Agrobiodiversity and its Conservation in Nepal

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Received 25 July 2019, Revised 07 Nov 2019, Accepted 15 Jan 2020, Published 17 March 2020

Scientific Editors: Madan R. Bhatta, Ppushpati Chaudhari, Hari K. Upreti, Krishna Timsina
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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 agroeocosystem, species, variety/breed/biotype/race/strain, genotype and allele levels, within an altitude range from 60 to 5,000 masl. There are 12 agroeocosystems supporting 1,026 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
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 utilization in breeding for the CGIAR system (Joshi et al 2017a). 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 are 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 multilateral 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 Biodiversity 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.

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

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

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), multilane, 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 5000 m (Abington 1992). There are total of 510 forage species including 50 exotic.
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 (battaa 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 (rraajhaas). 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 (i.e. 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 1. 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.
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 (Shapit 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**

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

**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 Pakhriras 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; Pakhriras for Pakhriras 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 exits 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, Koreas. 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://eurisco.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

| SN | Type of bank                  | Total banks, n | Species conserved, n | Accession conserved, n | Agrobiodiversity component | Initiated date |
|----|-------------------------------|----------------|----------------------|------------------------|---------------------------|----------------|
| 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          |
| 18 | World Seed Vault, Korea       | 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-ITPGFRA                   | 1              | 20                   | 614                    | Crops and forages         | 2017          |

**Nepalese accessions at global database**

| SN | Type of bank | Total banks, n | Species conserved, n | Accession conserved, n | Agrobiodiversity component | Initiated date |
|----|--------------|----------------|----------------------|------------------------|---------------------------|----------------|
| 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.

ACKNOWLEDGEMENTS

A large number of farmers and experts have been involved in generating information and implementing different actions including good practices and they all are highly acknowledged. Special thanks go to Bhola Shrestha, Tek Bahadur Gurung, Ajaya Chaudhary, Harish Chandra Bastola, Anil Acharya, Bidya Pandey, Hari Bahadur KC, Suraj Baidya, Shree Prasad Vista and Prem Nidhi Sharma. Some good practices and actions were implemented with the financial support from NARC, LI-BIRD, Bioversity International, MoAD, IUCN, MoFSC, IAAS, Parivartan Nepal and DoA.

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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, Hariyop |
| 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 | Fagopyrus spp | Tite Faper, Mithe, Bhte, Bharule |
| 7. | Cowpea | Bodi | Vigna unguiculata (L.) Walp. | Tane Bodi, Kattike Bodi, Gaajale Bodhi, Makai Bodi, Fokse Bodi, Seto Bodhi |
| 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 kerai | Pisum sativum L. | Saano, Thulo, Hariyop, Lahare |
| 16. | Pigeonpea | Rahar | Cajanus cajan (L.) Millsp. | Raato, Seto, Chanki, Pjawa, Chaite, Lalkaa, Baisalaki |
| 17. | Proso millet | Chino | Panicum miliaceum L. | Dudhe, Haade, Raato, Kaptade |
| 18. | Rapeseed | Tori | Brassica rapa L. | Kala, Pliaa |
| 19. | Rice | Dhaan | Orzya sativa L. | Jumli Maarshi, Kalanamak, Ekle, Bhaati, Jethobudo, Anadi, Aajpjupe, Ghaiya, Gurdii, Jhnuwaa, Lalka Basmati, Samundraophi, Pahela, Nakhisaro, Giupuri, Titik, Krishnahbog |
| 20. | Soybean | Bhatmas | Glycine max (L.) Merrl. | Seto, Kaanchi, Thulo, Kaalo, Saano, Khairo |
| 21. | Wheat | Gahu | Triticum aestivum L. | Nanal, Mudule, Hansaa, Saadbi, Pawai, Saano, Raani, Jhsse, Bhtoe, Duddhe |
| **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 | Darim | Punica granatum | Nepali Darim |
| 32. | Sugar apple, custard apple | Raam phal or sarifa | Annona squamosa Linn. | Sarifa |
| 33. | Sweet orange | Junaar | Citrus sinensis (L.) Osbeck | Sindhuli Local, Dadelledhura 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 |
|----|-------------|-------------|----------------|-------------------------|
| 36. | Brinjal | Bhentaa, bajian | Solanum melongena L. | Birgunj Local |
| 37. | Chilli | Khursaani | Capsicum frutescens L. | Jhyannma Thalle Khursani, Akabare Khursani, Jire Khursani |
| 38. | Cucumber | Kaaakra | 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 | Bose Adhuwa |
| 41. | Large Cardamom | Achi | Amomum subulatum Roxb | Jirmale, Bharlange, Salakpure, Saaune |
| 42. | Lettuce | Latte ko saag | Lactuca sativa | Ramechhap Hariyo |
| 43. | Potato | Aalu | Solanum tuberosum | Mude Local, Tharu Aalu, Helambu Local, Sidhuwa Local, Dhorpatan Local |
| 44. | Radish | Mula | Raphanus sativus L. | Pyuthane Local, Choto |
| 45. | Sponge Gourd | Ghiraula | 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 |

