The State of Nepal's Biodiversity for Food and Agriculture

Ministry of Agricultural Development
Kathmandu, Nepal

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Edited by
Bal K. Joshi, Anil K. Acharya, Devendra Gauchan and Pashupati Chaudhary

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The Ministry of Agricultural Development (MoAD) is the central body of the Government of Nepal responsible for agriculture and allied fields. The ministry consists of five divisions, two centres, one research and development fund, three departments, five projects, and autonomous bodies, consisting of a research council, a corporation, two development boards, two companies, and several development committees. The Honorable Minister for Agricultural Development is in charge of the ministry; the secretary is the administrative head and chief advisor to the minister.

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Foreword

Biodiversity underpins the livelihoods and wellbeing of humankind on earth. Not all nations are fortunate to enjoy rich biodiversity, but Nepal, despite being a small country, harbors world's 3.2% flora and 1.1% fauna, ranks the 31st richest country in the world and 10th in Asia in terms of biodiversity. A total of 284 flowering plants, 160 species of animals, one species of bird, and 14 species of herpeto fauna are endemic to Nepal. Astonishingly varied geographic, ecological, climatic, socioeconomic, and cultural factors are making possible such a tremendous biodiversity to exist. A large number of biodiversity is useful for food and agriculture and they are grouped as crop, livestock, aquatic, forest and associated biodiversity.

Biodiversity useful for food and agriculture is undergoing a rapid change, while several of them are rare and endemic and thus face further threat to extinction. A total of 54 species of wild mammals and 18 species of trees found in the mountains are threatened. Nine species of plants, 55 mammals, 149 birds, 64 herpeto-fauna and 21 fish are included in the IUCN Red List. A total of 15 group and species of plants, 52 mammals, 108 birds and 19 reptiles and three insects have been listed in the CITES. Similarly, 27 mammals, nine birds, 14 angiosperms, and four gymnosperms have been declared as protected species by the government. A large number of local varieties of crops and vegetables, livestock breeds, fish species, and wild edible species are eroding from their habitats and growing environments. Introduction of new technologies including varieties, erosion of traditional knowledge, poor utilization of local landraces, lack of proper policies, and poor implementation of policies are key underlying factors contributing to genetic erosion.

The Government of Nepal has made several initiatives in collaboration with relevant stakeholders. The Ministry of Agricultural Development (MoAD) is playing pivotal role to formulate and revise policies, facilitate conservation and utilization of agro-biodiversity, document information and knowledge. The MoAD in 2016 has prepared the Nepal chapter for the State of the World's Biodiversity for Food and Agriculture report (SoWBFA-Nepal chapter) in collaboration with research organizations, NGOs and other ministries and submitted to Commission on Genetic Resources for Food and Agriculture (CGRFA), FAO. Based on this SoWBFA-Nepal chapter, this synthesis book was prepared to share national and international experts as well as to help future conservation and utilization activities of agro-biodiversity. We are proud to have such informative book which was lacking on agro-biodiversity sector. We believe this document will be widely distributed and people make use of valuable information included herein. Several individuals representing different government and non-government organizations have put their endeavor to produce this high quality report and look forward to even stronger cooperation and collaboration.

We would like to thank core team members, namely Dr. Bal K. Joshi, Mr. Anil K. Acharya, Dr. Devendra Gauchan, Dr. Pashupati Chaudhary, Dr. Tek B. Gurung, Dhananjaya Lamichhane, Krishna Prasad Timsina, Lok Nath Paudel and Yam Prasad Poudel for their painstaking work in compiling, synthesizing and editing the document. The original document (SoWBFA-Nepal chapter) was contributed by a number of individuals under the leadership of Madan R. Bhatta, Bimal K. Nirmal, Tek Bahadur Gurung, Yubak Dhoj GC and Rom R. Lamichhane. We are thankful to them as well.

Suresh Babu Tiwari
Joint Secretary
MoAD

Suroj Pokhrel, PhD
Secretary
MoAD

Preface

This document "The State of Nepal's Biodiversity for Food and Agriculture (SoNBFA) is synthesized from the original country report of State of World's Biodiversity for Food and Agriculture (SoWBFA-Nepal chapter), which was submitted officially to Commission on Genetic Resources for Food and Agriculture (CGRFA), FAO in March 2016. This SoWBFA-Nepal chapter was prepared by different committees (core committee, team leader, technical sub committee consisting of expert members) formed by MoAD as per the requirement of the country to submit country report. The document includes 5 core components of agrobiodiversity; viz, Crop, Animal, Fishery, Forest and Associated Biodiversity. The preparation for the SoWBFA-Nepal chapter was initiated in 2014 and completed in 2015 December. The process of preparing SoWBFA-Nepal chapter is outlined below.

Adhering to the guidelines of the Commission on Genetic Resources for Food and Agriculture (CGRFA), a national core committee was formulated under the chairmanship of the National IT Focal Person in the Ministry of Agricultural Development. The Core committee included the following members:

- Joint Secretary, Food Security and Environment Division, MoAD -Chair person
- Director General, Department of Agriculture -Member
- Program Director, Directorate of Livestock Production -Member
- Director, Livestock and Fisheries, Nepal Agricultural Research Council -Member
- Chief, National Agriculture Genetic Resources Center, NARC -Member
- Chief, Socio-economic and Agriculture Research Policy Division, NARC -Member
- Under Secretary, Biodiversity Section, Ministry of Forest and Soil Sciences -Member
- Senior Agriculture Economist, Multilateral Foreign aid and Fund Coordination Section, MoAD -Member
- Senior Agriculture Officer, Gender Equity and Social Inclusion Section, MoAD -Member
- Biodiversity Expert, Representative of NGO (LI-BIRD) -Member
- Representative, FAO Nepal Country Office -Member
- Mr. Manaraj Kolakshyapati, Professor, Tribhuwan University -Member
- Mr. Shreeram Prasad Neopane, Professor (Livestock Genetic Sciences), HICAST -Member
- Senior Horticulture Development Officer, Agriculture Biodiversity Section, MoAD - Member Secretary

As per the expert advice and guidelines provided by the Commission on Genetic Resources for Food and Agriculture (CGRFA) of the FAO, following experts (Thematic leader) from five thematic areas from relevant organizations were identified to lead the thematic chapters such as Plant Genetic Resources (PGR), Animal Genetic Resources (AnGR), Fisheries Genetic Resources, Forest Genetic Resources experts and Associated Biodiversity.

Mr. Madan Raj Bhatta, Coordinator to PGR for Food and Agriculture Thematic Area	Chief, National Agriculture Genetic Resources Center, NARC
Dr. Bimal Kumar Nirmal, Coordinator to AnGR for Food and Agriculture Thematic Area	Program Director, Directorate of Livestock Production
Dr. Tek Bahadur Gurung, Coordinator to Aqua and Fisheries Genetic Resources for Food and Agriculture Thematic Area	Director, Livestock and Fisheries Research, Nepal Agricultural Research Council (NARC)
Dr. Yubak Dhoj GC, Coordinator to Associated Biodiversity for Food and Agriculture Thematic Area	Director General, Department of Agriculture
Mr. Rom Raj Lamichhane, Coordinator to Forest Genetic Resources for Food and Agriculture Thematic Area	Under Secretary, Biodiversity Section, Ministry of Forest and Soil Conservation, MoFSC

Thematic leaders formed following technical sub committees and worked in each chapter independently.

Thematic team	Team members
PGR for Food and Agriculture	Dr Bal Krishna Joshi, Dr. Devendra Gauchan, Mr. Krishna Hari Ghimire, Ms. Deepa Singh and Ms. Sunita Sanjyal
AnGR for Food and Agriculture	Mr. Bhola Shankar Shrestha, Dr. Loknath Paudel, Dr. Damayanti Shrestha, Mr. Surya Prasad Paudel, Mr. Nabin Ghimire and Mr. Jagadish Pandey
Fisheries Genetic Resources for Food and Agriculture	Mr. Suresh Wagle, Mr. Rama Nand Mishra, Ms. Neeta Pradhan and Ms. Asha Raymajhi, Dr. Tek B. Gurung
Associated Biodiversity for Food and Agriculture	Mr. Shyam Krishna Joshi, Mr. Mahesh Chandra Acharya and Mr. Amar Raj Sharma Ghimire
Forest Genetic Resources for Food and Agriculture	Mr. Bijaya Raj Paudel, Dr. Bishwa Nath Oli and Mr. Surya Prasad Khanal

A series of consultation meetings were held within their team members and other relevant stakeholders within their domain. Subsequent coordination meetings of the core committee in the MoAD and National Agriculture Genetic Resources Center (NAGRC), Khumaltar were also held with the aim of sharing their contents and progress. The thematic team leaders presented their reports in a workshop program held on 11 September 2015 at NAGRC, Khumaltar in the presence of core committee members, thematic members and other relevant stakeholders and experts. After receiving draft report, MoAD allocated budget to further compiling and editing this five theme reports as a single consolidated country report. The consolidation country report was finalized by Mr. Gopal Prashad Shrestha, Good Soul Nepal. The Secretariat including the members of national core committee reviewed the report and got approval from National Agricultural Biodiversity Conservation Committee (NABCC) on February 01, 2016.

After submission of SoWBFA- Nepal chapter to CGRFA on March 1, 2016, Ministry of Agricultural Development realized the importance of such documents to publish and make access to relevant persons and organizations. The MoAD then made a decision on 27 October 2016, to prepare synopsis from SoWBFA-Nepal chapter for publication and distribution to wide range of stakeholders in Nepal. For this, MoAD formed national task force under the chairmanship of the National IT Focal Person (Joint Secretary, FSABPED) with the following expert members.

Thematic area	Task force members
PGR for Food and Agriculture	Dr Bal Krishna Joshi and Dr Devendra Gauchan
AnGR for Food and Agriculture	Dr Lok Nath Paudel
Fisheries Genetic Resources for Food and Agriculture	Dr Tek Bahadur Gurung
Associated Biodiversity for Food and Agriculture	Mr Anil K. Acharya, Dr. Devendra Gauchan, Dr Bal K. Joshi, Mr Yam P. Paudel and Dr Dharma R. Dangol
Forest Genetic Resources for Food and Agriculture	Mr Dhananjaya Lamichhane
Report synthesis and editing	Dr Pashupati Chaudhary, Dr Devendra Gauchan, Dr Bal K. Joshi and Mr Anil K. Acharya

This task force committee organized several round of meetings, email discussion, telephone meeting, and on line discussion and set a common guidelines and format. Based on this format, team members prepared their respective chapters. It has five chapters (ie crop, animal, aquatic, forest and associated) and six sections in each chapter. Executive summary was presented section wise. After the recommendation made by Agro Biodiversity Technical Advisory Sub Committee, SoNBFA final version was presented in NABCC meeting and got approval for publication. We would like to thank MoAD for providing this opportunity, NABCC for their guidance and approval, thematic expert members for voluntarily synthesizing and updating information, and others for providing relevant documents. This publication is expected to serve as the official document to contribute as an important reference for the country's state and use of agrobiodiversity in Nepal.

Editors

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Abbreviations

ABD	Animal Breeding Division
ABS	Access and benefit sharing
AGDP	Agriculture gross domestic product
AI	Artificial insemination
AnGR	Animal Genetic Resources
APGR	Agricultural plant genetic resources
ARS	Agricultural research station
BSO	Breeding Seedling Orchards
C/FUG	Community/Forest User Group
CAT	Climate analog tool
CBD	Convention on Biological Diversity
CBS	Central Bureau of Statistics
CDD	Crop Development Directorate
CEAPRED	Centre for Agriculture, Policy Research, Extension, Environment and Development
DFO	District Forest Office/Officer
DLS	Department of Livestock Services
DLSO	District Livestock Services Offices
DoF	Department of Forests
DoLP	Directorate of Livestock Production
ELF	Experienced Leader Farmer
ET	Embryo transfer
FAO	Food and agriculture organization
FFS	Farmers' field school
FGR	Forest Genetic Resources
FORWARD	Forum for Rural Welfare and Agricultural Reform for Development
GCM	Global climate model
GDP	Gross domestic product
GIS	Geographical information system
GO	Government Organization
GoN	Government of Nepal
HICAST	Himalayan College of Agriculture, Science and Technology
IARC	International agriculture research center
IBPGR	International board for plant genetic resources
ICIMOD	International Centre for Integrated Mountain Development
INGO	International non-governmental organization
IPCC	Intergovernmental Panel on Climate Change
IPGRI	International plant genetic resources institute
IPM	Integrated Pest Management
IPNM	Integrated plant nutrient management
IPNS	Integrated Plant Nutrient System
IRRI	International rice research institute
IUCN	International Union for Conservation of Nature
LAPA	Local adaptation plan of action

LI-BIRD	Local Initiatives for Biodiversity, Research and Development
MDG	Millennium Development Goal
MFSC	Ministry of Forests and Soil Conservation
MIS	Monitoring and Information System
MoAC	Ministry of Agriculture and Cooperative, Government of Nepal
MoAD	Ministry of Agricultural Development
MoE	Ministry of Environment
MoFSC	Ministry of Forest and Soil Conservation
NA	Not Available
NABCC	National Agricultural Biodiversity Conservation Committee
NAGRC	National agriculture genetic resource center
NAPA	National adaptation plan of action
NARC	Nepal Agricultural Research Council
NARC	Nepal Agricultural Research Council
NAST	Nepal Academy of Science and Technology
NBCC	National Biodiversity Co-ordination Committee
NBSAP	National Biodiversity Strategy and Action Plan
NCCOAPPS	National Coordination Committee for Organic Agriculture Production and Processing System
NGO	Non Governmental Organization
NK	Not Known
NLBC	National Livestock Breeding Center
NOAAB	National Organic Agriculture Accreditation body (NOAAB)
NPWC	National Parks and Wildlife Conservation
NRs	Nepalese rupees
NTFP	Non-timber forest products
NTNC	National Trust for Nature Conservation
PES	Payments for Ecosystems Services
PGRFA	Plant genetic resources for food and agriculture
PIC	Prior informed consent
RARS	Regional agricultural research station
SAARC	South Asian Association for Regional Cooperation
SF	Stall feeding
SI	System semi-intensive
SSD	Soil science division
SSMP	Sustainable Soil Management Program
TISC	Tree Improvement and Silviculture Component
TM	Transhumant migratory
UNEP	United Nations Environment Programme
WEP	Wild edible plants
WTLCP	Western Tarai Landscape Project
WWF	World Wildlife Fund

Glossary

Terminology	Definition
Achhami cow	Local breed of cattle with nine-palm height
Agricultural plant genetic resources	All cultivated plant landraces and varieties, wild edible plants, and wild relatives of crops
Agriculture run-off	Water which flows down as a result of rain or melted snow which is not absorbed and held by the soil, but runs over the ground and through loose soil and can deposit into ponds, lakes, coastal waters, and underground sources
Agro-biodiversity	Includes four components of agro-biodiversity (plant and crop genetic resources, animal genetic resources, aqua genetic resources and associated genetic resources) and four sub-components in each component ie domesticated, semi-domesticated, wild edible and wild relative species
Animal farm genebank	Rearing of domesticated local and indigenous animals as well as improved breeds on-farm maintaining different species and breeds available around the command areas of research station or public farms for conservation, use and research
Animal genetic resources	Include all animal species, breeds and strains that are of economic, scientific and cultural interest to humankind in terms of food and agricultural production for the present or the future. Equivalent term increasingly used is farm animal genetic resources.
Aquaculture	Farming of fish, crustaceans, mollusks, aquatic plants, algae, and other aquatic organisms
Associated biodiversity	Includes micro-organisms including bacteria, viruses and fungi; invertebrates, including insects, spiders, worms, and all other invertebrates; vertebrates, including amphibians, reptiles, and wild (non-domesticated) birds and mammals, including wild relatives, of importance to crop, animal, fish and forest production as pests, predators, pollinators or in other ways, and wild and cultivated terrestrial and aquatic plants other than crops and crop wild relatives
Base broadening	Increasing the amount of genetic diversity used to produce new varieties or breeds used in agricultural production.
Biodiversity for food and agriculture	Includes the variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain the ecosystem structures, functions and processes in and around production systems, and that provide food and non-food agriculture products
Biological diversity or biodiversity	The richness and variety of living beings from all sources including, *inter alia*, terrestrial, marine and freshwater ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
Biological Resources	Includes genetic resources, organisms or parts thereof, populations or any other biotic component of ecosystems with actual or potential use or value for humanity
Biotechnology	Any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify biological products or processes for specific use

Terminology	Definition
Boreal	At least one month with monthly mean temperatures, corrected to sea level, below 5 °C and more than one but less than four months above 10°C
Community seed banks	Community seed banks are locally used seed storage structure and institutions managed by local community with collective action for strengthening local seed system and conserving local agricultural genetic resources.
Crop	Cultivated angiosperm plant species
Cultivar	Any distinct genotype under cultivation, including both landraces and varieties.
Domestic animal diversity	Refers to the genetic variation or diversity existing among the species, breeds, strains and individuals for all animal species which have been domesticated to meet human needs for food and agricultural production, and their immediate wild relatives.
Domesticated or cultivated species	Species in which the evolutionary process has been influenced by humans to meet their needs
Domestication	The development of new crop, aquatic, forest and animal species through deliberate breeding programmes or the continued selection and improvement of existing species from their wild progenitors. These activities may be carried out by national breeding programmes or by farmers and communities themselves.
Ecosystem diversity	Comprises the variety of habitats, the dynamic complexes of plant, animal and microorganism communities and their nonliving environment, which interact as a functional unit and their change over time. Ecologists have identified 118 ecosystems in Nepal representing distinct biological communities with their associated flora and fauna.
Endemic species	Organisms found only on particular geographical location and habitat.
Ex-situ conservation	The conservation of components of biological diversity outside of their natural habitats.
Farmers field School	It is a platform for learning and sharing ecological way of pest management in farmers' fields. Though it was originally used for implementation of IPM but now it is used as an extension tool for holistic management of agricultural production system covering soil, water and nutrients.
Fish	Cold-blooded, aquatic vertebrates mostly with an elongated body covered with scales, having gills for respiration and fins for locomotion.
Fisheries	Science of producing fish and other aquatic resources for the purpose of providing human food, as well as for sport or recreational fishing, or obtaining ornamental fish or other fish by products
Fishery	Industry or occupation devoted to the catching, processing, or selling of fish, shellfish, or other aquatic animals.
Genetic diversity	Refers to the variation of genes and/or genomes within living organisms, that is, the genetic differences between populations of a single species and between individuals within a population. In other words, this covers distinct populations of the same species such as the hundreds of traditional rice varieties in Nepal.
Ghanti Khuile Kukhura	Local poultry having naked neck.

Terminology	Definition
Habitat	Place or type of site where an organism or population naturally occurs.
Habitat provisioning	Role of ecosystems in creating and maintaining habitats for a wide variety of organisms. Providing diverse and suitable habitats for species; nursery function for migratory species and as breeding areas.
Home gardens	Home gardening is a traditional land use practice carried out around a homestead consisting of several species of plants that are grown and maintained by the family members with the primary objective of fulfilling the family's food and nutrition needs.
In-situ condition	Conditions where genetic resources exist within ecosystems and natural habitats and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.
In-situ conservation	Conservation of ecosystems and natural habitats and the recovery and maintenance of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.
Integrated Pest Management	Integrated pest management (IPM) is a broad-based approach aims to suppress pest populations below the economic injury level (EIL). It is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment.
Invasive species	A species that is not native and causes economic harm to a new environment.
Irrigated crops	Irrigated crops in areas purposely provided with water, including land irrigated by controlled flooding.
Landrace	Genotype not altered by breeders but grown continuously by farmers over years. It may be local or introduced.
Landscape approach	Planning and management of natural resources means a comprehensive, ecosystem-based approach, which takes into account living resources and includes local people and their well being within the context of their physical environment and in harmony with natural cycles and processes.
Livestock	Domesticated animals raised in an agricultural setting to produce commodities such as food, fiber and labor. The term is often used to refer solely to those raised for food, and sometimes only farmed ruminants, such as cattle and goats.
Livestock grassland-based systems	Systems in which the animals obtain a large proportion of their forage intake by grazing natural or sown pastures.
Livestock landless systems	Systems in which livestock production is separated from the land where the feed given to the animals is produced.
Local crop	Crop varieties and landraces grown continuously in particular location for at least over 60 years in same location.
Local goat	Indigenous breed of goat that is available in particular location and always relates particular area.
Makhana	A flowering aquatic plant classified in the water lily family, the Makhana

Terminology	Definition
	belongs to the genus *Euryale*. The fruits are highly regarded for its nutrition qualities, use in religious occasions mostly in Mithila culture.
Mithila culture	The way of lifestyle of the Maithili language speaking people of Nepal.
Native or indigenous breed	Entity has always been in the place where they are, rather than being brought there from somewhere else. Native and indigenous are similar meaning words that refer to naturally growing plants, living animals, and even original inhabitants of a particular region. When using for animals, indigenous is used for species, while native is used for particular animals and not whole species.
Non-timber forest products	Non-timber forest products (NTFPs) are any product or service other than timber that is produced in forests. They include fruits and nuts, vegetables, fish and game, medicinal plants, resins, essences and a range of barks and fibers such as bamboo, rattans, and a host of other palms and grasses.
Organic farming	Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity and prohibits use of agrochemicals.
Over-exploitation and over harvesting	Unsustainable extraction practices (eg overfishing; overhunting; overgrazing; logging and extractive activities exceeding replacement rates or affecting species of uncertain and at-risk conservation status, etc).
Pastoralist	Grassland-based systems in which the livestock keepers move with their herds or flocks in an opportunistic way on communal land to find feed and water for their animals (either from or not from a fixed home base).
Phytoplankton	Single-celled organisms of aquatic habitats that capable of making their own food by photosynthesis. Phytoplankton occurs almost anywhere there is water and sunlight.
Plant	Uncultivated and wild angiosperm plant species.
Production systems	Include the livestock, crop, fisheries and aquaculture and forest sectors.
Protected area	A geographically defined area that is regulated and managed to achieve specific conservation objectives.
Rainfed crop	Agricultural practice relying exclusively on rainfall as its source of water.
Ranching	Grassland-based systems in which livestock is kept on privately owned rangeland.
Reduced-impact logging	A series of practices to improve logging practices such as vine removal, directional felling, limiting skid trails, logging roads and stumping grounds, restrictions on the size and number of trees felled, and post felling removal of waterway blockages, to reduce the residual damage, biodiversity loss and excess CO_2 emissions associated with conventional logging practices.
Semi-migratory or semi-stationary with semi intensive	The animals are kept in shed during night in winter months and are taken out for grazing during day time.
Singhada	Water chestnut or water caltrop is an aquatic plant, belonging to the genus *Trapa,* whose odd-looking fruit encloses a single large edible seed.
Species diversity	Refers to the frequency and variety of species (wild or domesticated) within a

Terminology	Definition
	geographical area.
Stationary stall feeding or closed system intensive farming	Animals are kept in stall feeding system where the animals are fed with straws and other crop by products along with concentrates with limited amount of green fodders.
Subtropics	One or more months with monthly mean temperatures, corrected to sea level, below 18°C but above 5°C.
Sustainable soil management	Sustainable soil management is an approach that promotes a variety of appropriate and sustainable soil management (SSM) practices, based on the use of local resources, in order to improve soil fertility and increase household income.
Sustainable use	The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.
Swidden and shifting cultivation agriculture	Rotation of plots from intensive cultivation to extended fallow periods for the replenishment of soil fertility.
Temperate	At least one month with monthly mean temperatures, corrected to sea level, below 5°C and four or more months above 10°C.
Transhumant migratory system	System of movement of animals to the alpine meadows and temperate pasture in summer and to the lower altitude pastoral, forest and cropped areas around villages is the common animal production system in trans-himal region of Nepal.
Tropics	All months with monthly mean temperature, corrected to sea level, above 18°C.
Variety	Genotype developed by breeders. It may be under cultivation or in the process of development.
Zooplankton	Heterotrophic plankton organism that feeds on phytoplankton and others for food, drifting in aquatic environment, becomes the food for larger aquatic animals such as fish.

EXECUTIVE SUMMARY

Background of Biological Diversity for Food and Agriculture in Nepal

Biodiversity is the prime basis of life on earth. More specifically, biodiversity is an important source of food, nutrition, clothes, fodder, firewood, medicine, and recreational and comfort materials. It is also an important environmental resource as it plays important role in stabilizing ecosystem that we rely on for our livelihoods and wellbeing. Biodiversity exists at several levels and in several forms depending on the environmental condition they thrive on and the nature and extent of human interferences. Scientists claim from 10 to 100 million species of plants, animals, fungi, microbes, and other forms of life exist on earth.

Situated in the lap of the Himalaya, Nepal is blessed with beauty and bounty of biological resources that underpin our economy, livelihoods and ecological functions. Nepal ranks the 31st richest country in the world and 10th in Asia in terms of biodiversity. The bounty in Nepal has become possible due to exceptional variation in geography, ecology, and climatic conditions across the country. A total of 118 ecosystems, 12 of 867 global terrestrial eco-regions, and eight climatic zones (ranging from tropical to nival) are found in Nepal. Occupying merely 0.1 percent of global area, Nepal has the privilege of harboring world's 3.2 percent flora and 1.1 percent fauna, which include 5.2 percent of the world's known mammals, 9.5 percent birds, 5.1 percent gymnosperms, and 8.2 percent bryophytes. A large number of the species found across the country are useful for food and agriculture. Biological diversity useful for food and agriculture takes the forms of crops and their wild relatives, animal breeds, forest genetic resources, fish, and associated diversity.

Despite their great ecological and economic significance, several species are rare and/or threatened, while several are endemic to some particular geographic locations, particularly in high altitude rangelands. The Nepal Biodiversity Strategy and Action Plan, NBSAP (2014) report indicates a total of 284 flowering plants, 160 species of animals, one species of bird, and 14 species of herpeto fauna are endemic to Nepal. A total of 54 species of wild mammals and 18 species of trees found in the mountains are also threatened. Nine species of plants, 55 mammals, 149 birds, 64 herpeto-fauna and 21 fish are included in the IUCN Red List. A total of 15 group and species of plants, 52 mammals, 108 birds and 19 reptiles and three insects have been listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Similarly, 27 mammals, nine birds, 14 angiosperms, and four gymnosperms have been declared as protected species by the government.

