

Agrobiodiversity and its Conservation in Nepal

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ABSTRACT

Nepal is a part of the world's biodiversity hotspot and ranks the 49th in the world for biodiversity. Agrobiodiversity and its conservation status were studied through literature review, field survey, key informant survey and focus group discussion. Results of field implementation of some good practices and action research were also documented. Among 24,300 total species in the country, 28% are agricultural genetic resources (AGRs), termed as agrobiodiversity. Agrobiodiversity has six components (crops, forages, livestock, aquatic, insects and microorganisms) and four sub-components (domesticated, semi-domesticated, wild relatives and wild edible) in Nepal. Agrobiodiversity on each component exists at agroecosystem, species, variety/breed/biotype/race/strain, genotype and allele levels, within an altitude range from 60 to 5,000 masl. There are 12 agroecosystems supporting 1026 species under crop component, 510 under forage, 35 under livestock, 250 under the aquatic animal, 17 under aquatic plant, 3,500 under insect and 800 under microorganism. An estimated loss of agrobiodiversity is 40%, however, farmers have reported up to 100% loss of AGRs in some areas for a particular species. Conservation of agrobiodiversity has been initiated since 1986. Four strategies namely ex-situ, on-farm, in-situ and breeding have been adopted for conservation and sustainable utilization of AGRs. Eighty good practices including process, methods and actions for managing agrobiodiversity have been in practice and these practices come under five conservation components (sensitization, method and approach, accelerator, value and enabling environment). Within the country, 18,765 accessions of AGRs have been conserved in different kinds of banks. A total of 24,683 accessions of Nepalese crops, forages and microbes have been conserved in different international and foreign genebanks. Some collections are conserved as safety duplication and safety backup in different CGIARs' banks and World Seed Vault, Korea. Two global databases (GENESYS and EURISCO) have maintained 19,200 Nepalese accessions. Geographical Information System, Climate Analog Tool and biotechnological tools have been applied for better managing AGRs. Many stakeholders need to further concentrate on the conservation and utilization of AGRs. Global marketing of some native AGRs is necessary for sustaining agriculture and attracting young generations as well as conserving them through use.

Keywords: Agrobiodiversity, aquatic resource, conservation, crop, forage, good practices, insect, livestock, microorganism

सारांश

नेपाल विश्व जैविक विविधताको हिसाबले ४९ औं स्थानमा आउँछ। विविध सन्दर्भ सामग्री अध्ययन, फिल्ड सर्वेक्षण, मुख्य सूचनादाता सर्वेक्षण, केन्द्रित समुह छलफल, असल अभ्यास अवलम्बन र कार्यमूलक अनुसन्धान मार्फत नेपालमा कृषि जैविक विविधता र यसको संरक्षणको अवस्थाबारे अध्ययन गरिएको थियो। देशमा भएका कुल २४,३०० जीवित प्रजातिहरू मध्ये २८% कृषि आनुवंशिक स्रोतहरू छन्, जसलाई कृषि जैविक विविधता भनिन्छ। कृषि जैविक विविधताका बाली, घाँसे बाली, पशुपन्छी, जलचर, कीरा र सुक्ष्म जीवाणु गरी ६ वटा सम्भागहरू तथा खेती गरिने/घरपालुवा, अर्ध-जंगली, जंगली नातेदार र जंगली खान योग्य गरी ४ वटा उप-सम्भागहरू छन्। समुन्द्र सतहबाट ६० मिटरदेखि ५००० मिटरको उचाईसम्म पाइने कृषि जैविक विविधताका प्रत्येक सम्भागमा बिभिन्न तह (पारिस्थिकीय प्रणाली, प्रजाति, जात तथा आनुवंशिक) मा विविधता पाइन्छ। नेपालभर १२ कृषि पारिस्थिकीय प्रणालीमा करिब १०२६ प्रजातिका बालीहरू, ५१० प्रजातिका घाँसेबालीहरू, ३५ प्रजातिका पशुपन्छीहरू, २५० प्रजातिका जलचर प्राणीहरू, १७ प्रजातिका जलचर वनस्पतिहरू, ३५०० प्रजातिका लाभदायक कीराहरू तथा ८०० प्रजातिका लाभदायक सुक्ष्म जीवाणुहरू भएको अनुमान छ। बिभिन्न क्षेत्रहरूमा गरी औसतमा करिब ४०% कृषि जैविक विविधता हास भएको छ, तर पनि कतिपय क्षेत्र र प्रजातिमा शत प्रतिशतसम्म कृषि जैविक विविधता हास भएको रिपोर्ट छ। नेपालमा कृषि जैविक विविधता संरक्षणको काम २०४३ साल बाट शुरु भएको पाइन्छ। कृषि आनुवंशिक स्रोतहरूको संरक्षण तथा दिगो उपयोगको लागि पर-स्थान, खेती-स्थल, यथा-स्थान तथा प्रजनन गरी ४ किसिमका रणनीतिहरू अवलम्बन गरिएका छन्। कृषि जैविक विविधताको व्यवस्थापनको लागि ५ वटा संरक्षण सम्भाग (जागरण, तौर तरिका, उत्प्रेरणा बृद्धि, मुल्य-मान्यतायुक्त वातावरण) अन्तर्गत ८० वटा असल अभ्यासहरू प्रयोजनमा आएका छन्। देशभित्रका बिभिन्न बैंकहरूमा १८,७६५ वटा कृषि आनुवंशिक स्रोतहरू संरक्षित छन् भने बिदेशका बिभिन्न अन्तरराष्ट्रीय बैंकहरूमा नेपालका बाली, घाँसेबाली, कीरा तथा सुक्ष्म जीवाणुहरूका २४,६८३ वटा संकलनहरू रहेका छन्। यी मध्ये केही संकलनहरू सुरक्षित प्रतिरूप भण्डारणको रूपमा संरक्षित छन् भने दुईवटा विश्वव्यापी डाटाबेसमा १९,२०० वटा नेपाली संकलनहरू रहेका छन्। कृषि आनुवंशिक स्रोतको समुचित व्यवस्थापनको निम्ति भौगोलिक सूचना प्रणाली (GIS), सम-जलवायु टुल सफ्टवेयर (CAT) र जैविक प्रविधिको प्रयोग गरिएको छ। कृषि आनुवंशिक स्रोतको संरक्षण र उपयोगमा सबै सरोकारवालाहरूको ध्यान जानु आवश्यक छ। कृषिमा दिगोपना ल्याउन, युवा आकर्षण बढाउन तथा कृषि आनुवंशिक स्रोतको संरक्षण र उपयोगको निम्ति नेपालका केही बिशेष आनुवंशिक स्रोतहरूलाई विश्व बजारमा पुर्याउनु अति जरुरी हुन्छ।

INTRODUCTION

Total estimated species of living being on earth is 8.7 million, of which 1.3 million have been identified (Sweetlove 2011, Zimmer 2011). Nepal is part of world's biodiversity hotspot (<https://www.cbd.int/countries/profile/?country=np>). She ranks the 49th position in the world on biodiversity with 0.17 BioD index, the 31st and the 10th in flowering plant diversity in the world and Asia respectively. Brazil is the first country with 0.85 BioD index (<https://news.mongabay.com/2016/05/top-10-biodiverse-countries/>). On the basis of per unit area, Nepal ranks the 27th position with 1.16 BioD index per land area and Brunei comes 1st with 18.68 BioD index per land area. The country occupies 0.03% of the global area but harbors over 3% and 1% of the world's known flora and fauna, respectively. There are 118 types of ecosystems with 75 vegetation types, 35 forest types and 5 rangeland ecosystems (MoFSC 2014).

Nepal is a mountainous agricultural country where 65% populations are involved in agriculture, with only 21% (3,091,000 ha) cultivated land. A large number of landraces exist in the country, but up to now, only 37 local landraces of 19 crops have been utilized in breeding to develop 41 crop varieties (Joshi 2017a). In 2019 only, Nepal has imported 5,741 genotypes (accessions) of 31 crops for breeding and shared 221 accessions of wheat to the CGIAR system (Hari B. KC 2019, Personal Comm.). Crop cultivation ranges from 60 m (in Kechana Kalan, Jhapa, where rice is grown) to 4,700 m (in Khumbu, Solukhumbu, where potato is grown) altitude (Joshi et al 2017a). However, just three crops, rice, wheat and maize cover 83% of the total cultivated land of the country (Joshi et al 2019), indicating vulnerable to loss of crop diversity and climate change.

