NATIONAL CEREALS CONSERVATION

STRATEGIC ACTION PLAN

MINISTRY OF AGRICULTURE AND FORESTS

NATIONAL BIODIVERSITY CENTRE

June, 2016

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Drafting Team and Technical Task Force Members:

1. Mr. Ganesh Bahadur Chettri, Specialist II/Joint Director, DoA, MoAF
2. Dr. Tashi Yangzome Dorji, Program Director, NBC, MoAF
3. Mr. Mahesh Ghimiray, Specialist II, RDC-Bajo, MoAF
4. Mr. Tirtha Bdr. Katwal, Specialist III, RDC-Yusipang, MoAF
5. Ms. Asta Maya Tamang, Principal Biodiversity Officer, NBC, MoAF
6. Mr. Singay Dorji, National Coordinator, GEF-Small Grants Program, UNDP
7. Mr. Lhab Tshering, Biodiversity Officer, NBC, MoAF
8. Mr. Rinchen Dorji Sr. Biodiversity Supervisor II, NBC, MoAF

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National Biodiversity Center, Serbithang
P.O Box 875
Ministry of Agriculture and Forests
Thimphu; Bhutan

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ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture and Forests
Tashichhodzong
Thimphu:Bhutan

MINISTER

15 June 2016

FOREWORD

Cereal crops are central to Bhutanese diet, traditional and culture. The share of Dietary Energy supply from cereals, oilseeds and pulses is estimated to be about 87%. Bhutanese farming system and food habit is dominated by nine major staple cereals. Historically, the concept of *Dru-na-gu* (or nine food crops) that includes all important cereals namely rice, maize, wheat, barley, buckwheat, millets, pulses, oilseeds and amaranths is well established. It has been reported that about 80 species of agricultural crops are found in the country. The National Biodiversity Center (NBC) which is the nodal agency for coordination of all the conservation programs has recorded that there are some 350 rice varieties, 47 of maize, 24 of wheat, and 30 of barley based on farmers' naming system. All these crops and varieties have been conserved, carefully selected and passed on to us by our forefathers since time immemorial. Many of these crop varieties represent adaptations to some of the highest agricultural lands in the world for which finding a suitable alternative is all most impossible. The conservation, development and utilization of these cereals are not only critical for our national food and nutritional security; it is also our national heritage as they are closely associated with our culture and traditions.

Furthermore, agro-biodiversity in general and cereals in particular, play a significant role in the food security and livelihood of the Bhutanese people. Diversification of crops and farming system is the most recognized adaptation strategy of the farming communities at times of crop failures. However, there are increasing evidences now that the invaluable crop diversity is depleting faster than expected. Our traditional crops and varieties are getting marginalized, rapidly displaced and lost forever. In the backdrop of this situation, it has become imperative to put in place adequate policy instruments that

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ensure the conservation and sustainable utilization of agro-biodiversity for the benefit of present and future generations.

I am delighted to know that that NBC with support of the South East Asia Regional Initiative for Community Empowerment (SEARICE) with funds from the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGFRA) has developed the National Cereals Conservation Strategic Action Plan. The primary goal of this Strategic Action Plan (SAP) is to conserve, promote and sustainably use agro-biodiversity in order to enhance agricultural growth and ensure food and nutritional security for the people of Bhutan in light of the emerging challenges.

Finally, I take this opportunity to congratulate the NBC and its stakeholders for their timely initiative to come up with a very holistic and a realistic strategic action plan.

Tashi Delek

Yeshey Dorji
Minister

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Abbreviations

ABS	Access and Benefit Sharing
ABSD	Accelerating Bhutan's Socioeconomic Development
AVRDC	Asian Vegetables Research and Development Centre (World Vegetables Centre)
BAFRA	Bhutan Agriculture and Food Regulatory Authority
BAP	Biodiversity Action Plan
BPDP	Bhutan Potato Development Program
BUCAP	Biodiversity Use and Conservation Asia Program
CARD	Centre for Agricultural Research and Development (now RNR RDC)
CBD	Convention on Biological Diversity
CoRRB	Council for RNR Research of Bhutan
CIP	International Potato Centre
DoA	Department of Agriculture
FCB	Food Corporation of Bhutan
FYP	Five Year Plan
GDP	Gross Domestic Product
GEF	Global Environment Facility
GLOF	Glacial Lake Outburst Flood
GLS	Grey Leaf Spot
GNH	Gross National Happiness
HYV	High Yielding Variety
IHDP	Integrated Horticultural Development Project
ILCCP	Integrated Livestock and Crop Conservation Project
IRRI	International Rice Research Institute
ITPGRFA	International Treaty on PGR for Food and Agriculture
MHV	Mountain Hazelnut Venture
MoAF	Ministry of Agriculture and Forests
MT	Metric Tons (=1000 kg)
NBC	National Biodiversity Centre
PGR	Plant Genetic Resources
PIC	Prior Informed Consent
PPB	Participatory Plant Breeding
PVS	Participatory Variety Selection
RARS	Regional Agriculture Research Station
RDC	Research and Development Centre
RGoB	Royal Government of Bhutan
RNR	Renewable Natural Resources
SAP	Strategic Action Plan
SAPA	Sector Adaptation Plan of Action
SDA	Sustainable Development Agreement
SEARICE	South East Asia Regional Initiative for Community Empowerment
SMTA	Standard Material Transfer Agreement
UNDP	United Nations Development Program
VRC	Variety Release Committee

1. Introduction

1.1 The country and its farming systems

Bhutan is a small landlocked mountainous country located in the southern slopes of Eastern Himalayas. The country lies between latitudes 26°42'N and 28°14'N, and longitudes 88° 44'E and 92°07'E. The country has a total geographical area of 38,394 square kilometers with a population of 745,600 people. The forest (tree) cover of the country is about 70.46% but the cultivated land is only 2.93% of the total area (LCAR, 2010). Agriculture is the mainstay of the people with an estimated 69% of the population engaged in farming. Rice, maize, wheat, barley, buckwheat and millets are major cereal crops cultivated in Bhutan, however rice is by far the most important and preferred food crop of the Bhutanese. Agriculture is very important to the Bhutanese economy; the sector accounted for about 17.7% of the total GDP of the country in 2011 (RNR Stats, 2012). Majority of the Bhutanese farmers continue to practice self-sustaining, integrated and subsistence agricultural production system with small land holdings where farmers grow a variety of crops under different farming practices and rear livestock to meet their household food security.

Over centuries, farmers have selected and cultivated a wide array of crops and varieties of cereals that have adapted well to the micro-climatic niches. The types of farming practices are determined by the environment, agro-ecology, types of crops, needs of the farmers, the degree of risk of crop predation by wild animals, market demand and availability of water and farm labour. Bhutanese farmers also continue to practice different forms of multiple cropping that are dominated by traditional technologies innovated and selected by farmers through their experiences. The land use, farming systems, crops cultivated, opportunities and challenges in agriculture are predominantly dictated by climate, topography and altitude. For the purpose of agricultural planning, the country is divided into six major agro-ecological zones corresponding with altitudinal range and climatic conditions (Table 1). The alpine zone which covers the northern region is characterized by alpine meadows and is generally too high to grow food crops. However, small scale barley, mustard and potatoes are grown in Laya at elevation as high as 3839 m. In the cool temperate zone, rearing livestock is the most common way of living with some dryland farming. The main crops grown comprise wheat, potato, buckwheat, mustard, barley and vegetables. The warm temperate zone has moderately warm temperature except during winter when frost occurs and agriculture is widely practiced in terraced irrigated wetlands and drylands. In the wetland agricultural areas, rice is the main crop which is rotated with wheat, potato, seasonal fodder and several kinds of vegetables. A range of temperate fruit crops, wheat, barley and vegetables are grown in dryland agricultural areas.

Table 1: Major agro-ecological zones of Bhutan

Agro-Ecological Zone	Altitude (meters)	Temperature (degree Celsius)			Rainfall (mm per year)
		Monthly Maximum	Monthly Mean	Annual mean	
Alpine	3,600-4,600	12.0	-0.9	5.5	<650
Cool Temperate	2,600-3,600	22.3	0.1	9.9	650-850
Warm temperate	1800-2600	26.3	0.1	12.5	850-1,200
Dry Sub-Tropical	1200-1800	28.7	3.0	17.2	850-1,200
Humid Sub-Tropical	600-1200	33	4.6	19.5	1,200-2,500
Wet-Subtropical	150-600	34.6	11.6	23.6	2,500-5,500

Source: RNR Research Strategy and Plan Document, MoA, 1992

The dry subtropical zone is warm with moderate rainfall allowing the cultivation of a wide range of crops. Rice and maize, mustard, barley, different types of legumes, vegetables and variety of fruit crops are cultivated. The humid subtropical zone has relatively higher rainfall and temperature. The main cropping pattern in the wetland agricultural areas is rice followed by wheat and mustard. In the dryland agricultural areas, maize, millet, mustard, legumes, ginger, vegetables and fruit crops are the predominant crops. The wet subtropical zone has large areas for crop cultivation and suitable agro-ecological conditions that favours intensive agriculture. Rice is the main crop grown in summer which is rotated with wheat and maize that are grown in winter depending on irrigation. Irrigation sources are mostly rain-fed and dry up during winter. In the dryland agricultural areas, maize and millets are the main crops which are rotated with several types of grain and vegetable legumes, mustard, millets, different root and tuber crops, and a wide variety of vegetables.

It has been reported that about 80 species of agricultural crops are found in the country. Several crop species with unique landraces have evolved as an adaptation to micro-niches created by altitudinal and climatic variations. It has been recorded that there are some 350 rice varieties, 47 of maize, 24 of wheat, and 30 of barley as per farmers' naming system. Several of the crop varieties represent adaptations to some of the highest agricultural lands in the world. There are also numerous wild relatives of both indigenous and introduced cereal and horticultural crops (BAP, 2009).

1.2 Agro-biodiversity in the Bhutanese context

FAO defines agro-biodiversity as the variety and variability of crops, domestic animals and micro-organisms that are used directly or indirectly for food and agriculture, including fodder, fibre, fuel and pharmaceuticals. Conceptually, it refers to the diversity of agro-genetic resources (varieties, breeds, species, cultivated, reared or wild) used directly for food and agriculture; the diversity of species that support agro-ecosystems (agriculture, pastoral, forest and aquatic) as

well as the diversity of agro-ecosystem themselves (FAO, 2008). Like biological diversity, agro-biodiversity is considered in three levels: diversity of genetic resources of agro-species, diversity of agro-species and the diversity of agro-ecosystems. Diversity of genetic resources refers to the genetically transmitted characteristics of organisms, which are of actual or potential value such as high yield, diseases and pest resistance and environmental adaptation. Agro-ecosystems diversity is the variability of the ecosystems that are used for agriculture (e.g. monocultures and mixed systems including crop-livestock systems, agro-forestry and aquaculture, pasture and fallow lands).