It is crucial time for us to sustainably conserve our biological diversity and utilize it for the livelihoods and wellbeing current generation and posterity. However, past initiatives are inadequate to address the key drivers of biodiversity loss and vulnerability ensued by it. There has been a lack of documentation on these fronts, leading to inadequate information for formulating and revising policies and delivering action on ground. A team comprising scientists and practitioners in Nepal has prepared a Nepal Country Report on State of World's Biodiversity for Food and Agriculture (SoWBFA) to submit to the Commission on Genetic Resources for Food and Agriculture. This report is a synthesis of that report and summarizes key findings of the big report. This section highlights the current status of biodiversity, their importance, current threats of biodiversity loss and its drivers, initiatives taken to manage, conserve and use biodiversity, and future agenda for conservation and management of biodiversity. The report draws information from the chapters included in this reports, and brings in information from other sources too.

Status of Biodiversity for Food and Agriculture

Traditional farming is predominant in the rural areas in Nepal, which integrates crop, livestock, fisheries, agroforestry, and other associated biological resources. Crop diversity is tremendous. A variety of crops are grown in different geographic regions, and in different agro-ecological niches and climatic zones even within a geographic region. A total of 790 plant species are useful for food and 577 of them (including forage) are cultivated – 484 indigenous (74 crops, 145 horticultural crops and 275 forages) and 93 introduced. Moreover, there are 224 crop wild relatives that are closely related to crops. About 21% (3.2 million hectares) of the total land area of Nepal is used for cultivation and the principal crops are rice (45%), maize (20%), wheat (18%), millet (5%) and potatoes (3%), followed by sugarcane, jute, cotton, tea, barley, legumes, vegetables and fruits. In the mountains, finger millet, foxtail millet, proso millet, buckwheat, barley, naked barley, and amaranth constitute important staple crops. Crops such as rice, rice bean, eggplant, buckwheat, soybean, foxtail millet, citrus, and mango have high genetic diversity relative to other food crops.

Roughly 70 percent of households keep some type of livestock such as cattle, buffalo, goat, pig, horse, mule, poultry, ducks, etc. More than 2 million households own cattle and over 1.4 million households raise chickens. Farmers with small landholdings of between 0.2 and 0.5 ha keep almost 25 percent of the livestock, while people who have either no land or own less than 0.2 ha own about 11 percent of the livestock. Over half of the cattle, buffalo, goats, and sheep are kept in the hills, and about one third

in the *Terai*. Several economically and ecologically important livestock are reported but are rare. Among them, Lulu and *Achhami* cattle, *Lime* and *Parkote* buffalo, *Lampuchchhre* sheep, *Hurrah* and *Bampudke* pigs, *Sakini*, *GhantiKhuile* and *Pwankh ulte* (Dumse) chicken and Yak and *Chauri* are noteworthy. Livestock became one of the fastest growing sub-sectors in agriculture during the 1990s, averaging around 2.4 percent growth annually; it increased from 1.6 percent in first half of the 1990s to 3.6 percent in the second half. Nepal is also rich in local fish diversity. Altogether 232 fish species have been reported. They are found in rivers, streams, lakes, ponds, swamps, rice fields, and other types of wetlands. Besides, phytoplankton, zooplankton, mollusk, insect, crustacean, amphibian aquatic reptiles, birds and mammals are other valuable diversity in wetlands. Shrimp is eaten all over, but gastropods and bivalve are delicacy among Tharu and other communities in southern plains.

Forest is also an important source of food and agriculture. About 70 percent of the population of the country collects fodder for their livestock and 80 percent of it is met from trees grown in private and national forest. Similarly, about 64 percent of population use fuel wood for cooking and forest supplies approximately 89 percent of it. A study in Dolakha has documented 62 wild species belonging to 36 families, of which 39% were herbs, 37% trees, 14% shrubs, and 10 % climbers, fruits (46%) and green leafy vegetative parts (leaves and tender shoots; 37%) as food plants. Important tree species used for food include *Saurauia napaulensis, Castanopsis indica, Castanopsis tribuloides, Ficus auriculata, Ficus neriifolia, Dendrocalamus hamiltoni* and *Prunus cerasoides*. Associated biodiversity or non-crop living organisms, both below and above ground, found in an ecosystem include micro-organisms (including bacteria, viruses and protists) and fungi; invertebrates, including insects, spiders, worms; vertebrates, including amphibians, reptiles, and wild (non-domesticated) birds and mammals; wild relatives of importance to crop, animal, fish; and forest species as pests, predators, pollinators, and wild and cultivated terrestrial and aquatic plants other than crops and crop wild relatives. Estimates show that there are 1261 genera and 3325 species of invertebrate insects and a number of mushroom species, of which 110 as edible, 13 as medicinal, 45 as toxic and 6 others.

Status of Use of Biodiversity for Food and Agriculture

Both cultivated and natural habitats are home to a number of crops and animals that humans consume. The majority of our food comes from rice, wheat, maize, millet and potato. Rice occupies nearly 50% of the total cultivated land of the country and accounts for about 60% of total cereal production, 21% of agricultural GDP and 45% of food consumption. Wheat contributes about 20% in total cereal grain production and 7.14% in AGDP. Nepal also exports fresh vegetables (equivalent to NRs 2,205,176,903), fruits (NRs 4,161,032,798), coffee, tea and cardamom (NRs 6,985,985,053), oilseeds (NRs 1,624,086,225) and cereals (NRs 19,555,207). Livestock is an important source of meat, milk, fertilizer, fuel and traction. It is also an important source of economy in smallholder farmers and contributes about 14% of total protein requirement, 11.5% of total national GDP and 26.8% of the national agricultural GDP, which is more GDP than fishery and agricultural cash crop combined. In other words, livestock is an asset used as emergency capital and live cash, provide nutrition (milk, meat and eggs), soil nutrients (manure, urine and decaying carcasses), energy (draught power, transportation and fuel), animal fiber (wool, pashmina and hair), and carcass by-products (bone, hide and skin). Fish accounts for 1.7% of total protein supply, employs 700 thousand people (53 per cent women) and contributes US$ 154 million (>1.32% GDP) of total national income. There are at least 13 ethnic communities

representing about 10.8% of total population directly or indirectly depending on aquatic biodiversity in Nepal. The demand for aquaculture and fisheries will reach around 3,64,000 metric tons by 2032 (94% from aquaculture and rest from capture fisheries), which is a dramatic increase from 46,000 metric tons in 2008.

Forests represent an important repository of food and other resources that play a key role in contributing towards food security. Nepal is rich in forest genetic resources, which constitute a rich source of food, nutrition, herbs, spices, timber, fuel wood, fodder, green manure, pesticides, and several other sources of livelihoods and wellbeing. In addition to wild habitats, edible plant and animal species are also collected from wetlands, cultivated land and their surrounding areas. Rural people in Nepal use at least 1,463 species of herbal medicinal plants. The rich diversity of plants and animals that exists in wetlands provides a wide range of goods and services as well as income generating opportunities for the local people, mostly ethnic groups and tribal population. Microorganisms play an important role in maintenance of plant systems in nature as symbionts, pathogens, protectants, nutrient scavengers, and as associative members of the root zone that is central to establishment of species. Microorganism, a component of associated biodiversity also plays valuable role in nutrient cycling, soil formation, and pest management. These services are the backbone of increasing crop production and productivity.

Threats of Biodiversity for Food and Agriculture and its Drivers

Despite their high economic, social and ecological significance, all kinds of biodiversity for food and agriculture are threatened. Several of losses of biodiversity for food and agriculture are irrefutable and irreversible, with serious negative consequences on environment and livelihoods of people. Various underlying factors and proximate causes are responsible for the loss. The key underlying factors include the weak policy and regulatory framework, poor implementation and monitoring of existing policies, poor institutional set up to support implementation, lack of infrastructure, and inadequate trained human resources for policy formulation and implementation. This applies for almost all kinds of biodiversity for food and agriculture. NBSAP (2014) identified demographic changes, poverty, weak enforcement of the law, poor incentives for conservation, ignorance to biodiversity values in government and corporate accounting systems, unclear administrative jurisdictions, inadequate awareness and motivation to conserve biodiversity, and lack of an integrated approach to development planning at the national and district levels are major drivers.

A number of proximate causes directly or indirectly contribute to biodiversity loss. A large number of plant species and varieties are eroding from their habitats or growing environments. Chaudhary et al (2004) have examined how local rice varieties are being replaced by modern varieties on farm and what fate the remaining varieties have in the future. Rather than trying out our own locally evolved crop varieties, scientists have been relying heavily on foreign materials for breeding purpose as well. Rapid introduction of modern and hybrid varieties, indiscriminate use of insecticides and pesticides, commercialization, social changes, land use change, climate change, and natural disasters constitute major drivers of biodiversity loss. Local varieties are replaced by modern varieties mainly because the locals are not grown at scale and do not receive demand in market. Except few fine grain and aromatic varieties, all local varieties receive fewer prices than modern varieties due to scale.

Livestock and fishes are also under tremendous pressure when their survival in concerned. A large number of locally thrived livestock breeds are also becoming extinct or their number is gradually becoming smaller and smaller in most of the regions. Among the known species of domestic animals, pure *siri* cattle have become extinct, bampudke pig (*Sus scrofa*) is under threat of extinction, and Achhami cattle (*Bos indicus*) and lampuchhre sheep (*Ovis aries*) are near endangered. Very limited updated information exists regarding the country's genetic diversity. Increasing stall-feeding supplemented with feed supply, emergence of new diseases and parasites, and poor cattle shed management is thwarting livestock productivity. Pollution, overexploitation of grazing land, poor technologies, lack of proper structural breeding program, high disease incidence, lack of human resource, pollution and external inputs, change in international trade in animal products, change in lifestyle of people, change in gender role, erosion of traditional knowledge, change in water and land use, and climate change are also responsible for poor growth and development of AnGR in the country. Breeding programs also fail to make steady progress in developing new, more productive, insect and disease pest resistant, climate resilient, and locally preferred livestock species. Livestock suffers from increasing invasion of invasive species in forage and pasture (eg *Chromolaena odorata, Argemona maxicana, Parthenium hysterophorus, lantana camara, Mikania micaranth,* etc), lack of interest in local species.

Fishes are not free from risks associated with extinction. Well-known local fish species such as Sahar, Asala, Masheer, Bam, Hile machha, shrimp, crab, are highly threatened due to damming. Several of them are also becoming extinct from lakes, fresh water ecosystem, reservoirs, and other types of wetlands. Although there is a tremendous opportunity for increasing fish productivity by raising fish in cages, reservoirs, swamps, and natural lakes, adequate attention is not given to this. There are over 6,000 rivers presenting an opportunity to raise freshwater fish or collect water for aquaculture, but very little effort has been done so far. In addition, most of aquaculture activities are concentrated in the Terai region (90%) and mainly in earthen ponds (95%). The drivers of change in aquatic biodiversity for food and agriculture are mostly known to be several factors such as anthropogenic activities including damming, mining, diversion of rivers, road construction, urbanization, over fishing in lakes and rivers, poor law enforcement, lack of monitoring, sand removal from the rivers, encroachment of wetlands, agricultural runoff etc. Other causes include water and environmental pollution, drying up of wetland, and flood plains encroachment for agriculture and settlements, and increased use of seed, feed and fertilizers leading to eutrophication. The hydropower and irrigation development activities mostly ignore the aquatic habitats and organisms there in, while in southern sub-tropical areas rampant draining of wetland for various agricultural purpose, encroachment, over exploitation, use of agricultural pesticides have impact negatively on freshwater fish and aquatic organisms. Invasion of water hyacinth (*Eichhornia crassipes*) is also a major threat to tropical and sub-tropical wetlands.

Forest biodiversity and associated biodiversity are also going through similar turmoil, as they are not immune to extinction. Together with deforestation and forest degradation, habitats of a large number of wild animals and associated biodiversity are destroyed. Rangeland biodiversity is threatened, among others, by overgrazing and shrinkage of grassland habitats due to intrusion of woody species. Uncontrolled forest fires and destructive fishing are some other important threats. Loss, degradation and alteration of natural habitats, such as forests, grasslands, and wetlands; loss and degradation of

natural habitats caused by agricultural expansion, unplanned settlement, and road construction; overexploitation of forest resources for fuel wood, timber and NTFPs; invasion by alien species; pollution of water bodies; and natural disasters and climate change remain the predominant threats to forests and natural ecosystems. Natural disasters, such as landslides, glacial lake outburst floods and drought, as well as climate change are other common problems threatening biodiversity.

Initiatives Taken to Conserve and Manage Biodiversity for Food and Agriculture

Several affirmative steps have been taken to conserve, manage and utilize biological diversity of the country. A number of policies have been formulated in different sectors that contribute to conservation of biological diversity, yet they are poorly translated into action. Even if the policies are implemented, there has been poor follow up, monitoring and consequent revisions. For instance, Land Use Policy 2012, Environment Protection Act 1997, Rangeland policy 2012, National Biodiversity Strategy and Action Plan 2014 (NBSAP), and National Strategic Framework for Nature Conservation for Sustainable Development have a mention of either conservation, sustainable management or use of biodiversity. Key institutions involved in research, education and extension of biodiversity related materials and information on biodiversity include: National Agriculture Genetic Resource Centre (NAGRC or genebank), commodity research programs, disciplinary divisions, regional and area specific research stations of NARC, Nepal, Nepal Academy of Science and Technology (NAST), Department of Botany and Institute of Agriculture and Animal Sciences, Tribhuvan University, Agriculture and Forest University, Himalayan College of Agriculture, Science and Technology (HICAST). Major I/NGOs include Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Centre for Agriculture, Policy Research, Extension, Environment and Development (CEAPRED), Forum for Rural Welfare and Agrarian Reform and Development (FORWARD), World Wildlife Forum (WWF), International Center for Integrated Mountain Development (ICIMOD).

Major crop genetic resource related policies include: Agrobiodiversity Policy 2007 revised in 2014, National Biodiversity Strategy and Action Plan 2014, National Agricultural Policy 2004, Agricultural Development Strategy 2015, National Seed Vision 2013-25, Seed Policy 1999 and Seed Act 1988 amended 2008, Rangeland Policy 2013, Biotechnology Policy 2005, Agribusiness Policy 2006, Fertilizer Policy 2002, Plant Protection Act 2007 and Plant Protection Rules 2010. A national genebank has been established to conserve PGR, which also collaborates with NGOs and Community Seed Banks (CSBs) to exchange PGR and document knowledge. Major policies in AnGR include Rangeland Policy (2012), Poultry Husbandry Policy (2011), Dairy Development Policy (2007), Livestock Breeding Policy (2012): Draft, Livestock Husbandry Policy (2012): Draft, Animal Health and Livestock Services Act (1999), Livestock Slaughter House and Meat Inspection Act (1999), and Nepal Veterinary Council Act (2007). Integrated Plant Nutrient Management (IPNM); Integrated Pest Management (IPM); pollination management; community-based biodiversity management, community seed bank, landscape management; sustainable soil management practices; conservation agriculture; water management practices; water harvesting; agroforestry; organic agriculture; low external input agriculture; home gardens; climate smart agriculture are some initiatives taken in crop-based biodiversity conservation.

Several initiatives have been taken in conservation and management of AnGR. For diversification of animal genetic resources, investment is made for developing breeding strategy and support services,

such as collection of semen and artificial insemination (AI), embryo transfer (ET) and initiation in establishment of gene bank, as well as selection and performance recording system in cattle, buffalo and goat. In-situ conservation of indigenous breeds of livestock and poultry, community participatory program for conservation and utilization of indigenous animal genetic resources, and domestication of wild pigs, wild quails and wild fowls, cattle shed improvement, health camps, and market value chain are other initiatives taken by government. Efforts are made to protect endangered breeds like Lulu and Achhami cattle, Lime and Parkote buffalo, Lampuchchhre sheep, Hurrah and Bampudke pigs, Sakini, Ghanti Khuile and Pwankh ulte (Dumse) chicken and Yak and Chauri. Support services including vaccination, drenching, shed improvement are being provided to the farmers involved in in-situ conservation of *Achhami* and *Lulu* cattle, *Gaddi*, *Lime* and *Parkote* buffalo, *Lampuchhre* sheep under Department of Livestock Services/Directorate of Livestock Production/ District Livestock Service Office. Major policies related to AnGR include Rangeland Policy (2012), Poultry Husbandry Policy (2011), Dairy Development Policy (2007), Livestock Breeding Policy (2012): Draft, Livestock Husbandry Policy (2012): Draft, Animal Health and Livestock Services Act (1999), Livestock Slaughter House and Meat Inspection Act (1999), Nepal Veterinary Council Act (2007), National Agricultural Policy (2004), and Agriculture Development Strategy (2015).

Initiatives have also been make to protect important habitats of selected fish species. Lake Rara, a conserved area (National Park) is a habitat for three of endemic fish species (Terashima 1984) and other flora and fauna. Similarly in-situ conservation of Mahseer (*Tor putitora*) has been initiated in Lake Phewa that involves rearing of Mahseer broods in ponds, breeding, rearing of fry and releasing into the lake. Later the Mahseer are protected in the lake, as a result large population could be seen close to the Barahi Temple of Lake Phewa, where close to the temple Fisheries Research Station, Pokhara, has banned fishing. More than 50% of fish raising farmers are women. Associate biodiversity has received less attention than other biodiversity, mainly because their economic and ecological values are poorly understood and facts about such biodiversity has not been well documented, resulting in poor level of awareness of their importance in food security, nutrition, health, and economic security. However, different policies provide opportunity for conservation and promotion of such biodiversity.

For forestry sector, a large number of forest, conservation, wildlife and national park related policies, laws and acts have been developed and implemented. Among all biodiversity, conservation of forest diversity perhaps receives greatest attention and resource for conservation, management and promotion. Among all policies, acts and regulations, Forest Act 1993 amended 2016, Forest Regulation (1995) amended 2015 and National Parks and Wildlife Conservation (NPWC) Act 1973 are noteworthy. Article 23 of the Forest Act has a provision for designating and managing protected forest. The NPWC Act has a provision of declaring any forest area as a protected area if the area is ecologically important in terms of flora and fauna. Community Forestry User's Groups (CFUGs) also prepare their operational plans and implement them for the benefit of forest users as well as for the forests and associated ecology and environment.

Future agenda for conservation, management and use of biodiversity

It is imperative to review certain policies and make revision if that contradicts with others. Secondly, there has to be constant follow up on whether policies are implemented and producing intended benefits to people and to revise existing policies, if necessary. It is also important to foster collaboration between policies to ensure they complement each other rather than becoming redundant. More concerted, coordinated and collaborative efforts are needed, where multi-disciplinary and multi-institutional teams collectively work and support each other. More investment is required in research and extension and proper monitoring and follow up of actions is needed to ensure policies are translated into action and actions are delivered effectively in timely manner. Institutional capacity building is another area where government needs to pay attention to. It is also important to document biodiversity and their dynamics over time to support future planning, policy formulation, action setting and budget allocation. Traditional knowledge of capturing, holding, handling, preservation, smoking, storing, identification of breeding flocks, migration trend, collection of spawn, use of natural plant toxin for fish etc need to be documented.

Specifically, crop varieties giving higher yields and having ability to withstand new diseases and extreme weather events need to be developed. To develop a new variety, breeders may have to screen thousands of samples including local germplasms in search of a particular trait, and engage farmers to identify gap and needs. Plant genetic resources that are conserved in the genebank can be used for future use in breeding, improving direct use for agricultural production, conservation of diversity in environment, scientific use for experimental materials, genetic enhancement (pre-breeding) and as breeding materials for fostering sustainable agricultural development. Investment needs to be made to promote use of specific fish for specific medicinal purpose, use of milt to control skin disease, increasing awareness on medicinal and nutritional values of fish products and dried fish. Adoption of less damaging damming techniques, conservation of wetlands and other water sources, breeding program of native fishes to produce fingerlings, laboratory facilities to identify new diseases and treating them, value addition of fish and introduction of associated technologies, technical support to fish rearing farmers are some necessary steps forward for conserving and promoting fish population.

In forestry sector, investment is necessary mainly in the following actions: restoring degradation of grazing lands; introduction of new technologies for breeding and livestock management; identification and scaling up of climate change adaptation techniques; facilitation in changing cultural roles of livestock; policy in light of changing gender roles and rights; investment in structured breeding programs and treating emerging animal diseases; producing trained manpower and human resource; systematizing water and land use management; controlling pollution and external inputs, overexploitation and over harvesting; increasing demand for livestock products; changing international trade in animal products; and most importantly minimizing human-wildlife conflict. Proper delineation of protected areas needs to be done mainly to ensure most of important species, ecosystems, and climatic zones are covered in one or more protected areas. Associated biodiversity should also receive priority while formulating policies, plans, strategies, and delivery mechanisms of planned actions. Proper link of our interventions has to be made with Aichi Biodiversity Targets, relevant Sustainable Development Goals, Access to Benefit Sharing (ABS), and various national level policies.

The able-bodied youth of the country should be attracted towards conservation, promotion and marketing of biodiversity for food and agriculture by making such businesses more profitable and awarding. Collaboration needs to be done with universities for teaching and producing human resources. For extension and scaling up of good practices, collaboration among government organization, NGOs, private organizations, academic institutions, farmers' cooperatives and other relevant actors is necessary at local, regional and national levels. Collaborative research is also necessary that brings together government, non-government, academic, private organizations and beneficiaries, and thus the delivery is more effective and its impact is long lasting.

Chapter I. Crop Biodiversity in Nepal

Bal K. Joshi and Devendra Gauchan

Introduction to the Role of Crop Biodiversity for Food and Agriculture

Nepal is rich in agro-biodiversity and national economy is based on the goods and services derived from these resources. Diverse agro-climatic environments with complex and varied farming systems, a broad mixture of ethnicity and races, varied socioeconomic settings, big differences in altitude and complex topography are the factors to create an array of micro-niches supportinghuge agricultural diversity in the country. Three physiographic zones of Nepal (**Figure** 1), Tarai, Hill (Mid Hill) and Mountain (High Hill) experience a wide range of climate from sub tropical to temperate and alpine cold semi desert. Prevalence of six seasons in Nepal indicates the unique climatic variation.

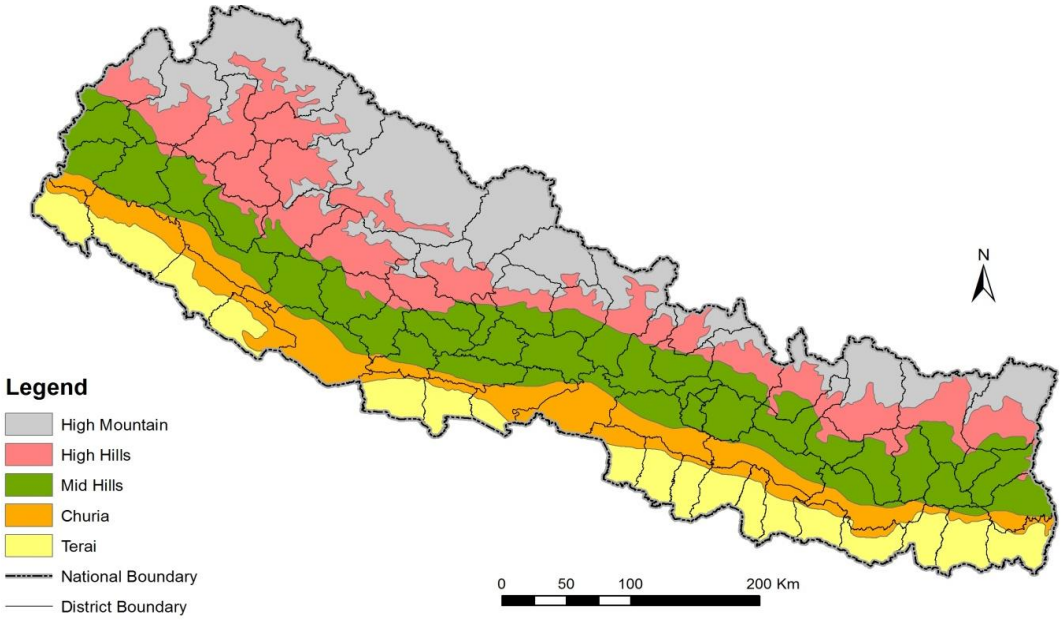

Figure 1 Physiographic zones of Nepal.
Source: S Lamichhane, SSD, NARC; Data from Department of Survey 1996.

Crop genetic resources are the raw materials for genetic improvement by plant breeders and farmers. Their availability is a fundamental requirement for further increasing productivity and nutritional values through plant breeding. To develop a new variety, breeders may have to screen thousands of samples in search of a particular trait. Plant genetic resources that are conserved in the genebank can be used for safe conservation for future use, direct use for agricultural production, conservation of diversity in environment, scientific use for experimental materials, genetic enhancement (pre-breeding) and breeding materials for the sustainable agricultural development.

About 21% (3.2 million hectares) of the total land area of Nepal is used for cultivation and the principal crops are rice (45%), maize (20%), wheat (18%),millet (5%) and potatoes (3%), followed by sugarcane, jute, cotton, tea, barley, legumes, vegetables and fruits. Production systems in the country are subtropics, temperate, boreal and highlands with irrigated and rainfed lands. Crops such as rice, rice bean, eggplant, buckwheat, soybean, foxtail millet, citrus, and mango have high genetic diversity relative to other food crops. Production of major food crops such as rice, maize and wheat has more than doubled since 1970. The role of PGRFA for minimizing food deficiency through increased productivity is significant. There is an increasing interest in neglected and underutilized crop species for export and domestic markets. Interest in neglected and underutilized crop species stems from a variety of factors, including their contribution to agricultural diversification, suitability in adverse climate, and better use of land.

Rice is the principle crop of Nepal because it occupies nearly 50% of the total cultivated land. It contributes about 60% to total cereal production and 21% in Agriculture GDP (MoAD 2014). About 45% food consumption is made of this crop. Maize stands in the second among the cereals and the fourth among the individual crops in terms of contribution to AGDP. Its contribution to AGDP is about 6.9%. It

is the most important crop in terms of area and production for the hills. Seventy percent of maize is produced in the mid-hills region, eight percent in the high hill and 22% in Tarai. Maize is the major cereal crop in the rainfed area which comprises 71% of the cultivated land. Wheat is the main winter and the third major crop. It contributes about 20% in total cereal grain production and 7.14% in AGDP. Millet is an important cereal crop in the hills particularly of poor farm families who generally own relatively less fertile marginal lands.