Agrobiodiversity is the most important subset of biodiversity. It is further divided into six components (crops, forages, livestock, aquatic, insects and microorganisms) and four sub-components (domesticated, semi-domesticated, wild relatives and wild edible) in Nepal. Crop component includes agronomic (cereals, pseudo-cereals, millets, pulses, oilseeds, sugar and starch, and fiber), horticultural (vegetable, spices, beverage, fruit, ornamental and domesticated medicinal) crops. Forage species cover grasses, trees and shrubs growing either in farming land or forest areas. Wild edible forages mean wild forage species, edible to livestock. Livestock includes wild and farm animals, birds that have direct values. Aquatic component covers agricultural animals and plants found in aquatic areas. Insect and microbe components cover only beneficial and economic species. Insect genetic resources

are moths, butterflies, and other insects, and also included spiders and worms, whereas microbial genetic resources include fungi, lichens, algae, bacteria and others. Beneficial insects and microorganisms mean those that have an indirect positive value, and economic organisms are those that have direct value to human mankind. Wild edible insect and microorganism cover both beneficial and food values organisms.

Conservation has got priority after the CBD 1992 in the world. Total genebank in the world is now 1,750 conserving 7.5 million accessions, most of which are orthodox crops and forages (FAO 2010). Altogether 5,515,066 accessions of different crop and forage species are available through the multi-lateral system (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (<https://mls.planttreaty.org/itt/index.php?r=stats/pubStats>). In Nepal, protected areas and National Genebank are the major milestones for the conservation of biodiversity and agrobiodiversity respectively. Twenty protected areas in Nepal cover 23% (34,193 km²) areas of the country (MoFSC 2014). Diversity in crop component is also supported by informal and non-formal seed supply systems, which accounts for about 85 to 100% in Nepal depending on crop species. Enabling the environment has been created through becoming members of different international agreements and developing national legal documents. Nepal became a member of the Convention on Biological Diversity (CBD) in 1992 and of ITPGRFA in 2009. Nepal is also a party of The Cartagena Protocol on Bio-safety-2000 since 2001, of Nagoya Protocol-2014 since 2019 and have Agrobiodiversity Policy (2007) revised 2014, Seed Act 1988 (Amend 2008), National Seed Vision 2013-25, National Seed Policy 1999, NBSAP 2014-2020, IPR Policy 2017 and IMISAP 2018-2025 for conservation of biodiversity including agrobiodiversity.

This paper has analyzed the status and initiatives for the management of agrobiodiversity in Nepal, with the objective of making conservation options, process, methods and good practices available, to develop the baseline and to make common understanding on agrobiodiversity and conservation.

METHODOLOGY

This paper is based on literature review, field survey, key informant survey (KIS) and focus group discussion. Results of field implementation of some good practices, processes, methods and action research were compiled. Agrobiodiversity conservation has been initiated since 1986 in Nepal. A number of publications are available since then. This study reviewed those publications along with relevant websites and electronic literature. Information was collected by visiting more than 50 different kinds of fields, eg farmer fields, protected areas, research stations, farming communities, etc. KIS was conducted with more than 50 experts, 25 focus group discussions (FGDs) were held and 100 farmers were consulted for information collection and validations. Interviews were either face to face interaction, email or telephone conversations. NAGRC, LI-BIRD, MoALD and Bioersity International have jointly implemented more than 25 agrobiodiversity conservation (ABC) projects across the country since 1997. Different methods and approaches have been adopted and these activities were directly implemented in the fields; labs and research stations. Outputs of these activities implemented in these sites were analyzed and summarized. A checklist on different perspectives of agrobiodiversity was used to collect information from 2015 to 2019. Species were grouped under different agrobiodiversity components considering their principal use.

RESULTS AND DISCUSSION

Agrobiodiversity in Nepal

A total of 24,300 biological species are reported in Nepal (**Figure 1**). Among them, 28% (ie 6,618 species) are agricultural species excluding 27 exotic ornamental fish species. The species richness of agricultural fauna (3,785 species) is higher than agricultural flora (2,833 species). The number of agricultural species is the highest in insect component (3,500), followed by crop component (1,026 species) and microorganism component (800 species). Species richness of livestock component is the least among six components of agrobiodiversity. The numbers of each component and sub-component of agrobiodiversity are given in **Table 1** along with the estimated loss percentage. The number of wild edible species is higher in all components except forage and livestock components. Due to the high

level of eco-geographic and climatic variation in Nepal, a total of 1,506 species of agricultural crop and forage genetic resources have been reported (Upadhyay and Joshi 2003, MoAD 2017, Joshi et al 2017). Out of these, 93 introduced species, 670 wild edible plants, 224 crop wild relatives, 35 semi-domesticated and 484 cultivated native species exist. Among 484 native cultivated species, 64 are agronomic, 145 are horticultural and 275 are forages species.

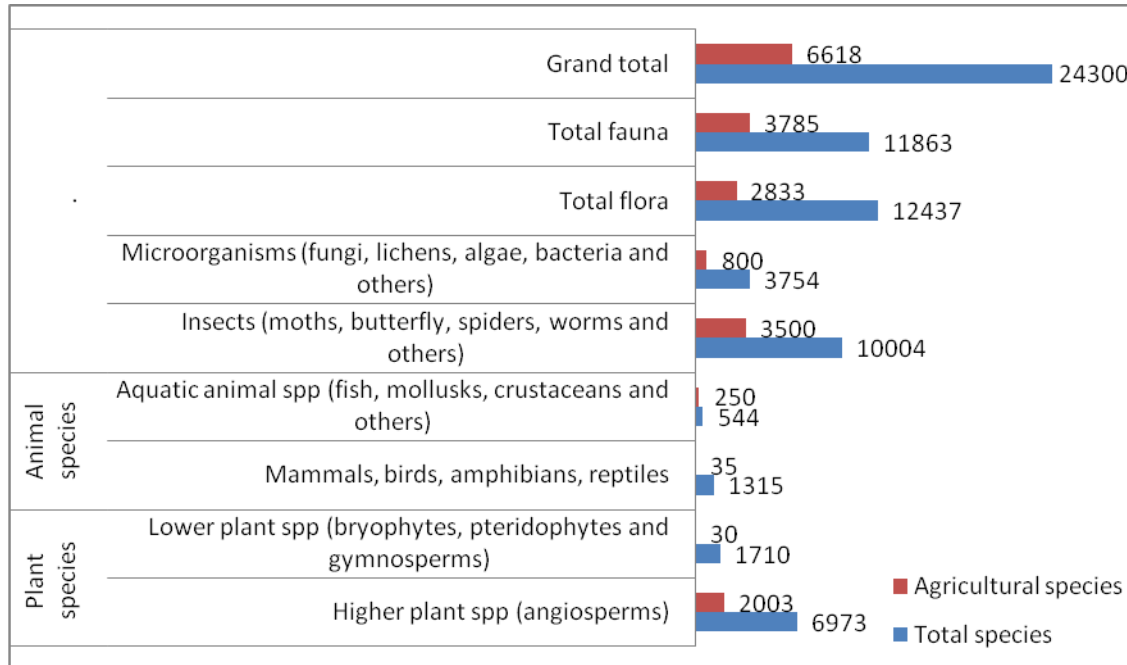


Figure 1. Total number of species and agricultural species in Nepal (27 exotic ornamental fish species available in Nepal are not included in the figure. Among 2003 higher plant species, there are 17 aquatic agricultural plant species, 300 ornamental species, 180 medicinal and 510 forage species. Altogether 232 fin fish species have been reported).

Source: Wilson 1997, Thapa 1997, Shrestha 1999, Upadhyay and Joshi 2003, Sharma 2007, van Huis et al 2013, MoFSC 2014, Raut 2014, Joshi et al 2016b, Joshi et al 2016c, Joshi et al 2017, Gurung 2017, Joshi et al 2019, Husen 2019

Cultivated ornamental plant species include 100 exotic and 200 natives (Anil Acharya, Personal Comm. 2019). Among 700 medicinal plant species, 120 native species are under cultivation and 60 species are exotic (Sharma 2007). Existing crop genotypes are 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 organism (GMO). However, in other agrobiodiversity components, there is very low intra-specific diversity (different genotypes). Forage species and rangeland are found from 60 m to 5000m (Abington 1992). There are total of 510 forage species including 50 exotic.