However, in the Bhutanese context agriculture connotes only to cultivation of food crops, and agro-biodiversity is largely understood as the variety of crops that are raised for direct consumption as food. Such crops may include cereals, vegetables, legumes and oilseeds. Domestic animals fall under the purview of livestock diversity, and fodder, fuel and fibre under forestry. Such a notion is entrenched by the existing organizational structure, delineated as separate departments of crops, livestock and forests. For the practical purpose of this document, agro-biodiversity therefore refers only to the diversity of food crops and excludes livestock and forest components. Further, cereals in Bhutan refer to primary and secondary food crops that farmers cultivate for their livelihood. These crops include rice, maize, wheat, barley, buckwheat and millets.

Agro-biodiversity co-evolves with specific environments, production practices, diet, traditional and cultural practices of people who depend on it. The dynamics and relationships between human societies, cultivated plants and environments are therefore reflected in the concept of agro-biodiversity.

1.3 Importance of cereals in Bhutan

The diet of the Bhutanese people is dominated by cereals. The ancient concept of *Dru-na-gu* (or nine food crops) includes all important cereals. *Dru-na-gu* is a collective term for nine traditional food crops grown in Bhutan which are still prevalent and recognized in the farming systems. The nine crops are rice, maize, wheat, barley, buckwheat, millets, pulses, oilseeds and amaranths. Their equivalent terms in Dzongkha are: *bja* or *rey*, *gayza, ka*, *nah*, *bjo* or *jarey, memja* or *cham, sem*, *peka* and *zimtse*. The successful cultivation of all the nine crops was an indication of the agricultural suitability of a place. In a self-contained society, the term also reflected the status of food self-sufficiency and security in the olden days.

Based on the extent of cultivation and contribution to diet of the Bhutanese people, *Dru-na-gu* forms the main food crops of Bhutan and play a fundamental role in culture, tradition, religion and livelihood. Majority of the *Dru-na-gu* are cereals or pseudo-cereals, except mustard and pulses. *Dru-na-gu* provide a means for people to conduct *rimdos* (religious rituals) and *loche* (annual religious ceremony) that are integral part of the culture and tradition of the Bhutanese people (Lhendup, 2008). These events require preparation and offering of *torm* (divine figurines)

made from cooked rice, wheat or barley flour, and *tshog* from cooked rice. *Dru-na-gu* also comprises of a sacred item (*zhung*) of a newly constructed *chorten* or stupa. Cereals are also used to prepare *ara* (local liquor) and *banchang* (local beer) that are considered as indispensible items for social gatherings and in entertaining visitors. *Ara* is also served as an offering to appease local deities (*serkaim*) or taken as a purification liquid (*duetsi*) during *rimdo* and *loche* (Lhendup, 2008).

Although rice is the preferred food cereal, the importance of indigenous crops like buckwheat, millets and barley that are often neglected as minor crops cannot be underrated. They play a vital role in constituting the overall food basket of the Bhutanese people, especially in remote rural areas. Barley grows in high altitudes where no other cereal can thrive. Similarly, different types of millets grow in poor soils and management situations throughout the country. Such crops provide a reliable source of food and nutrition to our people.

Globally, humans utilize less than 0.1% or fewer than 300 species of plants for nourishment. Approximately 17 plant species provide 90% of mankind's food supply, of which cereal grains supply far the greatest percentage. Eight cereal grains (wheat, maize, rice, barley, sorghum, oats, rye, and millet) provide 56% of the food energy and 50% of the protein consumed on earth (Cordian, 1999). However, only three cereals (wheat, maize and rice) together comprise at least 75% of the world's grain production. Humanity has become dependent upon cereal grains for the majority of its food supply. Bhutanese are no exception when it comes to dependence on cereals. According to MoAF (2007), cereals contribute 75% of diet composition of the Bhutanese people, non-cereals including livestock products contributing only 25%. Bhutanese diet thus consists mostly of cereals and the consumption of vegetables and fruits is low. Cereal agro-biodiversity thus assumes greater significance for a continuous and sustainable supply of food for the present and future generation of Bhutanese people.

1.4 Under-utilized crops and their value

Although the global food supply depends on few crop species, termed as 'major crops', millions of farmers still depend on a large number of crops that suit their agro-ecosystems where major crops often fail. Such crops are stigmatized as under-utilized or minor by mainstream research and development paradigm. Among the cereal crops, buckwheat, millets, barley and even dryland wheat are considered minor in Bhutan. Underutilized crops are marginalized by farmers and consumers due to agronomic, economic or cultural reasons, but might have been once important and major crop in the community. Buckwheat and barley are such examples in Bumthang before potato gained significance.

There is a need for greater exploitation of the crop genetic diversity in order to avoid dependence on few food crops. The under-utilized crops may have lesser importance nationally in terms of production and market value, but they continue to play an important role in the subsistence and economy of poor farmers especially in remote areas. These crops occupy special niches in the

local production and consumption systems. They also provide systems resilience in the face of climate change. Although they are important for the subsistence of local communities, yet they remain poorly documented and neglected by the mainstreamed research and development activities. There are hardly any research and development activities on minor crops undertaken by RNR RDCs in the country. Despite their potential for useful gene source, dietary diversification and the provision of micronutrients such as vitamins and minerals, they continue to attract little research and development attention. Lack of attention has meant that their potential value is underestimated and underexploited. It also places them in danger of continued genetic erosion and disappearance in the future.

In many cases, the under-utilized species have a much higher nutrient content than major crops. For instance, buckwheat is a very good source of manganese, magnesium, copper, and dietary fibre. Buckwheat contains two flavonoids (rutin and quercitin) with significant health-promoting actions. Flavonoids are phyto-nutrients that protect against disease by extending the action of vitamin C and acting as antioxidants. The protein in buckwheat is of high quality, containing all eight essential amino acids, including lysine. Diets that contain buckwheat have been linked to lowered risk of developing high cholesterol and high blood pressure.

Unrefined or whole wheat contains an excellent source of complex carbohydrates, 25% of which is dietary fibre. This source of carbohydrates is said to be ideal for diabetics. Wheat products make an excellent substitution for higher-fat snacks and foods. Wheat is also rich in B-vitamins, such as thiamine, niacin, riboflavin and folate. Barley is considered a nutritionally dense food. It is low in calories and not nearly as starchy as wheat or rice. Barley is especially an excellent provider of dietary fiber, B vitamins, iron, copper, manganese and selenium. High intake of these nutrients helps to promote stronger immunity against diseases and cancers. Due to its high fibre content, eating barley can offer a quick relief for irritable bowel syndrome and constipation.

Millets are other nutritionally interesting alternative to the more common grains. They are a good source of some very important nutrients, including manganese, phosphorus, and magnesium. Millets also have heart-protective properties. Magnesium has been shown in studies to reduce the severity of asthma, reduce the frequency of migraine attacks and lower high blood pressure.

1.5 Purpose of Strategic Action Plan

Agro-biodiversity, cereals in particular, play a significant role in the food security and livelihood of the Bhutanese people, who have been safeguarding and developing such diversity over hundreds of years. For an agrarian society like ours, agro-biodiversity is the backbone for sustainable agricultural development, food security and poverty alleviation. However, there are evidences now that the invaluable crop diversity is deteriorating and disappearing over the years. Thus it becomes imperative that the necessary policy instruments are put in place to conserve and sustainably utilize agro-biodiversity for the benefit of present and future generations.

The primary goal of this Strategic Action Plan (SAP) is to conserve, promote and sustainably use agro-biodiversity in order to enhance agricultural growth and ensure food security for the people of Bhutan. The objectives of SAP are to: provide a long term vision for the conservation, development and utilization of primary food crops of the country towards attaining food security and self-sufficiency; develop integrated and nationally inclusive strategies to address the threats and challenges to the primary food crops; and rescue and conserve critically endangered local landraces and traditional varieties of cereals for future utilization in the national crop development programs.

1.6 Formulation process

The SAP was formulated using a participatory approach which included three major components: formation of a technical working committee, a nation-wide field survey and a national consultation meeting. As the responsible agency for leading the SAP formulation process, NBC formed a technical work committee comprising of eight members representing the Department of Agriculture, Research and Development Centres and NBC. The members were selected for their expertise in the area of research and development, crop breeding, agronomy and agro-biodiversity management. The core group members were Ganesh B Chettri (agriculture development), Mahesh Ghimiray (crop breeding), Tirtha B Katwal (agronomy), Asta M Tamang (agro-biodiversity conservation), Singay Dorji (agro-biodiversity conservation), Rinchen Dorji (agro-biodiversity conservation), and Tashi Y Dorji (biodiversity management) and Lhab Tshering (agro-biodiversity conservation). The committee held several rounds of technical meetings. One of the initial meetings was attended by SEARICE representative providing background information on SAP and conceiving the outline which was further refined in subsequent sessions. Two members, Mahesh Ghimiray and Tirtha B Katwal, were assigned to actually draft the present document.

To incorporate the views and perspectives of farmers on SAP, a field survey was carried out in nine Dzongkhags (districts) and 20 Gewogs (blocks) covering four main agro-ecological zones, crops and threat levels (remote, accessible). A total of 404 farmers (237 male and 167 female) participated in the survey. The survey questionnaire captured three broad areas: status and trends on food cereals, management and persistence of cereals diversity, and climate change and farmers' adaptation strategies. The main findings from the survey are presented in this report.

A national level consultation meeting with relevant stakeholders was held on 10 December 2013 in Thimphu to incorporate views and suggestions for improvement of the SAP. More than 25 professionals participated in the meeting. These included Dzongkhag Agricultural Officers, Planning Officers of MoAF, representatives from Agricultural Marketing, National Plant Protection Centre, National Soils Centre, National Post Harvest Centre, National Organic Program, National Seeds Centre, RNR Research and Development Centres, Department of Agriculture, Bhutan Agriculture and Food Regulatory Authority and National Biodiversity Centre. Views and suggestions of the participants have been incorporated in the document.