Agriculture faces a tremendous challenge of feeding some 26.5 million people and of being instrumental to their prosperity. It is still an important sector of the economy while its position in terms of providing livelihoods to the great majority of the population has changed little over the years. The country heavily relies on domestic production of crop or plant products. Total edible food production in the country is 6,085,776 t with requirement of 5,295,886 t shows the balance of 789,890 t food. Despite positive food balance in the country, 30 of the 75 districts (10 mountains,13 hills and 7 Tarai districts) often remain food deficit. The deficit is met through imports mainly from India. In addition, agricultural commodities or products are also exported and imported from overseas. Major export commodities are fresh vegetables (NRs 2,205,176,903), fruits (NRs 4,161,032,798), coffee, tea and cardamom (NRs 6,985,985,053), oilseeds (NRs 1,624,086,225) and cereals (NRs 19,555,207).

The State of Use of Crop Biodiversity

The uses of biodiversity includes the direct use of genetic resources from different sectors or of associated biodiversity and wild foods, individually or in combination; the indirect use through the provision of supporting and regulating ecosystem services; the support for land/water restoration or other land/water management objectives; the support of cultural ecosystem services including use for cultural, amenity or social reasons and use in education or scientific research.

Nepal heavily relies (about 95-100% depending on crops) on foreign crop genetic resources (Joshi et al 2016a) mostly for developing new varieties in rice, maize, wheat, potato, legumes, oilseeds, fruits and vegetables. There are significant contributions of introduced crop genetic resources on increasing productivity, securing food and nutrition, and diversifying agricultural produces. Introduction and diversity exchange programs have provided option to select the genotypes for cultivation in different environments.

Many management practices have been adopted in Nepal that support maintenance and increment on crop diversity. They are Integrated Plant Nutrient Management (IPNM); Integrated Pest Management (IPM); pollination management; landscape management; sustainable soil management practices; conservation agriculture; water management practices; water harvesting; agroforestry; organic agriculture; low external input agriculture; home gardens; areas designated by virtue of production features and approaches; reduced-impact logging. However, actual areas covered by these practices under different production systems have not been recorded. These practices are adopted more in Mid Hill. It has been reported that there are increasing trend on adoption of IPNM, IPM, landscape management, sustainable soil management practices, conservation agriculture, water management practices, water harvesting, agroforestry, organic agriculture, low external input agriculture and home gardens in all production systems. Actual figures are lacking on change of crop diversity due to promotion of these practices. General observation is that these practices have contributed to increase crop biodiversity.

Diversity based practices that involve the enhanced use of biodiversity for food and agriculture are diversification; base broadening; domestication; maintenance or conservation of landscape complexity; restoration practices; management of micro-organisms; polyculture/aquaponics; Swidden agriculture or shifting cultivation; and enriched forests. Swidden agriculture or shifting cultivation is very common in Eastern and central Hills of Nepal and this practice has negative impact on some types of biodiversity due to burning of forests. It has been reported that there are increasing trend of diversification, base broadening and enriching of ecosystems in all production systems.

Major practices that negatively impact crop biodiversity and/or wild foods in the country are over-use of artificial fertilizers or external inputs; over-use of chemical control mechanisms (eg disease control agents, pesticides, herbicides, etc); inappropriate water management; practices leading to soil and water degradation; over-grazing; uncontrolled forest clearing; fishing in protected areas, and overharvesting.

Some of the activities undertaken to strengthen the contribution of crop biodiversity are diversity fair and minikit distribution; incentives to progressive farmers by providing training, inputs, seeds etc; value addition through non-breeding approaches as well as breeding approaches; free distribution of planting materials to farmers; creating favorable policy environment for exchange of genetic resources inside and outside the country; creating market for diverse agriculture produces; training and workshop. More than 100 different organizations including both governmental and non-governmental are involved inpromotion of crop diversity for the improvement of farmers' livelihood.

Contributions of each management practice have not been well documented. There are needs of strengthening management practices so that farmers can follow them easily for their livelihood improvement. Awareness program should be widely implemented providing some evidences. Due to the diversity in climate, geography, cultural practices and farming communities, different options of management practices need to be developed. There are very limited information and techniques available on sustainable use of crop biodiversity. Research is necessary on sustainable uses of crop genetic resources. Potentialities of local landraces have not been identified and researchers and extension workers focus on foreign genetic resources including modern varieties. Due to the limited coordination among relevant stakeholders, institutional framework is not strong to favor the sustainable use of crop biodiversity. Empirical evidences are required to generate widely applicable sustainable approaches in managing crop biodiversity. Contribution of crop biodiversity to improve productivity, food security and nutrition and livelihoods are well known. However, quantifiable data are not available on these aspects. Very limited information on ecosystem services, resilience and sustainability demands to works more on. Adoption of ecosystem approaches is still poor in Nepal. Landscape approaches have been adopted in some extent.

The State and Trends of Crop Biodiversity

Nepal is mountainous agricultural country, where crop cultivation ranges from 60 m (in Kechana Kalan, Jhapa where rice is grown) to 4700 m (in Khumbu, Solukhumbu where potato is grown) altitude. Rice is grown at an altitude of 3050 m in Chhumjul, Jumla, which is the highest elevation of rice growing areas in the world. In terms of biodiversity, she is at 31st position at global level and 10th position in Asia (MoFSC 2014). Nepal represents 3.2% of global angiosperm and flora diversity. Main four components of

agro-biodiversity are plant and crop genetic resources, animal genetic resources, aqua genetic resources and associated genetic resources. For each component, there are four sub-components ie domesticated, semi-domesticated, wild edible and wild relative species.

Indicators of biodiversity focusing on agro-biodiversity are given in **Figure** 2. There are 6973 flowering plant species, 790 food value plant species and 577 cultivated plant species including forage species. Eight agro-ecosystems available in the country are rainfed high hill, rainfed mid hill, rainfed Tarai, irrigated high hill, irrigated mid hill, irrigated Tarai, wetland agriculture and rangeland agriculture. Among 577 cultivated species; 484 species are indigenous and 93 are introduced species including forage species (**Figure** 3). About 224 wild species are closely related to crops (called crop wild relatives). Three broad groups of agricultural plant genetic resources (APGRs) are agronomic crops, horticultural crops and forages and number of known species under these groups are 64, 145 and 275 respectively (**Figure** 4). The highest numbers of species constitute tree forages followed by grass forages and spices. The numbers of species under different economic crop groups are given in **Figure** 4.

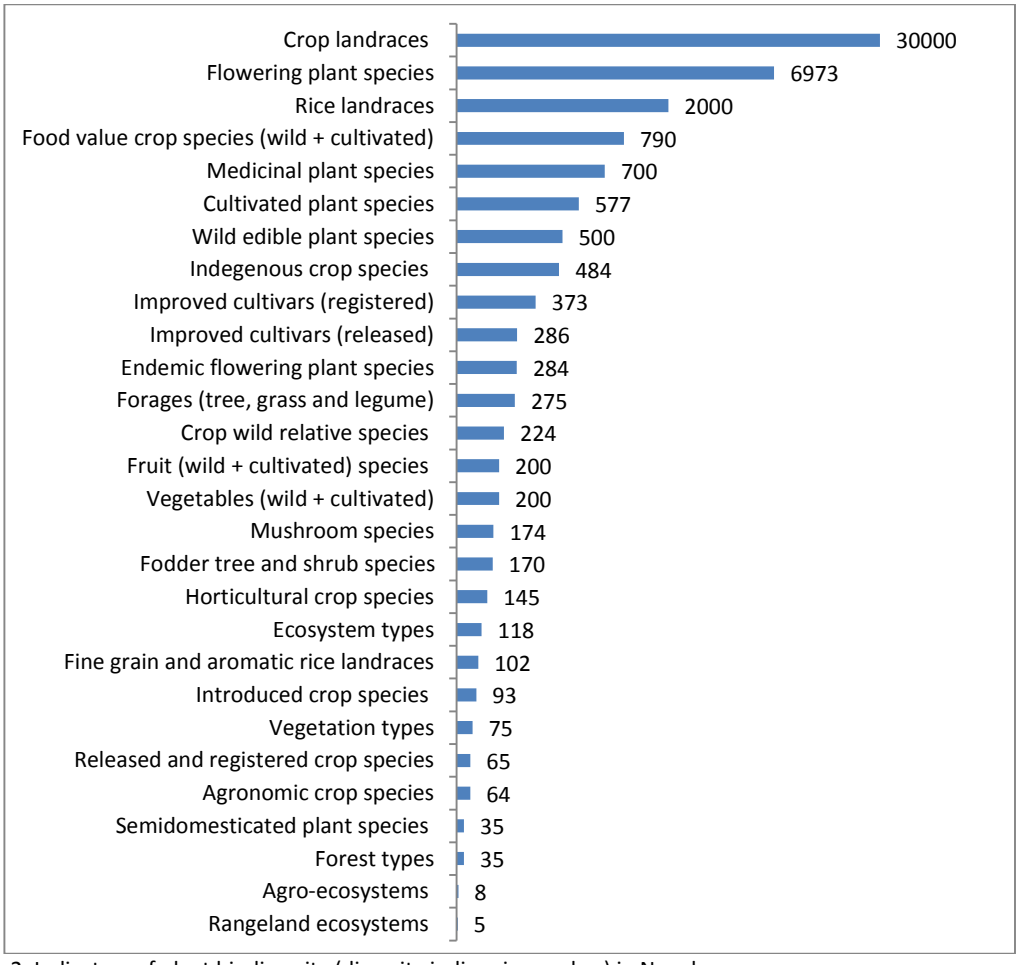

Figure 2. Indicators of plant biodiversity (diversity indices in number) in Nepal.
Adopted from Joshi 2017a.

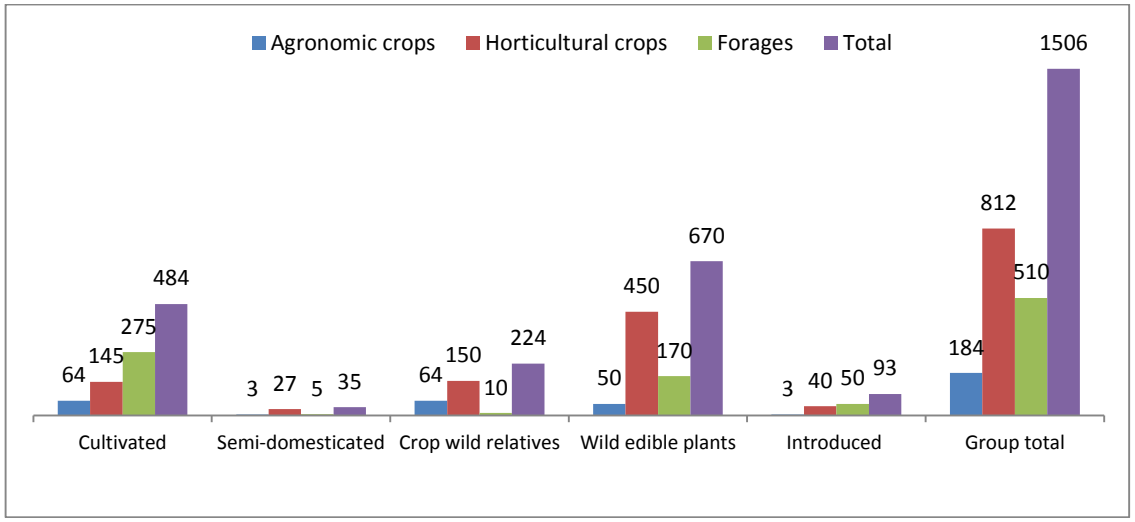

Figure 3. Number of crop species under different groups (wild edible plants also include 170 wild forage species and ornamental plants are not included).
Adopted from Joshi 2017a.

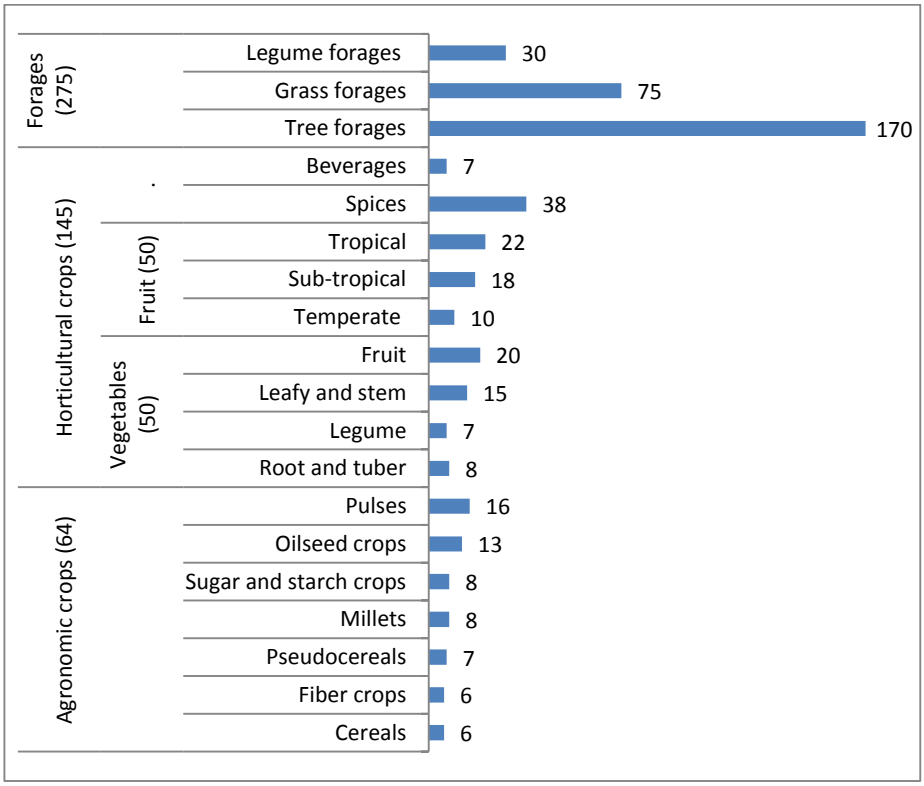

Figure 4. Number of available species under different groups of crops in Nepal (excluding ornamental plant species).
Adopted from Joshi 2017a.

Some of unique crop landraces are Gamadi rice, Anati, Ghayia Dhan, Mansara, Bhati, Samundaphinj, Pakhe masino, Radha-4, Taichung, Lahure Sahila, Goi Sahila, Makar Kandhu, Ekle rice, Chhommrong, Jumli Marshi, Amaghauj, Lekali Panheli, Mudule Dabad khani, Pauder local, Dailekh local, Jire, Ranga/ akabare, Gorlikhorka, etc (Joshi 2017c).

Genebank is conserving landraces, modern varieties, obsolete varieties, breeding lines (including recombinant inbred lines, near isogenic lines, differential lines), genetic stocks, exotic genetic resources, wild and wild relatives, wild edible plants. It has adopted three conservation strategies (namely ex-situ, on-farm and in-situ), which are only possible in collaboration with all stakeholders for exploration and collection, regeneration, multiplication, characterization and evaluation, pre-breeding, utilization and safety duplication. To effectively conserve, manage and utilize maximum diversity as much as possible, Genebank has established five banks, namely, Seed Bank, Field Genebank, Tissue Bank, DNA Bank and Community Seed Bank and Community Field Genebank (Joshi et al 2016b). Other supplementary mechanisms for conserving agro-biodiversity in Nepal are i. Ritual practices of Hindu (Rudraksha, Tulsi, Jai), ii. Culturally protected areas (Temple, and other religious places), iii. Government's protected areas, iv. National, leasehold, community and private forests, v. Rangeland and wetland management system, vi. Farmers seed network system and vii. Protection of some plant species.

Initially IBPGR (IPGRI) and IRRI were involved to collect the germplasm of different cultivated crops and their wild relatives. Later on, Japan provided support for plant exploration. In addition to the international exploration missions, NARC also regularly has collected crop plant genetic resources since 1986. NAGRC has started the collection mission of PGRFA since 2010, and until 2015, it has collected more than 7,299 accessions of 52 crops from 62 districts out of 75.

Traditional knowledge has been used for conservation and utilization of crop genetic resources in the country (Upadhyay and Joshi 2003). Religious places have been considered for conservation of crop and crop wild relatives. There are many cultural and religious norms that support to conserve crop genetic resources. Collection times, harvesting methods, storages techniques, sowing method and date, propagating techniques are some of the activities that largely depend on traditional knowledge.

Modernization and commercialization in agriculture have led to gradual disappearance of traditional agriculture genetic resources and indigenous knowledge, skills and technologies. The nation is now experiencing the effects of ecosystem and diversity decline along with detrimental effects of climate change. According to FAO, more than 75% of global crop diversity has disappeared irrevocably over the 20th century (1900 to 2000) (FAO 2010). About 50% of local landraces of important crop species have been lost from Nepal. One of the most important reason for the loss of traditional seeds, and thereby the loss of genetic diversity, is the replacement of genetically diverse farmers' varieties with modern varieties. A large number of wild relatives of important food crops are also likely to disappear over the next decades due to climate change and modernization.

Crop genetic resources have been eroding from most of the production system. Relatively diversity is decreasing more rapidly in Tarai area than Mid and High Hills. This is mainly because of availability of improved varieties and market oriented agriculture in the Tarai area. Among the five components of crop biodiversity (cereals; vegetables and fruits; oilseeds and pulses; fiber, spices and beverages; and fodder and pasture) are more affected and many local landraces of this component have been lost.

Regulating and supporting ecosystem services within production systems have not been documented well in Nepal. In most of the production systems, regulating and supporting ecosystem services have been decreasing and degrading. Due to the cultivation of more types of crops in rainfed areas coupled with application of chemical fertilizer and pesticides increase in pollination levels have been noticed in rainfed crops production system. Many farmers and consumers are aware of the importance of healthy production system and in some places there are increasing trend on minimizing the pesticides and chemical fertilizers. This helps to minimize the hazard resulted in the increasing role of production system in natural hazard regulation. There are no any crop species that are in some way managed in a way to help improve regulating or supporting ecosystem services. Many species of crop biodiversity are at risk of loss.

Earthquake and river obstruction are the major natural disaster that affect greatly on human lives and agro-biodiversity. River obstruction in Sunkoshi and Kali Gandaki covered many cultivated land and household by water for a number of days. Later, flooding had swept away crop species and planting materials stored in the house. This resulted in the loss of locally adapted crop landraces. Actual numbers of genotypes lost from these disasters were not recorded. Earthquake in 2015 is the major disaster that damaged a large chunk of local crop diversity in many locations. Many farmers in earthquake-affected areas could not save seeds of number of crop species.

There are many invasive alien species that have significant effects on crop biodiversity. Many agriculturists have observed significant loss on crop biodiversity due to new weeds. Their effects are also experienced in different ecosystem services. Due to poor seed quality control system in the country, spreading of invasive species has been enhanced even through formal seed system. Many of these species were introduced through formal research system. Many farmers and researchers have tried to find out the value of using these species and control measures.

There is lack of information on list of total species of crop available in the country and their trend on changes on diversity. Intra species diversity needs to be documented. There are many local landraces with same local name and same landraces with different local name. There are many gaps on ecosystem services. Traditional knowledge is also not well recognized and documented especially on underutilized crops and wild food plants. Information is widely scattered and most of the information is not digitized and not available on-line.

Both financial and technical staffs are very limited. Many species and sub species could not be identified due to paucity of taxonomist. Variation at genetic levels, and that too of associated biodiversity, are least studied. Changes of responsibilities also limit the progress on conservation and utilization of crop genetic resources. The Agro-biodiversity Policy (2007) does not cover wild edible plants and crop wild relatives. There is a need of agro-biodiversity conservation and utilization act and regulation. Weak implementation of policy, action plan and strategy has resulted in the poor management of agricultural plant genetic resources. Due to lack of coordination, poor institutional linkages, and limited communication among sectors have constrained systematized collaboration.

Database of crop biodiversity including crop wild relatives and wild food plants need to be well prepared. Identification of genotypes, diversity mapping, use of GIS+CAT and biotechnological tools are the major areas that need to be considered for effective and efficient conservation and utilization of

agricultural plant genetic resources. Research on landraces should be systematized and extensive research on local genepools needs to be strengthened. Potentiality of crop landraces needs to be explored to help accelerate the breeding program. Field Genebank should be established across the country in agriculture research stations, agricultural farms, communities and school areas. Clear strategies and action plans need to be developed for on-farm, in-situ and ex-situ conservation.

Drivers of Change in Crop Biodiversity

Agro-biodiversity is under threat due to use of high yielding varieties, destruction of natural habitat, overgrazing, land fragmentation, and commercialization of agriculture and the extension of modern high-yielding varieties, indiscriminate use of pesticides, population growth and urbanization, and changes in farmer's priorities (MoFSC 2002). The most important drivers in the last 10 years are the commercialization of agriculture, weak policy and regulatory framework, climate change, population growth and technological advancements (Ghale 1999, Shrestha and Shrestha 1999). These drivers are further elaborated below.

Commercialization of agriculture

It promotes monoculture which is said to be one of the main causes of genetic erosion as it replaces local and diverse landraces (Shrestha and Shrestha 1999). Out of 1800 indigenous and wild species of rice, only one variety is popularly cultivated in Tarai or irrigated subtropics production system (Shrestha and Upadhyay 1999). Hybrid and cross-bred varieties are promoted by agriculture policies and the international agricultural trade arrangements of transnational and multinational organizations (Ghale 1999, Timsina 2000). The increment on use of hybrid seed in tomato has been 620% in tomato, 123% in cauliflower, 260% in carrot, 447% in brinjal, 146% in okra and 100% in cabbage.

Weak policy and regulatory framework

Due to the conflict in economic development and conservation, conservation aspects are getting less attention in policies. The expansion of tourism sites in areas with rich diversity is contributing to the loss of biodiversity (Shrestha and Shrestha 1999). Nepal's Seed Act does not give due importance to the informal or farmers-to-farmers seed management system (Timisina 2000) that accounts formore than 90% of the seed flow. The agriculture policy of the country is more inclined towards monoculture and promotion of improved crops varieties with the aim to increase production and productivity, thus contradicts with the conservation policies and neglects the maintenance of varietal diversity on-farm.

Climate change

Irregular and unpredictable rainfall, prolonged high-intensity air temperature, short and warm winter with insufficient post-monsoon rainfall, and seasonal changes in rainfall patterns are common effects of climate change. There have already been alarming signs of sharp and sustained decline in food crops in Nepal; for instance, winter food crop harvests for 2009 in all regions have declined sharply. Outbreaks and extension of minor diseases, pests and unwanted weeds constitute major problems. Increase in temperature and CO_2 has led to increase in population of pests and severity of diseases in presence of host plant. In practice, since agricultural crops and varieties are selected for specific environments (soil, temperature, humidity, sunshine period and water/irrigation, rainfall regimes) then the diversity is likely to be significantly affected by climate change.

The GCM projections indicate a potential increase in temperature across Nepal of 0.5-2.0°C with a multimodal mean of 1.4°C by the 2030s and 3.0-6.3°C with a multimodal mean of 4.7°C by the 2090s (NCVST 2009). For precipitation, GCMs project a wide range of changes, especially in monsoon, -14 to 40% by the 2030s and -52 to +135% by the 2090s (NCVST 2009). This projection suggests that Nepal's agriculture will face many challenges over the coming decades due to climate related variability. Existing problems such as soil degradation and increasingly limited water resources are likely to be exacerbated by climate change. Shifting of climatic zones has been observed in the country. Extinction of local crops such as local basmati rice, some local wheat, maize and other agricultural crops was also observed (Joshi 2017b).

The observed extreme severe weather events between 2006 and 2009 including droughts and floods have significantly affected food production in Nepal (WFP 2009). However, the combined effects of increasing CO_2 levels, rising temperatures and changing moisture availability are likely to be complex and are still largely uncertain. Rice yields might increase under elevated CO_2 and 4°C increase in the Tarai (lowland) (3.4%), hills (17.9%) and mountains (36.1%). Similarly, wheat production might increase by 41.5% in the Tarai, 24.4% in the hills and 21.2% in the mountains under elevated CO_2 but there would be a significant decrease in production with a 4°C rise. Maize yields were expected to increase in the hills and mountains, but decreased in the Tarai with 4°C rise (Malla 2008, Gautam 2008). Farmers of the Mustang and Manang districts have noticed improved apple sizes in recent years. Other farmers are able to grow cauliflower, cabbage, chili, tomato and cucumber, which used to require greenhouses in order to survive. Similarly, a farmer in the Murza VDC (village development committee) of Myagdi district in Western Nepal reported that the rice cultivation is becoming possible in higher elevation currently from 1,800 m to 2,400 m (Dahal 2006). A comparative study (Bhandari 2009) of hill and Tarai agro-ecosystems found that more households (40%) in the Tarai rather than in the hills (11.6%) reported production decreases (of 5-25%) due to abnormal rainfall which has affected the modern varieties.

Social changes, land use pattern, natural disaster

In recent decades, there is a high migration rate of people inside and outside the country due to several factors like conflict and natural disasters (push factors), as well as growing opportunity for employment (pull factor). There is a great migration rate of rural people to urban and peri-urban areas for more security, job opportunities and better livelihoods and young generations moving out–off country as well. The farmers around peri-urban areas are more profit oriented thus the traditional farming systems ie rice, maize have gradually been replaced by commercial vegetable farming which has resulted in decrease in the area under traditional crops as well as its varieties and landraces. Land abandonment in rural areas is increasing due to migration and consequent labour shortage, which in turn has contributed to a gradual decline in the diversity of local crops and landraces on-farm. For example growing finger millet is labour intensive, so nowadays farmers prefer to keep the upland fallow due to labor shortage.

Land fragmentation has resulted in low land holding of farmers which enables them to choose food crop instead of forage, which has affected the forage diversity. Natural disaster like earthquake and landslides which occurred recently have massive impact on agro-biodiversity. The actual estimation of loss is yet to be carried out but the mid hills which are rich in biodiversity are the most affected areas thus large number of invaluable agro-biodiversity and wild relatives are lost from these areas.

Population pressure

Increased population pressure, rampant poverty and environmental degradation in Nepal are posing severe threats to flora and fauna diversity (Upreti 2000). The total population of the country increased from 23 million in 2001 to 26 million in 2011 with the population density of 157 persons to 180 per square kilometer (CBS 2011). The population increment is at the rate of 1.35% (CBS 2011). Land holding is very small; person per hectare of cultivating land was 6.6 in 1991 and 0.68 ha in 2011. The fast rate of population growth has caused large pressure on existing agro-biodiversity. There is more population pressure in Tarai region than in mid hill. The rapid and unplanned urbanization, lack of appropriate land use policy and weak institutional arrangements in Tarai and mid hill areexerting enormous pressure on land which is leading to agro-biodiversity loss. The increasing pace of rural to urban migration is posing several socio-economic and conservation related threats. Rapid urbanization, expansion of feeder roads, building and industrial premises are also contributing to agro-biodiversity loss in Tarai districts like Chitwan, Banke and Kanchanpur. In several wetland areas, important habitats of indigenous crop species are degrading and species are getting lost due to conversion of land to rice fields, fish ponds, extended settlements, and due to sedimentation (Siwakoti and Tiwari 2007).

