.R. (1998). Inventory of indigenous rainfed and *aromatic* rice landraces in Seti river valley. *LI-BIRD Technical Paper* (Issue 2). LI-BIRD, Pokhara. Available online at: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/23370/113255.pdf?sequence=1 (accessed 7 March 2023)

Shrestha, R. and Shrestha, B. (eds.) (1999). Wild Relatives of Cultivated Plants in Nepal. In: *Proceedings of National Conference on Wild Relatives of Cultivated Plants in Nepal.* Kathmandu, Nepal: The Green Energy Mission/Nepal.

Siwakoti, M. and Tiwari, S. (2007). Emerging needs of wetlands protection for the conservation of wild rice biodiversity in Nepal: A case study from Lumbini area. *Sci. World*, 5(5): 95–99. DOI: https://doi.org/10.3126/sw.v5i5.2664

Sthapit, B., Rana, R., Subedi, A., Gyawali, S., Bajracharya, J., Chaudhary, P., Joshi, B. K., Sthapit, S., Joshi, K. D. and Shrestha, P. (2012). Participatory four-cell analysis (FCA) for understanding local crop diversity. In: Sthapit, B., Shrestha, P. and Upadhyay, M. (eds.), *On-farm management of agrobiodiversity in Nepal: Good practices,* pp. 13–16. NARC, LI-BIRD and Bioversity International.

Thomas, D.S.G., Twyman, C., Osbahr, H. and Hewitson, B. (2007). Adaptation to climate change and variability: Farmer responses to intra-seasonal precipitation trends in South Africa. *Climatic Change*, 83: 301–322. DOI: https://doi.org/10.1007/s10584-006-9205-4

Timsina, N.P. (2000). Seed management system in Nepal: Where does it stand! An Assessment of Existing Seed Situation and Related Policies. Kathmandu: Action Aid Nepal.

Tiwari, K.R., Awasthi, K.D., Balla, M.K. and Sitaula, B.K. (2010). *Local people's perception on Climate Change, its impact and adaptation practices in Himalaya to Terai regions of Nepal*. Kathmandu. Available online at: https://digitalrepository.unm.edu/nsc_research/48 (accessed 7 March 2023).

Upreti, B.R. (2000). Social transformation through community forestry: Experience and lessons from Nepal. Mountain forum online library document. Available online at: https://lib.icimod.org/record/10562 (accessed 7 March 2023).

Upreti, B.R. and Upreti, Y.G. (2002). Factors leading to agro-biodiversity loss in developing countries: the case of Nepal. *Biodivers conserv*, 11(9): 607–1621. DOI: https://doi.org/10.1023/A:1016862200156

Upreti, D.C. and Ghale, U.Y. (2000). Indigenous Knowledge and Food Security in Developing Countries: Opportunities and Challenges. In: *A paper submitted to 16th Symposium of the International Farming Systems Association*. Santiago, Chile.

Viglizzo, E.F., Roberto, Z.E., Lertora, F., Gay, E.L. and Bernardos, J. (1997). Climate and land-use change in field-*crop* ecosystems of Argentina. *Agriculture, Ecosystems and Environment*, 66: 61–70. DOI: https://doi.org/10.1016/S0167-8809(97)00079-0

Yonzon, B. (2000). Opportunities in ecoregion based conservation in the Kanchenjunga region, eastern Nepal. *Biodiversity assessment and conservation planning in Kanchenjunga mountain complex* [Preprint]. Kathmandu, Nepal: WWF Nepal Program.

## Authors' Declarations and Essential Ethical Compliances

*Authors' Contributions (in accordance with ICMJE criteria for authorship)*

| Contribution | Author 1 | Author 2 | Author 3 | Author 4 | Author 5 |
|---|---|---|---|---|---|
| Conceived and designed the research or analysis | Yes | No | No | No | No |
| Collected the data | Yes | Yes | Yes | Yes | No |
| Contributed to data analysis and interpretation | Yes | Yes | No | No | No |
| Wrote the article/paper | Yes | Yes | Yes | Yes | Yes |
| Critical revision of the article/paper | Yes | Yes | No | Yes | Yes |
| Editing of the article/paper | Yes | No | No | No | No |
| Supervision | Yes | No | No | No | No |
| Project Administration | Yes | No | No | No | No |
| Funding Acquisition | No | No | No | No | No |
| Overall Contribution Proportion (%) | 45 | 15 | 15 | 15 | 10 |

*Funding*
No funding was available for the research conducted for and writing of this paper. Therefore, acknowledging any support agency is not applicable in case of this research or the written work. However, informal support of institutional supervisors, colleagues and respondents is duly acknowledged.