2. Current status of cereals agro-biodiversity

Relative to its small size, Bhutan has considerable diversity of agricultural crops, varieties and agro-ecosystems. Such a diversity is partly a result of altitudinal and temperature variations as one travels from north to south of the country. The major food cereals of Bhutan are rice and maize, based on the area grown, production and per capita consumption. Grown to a lesser extent, wheat, buckwheat, millets and barley are other crops that fill up the food basket of the Bhutanese people. Genetic variation is the key to agricultural development and food security and the value of conserving agro-biodiversity lies in its potential to supply raw materials for future development needs. It is generally accepted that the wealth of landraces is slowly diminishing in the country due to a number of factors ranging from agricultural modernization, commercialization and loss of cultivated lands. A nation-wide survey of the crop genetic resources for food and agriculture was carried out in 2002-03 which led to the first documentation of field or food crops diversity. Over 621 accessions of food cereals were collected then, which has increased to over 2200 accessions now. The sections below dwell on the important food crops, their diversity as known so far, status of exotic crop varieties popularized in the country as well as the main causes of genetic erosion of agro-biodiversity.

2.1 Local diversity of crops and varieties

As a result of topographic and climatic variations, a number of food crops and crop varieties thrive in the country. The main cereals grown in the country include rice, maize, wheat, barley, buckwheat and millets. Table 2 provides the current status of cereals diversity in terms of the number of varieties, both improved and local, in the country (Survey, 2013). The native crop varieties possess unique genetic variation through natural as well as human selection over time (Chettri *et al*, 2000). Not many genetic or molecular studies have been done to document diversity, however many reports are available based on eco-geographic and morphological attributes. A brief summary of the extant of diversity of important crops are presented in table 2.

Table 2: Current status of cereals diversity, 2013.

Crop	Improved varieties	Traditional varieties	Total varieties cultivated
Rice	13	84	97
Maize	5	34	39
Wheat	6	19	25
Barley	0	14	14
Buckwheat	1	13	14
Millet	0	30	30
Total	25	194	219

2.1.1 Rice

Rice is grown in diverse ecosystems and altitudinal range in the country. It is grown in three major ecosystems: irrigated, rainfed and upland and at elevations ranging from about 200 m in the south to 2780 m in the north. The variations in agro-ecological conditions and altitudes create diversity of rice varieties that can adapt well to the requirements of a given locality. In general, Japonica cultivars are confined to temperate regions and Indica varieties are common in sub-tropical areas. However, there are no clear cut distinctions and many intermediate types have been reported (Chettri, 1992). In addition to the cultivated types, weed races of rice are also known to occur as a result of introgressive hybridization between wild and cultivated varieties (Loresto, 1998). Locally, such rice variants are known as *khem* or *pchem* in Paro and *sem* in Wangdue. Further, occurrence of wild relatives of rice, e.g. *Oryza officinalis* has also been reported by NBC.

The traditional Bhutanese rice varieties can be broadly classified as "BjaMaap" (red pericarp varieties) and "Bja Kaap" (white pericarp varieties). Bja Maap are predominant in higher elevations usually above 1500 m, while Bja Kaap are more commonly grown in lower elevations. Traditional varieties are generally heterogeneous for various traits and morphological differences are displayed in the field. Bhutanese farmers cultivate and maintain a range of varieties in their fields. According to Duba *et al* (1995), a single farmer cultivates 2-5 rice varieties in small parcels of land to fulfill varied needs such as for *tho* (cooked rice), *zaw* or *siroula* (puffed rice), *seep* or *chiura* (flattened rice), *selroti* and *mekhu* (roti-like cooked in oil), *torm* (ritualistic divine figures), *khir* (rice cooked with milk) and c*hankey* and *ara* (local brew). On-farm rice diversity has been an integral part of the tradition, religion and culture of the Bhutanese people. Some rice varieties are cultivated for specific purposes. For instance, Dumbja is used mostly for seep as it is one of the few local varieties with white grains in high altitudes. Red grained rice varieties are not commonly used for making *seep* or *zaw*. Hamzam is a local variety grown for making *torm* due to its sticky grain texture. Olanam is specifically grown for brewing alcohol. Bondey, Masino and Bhog are aromatic and fine grained quality rice with a premium price in the local market.

Rice is grown in all the 20 Dzongkhags of the country, but the acreage and diversity of ecosystems vary. According to the Survey (2013), farmers in the sampled Dzongkhags grow a total of 97 rice varieties including 13 improved and 84 local varieties. Dzongkhags with high varietal diversity include Punakha, Samtse, Trashiyangtse, Zhemgang, Wangdue and Sarpang (NBC, 2008). Other important Dzongkhags are Samdrup Jongkhar, Trashigang, Trongsa and Chukha. Due to limited area and with only temperate agroecology, Haa and Gasa have low diversity of local varieties. NBC has so far recorded 384 landraces of rice. Other published literatures show a total of 394 varieties (Chettri *et al*, 2000).

2.1.2 Maize

No information exists as to when maize was introduced into the country; however its presence was noted by George Bogle in 1774. Maize is cultivated mainly for subsistence and it plays a critical role in the household food security. It ranks first in terms of area cultivated among the food crops (RNR Stats, 2012). Maize is grown in all the 20 Dzongkhags from an elevation of 150 m to nearly up to 2800 m, although the extent of cultivation varies. The maize production environment in the country is broadly categorized into three zones based on the altitude. The three production zones are, Sub-tropical maize production zone I (<1200 m asl) or low altitudes, Sub-tropical maize production zone II (1200 -1800 m asl) or mid altitudes and the Highland maize production zone (>1800 m asl). Maize is predominantly grown as a rainfed crop on sloping and un-irrigated upland fields. A small portion however is also grown in the terraced wetlands prior to rice. It is predominantly cultivated in the six eastern Dzongkhags where it is consumed as a staple food and to a slightly lesser extent in the southern and central parts of Bhutan. Due to its versatility to adapt to a wide range of agro-ecology and cropping systems the cultivation of maize is expanding to non-traditional maize growing Dzongkhags like Bumthang, Thimphu, Paro and Haa.

It is estimated that 80% of the total production is consumed at the household level by the farmers which is valued at Nu. 353 Million (1 USD = 54 Nu.) annually. About 6% of the total production is sold which is an important source of household. About 6% of the total production is sold which is an important source of household income (Katwal *et al*, 2006). The rest of the production is used as seed, processed into different products and fed to the livestock. Green stover and maize husk are fed to cattle.

Different types of maize are cultivated in the country which includes with a variety of colored kernels that are white, deep yellow, light yellow, orange and black that are either dent, semi dent and flint. Except for one improved maize variety Shafangma Ashom (S03TLYQ AB05) released in 2012 which is a Quality Protein Maize (QPM), all other maize varieties cultivated in the country are normal maize. Popcorn is very popular and is mainly cultivated for its popping quality. Baby corn is cultivated in relatively smaller scale in peri-urban areas. Most of the varieties cultivated can be categorized as full season varieties with long maturity period with the exception of a very few short duration varieties that are used for double cropping and those used in the rice-maize rotation. The local varieties are recognizable by their distinctive morphological traits especially the tall height, small and compact tassel, tight and cobs fully covered by husk, usually slender stalk and, small and slender size of cobs. Such landraces are genetically diverse although detailed studies are lacking. Some of the popular landraces of maize are Baipo Ashom, Kanglungpa, Bartshampa and Udzorongpa whose names indicates the areas where they are popularly cultivated. Theksumpa is the most popular traditional extra early variety that matures in 90 days and is popularly grown as the second crop of maize in the maize-maize rotation. The most popular traditional pop corn variety is known as the Sharpa Ashom and is widely used by

farmers for popping. Farmers give different names to varieties that show adaptation to micro-niches, soil types, sowing time, nutritive value and other properties. Farmers currently grow 39 maize varieties, including 5 improved and 34 local varieties (Survey, 2013). NBC has so far collected and documented a total of 105 landraces from 15 Dzongkhags. Dzongkhags showing high diversity include Pemagatshel, Samdrup Jongkhar, Lhuentse, Monggar, Trashigang and Trongsa (NBC, 2008). Although maize is cultivated in other Dzongkhags like Dagana, Wangdue, Punakha and Haa, NBC is yet to record varieties from there.

2.1.3 Wheat

Records on the introduction of wheat to Bhutan are not available. Some speculate that it might have come from Tibet. Records of early visitors to Bhutan suggest that wheat was an important crop after rice in the last century than today. Wheat today is limited to 2,246 ha with a production of 6,105 MT (RNR Stats, 2012). Wheat is cultivated in different agro-ecological regions from about 200 m to above 3000 m. It is grown as a main or secondary crop after maize, rice and potato and in rotation with buckwheat at higher altitudes. Apart from grain, wheat is also grown as winter fodder and for hay making in high altitudes. Wheat grown in Bhutan are classified into two major groups: winter wheat and spring wheat. Winter wheat is cold hardy, requiring vernalization and is confined to higher elevation drylands. Spring wheat fits well in the rice-based cropping system in lower elevations. Wheat is used both for human consumption and for animal feed. Wheat is consumed traditionally as *kapchi* which is a flour product after roasting and grinding, apart from brewing into *banchang* and *ara.*Wheat flour is also used to make *torm* where rice and other crops are not easily available.

In terms of varietal diversity, NBC has so far documented 36 varieties of wheat from 10 Dzongkhags. The Survey of 2013 showed that there are 25 (5 improved and 19 local) varieties presently grown by farmers. There is however no differentiation between winter and spring types. It is speculated that the diversity is higher in the upper drylands where winter types dominate. Farmers seem to distinguish two types of wheat based on their origin. These are *Dubai ka* (Bhutan wheat) and *Byoka* (Tibet wheat). *Dubai ka* resembles more of spring wheat with profuse awns, whereas *Byoka* is awnless and probably a winter type. Chuka and Bumthang exhibit high diversity followed by Paro, Wangdue, Thimphu, Samtse and Zhemgang (NBC, 2008).

2.1.4 Millets

There are three types or species of millets grown in Bhutan. These are finger millet (*Elusine coracana*), foxtail millet (*Setaria italica*) and common millet (*Panicum miliaceum*). The most widely adapted and commonly cultivated type is the finger millet. It is grown from an elevation of about 200 m till 2300 m on drylands as a sole crop or intercropped with perilla, amaranth, maize or legumes. In the humid and wet sub-tropics, it is a common practice for farmers to grow millets under mandarin orchards from June-July to September-October. The Dzongkhags of

Samtse, Sarpang, Tsirang and Samdrup Jongkhar have maximum area under finger millets. The total area grown to millets stands at 3,614 ha. Although millets are stigmatized as minor crops, they play an important role in household food security of poor and marginal farmers. Millets are consumed as *keptang* or *roti* (traditional pancakes) or *dengo* or *dhido* (cooked dough), apart from *banchang*, *tongba* and *ara* (traditional drinks). Millet straw serves as an important cattle feed during times of fodder scarcity.