Main drivers are changes in land and water use and management, pollution and external inputs, over-exploitation and overharvesting, climate change, natural disasters, pests, diseases, alien invasive species, markets, trade and the private sector, policies, population growth and urbanization, changing economic, socio-political, and cultural factors, advancements and innovations in science and technology also affect ecosystem services (pollution, pest and disease regulation, water purification and waste treatment, natural hazard regulation, nutrient cycling, soil formation and protection, water cycling, habitat provisioning, production of oxygen /gas regulation) and survival of biological diversity.

The State of Intervention in the Conservation and Use of Crop Biodiversity

The main policies, legislation and enabling framework that support and influence conservation and sustainable use of biodiversity for food and agriculture and the provision of ecosystem services are Agrobiodiversity Policy 2007 revised in 2014, National Biodiversity Strategy and Action Plan 2014-2020, National Agricultural Policy 2004, Agricultural Development Strategy 2015, National Seed Vision 2013-25, Seed Policy 1999 and Seed Act 1988 amended 2008, Rangeland Policy 2013, Biotechnology Policy 2005, Agribusiness Policy 2006, Fertilizer Policy 2002, Plant Protection Act 2007 and Plant Protection Rules (2010**).** Some policies, legislations and enabling frameworks that enhance the application of ecosystem approach or a landscape approach and contain reference to biodiversity include Land Use Policy 2012, Environment Protection Act 1997, Rangeland policy 2012, and National Biodiversity Strategy and Action Plan 2014 (NBSAP).

Climate change policy is the only officially approved policy for adapting climatic change framework. National adaptation programme of action (NAPA), Climate Change Policy (2011) and local adaptation plan of action (LAPA) are three important policies and programs focusing on climate change adaptation at the national and local level respectively. There are no specific policies other than these that devote on climate change. There are two major broad policies that take into consideration of agro-biodiversity planning and monitoring. These include NBSAP and National Strategic Framework for Nature Conservation for Sustainable Development.

The major obstacles to achieving or enhancing the fair and equitable sharing of the benefits derived from the use of genetic resources are lack of information about the use, value and importance of genetic resources, bio-prospecting and breeding among stakeholders at large; lack of appropriate documentation and registration of resources (for example, identifying the multiple owners in different districts); limited institutional arrangements required to facilitate access, prior informed consent (PIC) as well as benefit sharing at both government and community levels; and the lack of dispute settlement mechanism at the community level. The sharing of non-monetary benefits might also contribute to confusions as it would be difficult to fairly and equitably share the benefits among the government, the authority, and the communities. The country has made initiative to draft access and benefit sharing (ABS) legislation that aims to make provision of PIC for access to its genetic resources and benefit sharing provision. But the draft ABS legislation has not yet been officially approved. Hence, practical means of implementation has not been initiated.

An enabling policy environment – especially the incentives it generates through price, credit, subsidies, technology, institutions and regulatory framework – plays a pivotal role in sustainable harnessing, value addition and conservation of PGRFA (Gauchan et al 1999). However, there are no mechanisms developed to provide incentives or benefits for the conservation of crop biodiversity. Payments for conservation of crop biodiversity, provision of subsidies or inputs to cultivation and use of traditional crops and varieties and other forms of direct incentives/benefits do not exist from the formal sector agencies.

Presently the existing linkages and collaboration between sectors in national programmes and policies is limited for conservation and sustainable use of biodiversity for food and agriculture. The linkages and flow of information among the many government ministries associated with conservation and use is often irregular and *ad hoc.* There is also a poor availability, accessibility and relevance of information flowing between the government (Ministry of Agricultural Development) and the private-l/NGO sectors, grass-root institutions and farming communities due to lack of common platforms and regular mechanisms for information sharing on issues relating to policy debates and development. There is a National Agriculture Biodiversity Conservation Committee (NABCC) at the national level responsible for coordinating stakeholders in national programme and policies related to conservation and sustainable use of agrobiodiversity. However, the committee lacks adequate resources and programme and mechanisms for linkages and collaboration in agrobiodiversity issues.

The Government has just approved NBSAP in 2014 and plan to implement Aichi targets through coordination with different ministries for the conservation and sustainable use of biodiversity for food and agriculture. But concrete programs and action plans are yet to be formulated with adequate resource allocation in agricultural sectors. Nepal is putting efforts to implement regional efforts such as SAARC Seed Bank and Food Bank but not fully being yet implemented.

A short training program (one week) is being implemented once in a year in the conservation and sustainable use of agrobiodiversity in Nepal by the Directorate of Training, Department of Agriculture since 2006 . The training is focused for the professionals employed in Department of Agriculture. There is no separate graduate and undergraduate program specifically delivering degree program in crop biodiversity. But one course within the specific subject such as agronomy, breeding and natural resource management, agrobiodiversity conservation is offered.

The major institutions that are directly involved in research on the conservation and sustainable use of crop biodiversity in Nepal are National Agriculture Genetic Resources Centre, Khumaltar, Lalitpur, National Commodity Research Programs of NARC (eg rice, wheat, maize, potato, grain legumes, oilseeds, sugarcane, tobacco, ginger), Disciplinary Divisions under NARC (Agriculture Botany, Horticulture, Biotechnology, Seed Science & Technology, Pasture and Fodder), Regional and Local Agricultural Research Stations (R/ARS) of NARC, Nepal Academy of Science and Technology (NAST), Department of Botany, Tribhuwon University Kathmandu, Institute of Agriculture and Animal Sciences, Tribhuwon University, Agriculture and Forest University, Rampur, Himalayan College of Agriculture, Science and Technology (HICAST), Kathmandu, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Centre for Agriculture, Policy Research, Extension, Environment and Development (CEAPRED), Kathmandu, and Forum for Rural Welfare and Agrarian Reform and Development (FORWARD), Chitwan.

Future Agendas for Management of Crop Biodiversity

For improving food security and nutrition

The important traits available in crop diversity shall be identified through molecular based technologies and efficiently utilized in public and private breeding programs including participatory plant breeding. PGRFA with high yielding, biotic and abiotic stresses resistance/tolerance and better nutrition traits shall be identified and used in breeding programs. A fast track breeding and seed production system shall be adopted to speed up variety release and their dissemination in the country as envisioned in National Seed Vision 2013-2015 and Agriculture Development Strategy 2015. Further the collaboration among different related institutions such as universities, government, NGOs, private breeders, organizations and social movements of small-scale producers shall be strengthened.

For improving rural livelihoods

Livelihoods of rural communities can be enhanced through the implementation of "one village, one product" as implemented by MoAD. Technology should be developed using participatory approach in rural communities and we need to diversify the products of niche specific crops and better to link the products originating from traditional and underutilized varieties and crops with local, regional, national and international markets. Models should be developed for the management of protected areas involving community participation, and implement mechanisms to share benefits in an equitable way among stakeholders.

For improving productivity

Productivity can be enhanced through strong linkages with IARCs for specific germplasm needs, molecular supported plant breeding, base broadening of indigenous/local germplasm, fast track breeding for developing crop varieties, farmer participatory plant breeding to develop location specific and farmer preferred crop varieties, strong seed production and delivery system to enhance variety and seed replacement rates, enhancing quality seed production with strong monitoring system.

For supporting ecosystem function and the provision of ecosystem services

It is essential to better understand the roles and values of diversity of plant genetic resources in terms of achieving economic, social, cultural and ecological goals. Understanding the ecological services and the diverse values of the diversity would promote the conservation and sustainable use of the valuable

plant genetic resources. Ecosystem services into different ecological niches shall be improved through crop diversification to support pollination services and resilience.

For improving the sustainability and resilience of production systems

NAPA and LAPA are being implemented by the Government of Nepal. Crop specific national research programs have breeding program to address climate change issues through the development of climate resilience crop varieties and technologies at different levels.

Future action plans

- Registration of biodiversity in all the districts covering ethnic and ecological diversity.
- Endorsement of national legislation on access of genetic resources and benefit sharing by the parliament.
- Creating a forum and/ or an institution for innovation in genetic resources and traditional knowledge.
- Capacity building through developing and teaching agrobiodiversity course in universities and schools.
- Developing and implementing farmers' field schools.
- Generating technical and financial supports.
- Providing incentives/ economic benefits to farming communities for their roles in conservation and sustainable use of PGRFA.
- Setting national priorities and action plans to support the role of farmers and preparing action plans accordingly.
- Rewarding custodian (agro-biodiversity rich) farmers for their conservation efforts.
- Development of regional/global partnership for on-farm conservation and sustainable use of PGRFA.
- Organizing diversity fairs at community levels and establishing community seed banks.
- Encouraging women farmers in agrobiodiversity conservation.

Challenges

- Inadequate trained staffs at ground level and inadequate numbers of taxonomist.
- Limited awareness on the value of genetic resources.
- Lack of regional collaborative efforts to assess diversity and lack of national action plan.
- Education level of rural women farmers is inadequate to understand and keep record of genetic resources, however possesses enough traditional knowledge.

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Chapter II. Animal Biodiversity for Food and Agriculture in Nepal

Lok Nath Paudel


The Role of Animal Biodiversity for Food and Agriculture

Though Nepal is very rich in Animal Genetic Resources both in terms of diversity and numbers but these resources are exploited to a limited scale till now. Out of the total population, only 15% cattle and 36% buffaloes are estimated to be crossbred (Sherchand 2001, DoLP 2014). Similarly the percentage of cross bred Animal Genetic Resources (AnGR) in other species of livestock (sheep, goats, pigs and poultry) is grossly estimated to range from 5 to 50% (5 to 10% in sheep and goats, 25% in pigs and 50% in poultry). Livestock can utilize the vast natural resources and convert these to high value nutritive food like milk, meat, eggs and draught power and fertilizer to support agriculture production system. The share of Nepalese livestock to the national agricultural GDP is around 26.8% accounting food, fiber, power, fertilizer, fuel and transportation. The contribution of livestock sector has been reduced from 18 to 13% of GDP within last 15 years (ADS 2015). This situation can only be improved through the increase of productivity of livestock.

Lime, Parkote, Gaddi and Tarai buffaloes are the main breeds of native buffalo which along with the Murrah breed contribute about 70% of the total milk production in Nepal. Buffaloes are considered to be the most economically important animals for milk and meat production. Among the local buffaloes, Lime buffaloes are declining in number. Among cattle, *Lulu, Achhami, Khaila, Pahadi, Terai* and *Siri* along with the *Yak, Nak* and *Chauries* are popular in the country. It is bitter to note that *Siri* cattle, which was perceived as the best performing indigenous cattle and found in the eastern part of Nepal, is believed to be gone extinct where as the number of Yak and *Nak* is reducing day by day because of cross breeding with local cattle and yak herders switching to other occupations like tourism and migration to other areas.

Khari, Terai, Sinhal and *Chyangra* (local goats) are the predominant type of goats for meat production which is acceptable to almost all entities of the Nepalese community. Khari goat performs best in terms of fertility and meat production. *Baruawal, Bhyanglung, Kage* and *Lampuchhre* are the important sheep for wool and meat. Baruwal sheep are used for draught and can carry load up to 13 kg on their back.

Kage is smaller breed for meat and wool. *Hurrah* breed of pigs is reared at scavenging system of production in smaller scale. *Chwanche* (local pig breed) are also reared in backyard pig raising system in hilly areas. *Bampudke* pigs are the smallest breed and are on the verge of extinction in Nepal. Native pigs are reared for meat and manure purpose by ethnic and marginalized people. *Sakini*, *Ghanti Khuile* (naked neck) and *Puwankh Ulte* (*Dumse*) are the breeds of indigenous poultry found in Nepal. The native chicken is tastier than commercial type for meat and eggs and hence their products fetch higher prices in Nepal. In spite of their lower productivity they have their great potential for improving the production and productivity.

Broadly, livestock production system can be grouped into three major types: (a) Transhumant migratory system (b) Semi-migratory or semi-stationary with semi intensive and (c) Stationary stall feeding or closed system intensive farming. The migratory Transhumant system of movement of animals to the alpine meadows and temperate pasture in summer and to the lower altitude pastoral, forest and cropped areas around villages is the common animal production system in trans-himal region of Nepal. The herds of *Yak, Nak, Chauries, Chyangra* goat and *Bhyanlung* sheep are taken to the alpine meadows and temperate pasture for four months from June to September by keeping them in different pastoral areas depending on the feed availability and weather conditions.

Stationary with semi-migratory or with semi-intensive is more common in the mid hill region. The animals are kept in shed during night in winter months and are taken out for grazing during day time. In summer, the dry animals are taken to high pasture areas as migratory type. The high valued animals like lactating, pregnant and sick animals are kept in sheds around villages for intensive care and management. In winter animals are kept on moving in cultivated land for fertilizing the land from terraces to terraces. *Baruwal* sheep, *Sinhal* and *Khari* goats, *Pahadi* cattle, *Chauries* and buffaloes are reared in semi migratory type.

In most of the urban and peri-urban areas, animals are kept in stall feeding system where the animals are fed with straws and other crop by products along with concentrates with limited amount of green fodders. The non-ruminants are kept as closed system even in Tarai or in peri-urban areas. Farmers in dairy pocket areas have followed this type of animal production system in Nepal. Cross-bred cattle, buffaloes, *Khari* goats and *Barbari* goats are kept such a way.

Some of the livestock products are very popular in domestic and international market. Yak cheese from Nak and *Chauries* has been the valuable production in Nepal. The blending of Nepalese carpet from the wool of Bhyanlung breed of sheep has been well recognized in Europe and America. However, because of the decreasing Bhyanglung sheep population the Nepalese carpet industry has to depend on imported wool from Tibet, China and New Zealand. *Chyangra* has been used for Pashmina production. *Pahadi* black cattle and *Terai* white cattle along with some Jersey crossbred and Holstein crossbred are the important cattle which are important genetic resources for providing milk, manures and draught for sustainable agricultural production. *Achhami* (nine-palm height cattle) is popular in far western region for its smaller body size and production of strong bulls used for plowing the sloppy terraces in the regions. *Lulu* cattle can be easily raised in the very harsh environmental regions, such as Manang and Mustang where they can produce reasonable volume of milk which is used for nutritional security in the region. They are also raised for producing organic manure and bulls for plowing lands even in windy and cold climates.

Roughly 70% of households keep some type of livestock. Farmers with small landholdings of between 0.2 and 0.5 ha keep almost 25 percent of the livestock, while people who have either no land or own less than 0.2 ha own about 11 percent of the livestock. Over half of the cattle, buffalo, goats, and sheep are kept in the hills, and about one third in the Tarai. Poultry production is characterized by traditional smallholder farms (100-300), and about 80 percent of commercial poultry farms are concentrated in urban and peri-urban areas. In the last two decades, growth in animal numbers contributed a significant proportion to output growth, while productivity levels have not significantly increased. Nevertheless, the livestock sub-sector has been one of the fastest-growing sub-sectors in agriculture during the 1990s, averaging around 2.4 percent growth annually, accelerating from 1.6 percent during the first half of the 1990s to 3.6 percent in the second half. Nepal runs a deficit on its trade balance, even though agricultural trade records a positive balance (FAO 2005).

Due to low production and productivity of indigenous animals, even the national demand is not fulfilled. There is some niche and organic products and rather their demands are high in both local and international markets. The milk from local buffaloes produce high percentage butter, the local goats are more preferable to the consumers. The products from *Yak* are also valuable. Almost half of the poultry population in Nepal is local and their demand is increasing due to tourism development. The livestock which has been reared under transhumant migratory system are usually organic and preferable to the consumers. Large number of livestock in hills and terai regions are kept under semi-migratory and semi-intensive system but their productivity is very low due to poor husbandry practices. Commercial farming of indigenous animals is very rare in all ecological regions of Nepal (Paudel et al 2009).

The State of Use of Animal Biodiversity for Food and Agriculture

The livestock are assets used as emergency capital and live cash. It provides nutrition (milk, meat and eggs), soil nutrients (manure, urine and decaying carcasses), energy (draught power, transportation and fuel), animal fiber (wool, pashmina and hair), and carcass by-products (bone, hide and skin). It is also associated with religious sentiments. Some of the animals, like, cattle are worshiped as a god/goddess in majorities of Hindu and Buddhist communities. As the larger proportion of the livestock by-products are consumed in urban centers, and by the well-off non-farming families, the livestock sector is a major source of cash in rural areas and for the poorer households. Livestock sub-sector plays a significant role by contributing about 11.5% of total country GDP and 26.8% to the agricultural sector (MoLD 2017).

Sustainable utilization and productivity enhancement

For diversification of animal genetic resources, use of breeding strategy and support services programs to the livestock farmers in breeding have been undertaken through collection of semen and practice of artificial insemination (AI), embryo transfer (ET) and initiation in establishment of gene bank, as well as selection and performance recording system in cattle, buffalo and goat. In-situ conservation of certain identified indigenous breeds of local livestock and poultry, the population of which are declining, community participatory program for conservation and utilization of indigenous animal genetic resources in Nepal being implemented by District Livestock Service Offices in coordination with Directorate of Livestock Production.

For domestication of wild pigs, wild quails and wild fowls, programs are in line for implementation to support feed, shed, health and market aspects. There are some conservation friendly policies that need

to be scaled up at wider scale. In-situ conservation programs, particularly at farmers' community level are going on and ex-situ conservation is also focused for endangered and local breeds in the country.

Provision and actions undertaken for animal biodiversity

- National Agricultural Policy (2004); Agro bio-diversity Policy (2007); Animal Breeding Policy (in draft); National Biodiversity Strategy (2002) and revision of national biodiversity strategy and action plan (2014-2020) under preparation.
- The national biodiversity strategy and action plan has the provision of integrating agro-ecosystem approach for AnGR management.
- Program on conservation (in-situ as well as ex-situ) of certain identified indigenous breeds of local livestock and poultry from government and non-governmental organizations have also been launched in the country.
- Community-Based Management of Animal Genetic Resource Conservation, improvement and utilization of AnGR for different domains and ecologies.
- Genetic improvement programs have been undertaken through selection, AI, ET and performance recording systems for sustainable use and genetic improvement.
- National Livestock Breeding Centre, Pokhara, under DLS has been involved in the artificial insemination (AI) program particularly with introduced bulls (Jersey and Holstein-Friesian cattle and Murrah buffalo), also in goats (Sannen and Boer) indifferent parts of the country. Animal Breeding Division, NARC has initiated ex-situ cryopreservation work for *Achhami* cattle.
- Developed and strengthened the resource centers identified elite breeder in dairy cattle buffalo, pig and goat.
- Developed and implemented the technical directives approaches and guidelines for conservation, promotion and utilization of animal production.
- Promotional programs on processing and diversification of niche products.
- Initiation to establish gene and seed bank and eco-parks.
- Established and strengthened partnership of research and education on AnGR.
- Rangeland / forest conservation and management.
- Value addition and commercialization.
- Regulatory policies and laws for protection of indigenous breeds and benefit sharing.
- Risk minimizing measures. Subsidy and insurance policies.
- Inventory and early warning system.
- Youth targeted commercial livestock programs for income and employment generation.
- Livestock-based poverty reduction and food and nutrition security program in remote mountainous and hill districts of Nepal.
- *Suaahara* program of small-scale livestock farming for 1000 golden days nutritional supplement program for pregnant and lactating women.
- AnGR program for the communities of home stay and agro-tourism.
- Integration of small ruminants in home garden programs.

Gaps and priorities

- Inadequate resources incentives, financial and skill human resources, laboratory and other infrastructure facilities
- Limited awareness and knowhow about proven technologies
- Inadequate coverage of research and development and extension services
- Lack of system approach in tackling challenges related to AnGR conservation and promotion

- Limited use of regulatory policies and laws as well as code of practices for different livestock farming
- Weak implementation of land use management policy, safety regulation policy subsidy and research support policy
- Use of multi species, multi breed herds to maintain high diversity on farm niches
- Effective participation of indigenous people and local communities local stakeholders
- Less priority on documentation and reorganization and use of traditional knowledge and practices of local communities
- Promotion and preservation and utilization of traditional knowledge as well as proven technology
- Increase in public education participation and awareness
- Promotion of Institutional and socio economic enabling environment such as incentive measure
- Voluntary sharing of knowledge and good practices
- Expand public investment and incentives to ensure sustainable management practices
- Enhance national and international knowledge sharing cooperation capacity building and exchange of good livestock farming management practice
- Promotion to increase consumption of local species and varieties through awareness and market intervention
- Promotion of subsidy and incentive to farms for conservation and utilization in PPP model

The State and Trend of Animal Biodiversity for Food and Agriculture

Nepal is rich in animal biodiversity. There are seven different indigenous breeds of cattle (*Lulu, Achhami, Phahadi, Khaila, Terai, Siri* and *yaks*), three buffaloes (*Lime, Parkote* and *Gaddi*), four goats (*Khari, Sinhal,Chyangra* and *Terai*), four sheep (*Lampuchchre, Baruwal, Kage* and *Bhyanlung*), three pigs (*Chwanche, Bampudke* and *Hurrah*), three chicken (*Sakhini, Ghati khuile* and *Pwankh ulte*) one breed of indigenous horse (*Jumli*). Among these breeds, *Siri* cattle is said extinct, the number of Lime buffalo, *Lampuchchre* sheep, *Bampudke* and *Hurrah* pigs and *GhatiKhuile* and *Pwankhulte* chickenare said declining. Therefore, special attention has to be paid for the conservation, promotion and utilization of these breeds for the food and agriculture in Nepal. The state of AnGR, its trend, reasons behind extinction, as well as special measures to be adopted are clearly documented in the Second Country Report prepared and submitted by Directorate of Livestock Production (DoLP), Nepal in 2014 (Paudel et al 2014). Evidence of a significant threat of extinction of animal biodiversity is given in **Table** 1.

Table 1. State of local livestock species (DoLP 2015).

Associated biodiversity species	Degree of threat	Main threat (indicate)
Cattle	*Siri*	Extinct from Nepal
	Lulu	Population declining
	Pahadi	Population declining
	Khaila	Population declining
Buffalo	*Lime*	Population declining
Sheep	*Lampuchchhre*	Population declining and becoming at risk
Poultry	*Ghati Khuile and Pwankh ulte*	Population declining and at risk
Pig	*Bampudke Hurrah*	Population at risk (endangered stage)

Conservation systems for AnGR

Some in-situ conservation programs have been launched for different livestock species with local people participation in different parts of Nepal. However, the packages of practices and incentive measures for the conservation programs are not enough. Some ex-situ programs, such as collection of semen from indigenous cattle, eg, *Lulu* and *Achhami*, from indigenous buffalo like *Lime*, *Parkote* and *Gaddhi* have been started in ABD, NARC, Khumaltar. The same type of programs have been planned to be started soon in National Livestock Breeding Center, Pokhara, under the DLS. The in-vitro conservation measure is not practiced for the conservation of AnGR till now. The conservation practices, from the farmer's side, are mainly guided by the socio-economic, cultural and geographical aspects rather than the knowledge of the importance of AnGR in the areas of genetic improvement and/or biodiversity conservation. There is a need to have the provision of well defined direct & indirect incentive mechanisms for the farmers in the specifically selected areas.

In-situ conservation and management activities

DoLP in association with respective District Livestock Services Offices (DLSO) and farmers' groups has been launching in situ conservation programs for the indigenous animals, like, Lulu and *Achhami* cattle, *Lime* and *Parkote* buffalo, *Lampuchchhre* sheep, *Hurrah* and *Bampudke* pigs, *Sakini*, *GhantiKhuile* and *Pwankh ulte* (Dumse) chicken and Yak and *Chauri* in different districts of Nepal.

Activities to maintain traditional knowledge

Experience sharing among the farmers and from farmers to extension workers often take place, which is keeping alive traditional knowledge associated with biodiversity. Some of the traditional practices eg churning milk, hay making in the high lands, use of herbal medicines in parasites control, traditional shelter to protect animals from the cold, etc are some of the traditional knowledge and practices that are associated with the biodiversity conservation in Nepal. Though, there is no clear cut demarcation of the knowledge of men and women for the conservation, promotion and proper utilization of AnGR, still men are ahead in getting the training and other opportunities where as women are engaged in the farm works more significantly than men. In some areas eg, in migratory animal farming system, men are more actively engaged than women counterparts. Therefore, there is no doubt that women should get the opportunity in enriching their knowledge and skills for the conservation, promotion and proper use of AnGR for food and agriculture in Nepal. These issues are to be considered while formulating gender friendly programs.

Natural or human-made disasters

Though several natural disasters, including landslide, erosion, flooding, earthquake, etc happen in Nepal, they don't cause wide spread effect on biodiversity for food and agriculture; most of the effects are localized as the event take place in certain regions. Sometime significant impact happens in the area where such events strike.

Effects of the invasive alien species

Banmara **(***Chromolaena odorata)* is increasing invading the forage and pasture land of tropics, subtropics and alpine areas. Though, it is said that Banmara can be used in green manuring and bricket production, its beneficial effects are negligible as compared to the harm it does in livestock production. The thorny weeds like Satyanashi (*Argemona maxicana)* are also destructive in forage and pasture land. These weeds not only affect on the forage production but also harm the grazing animals. *Parthenium hysterophorus*is newly emerging weeds in several parts of Nepal which is very destructive and invasive

in fodder pasture production. *Lantana camara* is a flowering plant which is toxic especially to goat. This species is also growing very fast in the tropics and subtropics. Lahare Banmasa *(Mikania micrantha*) is emerging as a harmful vine, especially in Chitwan National Park disturbing the rhinoceros, deers and others wildlife in grazing and moving from one part to another. There are some other invasive alien species that create negative effects to AnGR in different livestock farming systems.