Table 1. Number of species and estimated loss percentage (in parenthesis) of agricultural genetic resources in Nepal

Agrobiodiversity Component	Subcomponent				Total (Average)
	A. Domesticated [exotic]	B. Semi domesticated	C. Wild relatives	D. Wild edible	
1. Crop genetic resources	252 [ex.43] (60)	30 (45)	214 (45)	500 (50)	996 (50)
2. Forage genetic resources	325 [ex.50] (40)	5 (35)	10 (40)	170 (45)	510 (40)
3. Livestock genetic resources	17 [ex.4] (45)	3 (35)	4 (30)	11 (50)	35 (40)
4. Aquatic genetic resources (animal+plant)	28 [ex.16] (40) + 2 [ex.0] (40)	5 (30) + 2 (30)	NK	217 (35) + 13 (35)	250 (30) + 17 (35)
5. Insect genetic resources	18 [ex.11] (15)	5 (10)	10 (10)	3467* (45)	3500 (20)
6. Microbial genetic resources	24 [ex.8] (15)	10 (10)	6 (20)	760* (35)	800 (20)
Total	658 [ex.124] (36)	60 (28)	244 (30)	5146 (45)	6108 (35)

NK, Not known. Domesticated species includes both native and exotic species. Numbers of exotic [ex.] species are in square bracket. For insect genetic resources domesticated species also include species that are used for humankind by artificial mass rearing for managing insect pests or weeds as a means of biological control. Ornamental (300), medicinal (180) and lower agricultural plant (30) species are not included in this table. * This is an estimated value based on survey and literature.

Source: Regmi 1982, Banwart 1989, Paudel and Tiwari 1992, Upadhyay et al 1995, Smith et al 1996, Thapa 1997, Wilson 1997, Shrestha and Shrestha 1999, Shrestha 1999, Yami et al 2003, Upadhyay and Joshi 2003, Arjyal et al 2004, MoAC 2004, Takeda et al 2004, Sharma 2007, Christensen et al 2008, Niroula and Sing 2011, Acharya and Atreaya 2012, van Huis et al 2013, MoFSC 2014, Raut 2014, Gotame et al 2014, Aryal et al 2015, Bhattarai et al 2015, Shimada and Basnet 2015, Paudel 2017, Subba et al 2017, Joshi et al 2017, Gurung 2017, Wilson 2017, Joshi et al 2019, Husen 2019, Limbu et al 2019, FAO 2019, Suresh Wagle, Personal Comm. 2019, Ajaya Chaudhary, Personal Comm. 2019

Livestock is reared at an altitude range of 60 m to 5,000 m (Abington 1992). Among the 35 agricultural animal species, 17 are domesticated which consist of 13 native and four exotic livestock species. Four semi-domesticated animals are Dhorel sheep, wild yak, pigeon (rock dove, parewa) and quail bird (battaai charaa). Four wild relatives of livestock species are wild boar (Badel), Arna (buffalo), red jungle fowl (chicken) and gaur. There are about 11 wild edible animal species (though they are not killed for this purpose from the forest). They are Kaalij Pheasant, Wild Rabbit (Hispid hare), Mountain goat (Jharaal), Deer (harin), Himalayan Thar (Wild Goat, Hemitragus tahr), Bharal or blue sheep, Mountain quail or partridge (Titraa), Dove (Dhukur), Bat (chamero), Dumsi and Swan (raajhaas). Three common pet animals are dog, cat and parrot.

Aquatic agricultural genetic resources (aquatic agrobiodiversity) include aquatic plants and animal species. There are 17 aquatic agricultural plant species and 250 aquatic agricultural animal species (MoFSC 2014, Gurung 2017, Joshi et al 2019, Ajaya Chaudhary, Personal Comm. 2019). Fish species are reported from wide range of altitudes (ie 60 to 4000 m) (Shrestha 1999, <http://www.fao.org/3/x2614e/x2614e03.htm>). Among the total 232 fin fish, 16 are exotic and 216 indigenous including 15 ornamental fish species (Gurung 2017, Husen 2019). All fish species are edible and 28 species (16 exotic and 12 native) are under cultivation. Fish species richness is assessed from many areas but diversity below species levels, mainly at strain level has not been studied.

Insect genetic resources include beneficial insects that have been used in biological control, pollination or industrial purposes such as predators and parasitoids, and economic insect eg honeybees, stingless bees and lac insects. The number of native insect species is 10004, of which 3500 are estimated as beneficial and economic insect species (Thapa 1997, MoFSC 2014). About 18 species are domesticated including eleven exotic species. Here domestication represents at least mass rearing of an insect for humankind. Exotic species are either imported by a government body (7 species) or unintentionally arrived in Nepal after their successful release in India (4 species). The widely domesticated indigenous insect species is Asian honeybee (*Apis cerana*), however European honeybee (*A. mellifera*) is widely domesticated exotic species. Other exotic species include five parasitoids, one predator, one species of silk moth, and four insect species for biological control of the weed. Most of the insect species are imported from a different origin other than Nepal as a means of classical biological control insect pests or weeds. Insect diversity at species level has been studied. However, diversity at strain and genotype levels needs to be assessed.

Among the 3,754 microbial species, 800 are reported to be beneficial and economic species. There are very limited studies on the diversity of microorganisms at species and strain levels. Twenty four species including 16 mushroom species are under cultivation. Eight cultivated microbial species are reported to be exotic. Diversity richness has been assessed in mushroom species. There are 136 wild edible mushrooms, 73 medicinal mushroom and 11 mushroom species are found both in wild and domestic land (Raut 2014, HC Bastola, Personal comm. 2019). Nepal is also a suitable living place for many beneficial micro-organisms that can kill insect pests by causing diseases on them called insect pathogens. Native Nucleopolyhedrosis viruses, granulosis viruses, green muscardine fungus, *Paecilomyces* fungus, white muscardine fungus, entomopathogenic nematodes including *Steinernema* and *Heterorhabditis* and Bt have been reported from Nepal (Joshi 2016).

Diversity on crop genetic resources is higher at all five levels (agroecosystem, species, variety, genotype and allele) (Table 2). There are 12 agroecosystems, namely upland mountain agriculture, irrigated mountain agriculture, upland temperate agriculture, irrigated temperate agriculture, upland tropical agriculture, irrigated tropical agriculture, mountain wetland, temperate wetland, tropical wetland, mountain rangeland, temperate rangeland and tropical rangeland (Joshi et al 2017). All components are relatively high in species richness, however, there is low diversity at varietal/breed/strain/biotype/race, genotype and allele levels in all components except crop genetic resources. This might be because of a lack of sufficient data or research on these components.

Table 2. Relative diversity assessment on each component over five levels of agrobiodiversity

Agrobiodiversity Component	Agroecosystem diversity	Species diversity	Variety/breed/race/strain/biotype diversity	Genotype diversity	Allele diversity
1. Crop genetic resources	High	High	High	High	High
2. Forage genetic resources	High	High	Low	Low	Low
3. Livestock genetic resources	Medium	Medium	Medium	Low	Low
4. Aquatic genetic resources	High	High	Low	Low	Low
5. Insect genetic resources	High	High	Low	Low	Low
6. Microbial genetic resources	Medium	Medium	Low	Low	Low

There are many site specific landraces of crops, forages, livestock, aquatic animal and plant, insect and microorganisms (Regmi 1982, Paudel and Tiwari 1992, Upadhyay et al 1995, Smith et al 1996, Wilson 1997, Yami et al 2003, Christensen et al 2008, Niroula and Sing 2011, Gotame et al 2014, Aryal et al 2015, Wilson 2017, Subba et al 2017, Joshi et al 2017b, Joshi et al 2018, Limbu et al 2019). But there is very limited information on diversity below species levels in all components of agrobiodiversity. In some extent, diversity below the species level is measured on crops and livestock components. Some of them are listed in Annex I. They are potential for getting geographical indication right, however, many of them are endangered and demand immediate attention for conservation and improvement.