The traditional finger millet varieties are diverse in finger types ranging from compact to free. A total of 146 accessions from 18 Dzongkhags are conserved in the national genebank managed by NBC. Farmers presently grow 30 traditional varieties (Survey, 2013). Dzongkhags that show high diversity include Sarpang, Samtse, Chuka, Lhuentse and Samdrup Jongkhar (NBC, 2008). Foxtail millet is popular in the east and east-central parts of the country. It is grown from 200 to 2000 m, mostly in Samdrup Jongkhar, Pemagatshel, Zhemgang and Sarpang. It is largely a dryland rainfed crop grown solely or together with maize. Foxtail millet used to be grown under *tseri* (slash and burn) cropping system, however such a practice is officially banned for environmental reasons. Apart from brewing, foxtail millet is consumed as *thueb* (porridge). It can also be mixed with rice or maize and cooked together. In terms of wild relatives diversity, two species (*Setaria viridis* and *S. pumila*) are reported. NBC has collected 36 landraces from 7 Dzongkhags. The highest diversity was recorded from Samdrup Jongkhar followed by Lhuentse, Trashigang and Pemagatshel. Very little is known and documented about the diversity of common millet.

2.1.5 Buckwheat

Two species of buckwheat are grown in Bhutan. These are sweet buckwheat (*Fagopyrum esculentum*) and bitter buckwheat (*F. tataricum*). Based on allozyme studies, buckwheat was introduced in Bhutan from China through Myanmar and North East India (NBC, 2008). Buckwheat is widely adaptable growing from about 150 m to 3000 m. It is cultivated both in dryland and wetland systems. In cooler drylands, it is grown as a sole crop in rotation with potato, maize or barley. In the warmer wetlands, it is grown as a pre-rice crop. Sweet buckwheat is an important crop in Bumthang, Samtse, Samdrup Jongkhar, Chuka, Tsirang and Monggar. Bitter buckwheat is grown in Samdrup Jongkhar, Chuka, Pemagatshel and Bumthang. Together, buckwheat area is around 3,777 ha. Although buckwheats are classified as minor crop, they are an integral component of the food basket in areas where major cereals cannot grow. Buckwheat products range from *keptang* (flat bread), *khuli* (pancake), *puta* (noodles) and *dengo* (cooked dough). There are many traditional varieties of buckwheat adapted to different altitude regimes. A total of 10 landraces of sweet buckwheat are documented by NBC. However, there are 14 varieties grown in the farmers' fields (Survey, 2013). Bumthang has the highest level of diversity. In bitter buckwheat, 11 landraces have been collected with maximum diversity in Bumthang and Paro. In terms of wild relatives, one species of wild relative is reported.

Other food crops of importance include barley and amaranths. Barley, mostly naked type, is well adapted to higher altitudes. In fact, barley is the only grain crop available to farmers and livestock herders above 3500 m. Barley was probably introduced from Tibet. Barley is consumed as *kapchi* (roasted and powdered) in addition to brewing alcoholic drinks. Both hulled and hull-less types of barley are found. A total of 62 landraces are collected and conserved by NBC. Amaranths are cultivated on a small scale mostly in eastern Bhutan. Amaranth leaves are eaten as vegetable, while seeds are used in various forms often as additive to improve the taste and cooking quality of food. NBC has collected 21 landraces from Samdrup Jongkhar, Wangdue, Lhuentse, Paro, Punakha and Pemagatshel.

2.2 Introduced cereal varieties

Bhutan opened its door to the outside world in the early 1960s when Indian assistance was sought to begin the first Five Year Plan. Agricultural development to boost food production was given high priority. As a consequence, introduction and promotion of new crops, crop varieties and production technologies was begun. Records show that the first modern rice variety, No. 11, was introduced in 1968 from Japan and grown in Bondey, Paro. Horticultural crops like apple, peach, cherry and assorted vegetables (cabbage, cauliflower) were also introduced and grown in Paro.

In 1963, the Regional Agriculture Research Station (RARS) was started in Bhur, Gelephu to train Bhutanese agriculturists and to showcase new agricultural technologies in collaboration with India. The station was responsible for introducing a number of high yielding varieties of wheat (Sonalika, Kalyan Sona), rice (Jaya, IR 8) and other crops in the 1970s. Introduction of a new open-pollinated maize variety, Yangtsipa (Suwan 1, a CIMMYT line developed in Thailand) is attributed to two staff of the Department of Agriculture who hand-carried the seed in 1991 after attending a seed meeting cum exposition in Bangkok. It was first experimented in Yangtse farm and later released nationally.

Systematic research and development on agriculture started in 1982 with the establishment of Centre for Agricultural Research and Development (CARD), now renamed as RNR Research and Development Centre at Bajo, Wangdue. CARD soon developed institutional linkages with CG centres like IRRI, CIMMYT and AVRDC. The introduction of exotic germplasm then became formal and institutionalized. On an annual basis, RNR RDCs receive and evaluate hundreds of new germplasm of cereals including rice, maize, wheat and barley. The introduced germplasm, once evaluated and proven to be superior in yield, pest resistance and other desired traits, are submitted for final assessment and official release to the Variety Release Committee (VRC) of the Council for RNR Research of Bhutan (CoRRB). So far a total of 23 rice, 5 maize, 3 wheat and 2 finger millet varieties have been released in the country (Table 3). Breeder seeds of the new varieties are passed on to the National Seeds Centre for mass multiplication and supply to the farmers. However, variety release protocol is silent on the need for genetic diversity assessment and collection prior to release in the targeted areas.

Table 3 : Modern high yielding cereal varieties released in Bhutan.

Crop	No of varieties	Variety names
Rice	23	IR 64, M 54, IR 20913, No 11, Barkat, BajoMaap1, Bajo Maap2, Bajo Kaap1, Bajo Kaap2, Yusirey Maap1, Yusirey Maap 2, Yusirey Kaap1, Yusirey Kaap2, Khangma Maap, Wengkhar Rey Kaap2, Wengkhar Rey Kaap6, Jakar Rey Naab, BR153, BW293, Bhur Rey Kaap1, Bhur Rey Kaap2, Bhur Kambja1, Bhur Kambja2
Maize	5	Yangtsipa, Khangma Ahsom-1, KA-2, Shafangma Ashom, Chaskarpa
Wheat	3	Sonalika, Bajoka-1, Bajoka-2
Finger millet	2	Limithang Kongfu-1 and Limithang Kongfu-2.
Total	33	

Source: VRC records

3. Conservation and utilization of cereals diversity

Agro-biodiversity is the result of thousands of years of effort by farmers in selection and breeding and developing appropriate crop production systems. Crop genetic resources are the source material for further development of crop varieties by farmers and breeders. Marginal and subsistence farmers are particularly dependent upon the diversity of genetic resources. A rich diversity of native and locally adapted crop varieties secures their survival in the face of changing climate. Traditional crop genetic resources can be utilized with minimum agricultural input, have quality characteristics that correspond to needs of the people and play an important role in the culture and tradition of rural population. Landraces represent high levels of genetic diversity and are therefore the focus of most crop improvement programs. In Bhutan, efforts to utilize local crop diversity in crop improvement programs are so far limited to rice.

3.1 Use of local diversity in crop improvement programs

Local crop genetic resources have the potential to provide useful genes for desired traits like culinary and eating qualities in a crop breeding program. The rice breeding and improvement program of Bhutan has utilized local rice genetic resources to develop preferred varieties. Hybridization of traditional Bhutanese rice cultivars with improved varieties or lines was started in the mid 1980s as a longer-term strategy for the improvement of Bhutanese indigenous rice varieties. The Bhutanese rice varieties are low yielding as response to added inputs is limited by lodging and disease manifestation. However, they are valued for their yield stability and grain quality.

The principal objective of the cross breeding program is to assimilate desirable genes for high yield, adaptability, grain quality, cold tolerance and disease resistance from various sources. More than 150 crosses have been made involving traditional varieties of Bhutan and improved breeding lines and/or varieties from elsewhere (Ghimiray, 1999). More than 60 popularly grown varieties from the high and mid-altitude rice growing zones were used as local parents. Some of the local parents frequently used in crossing are Kaap, Maap, Zakha, Kochum, Dumbja, Bjanaab, Paro Maap, Punakha Maap, Attey, Masino, Zuchem and Sungsung Bara. The breeding program generated over 5000 lines and bulks that were tested in different rice agro-ecologies. Such an effort has resulted in developing eight rice varieties using local germplasm.

Bhutanese red rice varieties are highly valued for their taste and social standing, however they are susceptible to diseases and lodging. Such varieties are crossed to improve agronomic characters without compromising their cooking and eating qualities. Lines with superior yield and desired grain characteristics such as red pericarp have been identified and formally released (Table 4).

Table 4.Developed rice varieties using local rice genetic resources

Variety	Parents	Year released	Developed by	Altitudes (m)
Bajo Maap 1	Punakha Maap/IR 64	1999	RC Bajo	600-1500
Bajo Maap 2	Local Maap/IR 64	1999	RC Bajo	600-1500
Bajo Kaap 1	Paro Maap/IR41996	1999	RC Bajo	600-1500
Bajo Kaap 2	Bja Naab/IR41996	1999	RC Bajo	600-1500
Yusi Ray Maap1	Suweon 359//IR41996-118-2-13/Thimphu Maap	2002	RC Yusipang	Above 1800
Yusi Ray Kaap1	YR3825-11-3-2-1/ YR3825-11-3-2-1/Barkat	2002	RC Yusipang	Above 1800
Yusi Ray kaap 2	Akiyutaka/Naam	2010	RC Yusipang	>1800 m
Yusi Ray maap 2	Akiyutaka/Rey Maap	2010	RC Yusipang	>1800 m

Source: Ghimiray, 2010

Insurgence of new diseases and their spread is not a new phenomenon. Development and adaptation of crop varieties continue to be the most sustainable option to manage disease epidemics. In 1995, rice blast, a disease most prevalent in sub-tropics caused by *Pyrcularia grisea,* occurred in an epidemic scale in high altitude rice growing areas above 1800 m severely affecting all the traditional rice varieties. The disease devastated over 700 ha of rice area and led to an estimated loss of about 1099 tons of paddy. Not a single traditional rice variety displayed any appreciable blast resistance. Breeding for blast resistance is thus accorded high priority. The breeding program has yielded four varieties (Yusirey Kaap and Maap series) that combine blast resistance and grain quality traits (Table 4). Khangma Maap, an introduced variety that showed tolerance to blast was also released as a sustainable option to contain the disease. Similarly in maize, Gray Leaf Spot (GLS), a disease never reported in Bhutan was confirmed in 2007 at higher elevations. To respond to this disease the maize program introduced several genotypes from different sources and has initiated cross breeding activities to improve the resistance of local genotypes.