Factors affecting AnGR

- Lack of breeding policy: Nepal still lacks animal breeding policy though a draft of the same was already submitted to the ministry five years ago by the Department of Livestock Services
- Indiscriminate breeding systems leading to little success in producing highly productive breeds
- Unscientific sire selection and free movement of bulls in some parts of the country
- No mass castration of the unwanted male animals
- Prevailing of inbreeding
- No rules and regulation for the use of semen and sires
- Mass grazing, no tagging, poor recording system

Gaps and priorities

- Limited knowledge of farmers about the importance and opportunities of AnGR
- Limited training and awareness to the stakeholders for the conservation and promotion of AnGR for food and agriculture
- No or very limited incentives for the farmers who keep the AnGR with them
- Limited programs and interventions in ex-situ and in-situ conservation of AnGR. However, some of the initiatives have been started in recent years. For instance, AnGR conservation programs from DoLP in different potential districts are the examples for the in-situ conservation whereas semen collection and storage of *Lime* and *Parkote* buffaloes in NLBC (National Livestock Breeding Center) and rearing *Lulu* cattle at ABD (Animal Breeding Division), NARC (Nepal Agriculture Research Council) can be taken as the Ex-situ programs recently launched for the conservation and promotion of AnGR.
- Orientation programs need to conduct for stakeholders on identification and knowledge on the alien species
- Research on the effect and impact of invasive and alien species on AnGR

Drivers of Change in Animal Biodiversity

Main drivers and their effects on animal biodiversity

There has been a positive change for demand of livestock products both in terms of quantity and quality due to population growth, urbanization, higher income and market access. This will impact on the promotion of AnGR. For examples, supermarkets are becoming popular in some urban areas. Use of frozen meat and meat product and milk and milk products are in increasing trend. This will affect AnGR positively. The taste and preference of the consumers is changing. Consumers seem to like the convenient parts (breast and legs in chicken; legs in goat, more lean and less fat) and organic products and products that are produced at low input system. This will encourage the promotion of local breeds (Country Report of AnGR 2013). At the same time, there has been a continuous alarming of affecting the extent and distribution of biodiversity in the country. Important drivers affecting the extent and distribution of animal biodiversity in last ten years (2005-2015) are listed below:

Table 2. Important drivers of change and their effects on farming systems

SN	Important drivers of changes	Change (positive/negative)	More affected farming system/s
1	Degradation of grazing lands	Negative	Transhumant migratory (TM), semi-intensive (SI) and Stall feeding (SF) system
2	Use of technologies	Positive	SI and SF
3	Climate change	Negative	TM, SI and SF
4	Structured Breeding Programs	Positive	TM, SI and SF
5	Emerging Animal Diseases	Negative	TM, SI and SF
6	Manpower and resource constraints	Negative	TM, SI and SF
7	Associated biodiversity	Negative	TM, SI and SF
8	Changes in water and Land use	Negative	TM, SI and SF
9	Pollution and external inputs	Negative	TM, SI and SF
10	Over exploitation and over harvesting	Negative	TM, SI and SF
11	Changing demand for livestock products	Positive	TM, SI and SF
12	Changes in international trade in animal products	Positive	TM, SI and SF
13	Economic, livelihood or lifestyle	Positive	SI and SF (may affect negatively to the TM)
14	Changing cultural roles of livestock	Negative	TM and SI
15	Changing gender roles and rights	Positive	TM, SI and SF
16	Traditional knowledge	Positive	TM, SI and SF

Counter measures addressing current and emerging drivers of change, best practices and lessons learned

Three different livestock production systems (TM, SI and SF) still exist for the livelihood and income generation in Nepal. Large group of people still depend upon agriculture and livestock for food and employment. However, the country is not self sufficient in animal products. The per capita per annum meat and milk consumption is 11.2 kg and 64 kg respectively which is far below the requirement. The per capita requirement has been estimated to be 14 kg meat and 91 kg milk (DLS 2015). These data have demanded more animal products and hence there is ample scope of livestock industries in Nepal. Government of Nepal has initiated new approaches and campaigns for livestock breed improvement, forage production, animal health and human resource development. These new initiative of technology especially the breeding processes of livestock may hinder the sustainability of biodiversity. The adverse consequences have been arisen in many situations; however different counter measures have been adopted in last decade. Due care has been paid to protect and conserve the AnGR. Some promotional activities, eg, incentives for the improvement of livestock sheds, local selection for breeding purposes, awareness campaigns, and production of value added products are some of the initiatives carried out by the Ministry of Livestock Development, Department of Livestock Services, and Directorate of Livestock Production in Nepal. Some of the mitigation and adaptation measures as prescribed in NAPA and LAPA have been carried to address the negative effects of climate change in animal production system in Nepal.

Though the number of livestock per household is quite higher in size, however their productivity is very less. The selection method for breed improvement had been adopted to enhance the production and productivity of livestock. There has been change in care and management of livestock in different parts

of country. The scientific shed has been reconstructed in many places; people have been encouraged to practice the intensive selection and rear the indigenous livestock as commercial enterprises. The consumers have been motivated for the taste preference of indigenous livestock products. The relationship of livestock, wild animals and other biodiversity has been well defined in the rangeland and other relevant policies. Rangeland has been improved for the migratory flock. Females have been encouraged to participate in the marketing and trade of livestock products. Farmers are organized for the empowerment and mainstreaming to the livestock enterprises. A lot of market interventions and livestock value chain have been introduced or changed for better profitability of the farmers.

The State of Intervention in the Conservation and Use of Animal Biodiversity

Major policies, strategies, acts and regulation

The following are the major policies (endorsed or in the process of endorsement), strategies, acts, regulations and programs that address conservation and sustainable utilization of farm animal biodiversity in the country.

- Rangeland Policy (2012)
- Poultry Husbandry Policy (2011)
- Dairy Development Policy (2007)
- Livestock Breeding Policy (2012): Draft
- Livestock Husbandry Policy (2012): Draft
- Animal Health and Livestock Services Act (1999)
- Livestock Slaughter House and Meat Inspection Act (1999)
- Nepal Veterinary Council Act (2007)
- National Agricultural Policy (2004)
- Agriculture Development Strategy (2015)

The major obstacles in developing and implementing the legislations associated with the AnGR are mentioned in **Table** 3.

Table 3. Obstacles to developing and implementing legislation that would protect biodiversity in the country

Component of associated biodiversity	Obstacles to legislation for protection of AnGR and associated biodiversity
Animal Genetic Resources on free range production system	Community Forest groups prevent the livestock like goats and cattle for grazing.
Animal feed resources	The agriculture lands are being utilized by real estate as the population increases, this will also decrease the feed resources and enough land for livestock farming.
Animal grazing	The wildlife conservation prevents the livestock to enter into the forest and in the periphery locations; animals are attacked by wild animals.

Stakeholder participation and ongoing activities

Following are some of the important stakeholders or organizations that are active in conservation, promotion and utilization of AnGR in Nepal:

- Directorate of Livestock Production/DLS has implemented many programs of AnGR in 17 districts and the fund directly goes to local communities. They themselves implement the program whereas respective DLSOs provides technical assistance.

- Some of DLSOs also implement AnGR programs as per their district's demand. They manage the fund either from local government budget or they spend devolved budget eg Lampuchhre sheep conservation program in Dhanusha and Siraha.
- LI-BIRD, a Pokhara-based NGO implements certain programs of AnGR with the collaboration of GoN (eg *Hurrah* pig in Nawalparasi and Dang and Sakini and Pwankh ulte chicken in Dang, Khari goat in Tanahu).
- NARC is doing research at Khumaltar, Lalitpur and other regional research stations eg *Lulu* cattle at Khumaltar, *Lime and Parkote* buffaloes at Lumle, *Baruwal* sheep at Jumla.
- The Government Livestock Development farms maintain resource centers and distribute breeding animals to farmers and other private resource centers, eg Livestock Development Farm, Pokhara maintains *Kage* sheep. Sheep Development Farm, Pansayakhola, Nuwakot maintains *Baruwal* sheep, Goat Development Farm Budhitola and Chitalan maintains *Khari* goat. Likewise, Syangboche Farm rears *Yak/Nak*. Livestock development farms in Pokhara and Nepalgunj Khajura maintain and distribute dual-purpose poultry ie Black Austrolop and New Hampshire.
- Private breeding farms are rearing and developing the pure local breeds of animals.
- Community-based farming and organizations maintain the AnGR for their socio-cultural value and for their livelihood and source of income.
- National Livestock Breeding Center (NLBC) collects semen and cryopreserves for many local breeds eg *Kage* sheep, *Khari* goat, *Sinhal* goat, *Lime and Parkote* buffaloes and *Achhami* cattle, etc.
- FAO cooperates with the Ministry and DLS for country report writing and capacity development.

Incentives or benefits to support activities for the conservation and use of animal biodiversity

Direct payment of incentives or subsidies is not a common system in Nepal for promotion of conservation of farm animal genetic resources. However**,** support services including vaccination, drenching, shed improvement are being provided to the farmers involved in in-situ conservation of *Achhami* and *Lulu* cattle, *Gaddi*, *Lime* and *Parkote* buffalo, *Lampuchhre* sheep under Department of Livestock Services/Directorate of Livestock Production/ District Livestock Service Office. Similar supports are provided to the farmers in the occasional projects that are implemented by various NGOs/Development agencies. Support from the government for livestock farmers for commercialization is also available.

Future Agendas for Management of Animal Biodiversity

The important traits shall be identified through molecular based technologies and efficiently utilized in public and private breeding programs. Appropriate animal breeding policy and seed production system should be adopted to speed up breed improvement programs and their dissemination in the country. Selective breeding should be done for identifying better local animal breeds and their utilization. Livelihood improvement of rural communities can be enhanced through the proper utilization of animal genetic resources. Enabling environment should be developed for creating and maintaining animal biodiversity. Animal farm genebank should be established across the country.

National adaptation programmeof action (NAPA) and local adaptation plan of action (LAPA) are being implemented by the government of Nepal to address climate change effect and improve sustainability

and resilience of different production systems at national as well as local level. Animal specific national research programs have to address climate change issues and develop climate resilience crop varieties, livestock breeds and technologies at different level. Focus should be towards:

- Meeting the Aichi Biodiversity Targets and relevant and Sustainable Development Goals (SDGs). A number of strategies has been formulated by the National Biodiversity Strategy and Action Plan 2014 to meet the Aichi Biodiversity Targets and to ensure environmental sustainability by 2020. Each strategy is to be met through implementation of a number of priority actions linked to each of the strategies.
- An Access to Benefit Sharing (ABS) bill which has been drafted and submitted to the parliament for final approval. After endorsement of the bill by government of Nepal, that will ease to implement the benefit sharing of biodiversity and genetic resources.
- Approval and enforcement of Fishery Policy, Livestock Breeding Policy, and Animal Husbandry Policy that have been submitted to MoAD/MoLD for approval process for conservation and sustainable use of specific sub-sectoral/thematic biodiversity.
- Formulation of specific program and activities to address the component of associated biodiversity and their implementation.
- Strengthening database through proper documentation, monitoring, knowledge management of biodiversity related activities and effective coordination and networking among stakeholders at different levels.
- Strengthening human resource capacity in conservation and sustainable use of animal biodiversity.
- Allocation of program budget on biodiversity conservation and sustainable use.

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Chapter III. Aquatic Biodiversity for Food and Agriculture in Nepal

Tek B. Gurung


The Role of Aquatic Biodiversity for Food and Agriculture in Nepal

Aquaculture is cultivation of aquatic organisms (fin fish, shell fish and aquatic plants). The fin fish are common fish having vertebral column, scales on their body, gills for respiration, and fins for locomotion. Shell fish are invertebrates with body covered by shell belonging to gastropods, bivalve, crustacean, etc, for example, snail, mussel, crab, shrimp etc. Some aquatic plants that are cultivated for food, nutrition and economic benefits include water chestnut, *Makhan* and some other ornamental plants. Nepal is rich in water resources in the form of rivers, lakes, swamps, reservoir, ponds, rice-field etc. There are 3 major river basins and 1 river system that contribute to the diversity of fishes in Nepal. There are altogether 232 fin fish in Nepal. Out of them about 12 species are commercially cultivated, while numerous other species are being domesticated to meet the future food and nutrition demands. The aquaculture of fin fish in Nepal is comprised of carp, tilapia, catfish such as *Pangas* and trout. Shell fish such as shrimp, crab, snail and mussel are collected from wild. The prawn, snail and mussel are being attempted for cultivation.

The highest mountain peak (Mt. Everest) of the world situated in the north border of Nepal the highest watershed of the world, while the lower most location in the country representing by 64 m elevation in eastern Nepal. Nepal has remarkably higher vertical slopes within a span of about 250 km from south to north. The population of Nepal is increasing which is creating more food demands. As a result there are growing farmer's interest, along with which government is taking more initiatives and making more plans to promote its aquaculture. The modern aquaculture was started about 6-8 decades ago with carp-based subsistence farming. However, with rapid communication, modernization and intervention by government agencies, donors, academia, farmer's initiatives, and market partners, per annum growth rate of aquaculture has increased, making fisheries one of the highest (8-9% per annum) contributors of national economy, accounting for about 1.22% of total Gross Domestic Production, and 4.32% of Agricultural GDP in the country (Gurung 2016).

Now, fish farming is moving from subsistence to neo-commercialization types. Earlier started with pond aquaculture, farmers have now entered rice-fish, cage, enclosures, raceways etc. Fish is a low cost but

high nutritive animal protein food. The per capita fish consumption worldwide is about 12 kg, while it is about 2 kg in Nepal. Recently, Agriculture Development Strategy (2015-2035) has emphasized fisheries and aquaculture production for food and nutrition security. Demand of shell fish (Gastropod, Shrimp, Crab and Mussel) production technologies are increasing in market places, indicating that the importance and consumption of aquaculture products is increasing day by day. The value of per capita fish consumption would increase, if native shellfish (gastropod, crab, shrimp, and turtle), frogs and aquatic plants such as foxnut (*Euryale ferox*) and water chestnut (*Trapa sp*) which are consumed by ethnic communities are added. In the fish production among the five development regions of the country, Central Development Region was at the top, while Far-Western Development Region was at the bottom. However, on altitudinal basis, southern plains contribute highest production, while least is in mountain areas although potentiality of cold-water aquaculture seems high. These imply that support services and innovation should be extended in the Western Development Region and mountainous regions in addition to the plains for improving fisheries-based food and nutrition security (Gurung 2016).

However, as a major threat to aquaculture biodiversity due to climate change, increasing anthropogenic activities, urbanization, increasing agricultural run-offs, pollution, and river diversion for hydropower and irrigation have been reported to be the major threats. In next coming 15 years, it has been predicted that there would be more number of threatened species of indigenous fish in Nepal. As a safeguards more scientific innovative works, live gene bank, nature conservation, in-situ and ex-situ conservation of fisheries and aquaculture biodiversity for sustainability have been identified.

The State of Use of Aqua Biodiversity

In Nepal altogether about 232 fish species are reported to occur. These all fishes are consumable. No fish yet is known to be inedible in Nepal. The shrimp, gastropods and bivalve are gathered from lakes, wetlands, ponds, streams of mid-hills and Tarai. Aquatic vertebrates playing important role as human food in specific areas, some specific frogs are consumed in communities in hills and mountains. The frog cultivation technology has not yet developed in Nepal.

In southern foothills, turtles are consumed by local communities. More than 16 species of turtles have been reported in Nepal (Kharel and Thapa 2012). In Nepalese river system especially down to the mid hills in large rivers, freshwater dolphins are also found. Likewise some other mammals such as otters are known to be caught and hunted for various purposes. In subtropical freshwater system economically important plants which are common food sources. These plants are naturally grown up and cultivated in natural wetlands of southern plain, and found naturally in lakes of mid hill mountains. Similarly, the lotus is harvested from natural lakes, wetlands, and ponds of Tarai and mid hills. Jute is another crop of wetlands in southern Tarai. There has been poor observation and studies how water purification waste treatment, natural hazard regulation, nutrient cycling, soil formation and protection, water cycling and provisioning of habitat might be impacting different production systems and associated biodiversity in Nepal.

The State and Trends of Aqua Biodiversity

The trends in the state of associated biodiversity within production systems of aquatic resources and fisheries in Nepal can be identified as: Self recruiting capture fisheries, feed based aquaculture, mixed

system (livestock, crop, forest and fisheries). Micro-organisms associated with the aquatic environment could be phytoplankton, rotifer, and other zooplanktons. The phytoplankton such as *Spirulina, Chlorella, Oscillotoria, Scenedesmus* are cultivated elsewhere as human food, and medicine etc but those practices in Nepal have yet to be started. The zooplanktons are produces in ponds as food to aquaculture species. The phytoplankton and zooplankton are commonly distributed from sub tropics to high mountain areas in Nepal (Aizaki et al 1987; Jones et al 1989; Surana et al 2005; Gurung et al 2010). Aquatic invertebrates such as crabs, shrimp, gastropods and bivalve are consumed as human food in Nepal (Subba 2012). Among these, shrimp is eaten all over, but gastropods and bivalve are delicacy among Tharu and other communities in southern plains (Subba 2012). Among aquatic vertebrates except the fishes other most consumable are amphibians (frogs), reptiles (turtles), and mammals (otter and dolphins).

The pollution is one of the most critical challengesfor self-recruiting fisheries, aquatic genetic resources, micro-organisms, invertebrates genetic resources, and associated biodiversity (**Table** 1). In all systems, the pests and diseases have been rated another chief factors causing negative impacts on production.

Table 1. Impact of changes in biodiversity for food and agriculture on ecosystem services

Changes	Impact of changes in biodiversity for food and agriculture on ecosystem services (Rating: 2, 1, 0, -1, -2, NK, NA)								
	Pollution	Pests & disease regulation	Water purification & waste treatment	Natural Hazard regulation	Nutrient cycling	Soil formation and protection	Water cycling	Provisioning of habitats	Others
Changes in aquatic genetic resources	-1	0	0	0	-1	-1	0	0	0
Changes in micro-organisms genetic resources (associated biodiversity)	-1	-1	0	0	-1	-1	0	0	0
Changes in invertebrates genetic resources (associated biodiversity	-1	-1	0	0	-1	-1	0	0	0
Changes in aquatic genetic resources	-1	-1	0	0	-1	-1	0	0	0
Changes in vertebrates genetic resources (associated biodiversity)	-1	-1	0	0	-1	-1	0	0	0

The trend in the state of associated biodiversity is likely to be declining due to pollution, drying up of wetland; and flood plains encroachment (**Table** 2). Frogs and fish might also in decreasing trend due to environmental pollution and several other factors. The aquatic mammals such as Dolphin (*Platanista gangetica)* are also known to be declining; however, some initiatives on conservation have been taken. The aquatic plants such as *Singhada, Makhana* and lotus might also be rated in declining trends because of over exploitation, drying up and encroachment of the wetlands due to over population, rapid urbanization, use of wetlands and lakes for traditional agriculture and town planning activities.

Table 2. Trends in impact of changes in aquatic biodiversity for food and agriculture on ecosystem services (Rating: 2, 1, 0-1, -2, Not Known (NK), not available (NA)

Production systems	Factors impacting								
	Pollution	Pests and disease regulation	Water purification and waste treatment	Natural Hazard regulation	Nutrient cycling	Soil formation & protection	Water cycling	Provisioning of habitats	Others
Self-recruiting capture fisheries: Sub tropics	+1	+1	-1	-1	+1	-1	-1	-1	NK
Self-recruiting capture fisheries: Temperate	+1	+1	-1	-1	-1	-1	-1	-1	NK
Culture based fisheries: Subtropics	+1	+1	0	-1	-1	-1	0	-1	NK
Culture based fisheries: Temperate	+1	+1	0	-1	-1	-1	0	-1	NK
Fed aquaculture: Subtropics	0	+1	0	1	1	NK	1	1	NK
Fed aquaculture: Temperate	0	+1	0	1	1	NK	1	1	NK
Non-fed aquaculture: Subtropics	+1	+1	0	-1	-1	-1	0	-1	NK

In Nepal, fish farming, in general, is gradually moving towards extensive to semi intensive and semi intensive to intensive farming practices resulting in increased used of inputs like seed, feed and fertilizers. Addition of feeds and fertilizers has improved fish productivity due to production of microorganisms. Aeration as additional inputs has much supported to supply dissolved oxygen improving fish production system comprised of plankton and detritus feeding carps.

Natural or human-made disaster(s) effect on biodiversity on ecosystem services

Numerous natural as well as man-made disasters have caused significant effect in fish and aquaculture biodiversity for food and agriculture and or on ecosystem services overthe past 10 years (**Table** 3).

In 1985 there was an outbreak of Epizootic Ulcerative Syndrome fish disease in southern plains and mid hills of Nepal. The native fishes were highly impacted because of the disease mass mortality of fish occurred in small streams, ponds, wetlands etc. The heavy mortality was also occurred in ponds. The cultured fish were also impacted causing heavy losses to farmers. The disease was outspread for 4-5 consecutive years. Recently, there was blockage of River Sunkoshi in Sindhupalanchowk District close to Kathmandu due to landslide on nearby hills. The river was blocked nearly for 45 days creating a big lake in the river.There has been probably rare studies of the impact of fisheries of such blockages; we speculate such incidences have substantial impact over the native fishes of the river. It is not only impacted the fish, but human casualties and death were occurred with the loss of livestock and hundreds of hectares of inundated cultivable land. Similarly, river flood in Seti River Pokhara caused by an avalanche in high Himalaya caused severe loss to aquatic life. The loss on aquatic resources probably could not be recorded, but it is estimated that there has been loss of fish habitats during the avalanche flood in Pokhara. Recent earthquake in Nepal has caused tremendous loss in crop, livestock and aquaculture especially in hills and mountains.

Table 3. Natural and human made disasters having significant effect on biodiversity in the past 10 years in the country (Rating: 2, 1, 0, -1, -2, NK)

Disaster description	Effect on overall biodiversity for food and agriculture	Effect on ecosystem services
Rupa Lake degradation due to vegetation& sedimentation	+2	+2
Sunkoshi river obstruction, 2014	1	1
12th April Earthquake, 2015	-1	-1
Kali Gandaki River obstruction, May 2015	-1	-1
Avalanche in PokharaSeti River	-1	-1
Flood and landslide in River Arun and Taplejung Districts	-2	-2
Kulekhani Reservoir	-1	-1
Degradation of Lake Phewa	-1	-1
Hydropower and irrigation dams	-1	-1
Soil erosion	-1	-1
River bed extraction	-1	-1

Evidence on changes in biodiversity by natural or human-made disasters

The human made disasters have been recorded to be devastating to fisheries, livelihoods and food security in Nepal. The construction of Kulekhani hydropower dam displaced about 300 families from the Kulekhani valley, earlier one of the best spot well known for Asala (snow trout) or *Shizothorax* fishery in River Kulekhani, where the reservoir has been constructed (Gurung et al 2009). However, after the dam construction that stored the water, the snow trout (*Shizothorax spp.*) capture fisheries demolished completely, because the snow trout could only flourish well in flowing waters, but not in stored water ecosystem (Pradhan and Swar 1987). Similarly, in Bagmati River, which flows from the middle of the Kathmandu valley, several fish species were reported earlier, but due to sewage discharge in the river, no fish known to exist in the river, especially in Kathmandu stretch. Sirsia stream of Birgunj, Parsadistrict is known to have similar fate as that of Bagmati because of effluent discharge from nearby industries. In the Kali Gandaki Hydropower, a largest power generating station of the country, a fish hatchery has been established with aim to mitigate the biodiversity loss due to construction of dam in the river. Now the hatchery produces fry of the native fishes to release into the down and up stream of the river (Gurung and Baidya 2012).

Drivers of Change in Aqua Biodiversity

The drivers of change in aquatic biodiversity for food and agriculture are mostly known to be several factors such as anthropogenic activities including dams, diversion of rivers, roads, urbanization, poverty status, over fishing in lakes and rivers, poor law enforcement, lack of monitoring, sand removal from the rivers, encroachment of wetlands, agricultural runoff etc. The hydropower and irrigation development activities mostly ignore the aquatic habitats and organisms there in, while in southern sub-tropical areas rampant draining of wetland for various agricultural purpose, encroachment, over exploitation, use of agricultural pesticides have impacted freshwater fish and aquatic organisms.

Nepal is known to be rich in aquatic resources, especially the rivers, which is represented by about 6,000 rivers in the country. Since these rivers are also the habitat of majority of fish species, as well as

suitable place for hydropower development, a challenge lies ahead in conservation of riverine fish species.

Nepal has 16 endemic fish species, these species inhabit in a range between200 to 1200 meters altitude. These are locations that are also considered more suitable for hydropower dam construction, and therefore major thrust should be given in these areas to conserve the endemic fish species. Southern tarai is also well known for rich fish biodiversity, where the flood plains and valleys are used for agriculture. In these areas the agricultural run-off has been considered as a major threat to fisheries and aquaculture biodiversity. Side by side, the over fishing, use of unconventional fishing methods, removal of sand from rivers, change in the river flows, loss of habitats might also be considered as the major threats and drivers of change in fisheries and aquaculture biodiversity. In recent studies, the climate change impacts higher altitude air temperature has been reported to be causing impact on sustainability of aquaculture biodiversityespecially in the hills and mountains.

The State of Intervention in the Conservation and Use of Aqua Biodiversity

Activities undertaken for maintenance of traditional knowledge of wild food species

Although the traditional knowledge in fisheries and aquaculture is rich in Nepal, however, poor efforts have been made to document the knowledge. In future, documentation of traditional knowledge should be prioritized along with the modern innovation. Various crafts and gear are implied for fishing in water bodies. Such gear and craft have been documented by Shrestha (1981). Further documentation of such crafts and gear and associated knowledge on how those tools are prepared should also be prioritized. The traditional knowledge of capturing, holding, handling, preservation, smoking, storing, identification of breeding flocks, migration trend, collection of spawn, use of natural plant toxin for fish, use of specific fish for specific medicinal purpose, use of milt to control skin disease, medicinal values of fish products, importance of dried fish for nutrition also need to be documented.

In southern plain one of the native catfish species known as *Clarias batrachus* are known to possess high medicinal values. It is said that the mothers in labour are fed with the *Clarias batrachus* fish to recover the blood losses during the delivery of the baby. It is believed in hills that feeding Bam, *Mastacembalus armatus*, on Friday and a freshwater eel to skinny weak and malnourished people can help to regain the strength and vitality. Similarly, the fresh milt of golden Mahseer (*Tor* spp.) can heal the white leprosy spots, if applied regularly. If gall bladder of fish is consumed after drying or fresh that helps in controlling the hypertension disease. How the seeds of *Makhan* and *Singada* are protected, requirement of water level in ponds during seeding, post-harvest, and nutrient management are required to be studied and documented. There is limited knowledge base on native shrimps, gastropod, bivalve which might be overcome by prioritizing in research soon.