Genetic Erosion and its Drivers

Estimated losses of each agrobiodiversity component are given in Table 1. On average, 40% of AGRs are lost in the country. The highest degree of loss is reported on crop genetic resources and the least on insect and microorganism diversity. Farmers in some areas have reported a loss of native AGRs up to 100%. FAO (1999) had reported a loss of more than 75% of global crop diversity over the 20th century. Many landraces are becoming rare and endangered (Upadhyay and Joshi 2003, Chaudhary et al 2004). The main reasons for genetic erosion are replacement by modern varieties, very limited use of local landraces in breeding, non-profit agricultural business, etc. Other drivers of change of agrobiodiversity are wide distribution of modern variety, natural and human-made disasters, epidemics of diseases and insect pests, changes in land use pattern and leaving land fallow or habitat loss, changes in occupation, war or insurgency, very old trees/orchards of which progeny has not been generated, rapid commercialization of agriculture; mono-genotyping, migration of farmers and land abandonment and over-exploitation eg loss of species caused by over-grazing or by uncontrolled harvesting of the wild genetic resources. There is a global debate on the decline of insect species over time (Møller 2019, Seibold et al 2019). The indiscriminate uses of pesticides are reported as the major cause. However, there is a lack of data at a global level too.

Conservation

The first collection and evaluation of indigenous plant materials were started in 1940 (Genebank 2016). Medium term seed house was established in 1986 and the first community seed bank was constructed in 1994 (Joshi 2017). The red listing system was developed in 2003 to prioritize the landraces for conservation (Joshi et al 2004). Since 2010, National Genebank with modern facilities has started working on the conservation of AGRs at a wider scale. Agrobiodiversity, though most important for food and nutrition security, relatively got less attention for conservation in comparison with forest genetic resources. Within AGRs, conservation is more focused on orthodox crop species

(Joshi 2017, Ghimire and Joshi 2019). This may be due to the availability of easy technology to conserve such crop species. Conservation good practices including process, methods and actions, and working strategies are given below.

Banking Principles

The main principle is facilitated access to all agricultural genetic resources through long term secured conservation and making maximum interaction with biotic and abiotic stresses with germplasm to accelerate the evolutionary process. Germplasm are being managed with the facility of tracing back and forward of any accession. Germplasm is for all at free of cost and forever. Anyone can deposit collections safely for a long period of time. The black box system of storage has been created for researchers and farmers to store their materials for future use. All kinds of AGRs are banked and have been accelerated for utilization through maintaining an electronic database. A common understanding is to collect, conserve and maintain as much diversity as possible in a minimum sample. The working principle is that each diversity has a value and considers diversity at agroecosystem, species, variety/breed/strain/biotype/race, genotype and allele levels.

Conservation Components and Good Practices

Conservation needs varied actions and multidisciplinary approaches. Conservation actions in Nepal can broadly be grouped into five components (Figure 2). Within each component, there are a number of good practices, process, methods and actions that support conservation and sustainable use of agrobiodiversity. First action is sensitization and understanding agrobiodiversity at all levels to all people. After understanding of agrobiodiversity, different methods and approaches can easily be implemented. Method and approach can be accelerated through the use of different other tools and techniques. The other two components are enabling environment and conservation values for secured long term conservation. In Nepal, 80 practices (process, methods, actions and good practices) are found implemented for conservation and utilization of native AGRs (Figure 3, Box 1) (Sthapit et al 2006, Joshi et al 2016a, Joshi et al 2017a, Joshi et al 2018, Joshi et al 2019). These practices are selected based on the location and types of AGRs. Among the five conservation components, only two are described below.

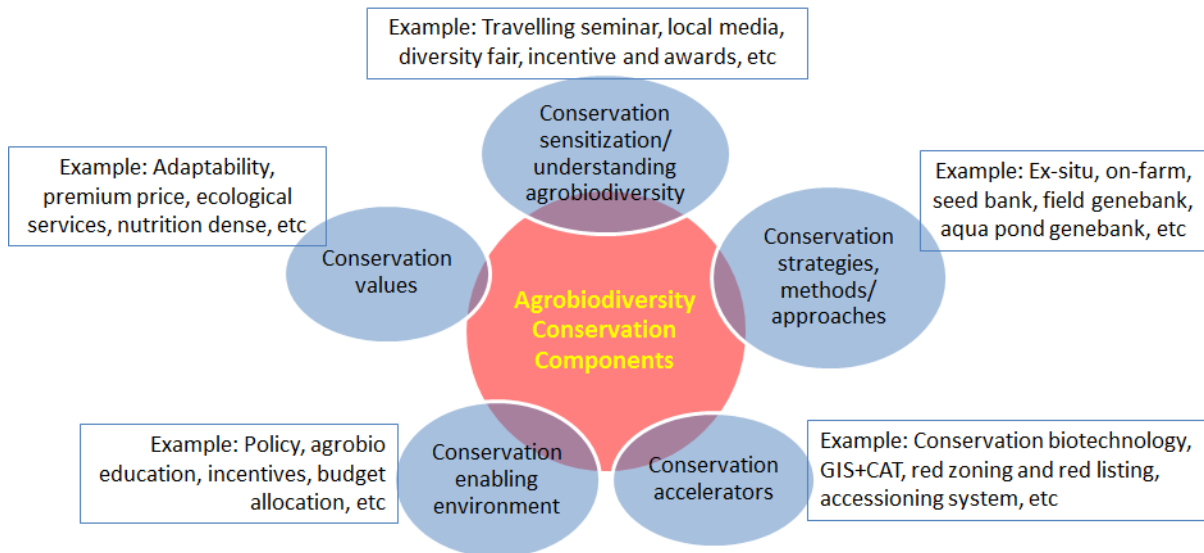


Figure 2. Agrobiodiversity conservation components with examples.

Conservation strategy: Four strategies have been widely used for the management of agrobiodiversity. They are ex-situ, on-farm, in-situ and breeding (Figure 3). Technical differences among these strategies are explained by Joshi and Upadhaya (2019). Breeding strategies have considered evolutionary, diversity and site-specific rather than non-evolutionary, uniformity and wide adaptation approach.

Conservation methods and approaches: About forty-four different methods for the management of all kinds of AGRs have been developed and adopted in Nepal (Figure 3). Some of them are described in other publications (Sthapit et al 2006, Joshi et al 2016a, Joshi et al 2017a, Joshi and Gauchan 2017, Joshi and Updhaya 2019). The main methods are seed bank for orthodox crops and field genebank for recalcitrant and vegetatively propagated crops, aqua pond genebank for aquatic agricultural animal and plant species, livestock farm genebank for livestock. For insects, mass rearing chamber or automated room can be considered as a method of ex-situ conservation, from where users can get beneficial organisms, usually predators and parasitoids upon formal request. Like insects, pure culture has been widely used to conserve and maintain microbes. At the on-farm level, community seed bank (CSB) and community field genebank (CFGB) are the main methods, which are systems of conservation and utilization of local genetic resources, operated at local levels and run by the community. Among 144 community seed banks in Nepal, 40 are active, six are passive (dormant), 95 are transmuted (transformed) and three are collapsed (Joshi et al 2018). Through 40 CSBs and CFGBs, 2045 accessions are being conserved and they represent from one to 47 different crop species. Conservation related banks are given their names with the prefix of the location followed by the type of bank, for example, Khumal Field Genebank, Khajura Aqua Pond Genebank, Dalchowki Community Seed Bank, Khumal Livestock Farm Genebank, etc.

Some of the notable good practices are red zoning and red listing, diversity fair, germplasm rescue, product diversification, school field genebank, office garden, and temple garden, etc. One of the noteworthy good practice adopted by Entomology Division of NARC is beneficial ex-situ field gene bank for conserving *Aphelinus mali* (Haldeman), a parasitoid of apple wooly aphid where host insect pests are maintained in an apple orchard in order to make year-round availability of food sources for parasitoids (Mainali et al 2016). Potential conservation methods that are still not established in Nepal are pollen bank, community river, insect park, conservation village, agrobiodiversity trail, and microbial field genebank. Recently, the agro gene sanctuary was established in Khumaltar, Kathmandu. After domestication, agricultural crops never return to nature. Seeds of such crops are kept carefully in manmade houses making sure they do not get chance to interact with nature. The natural evolutionary process is arrested and selection pressure favor to develop one-directional population. Agro Gene Sanctuary is therefore established in Khumaltar to let different crops grow together in more or less natural condition and let their seeds and other parts remain in the same field. It is the field where agricultural plant genetic resources are grown together and allowed to complete their life cycle in the same place over time. Technically it is the method of conservation of cultivated crops and their wild relatives together creating the in-situ condition. Interaction among crops, wild relatives and nature with less human interference may evolve better- adopted genotypes that can be used for research, production, and study. Such a complex gene pool in a single plot may provide genetic resources for researchers and could be a site for evolutionary study. Such an evolutionary field may be the key to developing suitable genotypes in the context of climate change.