The potential of cereal genetic resources in developing locally suited varieties still remains under-exploited though. One of the reasons is the limited technical capacity and manpower in the research system. Virtually no research and development activities have been undertaken in cereals other than rice, maize and to some extent wheat. Even in these three crops, much more

can be achieved if more resources are made available. Appropriate policy initiatives must be put in place to propel the development of local cereal resources.

3.2 Agro-biodiversity conservation programs

Agriculture is the source of livelihood for over 69% of the Bhutanese population and hence domestic agro-biodiversity continues to be the primary source of food and nutrition. Majority of Bhutanese farmers still practice traditional, subsistence and self-sustaining farming practice where land holdings are small and farmers grow a variety of crops to meet their household needs. Recognizing the role of the domestic diversity for food and nutritional security, the National Biodiversity Center since its establishment in 1998 has given a high priority for the conservation, development and utilization of domestic agro-biodiversity through the initiation of number of programs and projects. Agro-biodiversity conservation and development programs have also been successfully mainstreamed into the national development plans from the beginning of the 9th Five Year Plan.

The NBC has a full-fledged functional Plant Genetic Resources Section under which it has a unit fully dedicated to the agro-biodiversity. In 1998, NBC launched the Agro-biodiversity Project (ABP) with financial support of the Netherlands which was instrumental in laying the foundation for the conservation and development programs on agro-biodiversity. One of the milestones of the ABP is the establishment of the National Gene Bank at NBC for *ex situ* conservation of crop genetic resources in 2005. The agro-biodiversity unit manages the National Genebank, organizes annual collection of crop germplasm that are prone to losses and extinction from different threats. As of 2016, a total of 156 *Gewogs* have been covered and approximately 2200 samples of different crops collected and safely conserved. In order to take conservation to the door steps of farming communities who are the main custodians of agro-biodiversity and give them ownership of their traditional crops and varieties, NBC has initiated Community Seed Banks in Bumthang, Samdrup Jongkhar and Sarpang Dzongkhags. These are initiated in partnership with farmers, Research Centers, Gewog Extension Service and Local Government. The initiative on community seed bank is supported by the Small Grant Project (SGP) of the Global Environmental Facility (GEF) through the United Nations Development Program (UNDP), ITPGRFA and SEARICE. The community seed bank will be linked to the national gene bank for effective *ex situ* conservation of agro-biodiversity resources. Currently there are four functional Community Seed Banks in three Dzongkhags. Another key achievement of the ABP was the inventory and documentation of the status of the existing agro-biodiversity diversity in the country.

In order to enhance and strengthen On-farm Conservation of domestic agro-biodiversity, NBC launched the Biodiversity Use and Conservation in Asia Program (BUCAP) project in 2001.The BUCAP project was supported by the Development Fund (DF) of Norway, Swede Bio of Sweden and Oxfarm Novib. The BUCAP project is currently ongoing and is implemented by NBC with the technical support of South East Asia Regional Initiative on Community

Empowerment (SEARICE), an international non-governmental organization (NGO) based in the Philippines. BUCAP was the first project that initiated interventions and field programs on participatory conservation, development and utilization of agro-biodiversity engaging farmers, researchers and extension staff (Katwal *et al*, 2011). BUCAP focused on maintenance and improvement of the genetic diversity of important food crops of Bhutan, promotion and utilization of crop genetic resources for sustainable livelihoods, strengthening of farmers' agro-biodiversity management systems and local capacity, and the creation of an enabling policy environment for agro-biodiversity conservation. In partnership with research and development centers, BUCAP also facilitated and mainstreamed Participatory Plant Breeding (PPB) and Participatory Variety Section (PVS) tools that engage farmers as active research partners for development and selection of crop varieties to enhance the farm level diversity. The BUCAP project has been extended into the third phase as the Democratization of Agriculture Research and Extension (DARE) project and mainly focuses on improving the traditional seed systems and capacity development of farmers in agro-biodiversity conservation.

The Integrated Livestock and Crop Conservation Project (ILCCP) supported by the Global Environment Facility (GEF) of the United Nations has also been completed. The ILCCP focused on the development and utilization of traditional crops through product development and diversification, value addition and marketing for long term conservation and enhancing farming system resilience. Besides, ILCCP has tremendously contributed towards creating awareness and enhancing knowledge of all the stakeholders and the general public on the importance of agro-biodiversity conservation. The project has also supported in formulation of National Food and Nutritional Security Policy.

NBC is actively engaged in advocacy and awareness on the importance of agro-biodiversity, its conservation and sustainable utilization. It organizes regular seed fairs and crop competition coinciding with important national events in different parts of the country to engage rural communities in conservation. Active farmer participants are rewarded in different forms during such seed fairs and crop competitions. Such seed fairs and competitions help to promote seed exchange among communities and inculcate in them the need to conserve and maintain their agro-biodiversity resources. Seeds of rare and unique varieties are also collected from such seed fairs for conservation in the national genebank.

Under the framework of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), NBC has initiated number of projects on the conservation and development of important food crops as well as the capacity development of stakeholders in collaboration with Bioversity International.

4. Agro-biodiversity policies and legislation

The conservation of environment and biodiversity is not a new concept in Bhutan. The Buddhist philosophy of reverence of all living beings is central to our development thinking and policy making. The Constitution of Bhutan, as the supreme law of the land, enshrines environmental conservation as a national mandate. Over the years, many policies and legislations have evolved which seek to conserve environment and biological resources as well as actively manage and utilize the available resources for development. The Bhutanese policies and laws converge to contribute to the national development philosophy of Gross National Happiness (GNH), which embraces environmental sustainability as one of its pillars.

4.1 Institutional framework for agro-biodiversity management

The National Biodiversity Centre (NBC) was formally established as a non-departmental agency under the Ministry of Agriculture and Forests in 1998.The primary purpose of its establishment is to ensure organization and coordination of diverse conservation initiatives within the country under a unified management structure and to lay the foundation for local, regional and global efforts in biodiversity conservation and sustainable uses of its components. The primary mandate of NBC is to ensure effective conservation and sustainable utilization of the rich biological resources (including agro-biodiversity), and equitable sharing of benefits arising from the conservation and use of these resources. Specifically, it coordinates Bhutan's biodiversity related activities and serves as a national focal institute for biodiversity, facilitates national decision-making on biodiversity concerns cutting across sectors, ensures a national balance between conservation and sustainable utilization of bio-resources and between *in situ* and *ex situ* conservation, and facilitates sub-regional, regional and international cooperation. The overall authority and decision making on biodiversity matters rests with the Ministry of Agriculture and Forests at the Secretariat level. At the implementation level, there are several agencies involved, but the main ones are the RNR Research and Development Centres of the Department of Agriculture (DoA) and the field extension staff of the district administrations.

4.2 Policies and legislations related to agro-biodiversity

The overall policy objectives of the RGoB for Biodiversity are that biodiversity issues will be integrated into the economic development plans and programs, special attention will be given to support parks and protected areas and effective buffer zones management, and information on biological diversity will be developed for conservation and sustainable utilization of biodiversity resources. Bhutan's policies on biodiversity are parallel to those of the Convention on Biological Diversity (CBD), particularly those which specify that conservation of biological diversity is a priority national objective, any use of biodiversity components must be sustainable, and that there should be fair and equitable sharing of benefits arising out of biological resources.

There are no written policy documents, acts or regulations specific for agro-biodiversity. However, there are a number of policies, strategies, acts and by-laws governing biodiversity in general. The most important ones which bear relevance to agro-biodiversity are: Biodiversity Act of Bhutan (2003), Biodiversity Action Plan of Bhutan (1998, 2002, 2009 and 2014), Forest and Nature Conservation Act (1995), Seeds Act of Bhutan (2000), National Forest Policy (1974, 1991), National Bio-safety Framework (2006), National Environmental Protection Act (2007) and Bio-security Policy (2008). Some of the salient features of important acts are described below.

4.2.1 The Biodiversity Act

The Biodiversity Act of Bhutan (2003) is the most important act governing the conservation and utilization of plant genetic resources. It asserts the sovereignty of the country over its genetic resources, the need to promote conservation and sustainable use of biodiversity resources as well as equitable sharing of benefits arising from biological resources and the need to protect local people's knowledge and interests related to biodiversity. It lays down the conditions for grant of access, benefit sharing, protection, and describes various rights, offences and penalties. Currently, the rules and regulations for its implementation are being finalized. The purpose and objectives of the Act are:

- To ensure national sovereignty of the RGoB over genetic resources in accordance with relevant National and International Law.
- To ensure the conservation and sustainable use of the biochemical and genetic resources.
- To promote the equitable sharing of benefits derived from the use of genetic resources.
- To promote technology transfer and capacity building at the national and local levels.
- To recognize and protect Traditional Knowledge, innovation and practices of local communities associated with biodiversity.
- To regulate and facilitate the process by which collectors may legally obtain genetic resources.
- To recognize and protect the farmers' and breeder's rights.
- To promote access to foreign sources of improved plant varieties to Bhutanese farmers.

4.2.2 Biodiversity Action Plans

The Biodiversity Action Plans of a country are the primary policy documents regarding the status of biological resources and action plans to be undertaken to conserve and utilize those resources. The first Biodiversity Action Plan (BAP) of Bhutan was published in 1998. The second edition (BAP II) appeared in 2002 and the latest (BAP III) in 2009, which is currently under revision. BAP I was organized into five chapters covering assessment of the country's biodiversity resources, direct conservation actions, essential support measures, and additional strategic recommendations to enhance benefits from biodiversity conservation. The BAP II focused on

three key elements: incorporation of key developments in the field of biodiversity conservation since BAP I, assessment of biodiversity conservation efforts in terms of direct conservation actions, institutional development, policy and legislation, biodiversity information, public education and awareness, and international cooperation, and updates on the action plans. BAP III is an update of the previous Action Plans.

The primary goal of the Action Plans is the conservation and sustainable use of Bhutan's natural biodiversity for wellbeing of the present and future generations. The specific objectives are to: protect natural ecosystems from degradation, protect species and genetic diversity in general but especially those species and their genetic variants having ecological, economic and scientific values, integrate poverty reduction and enhancement of local livelihoods in biodiversity conservation programs, create public appreciation and support for biodiversity conservation, and use biodiversity resources as a development capital for national economic growth in a sustainable manner. Various strategies and actions are recommended to meet the stated goal and objectives.