Gender dimension, roles and insight of women and men of conservation and management

Involvement of women in fisheries is about 56% and more effective in fish conservation campaign (Gurung 2003). The women are also more effective on fish conservation in lakes, wetlands and marketing of local fish species. In majority of households in traditional ethnic community marketing part of fish products become the responsibility of women especially in hills. Besides that, women also maintain fishing gears, net for mending and repair etc. It is interesting to note that involvement of women fishers in open water fisheries overweighs males (DoFD 2010). This trend might be due to women responsibility to take care of family health, therefore her involvement in gathering of nutritious food become high. The fish plays very important role in household nutrition either in hills or in

mountain areas. In tiny markets of mid hills close to river areas occurrence of dry fish is common. The specialty of such market besides their tiny size is occurrence of dry fish in small bamboo baskets in cloth, tea, vegetable and general fruit shops as well. This might be because of smaller size of the product along with other selling items. The implications of the dry fish in these hilly and mountain areas are not only for long term preservation, but main factor might be associated with easy transportation. Most hilly villages located in remote areas are not connected to motorable roads. The 'dry fish' in such areas facilitate the easy transportation for fulfilling the micro-nutrients requirement of the mountain and hilly people. Mostly the dry fish comprises tiny fishes caught in rivers and the bigger fishes in dry form are mostly available in small dry pieces.

Evidence on enhancing use of biodiversity on improvements and invasive alien species

The enhanced use of biodiversity could contribute substantially to food and nutrition of communities. The communities displaced due to reservoir construction in Kulekhani Hydropower adopted later on cage and open water fisheries in the reservoir (Gurung et al 2010). Now the reservoir provides employment opportunities to most displaced communities by open water and cage fish culture practices in the reservoir. Similarly, Kali Gandaki fish hatchery releases nearly 1 million fry every year into the up and down stream of the river to support biodiversity and the livelihoods of fishers depending on fishing. Rupa Lake Restoration Cooperative, which is the largest cooperative in agricultural sector in the country, became successful to restore the degraded Lake Rupa around late nineties with 'biomanipulation' of lake with fish stocking (Gurung 2007). The lake now has been restored, cleaned up and has been the source of livelihood of about 740 families living nearby catchment areas. The annual fish harvest of the lake is nearly 60-70 mt per year. The Lake Rupa case is one of the examples showing pollution or natural or human made disasters. The conservation effort has become successful for improving livelihoods, food security and nutrition of local communities.

Invasive alien species

In fisheries and aquaculture sub sector invasive and alien species have been identified as a major threat. Generally most of the introduced fishes are alien species, while some of the plants, which have been introduced by unknown sources, have been defined as invasive as well. The water hyacinth and water lettuce are among the major invasive alien species identified in Nepal that has significant impact on aquatic biodiversity in Nepal. Similarly, African catfish (*Clarias gariepinus*) has been spread in most warm water wetlands and ponds as one of the undesirable fish to farmers and fishers in natural water bodies. To some extent, Tilapia is also known to have been spread in many wetlands. In water bodies the most invasive plants ever have been noticed is water hyacinth (*Eichhornia crassipes*), the other plant which also spreading in water bodies are Water lettuce (*Pistia sp).* The *Eichornia crassipes,* one of aquatic plant species, has been considered as one of the nuisance plants (Kafle et al 2009) for fisheries and aquaculture (**Table** 4). This plant absorbs most of the nutrients from the water body and thus does not allow the growth of planktons which is the basic food of fishes in larval stage. Some of the fish entirely depending on planktons are bighead and silver carp, in presence of water hyacinth the growth of the most plankton feeding fishes declines drastically.

Table 4. Invasive alien species that have had a significant effect on biodiversity for food and agriculture in the past 10 years (2, 1,0, -1, -2)

Invasive alien species (scientific name)	Production system (s) affected (code or name)	Effects of components of biodiversity for food & agriculture	Effect on ecosystem services
Clarias gariepinus	Self recruiting capture fisheries: Sub tropics (Betinitaal, Morang; in general)	-1	0
Water hyacinth (Eichhornia crassipes)	Self recruiting capture fisheries: Sub tropics	-2	-2
Water lettuce (Pistia stratiotes)	Self recruiting capture fisheries: Sub tropics Sub tropics and Temperate	-1	-1

There are several examples of effects of invasive alien species on different components of biodiversity for food and agriculture and on the effects on ecosystem services. It has been evident the water hyacinth has been one of the nuisance plants in many aquatic ecosystems chocking the lake due to their faster growth in suitable eutrophic lake environment. The plant can impact on ecosystem services of many kinds including activities such as boating, scenic beauty, navigation, open water capture fisheries etc. Excessive recruitment of Tilapia, as an alien fish species, has been reported to cause decline of population of several native species in lake systems of sub tropic. Similarly, it has been reported that the diversity and yield of both cultured and native populations of fish are negatively affected by the invasion of *Clarias gariepinus* in sub tropics and temperate regions.

Spread and proliferation or controlling of invasive alien species

Some studies on controlling of invasive tilapia using native *Tor putitora* as predators were attempted with partial success. Details on such studies are expected. The spread and proliferation of invasive species are increasing probably due to the porous borderline, lack of policy to control over the introduction of exotic or alien fish species and climate change impact. In general, the trend suggests that mostly tropical plants and fishes are invading towards inner parts of Nepal's mid and high hills indicating some shift of warmer temperature towards mountain side or higher altitude probably associated with change in climate warming up.

Similarities, differences and interactions

Realization of the importance of the associated biodiversity for food and nutrition security is emerging. The minor species of fishes which were considered as nuisance are now known to possess importance nutrients, which varies with species (Shakuntala and Wahab 2014). These implying that smaller fish, crabs and shrimp are of higher importance for food and nutritional security and livelihood. To protect and harness the smaller wild fish special project are emerging up. In fisheries sector, the contribution of the associated biodiversity as a food and nutrient source is positive, but the organisms related to associated biodiversity are least prioritized for production, because of lack of knowledge about the associated biodiversity. It is clear that the technologies of production of organisms related to associated biodiversity should be prioritized for conservation; and production should also be prioritized for food and nutritional security. It is understood that the synergies of trade-off between associated biodiversity and wild food diversity is directly associated in fisheries and aquaculture sectors. The wild food diversity in fisheries and aquaculture sector represents the associated biodiversity to great extent. Although the associated biodiversity represents the micro-organisms, but it has not been covered in wild food diversity. The ecosystem services of associated biodiversity should not be forgotten for the

wild food diversity. The importance of ecosystem services of the associated biodiversity services over the wild food diversity should not be minimized, but needs to be highlighted.

Future Agendas for Management of Aqua Biodiversity

For future agenda, the actions required would be incorporation of organisms of associated biodiversity in government plan and policies. Especially, the academic arena or research organization should have agenda to work on those on their plan and vision. These organizations may require developing the package of practices of farming of such important commodities of associated biodiversity. Gradually these commodities should also be prioritized to entitle for subsidies in their farming practices. Side by side after such technologies are developed gradually the market opportunities should also be explored and systematized for postharvest technologies.

Capacity limitations, policy and institutional constraints on conservation of wild resources used for food

The use of wild resources for food in aquaculture and fisheries is substantially high. The capture fisheries if we include as the part of the wild resources then the contribution becomes about 48% of total production contributing about 0.5% of total GDP in the country. Despite of contribution from wild resources, there have been only little efforts on the conservation aspects of fisheries. There exist big gap in information and knowledge despite of the fact Nepal is known to possess rich aquatic biodiversity. Such a gap is because of inadequate strategies of specific aquatic life conservation in national programs. The inadequate human resource with appropriate knowledge, and poor funding for research on aquatic biodiversity are major hindrances. Other constraints are in low priority in agriculture sector to fisheries.

Action required and priorities

With respect to the impact and response to natural or human made disasters and fisheries biodiversity for food and agriculture, it is essential to promote the ecosystem approach of biodiversity conservation. This strategy has rarely been taken into the consideration probably due to lack of diversification or specificity of work division in fisheries organization in government sector (research or extension sides) caused by theirs small organizational structure within the umbrella of agriculture sector.

Gaps in information and knowledge with respect to invasive on biodiversity

With respect to the state, trend and conservation of associated biodiversity and ecosystem services, there are huge gaps in information and knowledge. The associated biodiversity has often been rated negatively for production of fish products, although communities harnessing the food and nutritional values of those organisms, since time immortal. The importance of associated biodiversity is needed to be highlighted, prioritized and focused for better benefits in future. It is also necessary to focus on generation of relevant technologies on associated biodiversity. In terms of monetary values the importance of associated biodiversity commodities could be higher due to their importance in special occasion, festivals, and purpose for example as medicine etc. The capacity and resource limitation for them is accumulation of scattered knowledge, lack of synthesis of existing knowledge, lack of research and studies on traditional knowledge, specific programs for those high value products, specialized human resource or organization for those commodities develop and generate their technologies. The main policy and institutional constraints are low priority and paradigm shift in our traditional policies which hindered the importance of associated biodiversity over other agricultural commodities. There is need to develop the synergies among the associated biodiversity commodities along with general

commodities often considered of higher importance for food and nutritional security in our society, plan and policies.

Some works have been carried out by GO, NGO's and research systems on controlling of invasive species like water hyacinth. In the context of water hyacinth and other aquatic plants, it is necessary to enhance the public knowledge about the harms of the water hyacinth (Kafle et al 2010) of different ecosystem, fish and rice productivity reduced sharply in presence of invasive species such as water lettuce. This gap should be prioritized to be resolved in the communities. In government sector some efforts have been carrying out to control over the water hyacinth such as introduction and use of some beetles to control such invasive plants.

Incentives or benefits to support conservation and sustainable use of biodiversity

In fisheries sector there has been no incentives, in general, to support the conservation and sustainable use of biodiversity for food and agriculture or associated biodiversity. Some projects which helping the conservation of fish might be listed as shown in **Table** 5, while the description in Box 1 can be rated as directly or indirectly supporting aquatic biodiversity conservation in general. In Kali Gandaki River there has been a provision to produce juvenile of native species and released into the up and down stream of the dam constructed over the river for conservation, in order to not deplete the captured fish and livelihood of people depending in fisheries, as well as other higher organisms which might be depending in fish in food chain. In this case nearly 1 million fry are released annually in the river. Similar activities are conducted in lakes of Pokhara Valley; however the scale of fry release is less. Nearly 0.1 million fry are released annually. In some rivers as well the native fish fry are released as a part of the river fish conservation sparsely.

Table 5. List of major project supporting conservation and sustainable use of biodiversity to fisheries and aquaculture

Project	**Status**
Kali Gandaki Fish Hatchery Project	Ongoing
Tor putitora breeding program	Completed
Lake Rupa Restoration Project	Completed
WTLCP (Western Tarai Landscape Project)	

Box 1.Major landscape based initiatives

Landscape based initiatives to protect or recognize areas of land and water in the country with particular significance for biodiversity for food and agriculture: Chitwan National Park, Sagarmatha National Park, Langtang National Park, Bardiya National Park; Shey Phoksundo National Park; Rara National Park; Makalu Barun National Park and Conservation Area, Sukla Phanta Wild Life Reserve; Koshi Tappu Wild Life Reserve; Lake Rupa Restoration and Fisheries Cooperatives; Kali Gandaki Fish Hatchery Beltari, Syangja; Several Ramsar sites eg Ghoda Ghodi Tal Systems, Jagadishpur Reservoir, Bishazaar Tal.

Linkages and collaboration among sectors and policies governing conservation

It has been envisaged that a National Biodiversity Co-ordination Committee (NBCC) and NABCC different Thematic Sub-Committees formed under the Ministry of Forest and Soil Conservation and MoAD are the leading agencies to have linkages and collaboration between sectors and national programs and policies governing conservation and sustainable use of biodiversity for food and

agriculture. For regional level aquatic gene pools can be assumed to be supported by initiatives given in **Table** 6.

Table 6. Regional and international initiatives targeting the conservation and sustainable use of associated biodiversity

Initiatives	Scope	Description
Implementation of Ramsar convention	International	Several wetlands have been declared as Ramsar sites for conservation and sustainable use of associated biodiversity
Integrated Gangetic/ Bramhaputra Water Shade Conservation	Regional	Initiative has been taken for Integrated Koshi Basin conservation Action Plan

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Chapter IV. Forest Biodiversity for Food and Agriculture in Nepal

Dhananjaya Lamichhane

The Role of Forest Biodiversity for Food and Agriculture

Owing the huge ecological diversity, Nepal is endowed with rich forest genetic diversity, which is closely linked to food security and poverty alleviation in the country. About 85 percent of population resides in rural area (CBS 2011). Even though agriculture is the main source of food and income for many rural populations, it is not able to meet annual requirement. Hence, people rely on the forest products to supplement the food requirements. Many species of trees laying on farms, as well forest trees and associated under-story shrubs and grasses, are used as food when other food sources are scarce. It has been estimated that 80 percent of the fodder requirements of the country is met from the forest trees collected from private and national forests (CBS 2011). Forest trees contribute to the domestic livestock production, which in turn influences milk and meat production. Estimates show about 70 percent of the population of the country collects fodder for their livestock. As in many other developing countries, fuel wood is the main source of energy in Nepal. Research conducted in Nepal has shown that about 64 percent of population use fuel wood for cooking. Forest supplies approximately 89 percent of the fuel wood (CBS 2011). The fuel wood shortage affects the quality of food. These data indicate the link between forest resources in food security, economy and livelihoods of rural people in the country. It is often very poor people that depend highly on the forest products (CBS 2011). Households living on the margins of poverty are exposed to food security at certain times of the year when income levels drop (Dhakal et al 2007). During the lean season (the period when crops are growing in the fields and or in times of famine or food shortage), forest provides an important safety net to forest dependent families, making the forest an indispensable part of life in critical periods that the importance of forest foods in greatest.

A study by Shrestha and Dhillion (2006) undertaken in Dolakha district has found that 62 wild species belonging to 36 families were edible. Of these, 39% were herbs, 37% trees, 14% shrubs, and 10 % climbers. Fruits (46%) and green leafy vegetative parts (leaves and tender shoots; 37%) were the major type of food plants found. In addition, the study observed that most of the wild food plants collected and consumed by the local communities were supplementary and nutritionally important. Flowers of species such as *Rhododendron arboreum* was used for juice, pickles and snacks. Other important tree species that have been used for food included *Saurauia napaulensis*, *Castanopsis indica*, *Castanopsis tribuloides*, *Ficus auriculata*, *Ficus neriifolia, Dendrocalamus hamiltoni* and *Prunus cerasoides* (**Table** 1).

Nepal is socially heterogeneous and many tribal communities highly depend on forest products for their livelihoods and nutritional requirement (**Figure** 1). One of them is *Chepang* community, who is still having semi-nomadic way of life. The Chepang community is considered highly marginalised and usually confronted with food deficit problem. A study carried out in Chitwan District by Thapa (2008) indicated that Chepang community remained food deficit for six months. Overall, forest products contributed 18.14 percent in the total income. Even among them poor community derived higher income than medium and rich community. *Aesandra butyracea* was the most preferred tree species in the *Chepang* community. Besides, they derived income from tree species such as *Michilus odoratissima, Caeseria esculenta,Schleichera oleosa*, and *Tamarindus indica*. Furthermore, it was found that Chepang community has been using 17 species including tree species for food requirement. Other than species mentioned before, people use a large number of other tree species and their products as food, diet and medicines.

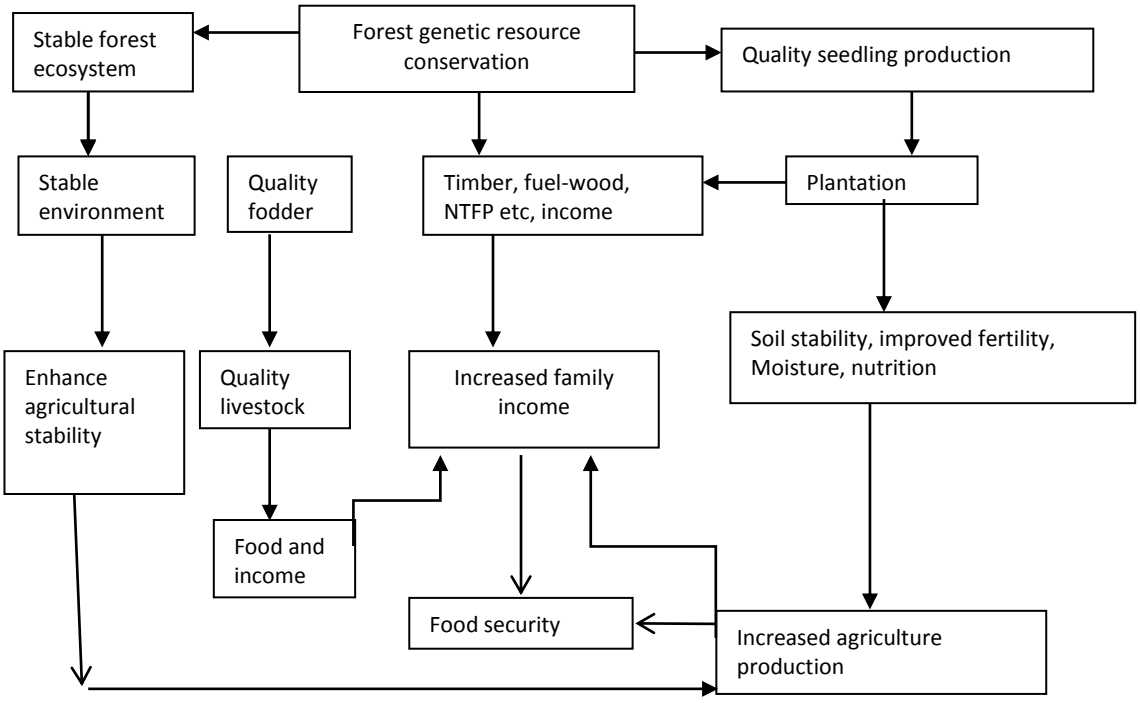

Figure 1. Linkages between forest genetic resources, food security and poverty.
Adapted from Jha 2006.

Eliminating poverty and sustaining development are highest priorities under Millennium Development Goals. Not only for food security, forest genetic resources are important sources for addressing poverty mainly among marginalised and forest dependent communities. Forests and trees grown on farm have been making a significant contribution to rural household incomes. Hundreds of species are used as non-timber forest product (NTFPs) and have great conservation and economic value for many households. In some communities, forest genetic resources provide up to 50 percent of the total family income (Edwards 1996). The use of NTFPs, however, varies from one community to other community depending on social structure and associated traditional practices of different ethnic groups. A recent study in Bardia district indicated that NTFPs have been significantly contributing to the livelihood and income of families in Tharu community. The study identified 101 species being used by Tharu families in the region. The important species used included *Bauhinia variegata, Syzygium cumini, Ficus racemosa, Aegle marmelos, Schleichera oleosa, Phyllanthus emblica, Terminalia chebula, Terminalia bellirica.* Despite the fact that many people use several forest tree species for income generation thereby reducing poverty, the products are not able to receive the potential value owing to the absence of competitive market opportunities. Hence, expansion of market opportunities and capacity building programmes for the local people and local institutions are essential.

Table 1. List of trees and other woody FGR contributing to food security and livelihoods

Scientific name	Native or exotic	Use for food security	Use for Income generation
Acacia catechu	N		
Acacia nilotica	N		√
Acorus calamus	N		√
Adina cordifolia	N		√
Aegle marmelos	N	√	
Azadirachta indica	N	√	√
Bassia butyracea	N	√	√
Bauhinia variegata	N	√	√
Bombax ceiba	N		√
Cajanus cajan	N	√	
Calamus tenuis	N		√
Careya arborea	N	√	
Castanopsis indica	N		√
Castanopsis tribuloides	N		√
Choerospondias axillaris	N	√	√
Dalbergia sissoo	N		√
D. hamiltonii	N	√	
Desmodium oojeinense	N	√	
Diospyros melanoxylon	N		√
Elaeocarpus sphaericus	N		√
Ficus auriculata	N	√	
Ficus hispida	N	√	√
Ficus lacor	N	√	
Ficus neriifolia	N	√	
Ficus racemosa	N	√	
Grewia optiva	N	√	
Hipppophae salicifolia	N	√	

Scientific name	Native or exotic	Use for food security	Use for Income generation
Juglans regia	N	√	
Lannea coromandelica	N		√
Madhuca longifolia	N	√	
Mangifera indica	N	√	
Morus serrata	N	√	
Myrica esculenta	N	√	
Phyllanthus emblica	N	√	
Piper longum	N	√	
Polyalthia longifolia	N	√	√
Prunus cerasoides	N	√	
Psidium guajava	N	√	
Putrajiva roxburghii	N	√	
Pyrus pashia	N	√	
Rhododendron spp.	N	√	√
Rubus ellipticus	N	√	
Sapindus mukorossi	N		√
Schleichera oleosa	N	√	√
Shorea robusta	N		√
Solanum surattense	N		√
Syzygium cumini	N	√	√
Terminalia bellirica	N	√	
Terminalia chebula	N	√	
Tinospora sinensis	N		√
Toona ciliata	N		√
Zizyphus mauritiana	N	√	

Source: Uprety et al 2010, Shrestha and Dhillion 2006

The State of Use of Forest Biodiversity

Wild edible plants (WEP) provide staple food for indigenous people, serve as complementary food for non-indigenous people and offer an alternative source of cash income. WEP are important nutrient and vitamin supplements for indigenous people. Therefore, wild food resources reduce the vulnerability of local communities to food insecurity and provide a buffer in times of food shortage. In addition, WEP have substantial potential for the development of new crops through domestication and provide a genetic resource pool for hybridization and selection. With the rapid decline of traditional knowledge about WEP and increased reliance on processed food, documentation and evaluation of the traditional knowledge related to the diversity, usage, and status of WEP is crucial. Documentation of traditional knowledge regarding WEP in Nepal is very limited compared to medicinal plants. Some of Nepal's WEP and uncultivated plants were documented in the past, but still many more wild species believed to be edible are yet undocumented (Tiwari et al 2012, Aryal et al 2009).

The availability, knowledge and diversity of wild foods have been affected to a varying extent in the different geographical regions, inhabitant tribes and because of the different drivers. Like other plant species, WEP are threatened due to various human activities and natural causes such as land use change (expansion of agricultural lands, developmental activities); habitat destruction (timber harvest, fuel wood collection, forest fire); over-harvesting; over-grazing; and invasive species. Though the recorded and published details are not available, it can be stated that availability of wild foods has increased with

the physical access to the remote areas and is not known or has been negatively affected with the other drivers. Rapid transformation of socio-economic conditions of rural people and the resulting changes in food habits result in decreased use of WEP and loss or degradation of the associated traditional knowledge (Rana et al 2012). The knowledge of the wild foods in the indigenous people is generally negatively affected with the year round availability of cultivated vegetables (off season vegetables), availability of food grains in the local markets and with the increasing purchasing power of the local people as they are no more interested in the local foods if other easy alternatives are available. At the immediate time, the effect of climate change on the wild foods seems to be positive as they are adapted to the higher altitudes. The growth of population and urbanization seems to have negative effect on all the three aspects availability, knowledge and diversity of wild foods**.**

The State and Trends of Forest Biodiversity

Over exploitation of high value and rare species, such as satisal (*Dalbergia latifolia*), champ *(Michelia champaca*), bijaysal (*Pterocarpus marsupiuym*) and wild olive (*Olea cuspidata*) has threatened the survival of these species in their natural habitats. Excessive commercial harvest of medicinal plants (legally and illegally) has caused direct threat to the high value species, including yarchagumba (*Ophiocordyceps sinensis*), jatamasi (*Valeriana jatamansi*), sarpagandha (*Rauvolvia serpentina*) and many species of orchids. Uncontrolled forest fire is a serious threat, particularly in the Siwalik region and high altitude areas. Most of the fires are deliberately set by local farmers to clear land for agriculture or stimulate early growth of grass for livestock to graze. Recurrent forest fires severely damage and prohibit regeneration and growth of seedlings, destroy non-timber forest products, injure ground flora and fauna and, inhibit development of understory vegetation thereby leading to an open forest with relatively low biodiversity. Overgrazing in forests has negatively affected regeneration and growth of seedlings and ultimately caused forest degradation in many places. The practice of grazing in forests has substantially decreased in the Middle Mountains as CFUGs rules usually do not allow grazing in community forests. In some areas of High Mountains (eg Taplejung, Rasuwa, Humla), however, the prohibition of grazing in community forests has invited conflicts between nomadic herders and CFUGs.

According to FGR (2013), at present, not all threatened or economically important species have been managed under ex-situ and in-situ conservation. There are still numerous threatened species for which conservation strategies and/or funding are lacking. In addition, it has been realized that area allocated for the conservation is not sufficient, or at least current protected areas do not represent some of important habitats of species (Shrestha et al 2010). Hence, conservation of more species and in larger area is needed. At present, the country has inadequate skilled human resources associated to FGR; hence international collaboration is essential to enhance trained human resources.

Other than forestland, farm land also contains tremendous tree diversity. Some of the tree species have only remained in agricultural farm, so incentive programme to the farmers is needed to ensure the conservation of the tree species (Acharya 2006). It is widely realized that gene bank for the forest tree species is of urgent need. Establishing gene bank involves high cost and the programme needs collaborative support from international programmes.

The National Tree Improvement and Silviculture Programme works in cooperation with other national programmes in related areas. One of the areas is agriculture, and import or export of forest tree seed even has to go through phytosanitary screening. The Seed Quality Control Centre and National Plant

Quarantine programme both under the Ministry of Agricultural Development oversee the phytosanitary screening of seed irrespective of whether it is agricultural seed or forest tree seed (Shrestha and Wulff 2007). In many instances, forest genetic programme has to follow Environment Act, 1997 and Rules, 1997. For example, if an area of monoculture plantation is more than 50 hectare and whether it is for genetic conservation or commercial purposes it requires Initial Environmental Examination.

Every year government conducts various types of programmes related to forest genetic resources. The MoFSC is the line ministry which is solely responsible for policy formulation and implementing programme associated with FGR conservation. The genetic conservation programs are implemented mainly through four departments under MoFSC. The Educational and Research institutions also have been conducting research on forest genetic resources. However, there is no adequate coordination between government agencies and academic institutions regarding the priority area of research. It is also observed that research findings are generally technical in nature, and are not well communicated to policy and decision makers for their appropriate action with respect to policy formulation and revisions.