Conservation methods and approaches are seed bank, tissue bank, field genebank, community seed bank, community field genebank for crops and forages species; aqua pond genebank and restocking for aquatic agricultural animal and plant species; cryobank and livestock farm genebank for livestock; insect genebank and insect field genebank for insect species, and microbial genebank and microbial field genebank for microorganisms. There are many other such methods and approaches listed in Figure 3 and Box 1.

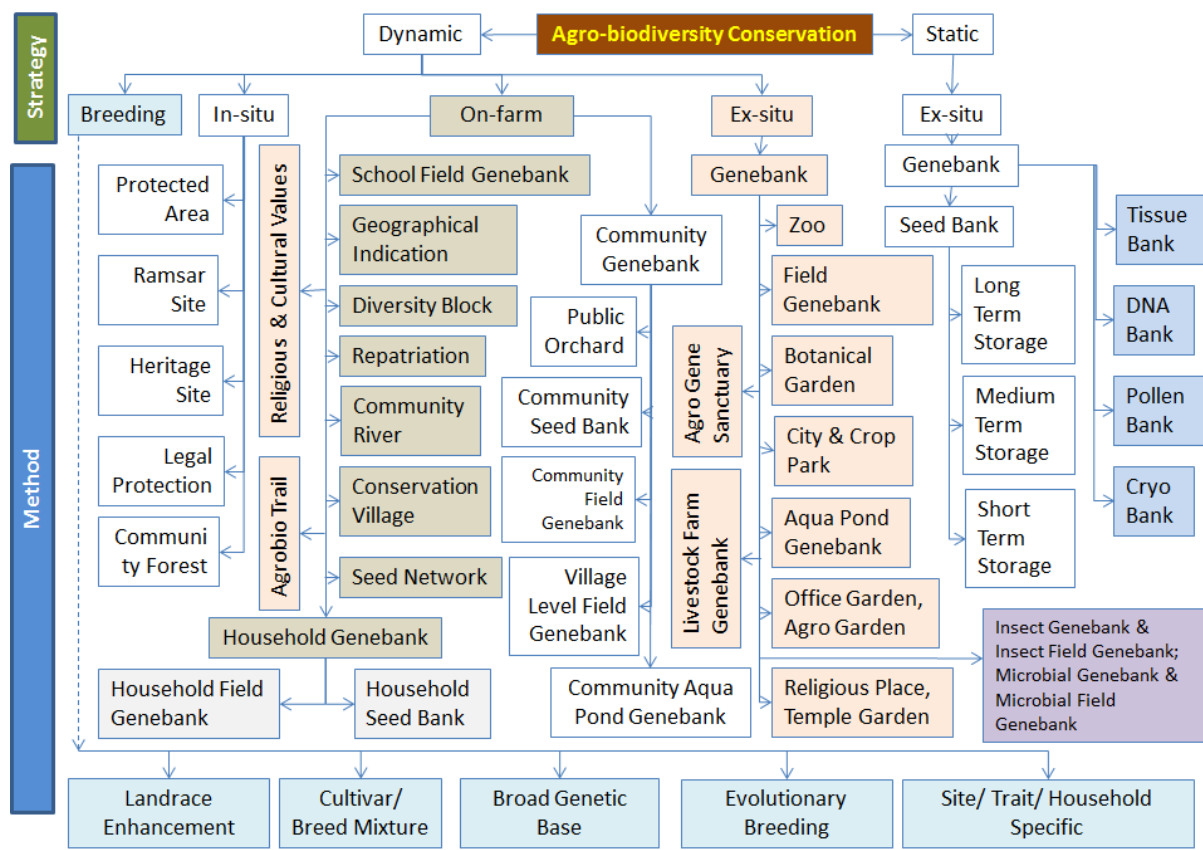


Figure 3. Four agrobiodiversity conservation strategies and 44 methods and approaches.

Source: Sthapit et al 2006, Genebank 2016, Joshi et al 2016a, Joshi et al 2017a, Joshi et al 2019

Box 1. Additional process, methods, actions and good practices used for conservation and sustainable utilization of AGRs

- | | | |
|--|--|--|
| 1. Accessioning and naming system | 15. Diversity fair/ seed fair | 28. Landraces catalog, ownership documentation, CBR and registration |
| 2. Agro-plantation | 16. Food fair & Himalayan super foods (PQTHN) | 29. Local media for community sensitization |
| 3. Agrobiodiversity rich farmers | 17. Local food shop | 30. On-farm agrobiodiversity measurement |
| 4. Incentive and award | 18. Diversity kit | 31. Diversity field school |
| 5. Black box and safety duplication and backup | 19. Diversity rich solution | 32. Simplifying the traditional tech |
| 6. Pre breeding & domestication | 20. Enhancing ecological services | 33. Home stay and market linkage |
| 7. GIS + CAT | 21. Global and national gene pools | 34. Agrobio poetry and folk song |
| 8. Restocking | 22. Each household as shop | 35. Sharingshop, writeshop and virtual workshop |
| 9. Image bank | 23. Participatory seed exchange | 36. Traveling seminar |
| 10. Seed and crop herbaria and agro museum | 24. Product diversification | |
| 11. Red zoning and red listing | 25. Value addition | |
| 12. Germplasm rescue | 26. Multi- stakeholder and disciplinary approaches | |
| 13. Agro haat bazaar | 27. Agrobio education | |
| 14. Site specific staple crop | | |

Conservation accelerator: Conservation accelerators are any practices or tools that accelerate the conservation of native AGRs. Some of them are diversity fairs, restocking, marketing, use of modern sciences, etc. Advanced tools such as geographical information system (GIS), climate analog tool (CAT) and biotechnology have been used for better management and utilization of APGRs in Nepal (Chaudhary et al 2016, Joshi et al 2017c, Mainali 2018). GIS is basically applied for collection map, gap analysis, information verification, and diversity analysis. CAT is used to identify analog sites for possible distribution of crops, introduction and repatriation of crop cultivars. NAGRC has developed DNA bank, Tissue bank and DNA fingerprint of some crop landraces (Table 3).

Conservation Status at National and International Levels

Details of the conservation status of Nepalese AGRs are given in **Table 3**. Within the country, a total of 18,765 accessions of AGRs have been conserved in 17 different kinds of banks (Joshi et al 2017a, Genebank 2018). A total of 264 agricultural species (ie 4%) are conserved in different banks. The highest number of conserved species and accessions are of orthodox crops. Conservation of lower plant species, aquatic plants, insects and microorganisms are very low in number. Two tissue banks have conserved 120 accessions of three species (potato, sweet potato and large cardamom). There are 15 field genebanks across the country and 650 accessions of 30 crops are being maintained. DNA bank has maintained 550 accessions of 10 species (rice, cardamom, sugarcane, chayote, pea, garlic, broad leaf mustard, wheat, mango and maize). Thirty accessions of 9 forage species are conserved in Seed Bank. More than 50 species are conserved in different field genebank (Khumal, Bandipur, Lumle and Pakhribas Forage Field Genebank).

There are twenty five domestic animal breeds of eight species identified so far in Nepal. Nineteen accessions of eight livestock species are conserved in Khumal livestock farm genebank. Other existing livestock farm genebanks are Doti for Achhami cattle; Jumla for Baruwal and Bhyanglung sheep, and Sinhal goat; Lumle for Lime and Parkote buffalo, Sinhal goat, and Baruwal and Bhyanglung sheep; Parwanipur for Sakini, Pwankh Ulte and Ghanti Khuile chicken; Tarahara for Nagpuri and Hurrah; Pakhribas for Pakhribas black pig, and Khari goat; Nepalgunj for Tarai goat, and Lampuchhre sheep, and Bandipur for Khari goat (Genebank 2018). Semen of three livestock breeds (Lulu cattle, Achhami cattle and Khari goat) are conserved in cryo bank in Animal Breeding Division (ABD). Conservation of fish species is promoted through restocking of 13 native fish species in Kali Gandaki and five species in Pokhara valley. There are five aqua pond genebanks in Nepal. Khajura aqua pond genebank is conserving four species along with some plant species (lotus, water chestnut, water spinach), Beltari aqua pond genebank has conserved seven species, Pokhara has conserved nine species, Parwanipur aqua pond genebank has conserved six species along with some plant species (fox nut, lotus, water chestnut) and Godawari aqua pond genebank has conserved one native species.