4.2.3 Forest and Nature Conservation Act

This Act constitutes one of the main legal frameworks for biodiversity conservation. It calls for biodiversity conservation strategies to be built upon two key precepts: conservation values lie in the cumulative effect of species diversity, and that natural resources must be used to meet the collective needs of the Bhutanese people. The main goal of the act is to protect and sustainably use forests, wildlife and related natural resources of Bhutan for the benefit of present and future generations. It emphasizes biodiversity conservation, particularly through *in situ* conservation, along with protection of all habitats, including grasslands and aquatic and alpine ecosystems.

4.2.4 The Seeds Act

This is an Act to regulate the quality of seeds and planting materials of agricultural use, regulate the import and export of quality seeds and seedlings and to promote seed industry in the country aimed at enhancing rural incomes and livelihoods. The over-arching aim of the Act is to ensure timely availability of high quality seeds and planting materials of superior varieties of crops with a view to increasing the production of crops, farmers' productivity, per capita farm incomes and export earnings. Specifically, the Act aims to:

- Ensure and facilitate multiplication and supply of sufficient quantities of quality seeds and planting materials of superior crops.
- Monitor, control and regulate the quality of seeds and planting materials.
- Streamline the procedures for the import of quality seeds of superior varieties for research and commercial purposes.
- Encourage the participation of private entrepreneurs and farmers' organizations in the seed industry.

- Promote farmers' acceptance and use of seeds of superior varieties.
- Promote the export oriented production of seeds taking the advantage of varied agro-climatic conditions of the country.

The Act is perhaps biased towards improved or high yielding varieties and seeds; it does not mention the importance of local or farmers' seeds, its regulation or promotion in the seed system. This is despite the fact that the country depends over 95% of the seed supply of food crops through the informal or farmers' seed systems.

4.3 Bhutan's commitment to international conventions and treaties

The Royal government of Bhutan recognizes the importance of co-operating with nations at the international forum to bring about biodiversity conservation and sustainable use. In keeping with this policy, Bhutan signed the Convention on Biological Diversity at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. Subsequent ratification of this convention in August 1995 by the 73rd National Assembly of Bhutan has accepted its global commitment to preserve the country's wealth of biodiversity. CBD has three main goals: the conservation of biodiversity; the sustainable use of its components; and the fair and equitable sharing of benefits from the use of bio-resources. A key obligation under the CBD is the development of national strategies, plans or programs for the conservation and sustainable use of biodiversity, and integration of biodiversity into relevant sectoral or cross-sectoral plans, programs and policies. This calls for biodiversity assessment, developing national strategies and action plans for implementation.

Bhutan recognizes the importance of the part of the convention, which assigns sovereign countries rights to genetic resources. Bhutan has also signed the Framework Convention on Climate Change and the National Assembly ratified the convention in 1995. Bhutan is also part of the cooperation agreement under the Sustainable Development Agreement (SDA) with Benin, Costa Rica and the Netherlands, based on the principles of equality, reciprocity and participation. One of the priority areas of cooperation identified between the countries is the conservation and sustainable use of biodiversity.

Bhutan is also a signatory to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which it signed on 10 June 2002 and ratified on 2 September 2003. ITPGRFA is the first international agreement focusing specifically on the conservation and sustainable use of plant genetic resources for food and agriculture (PGRFA) that is legally binding. It seeks to ensure both the conservation and access to PGRFA, which are necessary to provide food security in the future. The treaty was adopted at the FAO Conference in November 2001. Following its fortieth ratification, the treaty entered into force on 29th of June, 2004. The ITPGRFA is largely a response to pressing problems in the field of conservation and sustainable

use of PGRFA as well as the legal deficiencies that existed at the international level before the adoption of the ITPGRFA.

In September 2002, Bhutan acceded to the Cartageña Protocol on Biosafety, which serves as a component of CBD to protect biodiversity from potential risks posed by genetically modified organisms. The objective of the Biosafety Protocol is to contribute to ensuring an adequate level of protection in safe transfer, handling and use of 'living modified organisms resulting from modern biotechnology' that may have adverse effects on the conservation and sustainable use of biodiversity.

In June 2012, the Ninth Session of the First Parliament of Bhutan endorsed the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their Utilization. The Nagoya Protocol on ABS is a supplementary agreement to the Convention on Biological Diversity. It provides a transparent legal framework for effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

4.4 Policy gaps and issues

Because of its diverse farming systems, extreme variation in micro-agroecological conditions and varied socio-cultural settings, Bhutan is rich in agricultural biodiversity. Farmers since time immemorial have developed and maintained diverse crop genetic resources for their food needs and livelihood. In recent times, however, there are widespread concerns that the country is losing its plant genetic resources due to agricultural modernization and the lack of suitable policy measures for conservation of agro-biodiversity. No doubt, conservation of genetic diversity is essential for agricultural and economic development. This necessitates a supportive policy environment for agro-biodiversity conservation and agricultural development.

However, policies for conservation of agro-biodiversity have not received the same level of attention as the conservation of 'wild' biological diversity in the country. The agricultural policies do not specifically address conservation of agro-biodiversity and crop genetic resources. There is almost a one-sided focus on the conservation of wild biodiversity including forest resources and wildlife, often at the cost of agricultural biodiversity arising out of human-wildlife conflicts. Farmers often become helpless victims of encroaching forests and marauding wild animals, forcing them to migrate elsewhere for alternative livelihood sources.

In general the agricultural polices favour and focus on production of few uniform modern varieties of crops in favorable pockets with intensive input use and technical package approach without analyzing their consequences on on-farm genetic diversity. The notion that economic benefits can be derived only from the promotion of modern varieties and associated technologies still predominates the policy formulation process. Current agricultural and economic policies tend to focus on introduction and promotion of major crops and modern varieties, ignoring the

suitability and potential of local landraces. Consequently, there are no specific policies designed to conserve, utilize and protect the rich agro-biodiversity of the country. Some of the gaps related to agro-biodiversity are specified below.

Research

- Crop improvement programs focused only on introduction and adaptation
- Very little efforts on germplasm characterization, mapping and documentation
- Conventional plant breeding methods are commonly emphasized
- Limited research emphasis on minor crops and landraces

Germplasm access and exchange

- Policy and guidelines still under development stage
- Low institutional capacity for implementation

Extension

- Technology dissemination focused on major crops, modern varieties and inputs
- No extension advice and inputs for the promotion of landraces

Marketing

- Limited value addition and marketing support for local crops and landraces.
- Market support mostly favours major crops and MVs

Education

- Formal education system in agriculture primarily geared towards imparting knowledge, skills and attitudes on the cultivation and promotion of MVs and technologies
- No serious efforts to incorporate curricula, text books and teaching programs on agro-biodiversity in academia and extension programs

Regulatory

- Present variety release and seed regulatory framework require uniformity, quality standards and distinctness
- Lack of recognition of the important role of informal seed supply systems
- No legislation and support systems (certification and quality control) for seed multiplication and marketing of landraces and minor crops.

Subsidy

- Input and credit subsidies are mainly directed to modern varieties
- No subsidy for the promotion of minor crops and landraces.

5. Threats and opportunities for cereals diversity

At the global level, the genetic base of food crops is shrinking as genetic resources are being lost to changing tastes, industrialization, urbanization, mechanization of farming and commercialization of agriculture. Many of these influences have gained currency in our own local conditions and systems. The drive to modernize agriculture pushes back traditional systems and crops and varieties grown in them. Increasing commercialization of agriculture leads to a narrow genetic base of crops and varieties. Climate change and extreme weather variability of course are other key drivers of biodiversity loss. Neglect of traditional seed systems and gene flow mechanisms, although still predominant in the country, can only do more harm than good in relation to the richness of agro-biodiversity. In the light of such developments, conservation and use of agro-biodiversity is central to improving food crops and developing sustainable systems of food production. The wild relatives of crop plants are a reservoir of untapped and potentially important genes for crop improvement. This is especially true of genes for tolerance or resistance to biotic and abiotic stresses and for other important adaptive traits. However, wild relatives of food crops remain largely unexplored and unknown in the country.

5.1 Trends and key threats

Genetic erosion refers to the loss of genetic diversity at the level of genes or alleles, gene complexes, varieties or even a crop species. There are several important factors driving genetic erosion in Bhutan which are discussed below. The trend and major focus of agricultural development in the country has been skewed towards modern varieties and use of synthetic inputs that has a direct bearing on local agro-biodiversity.

5.1.1 Focus of agricultural development

Bhutan's first five year plan (FYP) was launched from 1961-66. During this period, the Department of Agriculture was established on 01 October 1961. Two agricultural farms at Lungtenphu and Bhur were started in 1963 for training of junior technicians and for demonstration purposes. The second FYP aimed to increase agricultural and horticultural output by introducing improved seeds and methods to increase food production. More farms for research, seed multiplication and demonstration were established. Such farms imported new crops and crop varieties for supply to farmers. The main objective in the 3FYP was stated as expansion of agriculture production through intensive methods of cultivation, use of high yielding varieties of seeds and irrigation facilities. This trend was continued in the 4FYP with 29% of the plan outlay allocated for agriculture and animal husbandry. The 5FYP stressed on "increasing improved seeds, production and achieving self-sufficiency to the extent possible". For the first time, production targets were set. For instance, cereal production target was 204,800

MT by 1987. One of the main mechanisms to achieve the target was through multiplication and supply of improved seeds and seedlings.

Agricultural development in the 6FYP aimed to increase self-sufficiency of staple foods, per capita income of farmers and productivity of land and labour. Supply of improved seeds and seedlings was one of the main programs with about 16% of the budget outlay. The use of the term "RNR sector" appeared for the first time in the 7FYP. The objectives of the agriculture sector were stated slightly differently as sustainable development of the arable production to enable self-sufficiency in food production for improved incomes and living standards. One of the main development programs was seed production and distribution, besides research, extension, plant protection, irrigation and farm mechanization services. The food security goal was reiterated in the 8FYP. It stressed on achieving a minimum of 70% self-sufficiency in food grain production besides ensuring household food security for rural people. Introduction of improved technologies with emphasis on agronomic and post harvest practices was stated as one of the strategies to achieve the goal. The role of research and extension was to provide a "menu" of technological choices to farmers. It may be worth noting here that the emphasis shifted from introducing new technologies to disseminating what already existed.