It is important to note that the local people are involved actively in the management of tree improvement programs. Various BSOs, seed stands and tree improvement trial plots are managed by the community forest user groups. Community members are involved in the entire activities from the identification of the site to the utilization of the benefits from the tree improvement programs. For example, BSOs of *Anthocephalus cadamba* and *Gmelina arborea* have been lying in the community forests. Likewise, TISC record indicates that 12 seed stands have been managed by community forest user groups, and they have been doing all the activities related to their management and TISC provides only technical assistance. According to the Forest Act 1993, all sorts of benefit from CF management including those derived from the management of tree improvement programmes goes to concerned CFUG. It is widely accepted that the tree improvement programs having community involvement are more successful and cost effective than which come under the jurisdiction of DFOs (Dhakal et al 2007).

Besides CFUGs, many individual farmers also have been involved in tree improvement programs. A large number of tree species are maintained in farms as a part of subsistence farming systems and these species are scarce in natural forests (TISC 2001). The trees are the main source of fodder for livestock, which in turn provides food products such as milk and meat, and maintains soil productivity through compost and manure (Acharya 2006). These tree species are identified as a good quality seed source. To this end, TISC has identified and registered various trees on farmland as the seed source. TISC has been providing all the technical help for the management. In addition, TISC facilitates to link individual farmer to the network of Seed Cooperatives. Individual farmer is the sole recipients of the benefits from the seed source (TISC 2001).

Drivers of Change in Forest Biodiversity

Loss and degradation of natural habitats

Continuous loss of forest area is a major threat to forest diversity. According to the Global Forest Resources Assessment by FAO, Nepal lost forest area by 1.4 percent during 1990-2000, and 2000-2005 respectively. During 1990-2000 the country lost 700 hectares of primary forest per year, but this figure rose by ten times to 7,000 hectares per year during 2000-2005 (FAO 2010). The factors driving loss of forest habitat slightly vary among the physiographic zones and include mainly the following drivers: a) encroachment of the forest areas for settlements is a major cause of deforestation in the Tarai and

Siwalik. Some encroachments especially along the East-West highway are also for the expansion of local markets. Most of such settlements are illegal. b) Expansion of cultivation into forest lands is taking place to meet increasing demands for agricultural land. The problem is more severe in the Tarai and Siwalik where productivity of land and population density is high and enforcement of law is generally weak. Shifting cultivation on steep hill slopes is a major cause of forest loss and degradation in some areas of the Siwalik and the adjoining Mahabharat range. c) Development of infrastructures inside forestland is an important factor causing forest loss and degradation. Unplanned and unregulated construction is widely believed to be a major threat in the Middle Mountains, although the exact scale of severity of this problem is yet to be determined. The Department of Roads estimates that around 25,000 kilometers rural road tracks had been opened by 2010, most of which have been constructed without any environment safeguard. Illegal construction of schools, hospitals, temples, water storage tanks and other infrastructure within forest is a problem, particularly in the Tarai and Siwalik. A total of 82,934 hectares forestland was under illegal occupation in 2012 (DoF 2012). This is 66 percent higher as compared to the encroached area in 1994. d) Planned conversion on forestland by the government for implementing economic development priority projects such as construction of roads, electricity transmission line and reservoir is a cause of habitat loss and degradation in some places.

Degradation of habitat

Degradation of forest habitats is a major threat to biodiversity. The World Bank (2008) estimated that one quarter of Nepal's forest area is heavily degraded, which has led to loss of biodiversity, increased landslides, and soil erosion. The major causes of forest habitat degradation are: unsustainable overharvesting of biological resources to meet persistently high demands for fuel, construction timber, fodder and other forest products is common in forests outside protected areas. Illicit felling of commercially valuable trees and the trans-boundary timber trade are major problems in the Tarai, Siwalik and some parts of the High Mountain regions. High demand for fuel wood and unemployment has motivated many people to engage in illegal collection of firewood for sale, particularly along the highways. Selective felling of trees for building materials and over-lopping for fodder and fuel wood also contribute significantly to forest degradation.

Climate change

As in the other part of the world, Nepal is also experiencing climate variation. A study showed that temperature has increased by an average 0.06^0 per year between 1977-1994 (Shrestha et al 1999). Plenty of evidence suggests that various ecosystems have been affected by events associated with climate change. Flood disasters in low land during wet season, species extinction due to frequent forest fire, glacial lake outburst floods are some of the events associated with climate change (Huq et al 2004, Kaab et al 2005). The consequences of these events not only have been affecting the environment of Nepal but also the lives of huge numbers of people. In these circumstances, the forest genetic resources only impacted by climate change, FGR also plays crucial role in climate change mitigation and adaption. The appropriate use of genetic diversity provides flexibility with respect to forest management and helps to reduce the risks associated with climate change. Forest genetic diversity plays a critical role in survival of population in rapidly change climate (FGR 2013).

According to the Nepal Fifth National Report to the Convention on Biological Diversity (2014) biodiversity and climate change are closely linked. According to the Millennium Ecosystem Assessment (2005), the changing climatic condition is likely to become the dominant direct driver of biodiversity loss by the end of this century. The Intergovernmental Panel on Climate Change estimated that 20-30

percent of species will likely to be at a higher risk of extinction with temperature increases greater than 1.5 degree centigrade and risk will increase with additional temperature rise (IPCC 2007).

The understanding of impacts of climate change on Nepal's biodiversity is weak. Some of the known impacts are i) shifts in agro-ecological zones, prolonged dry spells, and higher incidents of pests and diseases due to increased temperature and rainfall variability, ii) increased emergence and fast spread of invasive alien species (eg *Mikania micrantha, Parthenium hysterophorous*), iii) increased incidents of forest fire in recent years, iv) changes in phonological cycle of tree species, v) shifting of tree line in the Himalaya, and vi) depletion of wetlands (MoE 2010). The habitat shift for faunal species inhabiting narrow range (eg common leopard) is another potential consequence of climate change. The limited information indicates that the High Himal and High Mountain ecosystems are likely to be the worst affected by climate change in the near future.

According to the NBSAP 2014-2020, the following are some of the likely impacts of climate change on biodiversity, a) The climatic range of many species will move upward in elevation from their current locations. This will have differential effects on species. Some species will migrate through fragmented landscapes whilst others may not be able to do so, b) Many species that are already vulnerable are likely to become extinct. Species with limited climatic ranges and/or with limited geographical opportunities (eg mountain top species), with restricted habitat requirements, and/or small populations are typically the most vulnerable, c) Changes in frequency, intensity, extent, and locations of climatically and non-climatically induced disturbances will affect how and at what rate the existing ecosystems will be replaced by new plant and animal assemblages. The High Himal and High Mountain ecosystems are likely to be worst affected by climate change. Among the natural habitats, remnant native grasslands are highly vulnerable to the impacts of climate change.

The impacts of climate change are likely to increase in future, which will not only affect biodiversity but also livelihood of local and indigenous people who depend on the biodiversity. Disruption of ecological services on which they depend due to climate change is expected to especially affect the poorest and most vulnerable communities (UNEP 2010). However, there is significant change in extent and distribution of associated biodiversity in micro climate level in a decade but the level is not significant in country level. Changes in land and water use and management have negatively affected the ecosystem services. Overexploitation and overharvesting of forest resources has adversely affected the ecosystem services. Increased demands of agricultural land to fulfill the need of foods supplement have forced to shifting cultivation of forest lands. Population growth has also led to decrease in forest area as the so called domestic refugees needed resettlement in the forest areas. Although, the policies promulgated to cope with such problems are sufficient, weak implementation of enforcement of law and order has not addressed the problems in a pragmatic way.

The State of Intervention in the Conservation and Use of Forest Biodiversity

The Forest Act 1993, Forest Regulation, 1995 and National Parks and Wildlife Conservation (NPWC) Act, 1973 are three most important legal instruments to regulate the FGR of the country. Article 12 of the Forest Regulation, 1995 has provision for prohibiting collection, sale and distribution of any forest product. Under this article the government is empowered to put a ban on the collection of forest trees which are likely to be threatened or are significant for any other reasons. Besides, Article 23 of the Forest Act, 1993 has provision for protected forest. According to the article, if the government considers

that any part of a national forest is of special environmental, scientific or cultural importance or of any other special importance, it may declare such part of the National Forest as a Protected Forest. The government can limit the use of forest products from the protected forest. Likewise, NPWCA (1973) has provision to declare any forest area as a protected area if the area is ecologically important in terms of flora and fauna. Considering the provisions in the Forest and NPWC Acts, the government prepares strategies, programs and activities for conservation of FGR. Women are found sensitive in managing and protection of forests resources in the rural and remote areas. There are many community forests which are led and managed by women committee in mid hills. Since, women are supposed to be responsible to fetch firewood for cooking purpose, fodder for livestock feeding and leaf litters for animal bedding, they seem to be more responsible in managing forest resources. The CFUG's forest operational plans describe and prescribe the locations, timing and amount of forest resources collection and harvesting patterns in a community forests. Women are seen to follow the operation plans in a very practical manner and their participation in harvesting and collection of forest resources is much higher than the men.

Rapid decline of traditional knowledge about biodiversity for food and agriculture has been observed due to availability and use of external inputs, alien invasive species including weeds and invertebrates, increased access to markets and infrastructures (availability of easy alternatives). Rapid transformation of socio-economic conditions of rural people and the resulting changes in food habits have resulted in decreased use of wild food and loss or degradation of the associated traditional knowledge (Rana et al 2012). At the immediate time, the effect of climate change on the wild foods seems to be positive as they are adapted to the higher altitudes. The growth of population and urbanization seems to have negative effect on traditional knowledge on biodiversity for food and agriculture.

Future Agendas for Conservation and Sustainable Use of Forest Biodiversity

Rural women and indigenous communities hold and maintain the knowledge about gathering locations and seasons, preservation, processing, and culinary uses of such plants may play a great role in conservation and commercialization of indigenous vegetables. A study indicated that young people (12–25 years old) possessed more knowledge pertaining to wild fruit plants whereas the knowledge about vegetable plants was more confined to older female members of the households (> 35 years old) (Tiwari et al 2012). Rural women were the major players in utilizing wild traditional food plants including vegetables. They held and maintained a good knowledge on gathering locations and seasons, preservation, consumption and processing of wild vegetables. It was found that Tamang and Bankaria communities were the major consumers of wild vegetables as they lived nearby the forest. The Newar and Chhetri mainly lived in urban and sub-urban areas and were attracted to more improved varieties and exotic vegetables than wild vegetables (Joshi and Shivakoti 2012).

Various institutions are involved in the conservation of forest genetic resources. Institutions such as DoF, DNPWC, DPR and DFRS have been engaged in carrying out research and implementing FGR conservation at the field level. DPR is equipped with laboratory for tissue culture and other phytochemical studies. In addition, various academic institutions viz Central Department of Botany, Tribhuwan University; Department of Biotechnology, Kathmandu University run forest genetic resource related academic courses and are equipped with laboratory facilities. More than other the Central Department of Botany has a herbarium which holds about 22,000 specimens. The Nepal Academy of Science and Technology (NAST) which is mainly responsible to promote science and technology in the country is also equipped with laboratory facilities. NAST conducts research related to agricultural as

well as forest genetic resources. Currently, NAST has been analysing the genotype of economically important plant species such as *Taxus wallichiana*.

Agencies such as IUCN and WWF as well as local NGOs such as the National Trust for Nature Conservation are directly involved in forest genetic conservation. Many community-based organisations along with over 17000 community forest user groups participate in the conservation of natural resources through community forest management.

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Chapter V. Associated Biodiversity for Food and Agriculture in Nepal

Anil K. Acharya, Bal K. Joshi, Devendra Gauchan and Yam P. Poudel

The Role of Associated Biodiversity for Food and Agriculture

Nepal is rich in associated biodiversity which is important for healthy functioning of agroecosystems and improving livelihood of people in Nepal. Associated biodiversity is the sum of non-crop living organisms found in agroecosystems. This includes the range of organisms above and below ground that can harm or help agriculture, such as pests, diseases, and weeds; pollinators and biological control organisms; and the many organisms controlling nutrient cycling (http://www.fao.org/agriculture/crops/thematic-sitemap/theme/biodiversity/cab/en/). These organisms are micro-organisms (including bacteria, viruses and protists) and fungi; invertebrates, including insects, spiders, worms, and all other invertebrates; vertebrates, including amphibians, reptiles, and wild (non-domesticated) birds and mammals, including wild relatives, of importance to crop, animal, fish and forest production as pests, predators, pollinators or in other ways, and wild and cultivated terrestrial and aquatic plants other than crops and crop wild relatives.

Microorganisms play an unenviable role in maintenance of plant systems in nature as symbionts, pathogens, protectants, nutrient scavengers and as associative members of the root zone that is central to establishment of species. Microorganism, a component of associated biodiversity also plays valuable role in nutrient cycling, soil formation, pest management etc. These services are backbone of increasing crop production and productivity and ultimately help in food security. Food security, nutrition and a cash income, fodder, firewood and timber, spices, herbs and medicinal plants, green manures and pesticide crops and cultural and religious uses are the most important uses of agrobiodiversity especially of non timber forest products. Forests represent an important repository of food and other resources that can play a key role in contributing towards food security, especially if integrated into complex systems that are managed for multiple benefits. After recent earthquake in our country the food security situation was not ruined seriously. It is the evidence of sustainable food production system, which was possible due to underutilized crops and wild relatives of crop plants. There are no reliable statistics and assessment of the total number of associated biodiversity. However, there is some estimates for invertebrate insects in Nepal. Estimates show that there are 1261 genera and 3325 species

of invertebrate insects recorded from Nepal. As per utility values of Nepalese mushrooms there are 110 as edible, 13 as medicinal, 45 as toxic and 6 others (Adhikari 2000).

The State of Use of Associated Biodiversity

Table 1. Major practices that negatively impact on associated biodiversity and/or wild foods are listed below:

Types of practices	Major practice (Y/N)	Description
Over use of artificial fertilizers or external inputs	N	Limited commercial production pockets, problem in such pocket
Over use of chemical control mechanisms (eg disease control agents, pesticides, herbicides, veterinary drugs,etc)	N	Limited commercial production pockets, problem in such pocket
Inappropriate water management	Y	In irrigated system mostly wild flooding irrigation practices in most of crop being practiced except vegetable crops.
Practices leading to soil and water degradation	Y	Intensive farming in some pocket areas; Imbalanced and or indiscriminate use of agrochemicals leading to water pollution; Limited use of organic matter, mulching materials, improper tillage practices, cultivation in excessively sloppy areas; Grazing practices and mobile cattle shed in mountain; Rural road
Over harvesting	Y	Over harvesting of wild food (mushroom, ferns, bamboo shoots) and medicinal plants
Others	Y	Change in land use (rural road, real estate and housing and other infrastructures)

The above practices are in use due to lack of awareness and knowledge, lack of policy, land fragmentation, culture of family separation and ownership separation, and limited production, availability and improper distribution of alternatives of chemicals. Actions and counter measures taken to limit unsustainable use and/or support sustainable use of associated biodiversity and/or wild foods include: promotion of neglected and underutilized wild foods, scaling up of home gardening, establishment of nutrition garden and diversity blocks, cattle shed improvement program, SSMP practices/ IPM/ IPNS, and Organic farming/ Community forestry/leasehold forestry.

Effect of lack of biodiversity on livelihood, food security and nutrition

Biodiversity of beneficial micro-organism and natural enemies has declined in intensive production pockets. This caused increased use of agrochemicals thus increased cost of production leading to reduced farm income. In some pockets indiscriminate use of agrochemicals has led to health problems as well as nutritional problem and general loss of biodiversity in other ecosystems. In remote and inaccessible areas, overharvesting of wild food in time of food deficit has resulted in decline of diversity and production of wild food.

The experience of Farmer's field school approach clearly indicates that increase in biodiversity of agro ecosystem has increased production and productivity and decreased cost of production in a sustainable manner. Such practices have also contributed to production of healthy foods and

improvement in rural livelihoods, ecosystem services, and resilience capacity of the landscape supporting the habitats of associated biodiversity (IPM Report, SSMP Report). IPM is one of the important programmes that work on ecosystem principle. The major principles of IPM are conserving natural enemies, producing healthy crops and making the farmers knowledgeable. IPM programme is being carried out in almost all 75 districts and its outcomes are presented in tables below:

FFS and Participants

Program and date	Number of FFS conducted	Total participants	Female %
TCP and Community IPM Program (1997-2002)	708	17850	52
Ist Phase (2003-2007)	845	22725	58
IInd Phase (2008-2014)			
Year long FFS	180	4603	63
Season long FFS	420	11397	60
Total	2153	56575	57

IPM Community Resource Centres

Name of resource centre and address	Major activities
IPM Resource Centre, Kushadevi, Kavre	Trichoderma, Entomo-pathogenic Nematode
IPM Resource Centre, Mangalpur, Chitwan	Trichoderma, NPV
IPM Resource Centre, Kapuwa, Kapilvastu	Trichoderma, Botanical
IPM Resource Centre, Naubasta, Banke	Trichoderma, NPV
IPM Resource Centre, Sripur, Kailali	Trichoderma

Plant Protection Regional Laboratory

Name of resource centre and address	Major activities
RPPL Biratnagar	Trichoderma, Botanicals
RPPL, Harihar Bhavan	EPN, Metarhizium
RPPL, Pokhara	Trichogramma
RPPL, Nepalganj	NPV
RPPL, Sundarpur	Trichoderma

Intensive IPM District

1. Kavrepalanchok
2. Bara
3. Ilam
4. Jhapa
5. Syanja
6. Kapilvastu
7. Banke
8. Surkhet
9. Mustang
10. Jumla
11. Dadeldhura
12. Kailali
13. Chitwan
14. Dhading
15. Bardiya
16. Morang
17. Tanahu

Some proven and popular technologies such as micro-irrigation technologies (treadle pump, drip irrigation, sprinkler irrigation); plastic tunnels for vegetables; super grain bag for seed storage; rustic store for seed potato and cellar store for fruits in hills and mountain; metal bins for grain storage; kitchen/homestead gardening; Farmers Field School for technology dissemination; production of foundation seed in farmer's field; community seed bank; small scale women farmer friendly mechanization; promotion of indigenous crops such as millet, buckwheat, Kaguno, Chino; promotion of

superior indigenous breeds such as Khari and Sinhal goat, Achhami Naumuthe cow; and breed improvement of cattle, buffalo, and goat through both artificial insemination (AI) and natural insemination (NI) are being used in the above mentioned districts.

Soil Improvement Program

- Promotion of fodder crops in leasehold and community forests, community lands, private lands, and promotion of stall-feeding of livestock
- Compost improvement program
- Collection and use of livestock urine
- Integrated plant nutrient and pest management
- Awareness program on proper handling and use of compost manure

Food Safety and Nutrition

- Homestead gardens (vegetables, poultry, and fruits) in all regions
- Development of new food products from indigenous crops such as buckwheat and millet
- Research and awareness on the nutrition values of different food products
- Awareness and educational programs on health and sanitation including importance of proper cooking practices, hand washing practices, breast feeding practices, antenatal care, etc
- Awareness programs on the proper handling and use of pesticides
- Consumer awareness program on food safety issues
- Incentives for toilet construction for poor and vulnerable communities in the mountain districts
- Introduction of cheap water purification techniques among poor communities

Wild food use on a regular basis for food and nutrition

No information is available about the proportion of population using wild food on a regular basis and perhaps the wild food is supplementary in times of scarcity of the cultivated foods. Wild edible plants (WEP) provide staple food for indigenous people, serve as complementary food for non-indigenous people and offer an alternative source of cash income. WEP are important nutrient and vitamin supplements for indigenous people. Therefore, wild food resources reduce the vulnerability of local communities to food insecurity and provide a buffer in times of food shortage. Some of the tribal communities including *Chepang, Raji, Bankariya* and *Raute* are more dependent on the wild foods in scarce periods. They have their own unique culture and are not familiar with other communities/caste of people. The major food items used by these people are *Gittha, Vyakure, Kurilo, Bantarul, Sisnu* etc. The *Chepangs* are believed to have lived by hunting and gathering until the last 150 years as Brain Hodgson described them in his 1857 article 'On the *Chepang* and *Kusunda* Tribes of Nepal' as "living entirely upon wild fruit and the produce of the chase". It is supposed that agriculture is comparatively a newer phenomenon for them, and they practiced *Khoriya* cultivation in the hills. Currently, they practice sedentary and subsistence rain-fed agriculture on marginal land and farming for the mainstay of their livelihood. However, only a small percentage of *Chepang* households are fully self-sufficient (Thapa 2004).

Rural women and indigenous communities hold and maintain the knowledge about gathering locations and seasons, preservation, processing, and culinary uses of such plants. They play a great role in conservation and commercialization of indigenous vegetables (Joshi et al 2007). A study indicated that young people (12–25 years old) possessed more knowledge pertaining to wild fruit plants whereas the knowledge about vegetable plants was more confined to the older female members of the households

(> 35 years old) (Tiwari et al 2012). Rural women are the major players in utilizing wild traditional food plants including vegetables. They hold and maintain a good knowledge on gathering locations and seasons, preservation, consumption and processing of wild vegetables. It was found that Tamang and Bankaria communities were the major consumers of wild vegetables as they lived nearby the forest. The Newar and Chhetri mainly lived in urban and sub-urban areas and were attracted to more improved varieties and exotic vegetables than wild vegetables (Joshi and Shivakoti 2012).

Gaps and priorities

- Lack of research on aspects of associated biodiversity
- Weak understanding how associated biodiversity influences food and nutrition
- Less attraction and involvement of youth in agricultural sector resulting in lacking attitude in information sharing
- Hesitation to use wild foods because of insufficient knowledge on identification and edibility
- Handover of the experiences on associated biodiversity and especially on wild edible plants (sometimes deadly poisonous) to new generation
- Sufficient numbers of farmers' groups, trained farmers in IPM, IPNM and other ecosystem approaches
- Weak cross sectoral coordination, lack of qualified human resource, lack of alternatives and financial constraints are the major resource limitation regarding ecosystem approach
- No authority with assigned TOR to work on the aspects of associated biodiversity, wild, neglected and underutilized species
- Poor mechanism of sharing and documentation of the works done so far
- Conservation of indigenous, high quality, pest resistant crop varieties by the public sector
- Genebank will be maintained covering all aspects of associated biodiversity
- Focus on identification, characterization, domestication, utilization of indigenous/wild food plants
- Research on the utilization and management aspects of associated biodiversity
- Provision of special incentives for the researchers/promoters
- Provision of benefit sharing to the community
- Further promotion of homestead gardening/nutrition gardening
- Imbed the activities to document the biodiversity aspect by districts

The State and Trends of Associated Biodiversity

Wild plants for food production

Nepal, being proximal to the original and secondary sources of origin of different cultivated plants, has harbored numerous wild relatives of cultivated agricultural crop plants like rice, wheat, barley, buckwheat, citrus and other fruit crops, several vegetable crops, etc. It is reported that 83 different wild relatives of 46 genera under 18 families of 36 agricultural crops exists in the country. Besides major crops, different wild species of grain legume crops were found in Nepal. In Kakani Mountain near Kathmandu valley is the forest of *Atylosia* species. Similarly, at least 4 wild species of *Atylosia*, 3 wild species of *Cicer* and 5 wild species of *Lathyrus* have been reported. These wild species are locally used as fodder and feeds, ornamental plants, etc. Numerous wild relatives of fruit crops are found as the wild habitants in the temperate region of Nepal. At least, 9 species of *Prunus*, 3 species each of

Castanopsis, Malus, Morus, Pyrus are mentioned as temperate wild fruit relatives in the country. It is also observed that wild mango *Mangifera sylvatica* in the Lothar forest of Chitwan district while searching for wild rice O*ryza granulata* during mid 1980s. Wild banana, *Musa nepalensis* is found in the lower hills of Churiya range. There is ample scope for selection of promising clones from these existing wild relatives through systematic evaluation and selection. They are the building blocks of new varieties. Nepal already observed considerable genetic erosion of plant genetic resources due to mismanagement of developmental process. Status of wild species indicates decreasing trend because of loss of habitat, continuous deforestation and over exploitation of natural habitats by the ever increasing population. There are many wild relatives of cultivated plants in Nepal. But they are not properly surveyed, identified and catalogued (Gautam 2008).

Wild relatives of vegetable crops

Nepal is a land of extreme with her geo-edapho-climatic variability. Almost all types of world climate and a wide range of bio-diversity exist. Leaving aside the vast number of micro flora, the larger plants group alone is believed to be existing as 7 thousand in species. In case of food plants, 172 families, 296 genera, 599 species and 35 sub-species are found in the country. Out of them 60 families, 155 genera, 225 species and 31 sub species are in cultivation and rest is in wild states. Out of 599 species of food plants 400 species belongs to horticultural groups of which 200 species are vegetable crops. Out of 200 species, only 50 species are believed to be in cultivation. The vast number of wild relatives or species are ignored or remained unknown (Gautam 2008). Wild relatives of vegetable crops recorded in Nepal are Colocasia (3 spp.), Amaranthus (4 spp.), Chenopodum (2 spp.), Rumex (3 spp.), Pisum (3 spp.), Allum (3 spp.), Ipomoea (5 spp.), Dioscorea (4 spp.), Mentha (3 spp.), Trigonella (2 spp.), Solanum (2 spp.), Curcuma (5 spp.).

Ecosystem services

There is no sufficient studies conducted regarding the trends of associated biodiversity within production system, but based on experiences of farmers and related organization it can be stated that there is negative trend in irrigated rice based system both in tropics and sub-tropics because these systems are based on external inputs. Due to introduction of new varieties and crops and infestation of invasive alien plant species diversity of plant has been increasing. Mixed system is the most stable system in the country therefore no significant changes have been observed. Rainfed and mixed systems are based on low external input system so positive trends are observed. There are no any baseline data in this regard.

Irrigated rice based cropping systems both in tropics and sub-tropics are characterized as commercial production system, so pollinator population is declining. New pests and weeds are introduced with new crop varieties and management so there is negative impact on pest and diseases regulation; as these systems have higher cropping intensity some negative impacts are observed in nutrient cycling, soil formation and provisioning of habitat. Problematic pests are increasing but due to indiscriminate use of agrochemicals the diversity of natural enemies is decreasing which has negative impact in pest and diseases regulation in almost all production systems. As an effect of climate change shifting of ecological belt is the most observable change which caused shifting of pest accordingly, same as the case of mosquitoes, slugs and snails. Crop varieties including associated weeds diversity are also shifting in higher elevation zones. Outbreak of pests and invasion of new weeds such as water cabbage, water hyacinth, parthenium, etc, are common challenges invited by climate change. Pest problem in sugarcane area is becoming problematic annually and same is the case in citrus.