Insect park might be very importance for conservation as well as study. However, only insect field genebank exists where parasitoids are being conserved. Water hyacinth weevil, *Neochetina bruchi* Hustache, *Neochetina eichhorniae* Warner, both unintentionally introduced species (from India) and imported species (from USA) are being conserved on the special outdoor structure/chamber in Entomology Division, NARC. Further, isolated insect pathogens are conserved as a means of pure culture. Predators and parasitoids such as *Coccinella septempunctata* L, *Chrysoperla carnea* Stephens, *Trichogramma chilonis* Ishii, *Copidosoma koehleri* Blanchard, *Orgilus lepidus* Muesebeck, *Neochetina bruchi* Hustache, *Neochetina eichhorniae* Warner, *Zygogramma bicolorata* Pallister is cultured (mass reared) successfully by Entomology Division, NARC, most of which are exotic in nature. Sixteen species of mushrooms and 8 other microbial species are conserved in microbial genebank (Genebank 2018). Twenty Nepalese accessions of microbes are stored in Japan.

The global genepool is created only of crops and forages species. Safety mechanism has been adopted only in crops and forages species through storing safety backup of 2,045 accessions of eight crops in seven different CGIAR's banks and safety duplicate of 69 accessions of barley in World Seed Vault, Korea. A total of 24,683 accessions of Nepalese crops, forages and microbes have been conserved in different international and foreign genebanks. Two global databases have maintained 19,200 Nepalese accessions (<https://www.genesys-pgr.org/>, <https://euriscope.ipk-gatersleben.de/apex/f?p=103:1:::>). Indigenous Nepalese fish species *Tor putitora* (Sahar) was reported in Pakistan and *Schizothorax richardsonii* (buchhe asala) was reported in Papua New Guinea and *Oncorhynchus mykiss* (rainbow trout) was reported in Papua New Guinea and Thailand. Two insects, *Spenorala rutilans* and *Lilioceris impressa* (F) were exported from Nepal to USA and they successfully mass-reared these species to control skunk vine (*Paderia Foetida* L.) and air potato (*Dioscorea bulbifera* L.), respectively (Schmitz 2009).

Table 3. Nepalese accessions of agricultural genetic resources (crops, forages, livestock, aquatic plant and animal, microorganisms and insects) conserved in National and International Genebanks

S N	Type of bank	Total banks, n	Species conserved, n	Accession conserved, n	Agrobiodiversity component	Initiated date
National Genepool						
1.	Seed bank	1	105	14500	Orthodox crops	1986
2.	Forage seed bank	1	9	30	Orthodox forages	2010
3.	Field genebank	15	30	650	Non-orthodox crops	
4.	Tissue bank	2	3	120	Non-orthodox crops	2013
5.	DNA bank	1	10	550	Crops	2013
6.	Forage field genebank	3	50	50	Non-orthodox forages	2014
7.	Crop specific park	6	10	450	Non-orthodox crops	2012
8.	Aqua pond genebank	5	27	30	Fishes and aquatic plants	2016
9.	Cryo bank	1	3	3	Livestock	
10.	Livestock farm genebank	10	8	38	Livestock	2016
11.	Agro gene sanctuary	1	10	25	Crops	2018
12.	Microbial genebank	1	24	24	Micro organisms	2018
13.	Insect field genebank	1	11	11	Insects	2018
14.	Community seed bank	40	50	2045	Crops	1994
15.	Community field genebank	8	15	113	Non-orthodox crops	2012
16.	School field genebank	7	15	122	Non-orthodox crops	2014
17.	Protected area (in-situ bank)	10	4	4	Crop wild relatives	2018
Global genepool (outside country)						
18.	World Seed Vault, Korea (Safety duplicates)	1	1	69	Barley	2014
19.	AVRDC, Taiwan	1	NK	930	Vegetables	NK
20.	NIAS, Japan	1	NK	4136	Crops	NK
21.	NIAS, Japan	1	NK	20	Microbes	NK
22.	USDA, USA	1	NK	2781	Crops	NK
23.	NBPGR, India	1	NK	3000	Crops	NK
24.	CGIAR Banks	11	NK	11702	Crops and forages	NK
25.	Safety backup (CGIAR Banks)	7	8	2045	Crops	2013
26.	MLS-ITPGRFA	1	20	614	Crops and forages	2017
Nepalese accessions at global database						
27.	GENESYS	1	NK	15511	Crops and forages	NK
28.	EURISCO	1	NK	3689	Crops and forages	NK

NK, Not known.

Sources: Joshi 2017, Joshi et al 2017a, Joshi et al 2018, Genebank 2018, Joshi and Upadhyaya 2019.

Challenges and Issues

Nepal is an agrobiodiversity rich country but native genetic resources never got priority in research, education and development, resulted in genetic erosion. Major challenges are to stop genetic erosion, to make native AGRs competitive, to decrease the current 95-100% dependency (Joshi et al 2017d) on foreign germplasm, to secure food and nutrition conserving existing agrobiodiversity, to replace foreign agriculture products and germplasm by native AGRs and their products, to identify global potential native AGRs and market globally, to develop site-specific different products, to create

enabling environment for favoring diversity rich varieties, breeds and strains to accelerate the evolutionary population to capture diversity from wide range of agricultural areas, etc.

There is a need of extensive characterization, evaluation, and tagging of economically important traits. Adulteration by foreign germplasm needs to be minimized and education system should be revised to improve the traditional technologies rather than replacing native technologies including native AGRs. Alternative of many large scale production of monogenotyped variety or breed should be identified for sustainable agriculture and to diversify the products. Documents related to ownership of the landraces needs to be developed. Evidence of association of landraces with geography and cultural value need to be explored. An online database should be established to facilitate access to germplasm. Mountain areas are good for producing Himalayan super foods that are better in terms of purity, quality, taste, health and nutrition. Many potential wild AGRs exist in the country and research is necessary for domestication and commercialization.

CONCLUSION

Mainly because of neglected and underutilization of 85% native AGRs, 40% of diversity has been lost. Conservation work, therefore, should get priority. About 5-15% of native AGRs, depending on specific AGR, has been used in research and development. Priority for conservation and utilization should be given to native AGRs focusing on developing site-specific staple AGRs, marketing globally by involving all relevant stakeholders. Eighty process, methods, actions and good practices need to be scaled up widely for effectively conserving AGRs. Only 4% of total agricultural species have been conserved that demand to accelerate the conservation works in the country. To prioritize the AGRs for conservation, diversity should be assessed at all five levels ie agroecosystem, species, variety/breed/strain, genotype and allele. Agricultural science needs to advance on native AGRs.

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Annex I. Some important indigenous genotypes of agronomic crops, horticultural crops, forage species, livestock species, aquatic agricultural species, insects and microorganisms