The objectives of the agriculture sector in the 9FYP were enhancing rural income, achieving national food security, conserving and managing natural resources and generating employment opportunities. Strategies included an enabling policy and legal framework, generation of appropriate technologies, extension services, delivery of inputs, farm mechanization and marketing services. Among others, the policy objective of the 10FYP was to enhance food security through sustainable production and to transform subsistence agriculture to small scale commercial agriculture. Rice self-sufficiency was targeted to increase from 50 to 65% and cereals production from 140,000 to 150,000 MT. There were 29 programs to support the goal and for the first time in the history of FYPs, the National Biodiversity Conservation Program was included. One of the targets of this program was to characterize and document 75% of crop and 50% of animal genetic resources.

One of the recurrent themes or objectives of the FYPs was obviously to enhance food production and self-sufficiency. The main vehicle to achieve the objectives was through the use of improved varieties and seeds, which paved way for introduction and promotion of exotic germplasm. There is no evidence of any importance attached to indigenous crops and traditional varieties in Bhutanese agriculture, at least in the earlier plan periods. Biodiversity conservation gets a mention only in the 10FYP. It can be inferred that hardly any support or importance was given to indigenous agro-biodiversity by the government till recently. Agricultural development was largely driven by introduced crop varieties and associated technologies. One can only speculate the adverse impact of such an approach to the erosion of local agro-biodiversity.

5.1.2 Promotion and adoption of modern varieties

A series of research, development and technology transfer initiatives were taken between 1940s and 1970s that increased agriculture production worldwide. This mainly involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, distribution of hybridized seeds, synthetic fertilizers and pesticides to farmers. Green revolution was used to describe such an initiative. Agricultural scientists bred cultivars of maize, wheat, and rice that are generally referred to as "high-yielding varieties" or HYVs, that have higher nitrogen-absorbing potential than other varieties. Since cereals that absorbed extra nitrogen would typically lodge, semi-dwarfing genes (e.g. Norin 10 in wheat) were used. The green revolution technologies no doubt increased food production and averted famines in many parts of the world, but with a high cost to environment and biodiversity. The spread of HYVs and the use of synthetic inputs adversely affected both agricultural and wild biodiversity. There is little disagreement that the green revolution acted to reduce agricultural biodiversity, as it relied on just a few high yielding varieties of each crop. This also led to emergence of new pathogens and crop diseases that required increasing use of agrochemicals. Many valuable genetic traits bred into traditional varieties over thousands of years were lost.

The green revolution technologies were promoted in Bhutan since the start of the planned development. New high yielding varieties available in India were introduced and seeds multiplied on government farms for supply to farmers. A few of these varieties (e.g. wheat variety Sonalika, rice variety IR 8) are still prevalent with farmers. Along with the seeds, synthetic fertilizers and agro-chemicals were popularized. Large irrigation channels were built. In short, efforts were made to replicate green revolution success in Bhutan as well. However, the rate of success was low and limited, unlike in uniform tropical environments, due to the diversity of agro-ecological conditions, diverse farming systems, subsistence agriculture and low technology absorption capacity of Bhutanese farmers. In a way, this has helped to preserve much of our agro-biodiversity. The consistent bid to promote green revolution technologies nevertheless continues in our struggle to achieve a higher level of food self-sufficiency as evidenced by the five year plans.

The research and extension system of the Department of Agriculture is geared towards finding and promoting new high yielding crop varieties in an effort to enhance production, reduce imports and improve food sufficiency and security. Such a structured drive and effort brings success in displacing genetically diverse farmer cultivars with a few modern bred varieties that have a narrow genetic base. An adoption study of new rice varieties in 2010 showed that 42% of the total rice area in the country is under modern varieties (Ghimiray, 2012), dominated by three ‘mega’ varieties (IR 64, Khangma Maap and BR 153). Similarly, 49% of the maize area is occupied by modern varieties (Shrestha *et al*, 2006), dominated by a single variety Yangtsipa. There are no formal studies done on wheat but expert estimates show that the adoption rate is very high in the wetland system. According to the Survey (2013), a number of crop varieties

have been 'lost' or displaced in the past 20 years (Figure 1). Displacement has been considerable in rice and to a lesser extent in maize and wheat. There is no change in barley, whereas the varietal diversity has slightly increased in buckwheat.

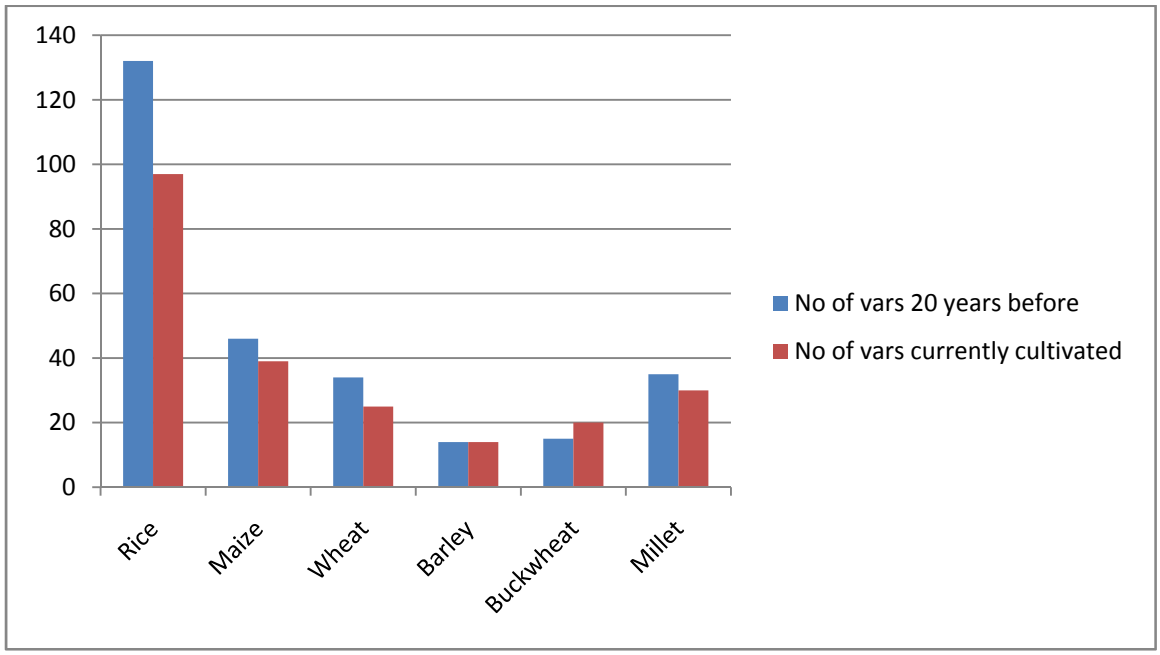


Figure 1: Number of crop varieties displaced in the past 20 years, 2013.

On a positive note, realization has eventually dawned on the value and importance of conserving and managing local agro-biodiversity for sustainable development. National programs on agro-biodiversity conservation are now in place. A genebank has been established and exploration, documentation and conservation of local diversity are underway. Added impetus needs to be given for such activities in the future.

5.1.3 Change in cropping systems

Cropping systems refer to crops and the sequence in which the crops are cultivated on a piece of land over a fixed period. The choice of crops is determined by the requirement of farmers, be it for food or cash income. Agricultural systems are dynamic and subject to change in response to several factors and forces. In a study of agricultural transformation in Bumthang, Wangchuk and Siebert (2013) found that the farmers have transitioned from cultivating a diversity of staple cereals to intensive mono cropping of potatoes using fertilizers and machines over the last 30 years or so. Most Bumthang farmers have stopped growing traditional grain crops like buckwheat, wheat and barley in their *pangzhing* and *tseri*. Instead, they have adopted intensive cultivation of potato utilizing chemical fertilizers and tractors. Secondary crops grown include chili, maize, cash crop vegetables and rice by some farmers. Primary reasons for effecting a change in the farming system, as reported by farmers, were improved road and market access and government prohibition against *tseri*. The case of Bumthang will apply to many other

temperate areas of Bhutan where potato dominates the cropping system today. Table 5 provides a glimpse of crops that have been replaced by new ones effecting a change in the cropping systems.

Table 5: Displacement of crops in different Dzongkhags, 2013.

Dzongkhags	Crops displaced	New Crops
Dagana	Maize	Citrus
Haa	Barley, Buckwheat, Wheat, Millet	Potato, Apple, Vegetable, Pasture
Paro	Wheat, Barley, Buckwheat	Potato
Samtse	Paddy, Maize, Wheat, Barley, Buckwheat, Millet	Ginger, Cardamom, Arecanut, Citrus, Vegetables
Sarpang	Rice, Maize, Wheat, Barley, Buckwheat, Millet	Arecanut, Cardamom, Litchi, Vegetables, Citrus, Pasture, Fodder
TrashiYangtse	Wheat, Buckwheat	Potato, Vegetables

Data source: Survey, 2013.

Potato crop became the focus of agricultural development in Bhutan in the late 1970s. The Royal government invited the International Potato Centre (CIP) to assess the opportunity of cultivating and marketing potato in 1982. Soon after, the Bhutan National Potato Program (BNPP) was started which provided seeds and production technologies. Thus potato production expanded rapidly and export in large quantities started in the 1970s after production areas became accessible by road (BPDP, 2008). The Food Corporation of Bhutan (FCB) started buying potatoes from farmers and introduced an auction yard system for marketing in 1980. These two factors provided a huge boost to potato production and area expansion. Today, potato has replaced traditional and locally adapted agricultural practices and associated agro-biodiversity in the *pangzhing* and *tseri*. This is likely to increase ecological risk as mono cropped potato requires increasing external inputs of fertilizers and fungicides to maintain or improve productivity. Potato is most widely grown in the altitude belt between 1800 to 3000 m where it has displaced wheat, barley, buckwheat and millets (BPDP, 2008). The entire diversity of crops and their varieties is likely to be lost from such a change in the farming system.

A change in the government policy led to the banning of *tseri* in 1993. The ban was adopted on the basis of advice by FAO which sought a global elimination of what it deemed a "destructive and backward" system (Wangchuk and Siebert, 2013), despite many farmers depending on *tseri* for their livelihood. Debates abound on the pros and cons of *tseri* but it is a sustainable system if done the way it is meant to be. Slash-and burn agriculture is one of the oldest land use systems, still practiced by at least 300 million people around the world (Roder, 2001). This system is sustainable with long fallow periods and where population densities are low, as is the case in Bhutan. Traditional systems may have low productivity per unit area, but give high returns to

labour and require low energy inputs. Penjore (2007) argues that the ban on *tseri* has increased farmers' food insecurity as forests encroach farmlands and harbor wild animals that predate on crops. More importantly, the whole range of diversity of crops and varieties which are specific to *tseri* is at the risk of disappearing as the age-old practice is increasingly discarded by cultivators. For instance, foxtail millet varieties (*Chema Yangra, Busing Yangra*) in Pemagatshel and Trashigang and finger millet varieties (*Kali kodo*) in Sarpang and Zhemgang have been reported to be lost (NBC, 2008).