*Research involving human bodies or organs or tissues (Helsinki Declaration)*
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

*Research involving animals (ARRIVE Checklist)*
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

*Research on Indigenous Peoples and/or Traditional Knowledge*
The author(s) solemnly declare(s) that this research has not involved any Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) and Self-Declaration in this regard are appended.

*Research involving Plants*
The author(s) solemnly declare(s) that this research has involved the plants for experiment or field studies. Some contexts of plants are also indirectly covered through literature review. Thus, during this research the author(s) obeyed the

principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

*Research Involving Local Community Participants (Non-Indigenous) or Children*
The author(s) solemnly declare(s) that this research has directly involved local community participants or respondents belonging to non-Indigenous peoples. But, this study did not involve any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people are only indirectly covered through literature review. A sample copy of the Consent Form implying prior informed consent (PIC) of the respondents is appended.

*(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)*
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

*Competing Interests/Conflict of Interest*
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

*Attribution and Representation*
All opinions and mistakes are the author(s)' own and cannot be attributed to the institutions they represent. The publisher is also not responsible either for such opinions and mistakes in the text or graphs or images.

## Rights and Permissions

**Open Access.** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

* * *

To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/aa030102

Government of Nepal
NEPAL AGRICULTURAL RESEARCH COUNCIL
(Established by the Government of Nepal under the Nepal Agricultural Research Council Act, 2048)
NATIONAL AGRICULTURE GENETIC RESOURCES CENTER
(Genebank)

Ref. No.:
Dispatch No.:

Khumaltar, Lalitpur
Nepal

# ETHICAL CLEARANCE CERTIFICATE

## Research Involving Indigenous Peoples and Traditional Knowledge

**Declaration by the Principal Investigator**

I certify that the study titled: "**The drivers of changes in the state of agrobiodiversity**", (ref: aa03-01-01), **does not involve** collection of data or information on (an) Indigenous land, including reserve, settlement, and land governed under a self-government rule/agreement; the study **involves** the criteria for participation, including membership in an indigenous community, group of communities, or organization, including urban indigenous populations; the study **seeks** inputs from participants (members of the indigenous community) regarding a community's cultural heritage, artifacts, traditional knowledge, biocultural or biological resources or unique characteristics/practices; and the study **does not involve** Aboriginal identity or membership in an indigenous community used or be used as a variable for the purpose of analysis. The present study is conducted on farming communities. I hereby declare the same and confirm that all personnel associated with the present study have read this application and have agreed to comply with procedures described and any conditions imposed by the World Intellectual Property Organization (WIPO), Geneva, with regards to research on Indigenous Peoples and/or Traditional Knowledge.

Principal Investigator: Bal Krishna Joshi

Date: 07/16/2023

**Declaration by Head of the Organization/Research Committee**

I have read this application and am satisfied that the study **does not involve** capturing and collection of data or information of the Indigenous Community's cultural heritage, artifacts, traditional knowledge, biocultural or biological resources or unique characteristics/practices. The study fully complies with the legislation and the general principles of the World Intellectual Property Organization (WIPO), Geneva.

Bal Krishna Joshi
Head of the Organization/Research Committee

Date: 07/16/2023

**Chief**

Mailing Address: P O Box 3055, Kathmandu, Nepal; Phone: 977-1-5275131, 5275325
E-mail: narc.genebank@gmail.com; genebank@narc.gov.np, website: www.narc.gov.np

# SELF-DECLARATION FORM
# Research on Indigenous Peoples and/or Traditional Knowledge

*The nature and extent of community engagement should be determined jointly by the researcher and the relevant community or collective, taking into account the characteristics and protocols of the community and the nature of the research.*

If your research involved/involves the Indigenous Peoples as participants or respondents, you should fill in and upload this Self-Declaration and/or Prior Informed Consent (PIC) from the Indigenous Peoples. [Please read carefully https://grassrootsjournals.org/credibility-compliance.php#Research-Ethics]

## 1. Conditions of the Research

1.1 Was or will the research (be) conducted on (an) Indigenous land, including reserve, settlement, and land governed under a self-government rule/agreement or?

No

1.2 Did/does any of the criteria for participation include membership in an Indigenous community, group of communities, or organization, including urban Indigenous populations?