SN	English name	Nepali name	Scientific name	Most important landraces
Agronomic crops				
1.	Amaranth	Latte	Amaranthus spp	Kalo, Seto, Jhule, Rato, Hariyo
2.	Barley	Jau	Hordeum vulgare L	Chawali, Lekali, Taakullo, Tude
3.	Bean	Simi	Phaseolus spp	Hiude Simi, Seto Simi, Gahate Simi, Taati Simi, Jire Simi
4.	Black gram	Maas	Vigna mungo (L.) Hepper Wild	Kaalo, Khairo, Saano, Thulo
5.	Broad bean	Bakulaa	Vicia faba L.	Saano, Thulo
6.	Buckwheat	Faapar	Fagopyrum spp	Tite Faper, Mithe, Bhate, Bharule
7.	Cowpea	Bodi	Vigna unguiculata (L.) Walp.	Tane Bodi, Katike Bodi, Gaajale Bodi, Makai Bodi, Fokse Bodi, Seto Bodi
8.	Finger millet	Kodo	Eleusine coracana (L.) Gaertn.	Dalle, Mudke, Samdhi, Nagre, Padure, Seto Kodo
9.	Foxtail millet	Kaguno	Setaria italica (L.) Beauv.	Raato, Aule, Kaalo, Pahenlo, Saano, Seto
10.	Groundnut, peanut	Badaam	Arachis hypogaea L.	Thuli, Saano
11.	Horsegram	Gahat	Macrotyloma uniflorum (Lam.) Verdc.	Khairo, Raato, Saano
12.	Indian Mustard	Rayo, rai, raichi, tora, barsale	Brassica juncea (L.) Czern. & Coss.	Raayo, Gujmuje, Kaade, Thulo Paate, Kaalo, Raato
13.	Lentil	Musuro	Lens culinaris Medikus	Kaalo Musuro, Khairo Musuro, Saano, Thulo
14.	Maize	Makai	Zea mays L.	Sathiya, Murali, Thulo Pahelo, Seto
15.	Pea	Matar kerau	Pisum sativum L.	Saano, Thulo, Hariyo, Lahare
16.	Pigeonpea	Rahar	Cajanus cajan (L.) Millsp.	Raato, Seto, Chanki, Pjawa, Chaite, Lalkaa, Baisaakhi
17.	Proso millet	Chino	Panicum miliaceum L.	Dudhe, Haade, Raato, Kaptade
18.	Rapeseed	Tori	Brassica rapa L.	Kala, Pilaa
19.	Rice	Dhaan	Orzya sativa L.	Jumli Maarshi, Kalanamak, Ekle, Bhaati, Jethobudo, Anadi, Aapjutte, Ghaiya, Gurdi, Jhinuwa, Lalka Basmati, Samundraphini, Papele, Nakhisaro, Giupuri, Tilki, Krishnabhog
20.	Soybean	Bhatmas	Glycine max (L.) Merrl.	Seto, Kaanchi, Thulo, Kaalo, Saano, Khairo
21.	Wheat	Gahu	Triticum aestivum L	Nafal, Mudule, Hansaa, Daabdi, Pawai, Saano, Raani, Jhuse, Bhote, Dudhe
Fruit crops				
22.	Apple	Shyau	Malus pumila Mill.	Dolpa Local, Helambu Local, Marpha Shyau, Jumla Shyau
23.	Apricot	Khurpaani	Prunus armeniaca Linn.	Humla Local, Jumla Local, Kakani Local
24.	Banana	Keraa	Musa paradisiaca L.	Mungre Kera, Local Maalbhog Kera, Jhaapali Maalbhog, Ghiu Keraa
25.	Guava	Aamba, belauti	Psidium guajava L.	Dhunibeshi Ko Aamba
26.	Jack fruit	Katahar	Artocarpus heterophyllus	Tarai Local
27.	Lemon	Nibuwa	Citrus limon (L.) Osbeck	Hill Lemon, Nepali Oblong
28.	Mandari Orange	Suntalaa	Citrus reticulata Blanco	Manakamana Local, Dhankuta Local, Ramjattar Local
29.	Mango	Aap	Mangifera indica L.	Siraha Local, Bhadaure, Supare
30.	Pear	Naashpati	Pyrus pyrifolia	Pharping Local
31.	Pomegranate	Daarim	Punica granatum	Nepaali Daarim
32.	Sugar apple, custard apple	Raam phal or sarifaa	Annona squamosa Linn.	Sarifa
33.	Sweet orange	Junaar	Citrus sinensis (L.) Osbeck	Sindhuli Local, Dadeldhura Local
34.	Walnut	Okhar	Juglans regia L.	Hard Shelled Okhar
Vegetable crops				
35.	Bean	Simi	Vicia faba L.	Jumla Local, Mustang Local, Humla

SN	English name	Nepali name	Scientific name	Most important landraces
				Local, Karnani Simi, Jumli Simi, Gatlange Simi, Asare Simi
36.	Brinjal	Bhenta, baijan	Solanum melongena L.	Birgunj Local
37.	Chilli	Khursaani	Capsicum frutescens L.	Jhyanmara Thalle Khursani, Akabare Khursani, Jire Khursani
38.	Cucumber	Kaakro	Cucumis sativus L.	Madale Kakro
39.	Garlic	Lasun	Allium sativum L.)	Kirtipur Local, Bhaktapur Local, Bhote Lasun, Sthaniya Bose, Tarai Lasun
40.	Ginger	Adhuwa	Zingiber officinale Roscoe	Bhose Adhuwa
41.	Large Cardamom	Alaichi	Amomum sabulatum Roxb	Jirmale, Bharlange, Salakpure, Saaune
42.	Lettuce	Latte ko saag	Latuca sativa	Ramechhap Hariyo
43.	Potato	Aalu	Solanum tuberosum	Mude Local, Tharu Aalu, Helambu Local, Sidhuwa Local, Dhorpatan Local
44.	Radish	Mulaa	Raphanus sativus L.	Pyuthane Local, Choto
45.	Sponge Gourd	Ghiraulaa	Luffa cylindrica	Basaune Ghiraula
46.	Taro	Pidaalu	Colocasia esculenta (L.) Schott	Thado Mukhe, Hatti Paaile, Sath Mukhe, Gante Pancha Mukhi, Chatre, Dudhe Pidalu, Khari Pidalu, Gandaki Hattipau
47.	Tomato	Golbedaa	Lycopersicon lycopersicum	Lasi Gede
Forage genetic resources				
48.	Barro	Barro	Terminalia bellirica	Barro
49.	Bermuda	Dubo	Cynodon dactylon L. pres.	Dubo
50.	Black Siris	Kalo Siris	Albizia lebbek	Kalo Siris
51.	Broom Grass	Amrisho	Thysanolaena maxima	Amrisho
52.	Chuletro	Chuletro	Brassiopsis hainla	Chuletro
53.	Coral Tree	Faledo	Erythrina strica/varigata	Faledo
54.	Cutch tree	Khayar	Acacia catechu (L.f.) Wild.	Khayar
55.	Dudhilo	Dudhilo	Ficus nemoralis	Dudhilo
56.	Dumri	Dumri	Ficus racemosa	Dumri
57.	Elephant fig	Kabro	Ficus lacor Buch.-Ham	Kabro
58.	Fodder fig	Khanaayo	Ficus semicordata Buch.-Ham ex Sm.	Khanaayo
59.	Gogan	Gogan	Saurauia nepaulensis DC.	Gogan
60.	Harro	Harro	Terminalia chebula	Harro
61.	Kans	Kans	Saccharum spontaneum	Kans
62.	Khasreto	Khasreto	Ficus hispida	Khasreto, Gelido
63.	Khasru	Khasru	Quercus semecarpifolia	Khasru
64.	Leucaena/ Ipil- Ipil	Ipil-Ipil	Leucaena leucocephala	Ipil-Ipil
65.	Litsea	Kutmero	Litsea monopetala (Roxb.) Pers.	Kutmero, Kutmiro
66.	Monkey jack	Badahar	Artocarpus lakoocha Wall. ex Roxb.	Badahar
67.	Mountain ebony	Koiralo	Bauhinia variegata L.	Koiralo
68.	Mulberry	Kimbu	Morus alba	Kimbu
69.	Nevaro	Nevaro	Ficus rosenbergii	Nevaro, Nimaro
70.	Oat	Jai	Avena sativa L.	Jai
71.	Pakhauri	Pakhauri	Ficus glaberrima	Pakhauri
72.	Pink bauhinia, Ebony	Taankee	Bauhinia purpurea L.	Taankee
73.	Premna	Ginderi	Premna integrifolia	Ginderi
74.	Red clover	Rato clover	Trifolium pretense L.	Rato clover
75.	Sacrificial grass	Kush	Desmostachys bipinnata (L.) Stapf	Kush
76.	Siru	Siru	Imperata cylindrica	Siru
77.	Tatelo	Tatelo	Oroxylum indicum (L.) Kurz	Tatelo
78.	Weeping willow	Bains	Salix babylonica L.	Bains
79.	White clover,	Pyauli	Trifolium repens L.	Pyauli, Beuli Jhar