**Forage genetic resources**

| SN | English name | Nepali name | Scientific name | Most important landraces |
|----|-------------|-------------|----------------|-------------------------|
| 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 semicordata Buch. | Dudhilo |
| 56. | Dunri | Dunri | Ficus racemosa | Dunri |
| 57. | Elephant fig | Kabro | Ficus lacon 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 variegate L. | Koiralo |
| 68. | Mulberry | Kimbu | Morus alba | Kimbu |
| 69. | Nevaro | Nevaro | Ficus rosendergii | Nevaro, Nimaro |
| 70. | Oat | Jai | Avena sativa L. | Jai |
| 71. | Pakhauri | Pakhauri | Ficus glaberrima | Pakhauri |
| 72. | Pink bauhinia, Ebony | Taanke | Bauhinia purpurea L. | Taanke |
| 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 | 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                        | Gai         | Bos taurus                             | Lulu                             |
| 85  | Chicken (fowl)                | Kukhura     | Gallus domesticus                      | Sakini, Pwankh Ulte, Ghanti Khule |
| 86  | Donkey, ass                   | Gadhaa      | Equus asinus                           | Gadhha                           |
| 87  | Duck                          | Haans       | Anas platyrhynchos                     | Haans                            |
| 88  | Goat                          | Bakhra      | Capra hircus                           | Chyangera, 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                         | Bhaianda    | Ovis aries                             | Bhyanglung, Baruwal, Kage, Lampuchre |
| 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   | Ampipnus 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                        | Goonch      | Bagarius yarrellii                    | Goonch                           |
| 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 mirgala                      | Naini                            |
| 110 | Mussel                        | Situ (Seepi) | Lamellidens marginalis               | Situ (Seepi)                     |
| 111 | Putitor mahseer, Golden mahseer, thick-lipped Mahseer, | Sahar, Mahseer, Pahele mahseer, Tor putitora | Sahar, Mahseer, Pahele 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                       | Mungrri     | Clarias batrachus                      | Mungrri                          |
| SN | English name               | Nepali name      | Scientific name          | Most important landraces      |
|----|---------------------------|------------------|--------------------------|-------------------------------|
| 115 | Wallago, Freshwater shark | Padni/ bohari    | Wallago attu              | Padni/ bohari                 |
| 116 | Zebra fish                | Chithari, pothi  | Danio rerio               | Chithari, pothi               |

**Aquatic agricultural plant genetic resources**

| SN | English name               | Nepali name      | Scientific name          | Most important landraces      |
|----|---------------------------|------------------|--------------------------|-------------------------------|
| 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**

| SN | English name               | Nepali name      | Scientific name          | Most important landraces      |
|----|---------------------------|------------------|--------------------------|-------------------------------|
| 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 swabhakho khapate | Coccinella spp. | Stri swabhakho 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**

| SN | English name               | Nepali name      | Scientific name          | Most important landraces      |
|----|---------------------------|------------------|--------------------------|-------------------------------|
| 140 | Termitomyces              | Kalo dungu chayu | Termitomyces spp         | Kalo dungu chayu              |
| 141 | Azotobacter               | Azotobacter      | Azotobacter spp          | Azotobacter                   |
| 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                  |

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| SN  | English name                  | Nepali name     | Scientific name                  | Most important landraces |
|-----|------------------------------|-----------------|----------------------------------|--------------------------|
| 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 chayu     | Clavatia spp                    | Padke chayu              |
| 149 | Rhizobium                    | Rhizobium spp   | Rhizobium                       | 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 spp | Trichoderma spp                 | Trichoderma              |
| 154 | White-muscantine 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, Yamii 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.