Yes

1.3 Did/does the research seek inputs from participants (members of the Indigenous community) regarding a community's cultural heritage, artifacts, traditional knowledge, biocultural or biological resources or unique characteristics/practices?

Yes

1.4 Did/will Aboriginal identity or membership in an Indigenous community used or be used as a variable for the purposes of analysis?

No

## 2. Community Engagement

2.1 If you answered "Yes" to questions 1.1, 1.2, 1.3 or 1.4, have you initiated or do you intend to initiate an engagement process with the Indigenous collective, community or communities for this study?

Yes

2.2 If you answered "Yes" to question 2.1, describe the process that you have followed or will follow with respect to community engagement. Include any documentation of

consultations (*i.e., formal research agreement, letter of approval, PIC, email communications, etc*.) and the role or position of those consulted, including their names if appropriate:

First questionnaires were developed and community members were consulted for discussion and questions answers. Verbal agreement was done for information use and analysis.

**3. No Community Consultation or Engagement**

If you answered "No" to question 2.1, briefly describe why community engagement will not be sought and how you can conduct a study that respects Aboriginal/ Indigenous communities and participants in the absence of community engagement.

Not Applicable

---

Name of Principal Researcher: Bal Krishna Joshi
Affiliation of Principal Researcher:

1. Senior Scientist (S-4), National Agriculture Genetic Resources Center, Nepal Agricultural Research Council, Nepal

Signature:

Date: 7/16/2023

*Declaration: Submitting this note by email to any journal published by The Grassroots Institute is your confirmation that the information declared above is correct and devoid of any manipulation.*

**INFORMATION AND CONSENT FORM FROM RESPONDENTS**
**(Non-Indigenous or Indigenous Respondents)**
*This form was translated into local language for the respondents*

# Title of the Research: The drivers of changes in the state of agrobiodiversity


Principal Researcher: Bal Krishna Joshi
National Agriculture Genetic Resources Center (Genebank)
Nepal Agricultural Research Council (NARC)

Research Supervisor: Self


## A) INFORMATION TO PARTICIPANTS

### 1. Objectives of the research
To measure the key drivers that affect the genetic diversity in the farming areas of Nepal.

### 2. Participation in research
The researcher will ask you several pertinent questions. This interview will be recorded in written form and should last about 50-60 minutes. The location and timing of the interview will be determined by you, depending on your availability and convenience.

### 3. Risks and disadvantages
There is no particular risk involved in this project. You may, however, refuse to answer any question at any time or even terminate the interview.

### 4. Advantanges and benefits
You will receive intangible benefits even if you refuse to answer some questions or decide to terminate the interview.

### 5. Confidentiality
Personal information you give us will be kept confidential. No information identifying you in any way will be published. In addition, each participant in the research will be assigned a code and only the researcher will know your identity.

### 6. Right of withdrawal
Your participation in this project is entirely voluntary and you can at any time withdraw from the research on simple verbal notice and without having to justify your decision, without consequence to you. If you decide to opt out of the research, please contact the researcher at the telephone number or email listed below. At your request, all information concerning you can also be destroyed. However, after the outbreak of the publishing process, it is impossible to destroy the analyses and results on the data collected.

## B) CONSENT

**Declaration of the participant**

- ⇨ I understand that I can take some time to think before agreeing or not to participate in the research.
- ⇨ I can ask the research team questions and ask for satisfactory answers.
- ⇨ I understand that by participating in this research project, I do not relinquish any of my rights, including my right to terminate the interview at any time.
- ⇨ I have read this information and consent form and agree to participate in the research project.
- ⇨ I agree that the interviews be recorded in written form by the researcher: Yes ( ) No ( )

Signature of the participant : _____ Date : _____

Surname : _____ First name : _____

**Researcher engagement**

I explained to the participant the conditions for participation in the research project. I answered to the best of my knowledge the questions asked and I made sure of the participant's understanding. I, along with the research team, agree to abide by what was agreed to in this information and consent form.

Signature of the researcher: Date : 07-11-2023

Surname: Joshi First name: Bal Middle name: Krishna

- ⇨ Should you have any questions regarding this study, or to withdraw from the research, please contact to Krishna Hari Ghimire by e-mail joshibalak@yahoo.com
- ⇨ If you have any concerns about your rights or about the responsibilities of researchers concerning your participation in this project, you can contact to National Agriculture Genetic Resources Center, Nepal Agricultural Research Council by email narc.genebank@gmail.com