SN	English name	Nepali name	Scientific name	Most important landraces
	Ladino			
80.	Wild sugarcane grass, thatch grass	Kaans	Saccharum spontaneum L.	Kaans
81.	Wodier	Dabdabe	Lannea coromandelica (Houtt.) Merr.	Dabdabe
Livestock genetic resources				
82.	Buffalo	Bhainsi	Bubalus bubalis	Lime, Parkote, Gaddi, Tarai
83.	Cattle	Gai	Bos indicus	Siri, Achhami, Khaila, Pahadi, Tarai
84.	Cattle		Bos taurus	Lulu
85.	Chicken (fowl)	Kukhura	Gallus domesticus	Sakini, Pwankh Ulte, Ghanti Khuile
86.	Donkey, ass	Gadhaa	Equus asinus	Gadhaa
87.	Duck	Haans	Anas platyrhynchos	Haans
88.	Goat	Bakhra	Capra hircus	Chyangra, Sinhal, Khari, Tarai
89.	Guinea fowl	Laukaat	Numida meleagris	Laukaat
90.	Horse	Ghonda	Equus caballus	Jumli Ghoda
91.	Mule	Khachhar	Horse x donkey	Khachhar
92.	Pig	Sungur	Sus scrofa domesticus	Chwanche, Bampudke, Hurrah, Nagpuri
93.	Pony	Tattu	Equus ferus caballus	Tattu
94.	Sheep	Bhainda	Ovis aries	Bhyanglung, Baruwal, Kage, Lampuchhre
95.	Yak	Yak	Bos gruniens	Yak, Nak
96.	Yak hybrid	Chauri	Yak x cow	Chauri
Aquatic agricultural animal genetic resources				
97.	Apple snail	Ghungi	Bellamya bengalensis	Ghungi
98.	Catla	Bhakur	Catla catla	Bhakur
99.	Chaguni	Rewa, Kasree, kubre	Chagunius chagunio	Rewa, Kasree, kubre
100.	Gangetic mud eel, Cuchia	Andho bam	Amphipnus cuchia	Andho bam
101.	Garua bacha	Jalkapoor, Baikha	Clupisoma garua	Jalkapoor, Baikha
102.	Giant Mottled Eel, Mottled Eel	Raja bam	Anguila bengalensis	Raja bam
103.	Goonch	Gonch	Bagarius yarrellii	Gonch
104.	Hill trout, Snow trout	Chuche Asala,	Schizothorax plagiostomus	Chuche Asala,
105.	Kalabans	Gardi	Labeo dero	Gardi
106.	Katli, Chocolate Mahseer, Copper mahseer	Katle	Neolissochilus hexagonolepis	Katle
107.	Kuncho River prawn	Guraicha or kunchochingri	Macrobrachium lamarrei	Jhinge machha, Sano jhinge, Thulo jhinge
108.	Mahseer	Falame sahar	Tor tor	Falame sahar
109.	Mrigal	Naini	Cirrhinus mrigala	Naini
110.	Mussel	Situ (Seepi)	Lamellidens marginalis	Situ (Seepi)
111.	Putitor mahseer, Golden mahseer, thick-lipped Mahseer,	Sahar, Mahseer, Pafele mahseer,	Tor putitora	Sahar , Mahseer, Pafele mahseer,
112.	Rohu	Rohu	Labeo rohita	Rohu
113.	Spotted snow trout, Alwan Snow trout	Buchhe asala, Blunt snout asala, Soal asala	Schizothorax richardsonii	Buchhe asala, Blunt snout asala, Soal asala
114.	Walking	Mungri	Clarias batrachus	Mungri

SN	English name	Nepali name	Scientific name	Most important landraces
	catfish; Magur			
115.	Wallago, Freshwater shark	Padni/ bohari	Wallago attu	Padni/ bohari
116.	Zebra fish	Chithari, pothi	Danio rerio	Chithari, pothi
Aquatic agricultural plant genetic resources				
117.	Deep water rice	Bhaati Dhaan	Oryza sativa L.	Bhaati Dhaan
118.	Gorgon nut, Prickly water Lily, Fox nut	Makhan, Makhana	Euryale ferox Salisb.	Makhan, Makhana
119.	Lotus	Komal	Nelumbo nucifera Gaertn	Komal
120.	Taro	Karkale	Colocasia esculenta (L.) Schott.	Karkale
121.	Toothed dock, Aegean dock	Ban Palungo	Rumex dentatus L.	Ban Palungo
122.	Water chestnut	Singhara, Singada	Trapa bispinosa Roxb	Singhara, Singada
123.	Water spinach	Karmi Saag	Ipomoea aquatica Forssk.	Karmi Saag
124.	Watercress	Sim Saag	Nasturtium microphyllum (Boenn.) Rchb.	Sim Saag
Insect genetic resources				
125.	Asiatic hive bees	Yasian mahuri	Apis cerana Fab. (Ecotypes - Apis cerana cerana, Apis cerana indica, Apis cerana himalaya)	Yasian mahuri
126.	Bumble bees	Bhamara	Bombus spp.	Bhamara
127.	Cotesia	Bareule kira	Cotesia flavipes Cameron (=Apanteles flavipes Szepligeti)	Bareule kira
128.	Green lace wing	Jalidar pakeheta bhayeko kira	Chrysoperla carnea Stephens	Jalidar pakeheta bhayeko kira
129.	Himalayan giant honey bee	Jangali mahuri	Apis dorsata Fabricius	Jangali mahuri
130.	Lac insets	Laha kira	Kerria lacca (Kerr)	Laha kira
131.	Ladybird beetle	Stri swabhabko khapate	Coccinella spp.	Stri swabhabko khapate
132.	Leptobatopsis	Bareule kira	Leptobatopsis indica (Cameron)	Bareule kira
133.	Little/small bee	Sano mahuri	Apis florea Fabricius	Sano mahuri
134.	Rock or cliff honey bees	Bhir mahuri	Apis laboriosa Smith	Bhir mahuri
135.	Stingless bees	Nachilne mahuri (putka)	Mellipona spp. Trigona spp.	Nachilne mahuri (putka)
136.	Tachinid fly	Tyakinid kira	Exorista japonica Townsend	Tyakinid kira
137.	Tamarixia	Bareule kira	Tamarixia radiata (Waterston)	Bareule kira
138.	Telenomus	Bareule kira	Telenomus sp.	Bareule kira
139.	Trichogramma	Bareule kira	Trichogramma chilonis Ishii,	Bareule kira
Microbial genetic resources				
140.	Termitomyces	Kalo dunge chayu	Termitomyces spp	Kalo dunge chayau
141.	Azotobactor	Azotobactor	Azotobactor spp	Azotobactor
142.	Black Forest Mushroom, Shiitake	Mruge Chyau	Lentinula edodes	Mruge Chyau
143.	Bt	Biti	Bacillus thuringiensis	Biti
144.	Clustered coral/	Thakre Chyau	Ramaria botrytis	Thakre Chyau

SN	English name	Nepali name	Scientific name	Most important landraces
	Cauliflower coral			
145.	Green muscardine fungus	Hariyo dhusi	Metarhizium anisopliae	Hariyo dhusi
146.	Milky Mushroom	Dudhe Chyau	Calocybe indica	Dudhe Chyau
147.	Morel	Guchhi Chyau	Morchella esculenta Fr.	Guchhi Chyau
148.	Puffball	Padke chayau	Clavatia spp	Padke chayau
149.	Rhizobium	Rhizobium	Rhizobium spp	Rhizobium
150.	Shaggy Ink Cap/ Shaggy Mane	Kalo Masi Chyau	Coprinus comatus	Kalo Masi Chyau
151.	Straw Mushroom	Parale Chyau	Volvariella volvacea	Parale Chyau
152.	Super Natural/Red Mushroom	Rato Chyau	Ganoderma spp	Rato Chyau
153.	Trichoderma	Trichoderma	Trichoderma spp	Trichoderma
154.	White-muscardine fungus	Seto Dhusi	Beauveria bassiana	Seto Dhusi
155.	Yarsha-gumba	Yarshaguumba	Cordyceps sinensis	Yarshaguumba
156.	Yeast	Dhahi jimaanu	Lactobacillus spp	Dhahi jimaanu
157.	Yeast	Dhahi jimaanu	Streptococcus	Dhahi jimaanu
158.	Yeast	Marcha jimaanu	Saccharomyces cerevisiae	Marcha jimaanu

Sources: Regmi 1982, Banwart 1989, Paudel and Tiwari 1992, Upadhyay et al 1995, Smith et al 1996, Wilson 1997, Shrestha and Shrestha 1999, Yami et al 2003, Arjyal et al 2004, MoAC 2004, Takeda et al 2004, Christensen et al 2008, Niroula and Sing 2011, Acharya and Atreaya 2012, Gotame et al 2014, Aryal et al 2015, Bhattarai et al 2015, Shimada and Basnet 2015, Paudel 2017, Subba et al 2017, Wilson 2017, Limbu et al 2019, FAO 2019.

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