Though there are no any authentic data regarding change in state of ecosystem services within the production system, it has been observed and experienced that ecosystem services are negative in irrigated rice based system. It is also observed that pest and diseases regulation services have negative trend due to indiscriminate use of pesticides. Due to lack of organic matter in commercial production pocket, the nutrient cycling process has also been negatively affected. Mixed system and unirrigated system are more stable system; they are not so affected within a decade.

The trend of bee foraging is increasing in mid hills and inner Tarai, which is resulting in positive impact in pollination but as a whole the decreasing population of pollinators has negative impact on pollination services. Indiscriminate use of agrochemicals in some commercial crop production areas resulted in decreased population and diversity of microorganism and affected soil formation process. Invasive weeds provide habitat to insect pests and have negative impact on insect regulation. Problem of monkeys and porcupines in plantation crops of subtropics has been reported in increasing trends.

Monitoring activities related to associated biodiversity

Government has no any specific monitoring system designed for associated biodiversity but as a program, monitoring of activities carried out by laboratories are undertaken by respective directorates. There are no any specific studies carried out but it is observable that *Apis laboriosa* and *A. florea,* two local honeybees are endangered. Practice of honey hunting, habitat destruction, and indiscriminate use of pesticides are the major causes of their loss.

Conservation of associated biodiversity

Ex-situ conservation and management: Specimen collection, identification and preservation is being done by NARC, Universities and Natural History Museum but there are no any activities carried out to conserve the components of associated biodiversity. Genebank has conserved genes of wild relatives of crops; botanical gardens and national parks have also conserved some wild edible plants. Similarly in conservation, community forests have also played important role. No any specific programmes and activities are designed by government to conserve components of associated biodiversity other than plants. Some INGOs/NGOs have taken initiative to conserve local flora and fauna in their command area. LI-BIRD has such programme in Kaski, Chitwan etc.

In-situ conservation and management: Some activities were implemented to prepare inventories of agrobiodiversity and wild foods, which are not continued now. Realizing the global concern for agrobiodiversity conservation, Nepal Agricultural Research Council (NARC), LI-BIRD and Bioversity International (Former, IPGRI) initiated the Nepal component of the global project on "Strengthening The Scientific Basis of In-situ Conservation of Agricultural Biodiversity" in 1997 in three eco-geographical regions Jumla (High hill), Kaski (Mid hill) and Bara (Terai). The objectives of the project were to generate understanding of farmers' decision making processes for in-situ conservation of domesticated crops along with habitats of their adaptation, strengthening national capabilities to carry out research activities in the area and enhancing the value of agrobiodiversity by direct involvement of farmers and other stakeholders. Participatory Plant Breeding (PPB) program was also initiated by LI-BIRD alone and in collaboration with NARC with the aim of understanding farmers' selection criteria, encouraging and strengthening farmers' participation in variety development, and offering to farmers a wide range of material adapted to their specific natural and socio-economic condition. The good

practices of the *in-situ* conservation program ie Community Seed Bank and Community Biodiversity Register also played a supportive role to improve the inventories and survey of the PGRFA in Nepal. Ministry of Forestry and Soil Conservation (MoFSC) with the support of Ministry of Agricultural Development (MoAD) has initiated to inventories and survey of PGRFA and other components of biodiversity in more than twenty districts of Nepal (Gautam 2008).

Activities undertaken to maintain traditional knowledge of associated biodiversity: Various government documents have emphasized to promote traditional knowledge but no any specific activities has been carried out in this aspect. LI-BIRD is one of the pioneer organizations working in this sector yet there is some lacking in case of associated biodiversity.

Wild resources used for food

About 35% of all vegetables consumed in households are collected from forests and bushes. It is estimated that out of more than 500 edible plant species, only 200 are cultivated (NBS 2002). These 200 species have not contributed towards nutrition but a part of bio-diversity and have protective role ie soil conservation. As a source of nutrition, they can play crucial role during the natural hazards and food deficiency in rural livelihood (Rai 2004). The study found that most of the food plants are consumed by the local communities as snacks, and are supplementary and nutritionally important especially prior to the harvest of staple foods. Many villagers also possess knowledge on the modes of propagation for the food plants that may be used in the process of domestication. The local communities expressed a strong desire for the establishment of community enterprises based on the wild food resources for long-term income generation sources (Shrestha and Dhillion 2006). Many indigenous people (including *Chepangs, Raji and Bankariya*) of Nepal rely on hunting and gathering wild products to meet their daily needs which constitute about 25% of their total dietary requirements in some localities (Thapa 2013).

Natural or human-made disasters

Different disasters have different effects on associated biodiversity for food and agriculture. The main disasters having significant impact on associated biodiversity for food and agriculture are as follows:

Natural disaster

Year	Event	Impact
1833	Earthquake	Unknown
1934	Earthquake	Unknown
1988	Flooding	Problem in Irrigation
1996	Flooding	Damage crops/land slide/irrigation channels
2001	Flooding/ Land slide	Damage Lands/Crops/roads
2014	Flooding	Damage crops/land slide/irrigation channels
2015	Earthquake	Damage Lands/Irrigation channels/Crops, Out break of Armyworm in Dolakha, Makawanpur, Jajarkot, Rasuwa

Pests outbreak

Year	Pest outbreak	Impact
1967	Armyworm outbreak in Nuwakot and Ilam in Maize	90% crop loss
1970	Bollworm in Banke in Cotton	Cotton replaced by other crops
1978	Armyworm outbreak in Lamjung (wheat)	70% crop losses
1991	Citrus Decline started from western region of Nepal	Reduction in orchard area
1997	Brown Plant Hopper out break in Chitwan	IPM program launched
1999	Grasshopper in rice in Surkhet district	Damage whole nursery in Surkhet
2006	Red Ant in Gorkha	Reduction in Yield
2008	Armyworm in Barley in Mustang	Yield Reduction
2008	Blast in Rice in Jumla	35% loss in Production
2008	Gray leaf spot in Maize in Midhills	50% yield loss
2012	Armyworm in Rice in Banke and Bardiya District	4 Crore and loss of Rice
2013	*Physoderma maydis* problem in Maize in Rukum	50% loss of maize in District
2013/14	Sugarcane hopper in Sarlahi	30-35% yield loss

Drivers of Change in Associated Biodiversity

The important drivers affecting the extent and distribution of associated biodiversity in last 10 years in Nepal are changes in land and water use and management, pollution and external inputs, over-exploitation and over harvesting, climate change, natural disasters and pest, diseases, alien invasive species. In irrigated production systems, because of higher use of external inputs especially agro-chemicals and higher cropping intensity, associated biodiversity is more affected as compared to rainfed production system.

Effect of climate change on associated biodiversity

Glacier shifting, snow storms, increased volume of glacier lakes and desertification are common in Himalayan region, whereas landslide, soil erosion and floods are common in hilly region. Appearance of tropical insect pests and diseases in higher altitudes are frequently reported. Erratic flooding, droughts and unusually distributed rainfall due to climate change have affected the associated biodiversity. For example citrus psylla, white fly and army worm are becoming problematic in higher altitude. The common cockroach and mosquitoes are now being observed in the high hill and mountainous areas where they were not observed earlier. Similarly, outbreaks of snails and slugs have been frequently reported. Raut (1999) found abundant populations of *Lissachatina fulica* in eastern urban areas of Nepal: Biratnagar, Jaleshwor, and Birgunj, with possible indication of its establishment of 60-70 years ago. In recent years it has spread to western limits of the Western Development Region of the *Terai* and extended north across the Siwalik Hills to Makwanpur, Chitwan and Tanahun. It has crossed the Mid Hill range and ascended the lower slopes of the Mahabharat Range at Baglung, Parbat, Arghakhanchi, Gulmi, Dhading Kaski and Syangjha (Budha and Fred 2008). It has become a serious crop pest, especially in home gardens, nursery and vegetable fields.

Farmers have described the effect of climate change on beekeeping and an increase in insect and pest numbers. The increased unpredictability and intensity of weather events and hazards have been described by farmers as causing significant disruption to rain-fed agriculture, contributing to the loss of

local associated biodiversity, a decline in some local grass species and reduced size of some fodder trees.

Other drivers affecting ecosystem services in production system

The other drivers affecting significant changes in extent and distribution of associated biodiversity in ecosystems services are changes in micro climate level and changes in land and water use and management. Level of use of external inputs particularly agrochemicals is very low in a national level but in some commercial vegetable production pockets there is overuse of insecticides and pesticides. In case of over harvesting and over exploitation, some wild foods like bamboo shoots (*Tusa*), ferns (Niuro/Daunde), some medicinal plants and NTFPs are over harvested without considering their sustainable use. In recent years, bee foraging practice is widely adopted by commercial bee farms and there is positive effect on pollination of rape seed and mustard in Chitwan, Dang, Surkhet and apple in Jumla. There is also a provision of transportation subsidy for the beekeepers for bee foraging, from the government side. Department of agriculture has adapted IPNM and IPM practices which have positive effect on extent and distribution of associated biodiversity.

Effect of drivers of change on wild foods: Wild edible plants (WEP) provide staple food for indigenous people, serve as complementary food for non-indigenous people and offer an alternative source of cash income. WEP are important nutrient and vitamin supplements for indigenous people. Therefore, wild food resources reduce the vulnerability of local communities to food insecurity and provide a buffer in times of food shortage. In addition, WEP have substantial potential for the development of new crops through domestication and provide a genetic resource pool for hybridization and selection. With the rapid decline of traditional knowledge about WEP and increased reliance on processed food, documentation and evaluation of the traditional knowledge related to the diversity, usage, and status of WEP is crucial. Documentation of traditional knowledge regarding WEP in Nepal is very limited compared to medicinal plants. Some of Nepal's WEP were documented in the past, but still many more wild species believed to be edible are yet undocumented (Tiwari et al 2012).

The availability, knowledge and diversity of wild foods have been affected to a varying extent in the different geographical regions, inhabitant tribes and because of the different drivers. Like other plant species, WEP are threatened due to various human activities and natural causes such as land use change (expansion of agricultural lands, developmental activities); habitat destruction (timber harvest, fuel wood collection, forest fire); over-harvesting; over-grazing; and invasive species. Though the recorded and published details are not available, it can be stated that availability of wild foods has increased with the physical access to the remote areas and is not known or has been negatively affected with the other drivers. Rapid transformation of socio-economic conditions of rural people and the resulting changes in food habits result in decreased use of WEP and loss or degradation of the associated traditional knowledge (Rana et al 2012). The knowledge of the wild foods in the indigenous people is generally negatively affected with the year round availability of cultivated vegetables, availability of food grains in the local markets and with the increasing purchasing power of the local people as they are no more interested in the local foods if other easy alternatives are available. At the immediate time, the effect of climate change on the wild foods seems to be positive as they are adapted to the higher altitudes. The growth of population and urbanization seems to have negative effect on all the three aspects availability, knowledge and diversity of wild foods.

Effect of drivers of change on gender: Rural women and indigenous communities hold and maintain the knowledge about gathering locations and seasons, preservation, processing, and culinary uses of such plants. Such knowledge plays a great role in conservation and commercialization of indigenous vegetables (Joshi et al 2007). A study indicated that young people (12–25 years old) possessed more knowledge pertaining to wild fruit plants whereas the knowledge about vegetable plants was more confined to the older female members of the households (> 35 years old) (Tiwariet al 2012). Rural women were the major players in utilizing wild traditional food plants including vegetables. They held and maintained a good knowledge on gathering locations and seasons, preservation, consumption and processing of wild vegetables. Past study showed that Tamang and Bankaria communities were the major consumers of wild vegetables as they lived nearby the forests. The Newar and Chhetri mainly lived in urban and sub-urban areas and were attracted to more improved varieties and exotic vegetables than wild vegetables (Joshi and Shivakoti 2012).

Effect of drivers of change on maintenance and use of traditional knowledge: Rapid decline of traditional knowledge about biodiversity for food and agriculture has been observed. Knowledge is eroding mainly due to availability and use of external inputs, alien invasive species including weeds and invertebrates, and increased access to markets and infrastructures. Rapid transformation of socio-economic conditions of rural people and the resulting changes in food habits have resulted in decreased use of wild food and loss or degradation of the associated traditional knowledge (Rana et al 2012). The growth of population and urbanization seems to have negative effect on traditional knowledge on biodiversity for food and agriculture.

Effect of drivers of change on improving food security and sustainability: The biodiversity has substantial potential for the development of new crops through domestication and provide a genetic resource pool for hybridization and selection breeding. Biodiversity for food and agriculture reduces the vulnerability of local communities to food insecurity and provide a buffer in times of food shortage and stability of the agro-ecosystem. It is negatively affected by changes in land use and crop management practices, use of external inputs (especially hybrid varieties, agrochemicals), pests, diseases and alien invasive species and changing markets.

Counter measures addressing current and emerging drivers of change, best practices and lessons learned

Counter measures planned or in place to reduce adverse consequences of drivers on associated biodiversity related to ecosystem services and wild foods are outlined below.

Farmer's Field School (FFS) on Integrated Pest Management (IPM): After the outbreak of Brown Plant Hopper (*Nilaparvata lugens* Stal) of rice in Kumroj and Kathar area of Chitwan district in 1997, Farmers' Field School approach was adopted in Nepal in 1998 (Kafle et al 2014). From the 9th Five Year Plan (1997-2002), Nepal Government has listed IPM-FFS on the top priority (PPD 2014). It has also been modified and applied in vegetables, cotton, potato, maize, tea and coffee. Recently, modified FFS also includes soil fertility management, land and water management, ground water management, conservation agriculture, land degradation, agroforestry, seed production, marketing, food & nutrition security, fishing, biodiversity, climate change and animal (goat FFS in Nepal) husbandry (Braun and Duveskog 2008). Now the program has been launched in all the 75 districts of Nepal. Presently IPM-FFS is considered as one of the important measures to conserve and promote associated biodiversity in agriculture.

Change in cultivation practices: Most of the IPM-FFS trained farmers (88%) had changed their cultivation practices. Major changes were observed in the use of improved seeds, use of mixture of organic and inorganic fertilizers, reduction in use of chemical pesticides, applying right pesticides at right time, applying right seed rate, crop rotation, proper irrigation and fertilizer application (Bhandari 2012). After successful implementation of FFS, farmers knew the ecosystem more than ever and they started to use nature based pesticides (GC 2011; Esser et al 2012). Numbers of nature based pesticides were also formulated and applied in the field (Katuwal et al 2012).

Changes in pesticide use*:* Jha (2008) found that IPM-FFS trained farmers used 36% lesser amount (1.82 kg/ha) of active ingredients of pesticides than the non-trained farmers (2.85 kg/ha). Similarly, another report (GC 2011) stated that the pesticide application reduced up to 40% in FFS implemented areas as compared with non-FFS areas. Paudel (2012) reported that IPM farmers spend nearly 3.2 times lesser money for pesticides than non-IPM farmers. Non-IPM farmers spend about 96%, 87 % and 82% more money for the pesticides than IPM-FFS farmers for paddy, potato and vegetables, respectively.

Perception about pesticide effects: Most of IPM-FFS trained and non-trained farmers had similar perception that pesticide affects human health but only 53% of non-participants perceived the negative effects of pesticides on beneficial organisms of agro-ecosystem (Jha 2008).

Change in crop diversity: Before participating in IPM-FFS, farmers used to grow only four types of vegetables (Broad leaf mustard, Radish, Local cucurbits, Beans) and after joining IPM-FFS they started growing seven different types (Cauliflower, Cabbage, Beans, Potato, Tomato, Cucumber and Pumpkins). As they knew crop diversification even within vegetables will result in better economic return (Bhandari 2012).

Other impacts*:* Over 80% of the IPM farmers agreed having a better health condition with less doctor visits and reduced medical costs. In the policy level, the linkage, coordination and collaboration between farmers and local government and I/NGOs have shown higher enthusiasm in IPM program (GC 2011). The IPM-FFS has become one of the important training courses among the agriculture-based organizations. The IPM-FFS has been widely accepted by many Government agencies, INGOs/NGOs and Academic institutions.

Sustainable Soil Management Program (SSMP): SSMP is another initiative that promotes a variety of appropriate and sustainable soil management (SSM) practices, based on the use of local resources, in order to improve soil fertility and increase household income especially focused in the rainfed bari land (uplands) of mid hills region of Nepal for the last 1.5 decades. SSM is a valuable tool for climate change adaptation and a pathway for safeguarding key ecosystem services and biodiversity (FAO 2017). Use of appropriate SSMP promotes soil micro flora and fauna resulting in better management of associated biodiversity and improved ecosystem services. SSMP has promoted various technologies for the last 15 years such as Improved Farm Yard Manure (FYM) Management techniques, Improved Cattle Shed to enhance efficient urine collection and use, urine-based bio-pesticides for managing crop insect pests, on-farm composting to improve soil fertility, inclusion of legumes in the cropping system to increase farm productivity, on-farm production of fodder/forage, promotion of green manuring to improve soil fertility and productivity, integrated plant nutrient management system, low-cost polyhouse tomato production during rainy season, ventilated polyhouse technology for off-season vegetable production, raising seedlings inside nursery tunnels, tand nursery, promotion of seasonal/off-season vegetables,

promotion of seasonal/off-season vegetables, promotion of cash crops, promotion of improved cereal crop varieties, and household waste water/rain water collection and use for crop production. Similarly, SSMP has adopted some key approaches like the farmer to farmer extension, Experienced Leader Farmer (ELF), decentralized agriculture extension at the local level, funding decentralized extension at the local level, the one-window approach at the local level, participatory planning at the local level, and linking research and extension at the local level. Followings are some adoption of SSM practices in 20 districts lead to improve livelihoods:

- 94% (54,768) of the 58,890 farmers who received focused programme from SSMP adopted 2 SSMP options as of July 2014.
- 17,433 households earn income from 20 thousands to 450 thousand per year from selling cash corps and vegetable.
- A survey among 3,564 farmers in the 7 districts has shown 47% of the farmers have increased their food sufficiency more than 6 months as compared to 2010.
- Vegetable area / hh was 0.5 ropani in 2010/11 and increased to 1 ropani in 2014.
- Productivity was 500 kg/ ropani in 2010 and increased to 700 kg/ ropani in 2014.

Home gardening/Homestead gardening*:* Home gardening is a traditional land use practice carried out around a homestead consisting of several species of plants that are grown and maintained by the family members with the primary objective of fulfilling the family's consumption needs (Abdoellah et al 2002; Eyzaguirre and Linares 2004; Shrestha et al 2004; Gautam et al 2004). Home gardening is one of the key components of the Nepalese farming system with over 70% of households maintaining home gardens at varying scales, ranging from 2 to 11% of the family's landholding (Gautam et al 2004; Sunwar et al 2006; Gautam et al 2008). Home gardening is also important part of on-farm biodiversity conservation with increased species and varietal diversity at the farm level.

Home gardens can increase dietary diversity (Trinh et al 2003) and help address household malnutrition. By promoting increased consumption of the available diversity, nutrition of farming families can be improved (Johns and Sthapit 2004, Shrestha et al 2002, 2004, Sthapit et al 2004). As home gardens are predominantly managed by women, they can also play an important role in ensuring proper diets of women and children, especially in rural areas (Suwal et al 2008). Hence, the real value of home gardens is in ensuring proper health of women and children first and foremost, who can then have more fulfilling lives to contribute as productive citizens. In addition to the family's food needs, home gardens also augment household income, especially for women, from the sale of surplus produce. Even with small cash incomes, women in villages can exercise greater economic agency in controlling small family expense. Women also tend to spend money differently than man giving priority to food, health care and education.

Home gardens involve the management of multipurpose trees, shrubs, annual and perennial vegetables and fruits, spices, herbs and medicinal plants, birds and animals on the same land units in a spatial or temporal sequence (Shrestha et al 2002, Gautam et al 2004, Suwal et al 2005). Traditionally people supplement food from wild and uncultivated crops besides cultivated species in gardens and arable farming systems (Daniggelis 2003). Many neglected and underutilized species, from a research perspective, are appreciated by local populations and food culture for their taste and nutritional value (Sthapit et al 2008, Johns and Sthapit 2004). The home garden therefore provides a bridge between the

social and the biological and cultivated spaces and natural ecosystems, eventually combining and conserving species diversity and cultural diversity.

Helen Keller International and USAID supported program Homestead Food Production Programme and Aama projects contributed to biodiversity, nutrition and family income in Nepal through homestead garden. Suaahara is a comprehensive community-focused project dedicated to improving the health and nutritional status of pregnant and lactating women and children under two years of age, thereby directly addressing the vulnerable points of development which result in chronic under-nutrition or stunting. Suaahara integrates health, nutrition, and agriculture and food security activities. Complementary nutrition and hygiene education, small-scale backyard farming, and greater access to and understanding of the need for a variety of healthy foods will improve the impact of agriculture production and economic development on nutritional status in the Mid and Far Western regions. Project approaches support the Government of Nepal's Multi-sectoral Nutrition Plan 2013-17 and the Hygiene and Sanitation Master Plan 2011-2015.

Community resource centers: To reduce the adverse effect of chemical pesticide DoA/PPD has established different community resource centres in various regions of country. They are manufacturing botanical pesticides and bio-pesticides under the guidance of PPD, which are as follows:

Name of resource centre and address	Major activities
IPM Resource Centre, Kushadevi, Kavre	Trichoderma, Entomo-pathogenic Nematode
IPM Resource Centre, Mangalpur, Chitwan	Trichoderma, NPV
IPM Resource Centre, Kapuwa, Kapilvastu	Trichoderma, Botanical
IPM Resource Centre, Naubasta, Banke	Trichoderma, NPV
IPM Resource Centre, Sripur, Kailali	Trichoderma

Cattle shed improvement/vermi-composting/subsidy to organic manure producers: Organic matter content is very important factor for soil health. It has reported that soil organic matter content of Nepalese soil has depleted seriously. To maintain soil health government of Nepal has started various programmes since 2010. Cattle shed improvement programme, production of vermi-compost, and subsidy to the purchase of machines used for producing organic manure are the special programme conducted by Soil Management Directorate (SMD). About 30 thousands cattle sheds are improved till the date. Similarly 8 organic manure producing factories are established and numbers of vermi-compost producing farms are established in the country.

Organic farming*:* Organic farming helps to produce safe, nutritious and quality food products together with maintaining ecological balance, biodiversity and its sustainability. People from most of the remote areas have limited access to external inputs specially agrochemicals. So it is said that about 0.5 million hectares of land is by default organic. A large numbers of groups of farmers are involved in organic farming. To support organic farming government has established enabling frameworks ie establishment of the National Organic Agriculture Accreditation body (NOAAB), the National Coordination Committee for Organic Agriculture Production and Processing System (NCCOAPPS), and policies supporting organic agriculture. The National standard for organic agriculture has also been established and endorsed by the government, and working guidelines for two certification systems (Internal Control System and Participatory Guarantee System). Likewise, government has been conducting promotional activities,

provide subsidy for certification to traders who certify their products and export it.

Community seed bank*:* Community seed bank established by both government and non government sectors are playing crucial role in preserving the local landraces in Nepal. Community Seed Bank in Nepal has been initiated in Bara district in the initiative of NARC, Bioversity International and LI-BIRD to enhance access, exchange, use and management of locally valuable, unique and endangered genetic resources. Government has realized the need to work with the farmer community to conserve agrobiodiversity, ensuring food security and developing a sustainable agriculture and has started to establish community seed bank since 2010 and planned to extend it. In Nepal, community seed banks have a long and rich history. Supported in particular by a number of non-government organizations and also by Crop Development Directorate (CDD) under DoA, they can now be found across the country from the *terai* to the high hill areas and from east to west. According to data of 2012, there are 115 community seed banks are active in Nepal (Shrestha et al 2013).

The State of Intervention in the Conservation and Use of Associated Biodiversity

Credit policy favours only for commercial production and profitable crops. There is a lack of policies to finance credits for associated biodiversity conservation. Input and credit subsidies are mainly directed to modern varieties. A food subsidy in remote areas has discouraged production of associated biodiversity.

Constraints

Both policy maker and farmers are not aware of the use of associated biodiversity. Farmers and local communities perceive and interpret policies differently from decision-makers. Policy makers do not have sufficient database and information regarding the associated biodiversity, but policies are formulated based on broad biodiversity term without appropriate balance and without analyzing the relation between macro and micro levels. Because of the lack of integration of macro level policy with micro level issues, users are less aware of policy incentives at the field level, whereas policy makers are less informed about policy constraints and gaps in policy formulation and implementation.

The major constraints of inventories and surveys for associated biodiversity are lack of fund and human resources, inadequate efforts to use biodiversity register for the benefit of communities and nation, lack of national legislation, lack of appropriate incentive mechanism and the weak linkages of formal institutions with the community.

Plans and priorities

There are few studies undertaken on associated biodiversity. The study findings are either not in the reach of policy makers or policy maker are not aware of it. So there must be a system that institutionalizes the flow of research findings to the policy level. Similarly, there must be fruitful interaction between researchers and policy makers.

Priorities for future inventories and surveys of associated biodiversity over the next 10 years are:

- Assessment and documentation of status of associated biodiversity and their sub-components
- Registration of associated biodiversity in all the districts covering ethnic and ecological diversity
- Endorsement of national legislation on access of associated genetic resources and benefit sharing by the constitution assembly

- Creating a forum and/or an institution for innovation in associated genetic resources and traditional knowledge
- Generating technical and financial supports
- Providing incentives/economic benefits to farming communities for their roles in conservation and sustainable use of associated biodiversity

Future Agendas for Management of Associated Biodiversity

Improving food security and nutrition

The important traits should be identified through molecular based technologies and efficiently utilized in public and private breeding programs.

Improving rural livelihoods

Livelihood improvement of rural communities can be enhanced through the proper utilization of available associated biodiversity as follows:

- Technology development through participatory approach in rural communities.
- Livelihoods of rural communities can be enhanced through the implementation of "one village, one product" as implemented by Ministry of Agricultural Development (MoAD) without harming existing agrobiodiversity.
- Product diversification of niche specific crops.
- Linking the products originating from traditional and underutilized crop varieties and wild edible plants with local, regional, national and international markets.

Supporting ecosystem function and the provision of ecosystem services

Payments for Ecosystems Services (PES) or Payment for Environmental Services is an economic tool used by people who benefit from ecosystem services to pay for the people who are participating in maintenance, protection and development of the ecosystem functions. To promote the effectiveness of this model and lessons learned from some countries, Government of Nepal has issued some legal documents about ecosystem services, particularly forest ecosystems. It is essential to better understand the roles and values of the diversity of associated genetic resources in terms of economic, social, cultural and ecological values. Understanding the ecological services and the diverse values of the diversity would promote the conservation and sustainable use of these genetic resources.

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