Prior to 1980s, farmers in the temperate areas secured all their food needs of primary staple cereals and secondary greens and vegetables from the fields they cultivated (Wangchuk and Siebert, 2013). The farmers now resort to purchasing most of their household foods from income earned from selling potatoes. Their staple food of locally grown grains like buckwheat, barley and wheat has given way to import rice from India. Likewise, most dryland farmers in the eastern and southern parts of the country who depended on maize as a staple food no longer consume *kharang* (maize grits) but distinctly prefer imported rice. One of the driving forces for such a change in food habit has been the establishment of FCB in 1974. True to its mandate of procuring and distributing food grains, FCB has retail outlets throughout the country providing easy access to subsidized rice and other cereals. A change in food habit leads to loss of agro-biodiversity as traditional crops and recipes disappear.

5.1.4 Agricultural commercialization

Agricultural diversification and commercialization in the Bhutanese context could be defined as a shift from subsistence farming to cultivation of a variety of crops primarily for markets. The switch to market-oriented agriculture can be brought about by accessibility to markets and availability of support facilities, in terms of infrastructure, education and technical know-how. Major commercial crops are apples, mandarin, cardamom, areca nut, ginger and potatoes which have had a major impact on income generation of farmers and dominate the export market today. The Ministry of Agriculture has taken recent initiatives to expand the range of commercial crops and even ushered in non-traditional crops like hazelnut and coffee in the country, apart from providing enormous momentum to production of rice and vegetables.

On the advice of McKinsey Consultants, the rice commercialization program as part of Accelerating Bhutan's Socio-economic Development (ABSD) Initiative was commenced in 2010. The program aims to increase rice productivity and production from 65% (15,000 ha) of the country's rice fields covering all major rice Dzongkhags by 2018. The key to increase production include the use of high yielding varieties and quality seeds, fertilizers, farm machines, irrigation, processing facilities and market organization. A select number of 8-10 high yielding rice varieties are vigorously promoted. From 2010-13, about 150 MT of seeds were supplied. The coverage (4000 ha) by improved seeds accounts for roughly 17% of the total rice area. The rice yield in the target Dzongkhags is reported to have registered a growth of 51% and the national rice production has gone up from 65,763 MT in 2009 to 78,730 MT in 2011. The rice

program has certainly made an impact but is there a cost to agro-biodiversity? How many traditional rice varieties have we replaced in the process?

Relatively a new concept in Bhutan, public-private-partnerships (PPPs) is seen as a key development strategy of the Royal Government of Bhutan. PPPs are already active in several sectors such as IT, education and air transport. In agriculture, PPPs have begun in plantation crops like hazelnut and coffee. The Mountain Hazelnut Venture (MHV) is Bhutan's first and only 100% foreign direct investment in the country. The investment supports MHV in setting up its nursery, hazelnut supply chain and processing operations in Bhutan to produce high quality hazelnuts for export. According to the project profile, MHV's supply chain spans from China to Bhutan, as it imports its hazelnut plantlets from a tissue culture lab in Kunming, China through a cold chain system. Under the project, MHV provides hazelnut seedlings to farmers at no charge and provides training and agricultural extension services. Farmers will grow the trees, harvest the nut, field-dry and deliver the in-shell nuts to MHV collection centers. MHV will buy nuts according to a guaranteed price structure agreed upon between farmers and MHV, and vetted by the MoAF. MHV will then further process the nuts in its processing facility and then export them. The project is implemented in eastern Bhutan with MHV's nursery located in Mongar. Hazelnuts will initially be grown in six eastern Dzongkhags of Trashigang, Trashiyangtse, Pemagatshel, Mongar, Lhuentse and Samdup Jongkhar. The project will eventually be expanded to three central Dzongkhags of Zhemgang, Bumthang, and Trongsa. MHV will set up a processing facility located in eastern Bhutan.

Over a five-year period, MHV will plant 10 million hazelnut trees in the country. The project supposedly utilizes barren, unproductive land and entire slopes where there is no vegetation. According to MoAF, it will not have any bearing in terms of land being used for hazelnut at the cost of other crops, particularly cereals. MHV will utilize those lands which are not suitable for growing other crops. Farmers are to earn income from those land which otherwise do not bring them any benefits. MoAF estimates that 10,000 to 15,000 households may be involved in the Hazelnut Project, comprising up to 15% of the population. The assumption that the hazelnut plantation will be confined to non-crop lands may not hold water if the program becomes a success. Farmers may use lands that they earlier used to raise crops putting agro-biodiversity at risk. Farmers may also divert more resources and labour for a cash crop like hazelnut than for food crops. The plantations might also unleash a greater human-wildlife conflict; after all the hazelnuts are equally palatable and nutritious to primates and other wild animals as for humans. Rodent population may increase and wild hazelnut (*Corylus spp)* may get contaminated with exotic species.

Arabica coffee is another commercial crop introduced in Bhutan. The inaugural coffee seedlings were planted at Sipsoo in Samtse in September 2011, marking the commencement of commercial coffee plantation in Bhutan. The project is a private sector initiative of Samden Group of Companies to undertake commercial coffee production in a public-private community partnership mode. The government has leased 300 acres of reserved forest land to Samden group

for cultivation of coffee. The investment in the project is worth about Nu. 90 million. Nationally, the initiative is coordinated by the Council for RNR Research of Bhutan (CoRRB) which also monitors and guides technical implementation of the project. According to a news release from MoAF, the objectives of the project include promotion of commercial utilization of lands in the southern region, environmental rehabilitation, create income generating opportunities and establish a successful commercial enterprise. The plantation will also provide impetus for integrated agro-based business by cultivating, processing and exporting coffee products to international markets. The project also envisages curbing rural-urban migration. According to project officials, coffee will not be planted in the paddy field which will ensure that it will not implicate rice production in the country, rather it can be inter-planted with existing areca nut trees. Coffee is seen as less prone to damage by wild elephants, which is a problem in other crops.

In horticulture, major investments were made by the Integrated Horticulture Development Program (IHDP) to develop horticultural on commercial lines. It started in 1997 with financial and technical support from UNDP for a period of five years and was further extended. The project comprised of eight sub-programs: coordination, marketing, post-harvest, technology generation (research), extension, and development of aromatic and medicinal plants (both research and marketing). As part of the project activities a number of new crops (notably nut crops like pecan) and crop varieties were introduced from Europe and Japan. Demonstration orchards were established in farmers' fields throughout the country to showcase new varieties. In vegetables, farmers are encouraged to produce different crops for domestic consumption as well as for export. This has gained urgency in recent time as the Bhutanese economy is facing shortage of Indian rupee due to trade imbalance; imports far outweighing exports in all sectors including trade in agricultural commodities. The aim is to restrict rupee outflow from imports of vegetables that can be grown easily in the country and even exported during seasons when Indian production is limited. New vegetable varieties including hybrid seeds are freely promoted in the country.

Agricultural intensification and commercialization will no doubt negatively affect local agro-biodiversity. Agro-biodiversity is the backbone of a nation's food security, but increasing commercialization of agriculture leads to almost extinction of traditional farming systems, local crops and varieties. A top-down approach of agricultural development, where farmers are seen merely as recipients rather than as participants, further exacerbates the situation. It may be too early to see the impacts now but the writing is certainly on the wall.

5.1.5 Loss of agricultural land

Land is a precious and scarce asset and land use competition between the green and brown sectors results in loss of agricultural lands. There are numerous examples of urban centres (towns), schools, hospitals, highways and industries being built on agricultural fields. Although prime agricultural lands such as wetland are protected by law, lapses in enforcing the law have

led to considerable loss. Many fertile lands are lost to land slips, often aggravated by mining or logging activities. Crops and crop varieties are indisputably lost along with the arable lands.

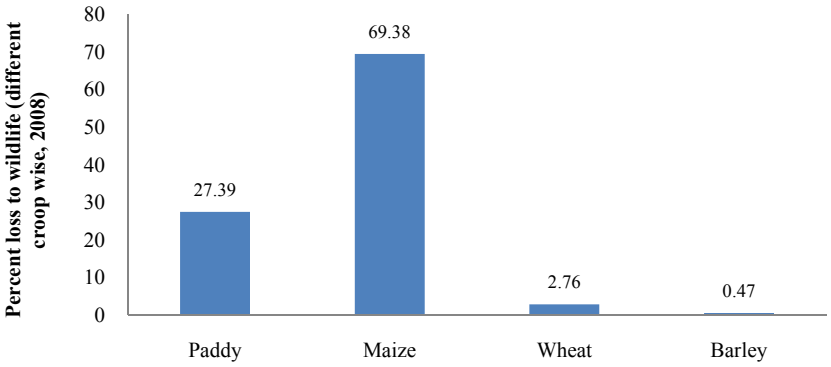
Farmers abandon, temporarily or permanently, their farms and move to urban areas for reasons ranging from predation by wild animals, lack of irrigation facilities to lack of labour for farming. Once farms are abandoned, many crops and varieties do not get planted and are eventually lost.

Other reasons for loss of agro-biodiversity include a change in food habit from traditional crops like maize, buckwheat or millets to rice which is easily available at affordable price. Fallowing of agricultural lands due to rural-urban migration and predation by wild animals also leads to genetic erosion.

5.1.6 Human wild-life conflicts

Notwithstanding its small geographical size, Bhutan has pursued a strong conservation policy that emphasizes the need to maintain and preserve its pristine environment and biodiversity. The Constitution of Bhutan mandates the country to maintain at least 60% of the area under forest covers for all times to come. Almost 51.32% of the country's total land area is set aside as Protected Areas and Biological Corridors. Although Bhutan has been widely recognized and commended for its sound conservation policies and programs, the Bhutanese rural communities are facing the consequences of large wildlife population and are seriously affected from the conflicts arising between humans and wildlife (NCD, 2008). Over 69% of the Bhutanese population live in rural areas and depend on agriculture for their livelihood. The rural communities dwell in close proximity to the forest as well as inside the protected areas and are highly vulnerable to crop raids and predation by wild animals. The different impacts of wildlife attack include economic losses from predation of crops, hardships in guarding crops at night, seasonal food shortages, abandoning of farming, predation of livestock and risks to human life. It has been estimated that annual crop losses range from 0.3 to18% of the total household income and on an average farmers spend two months in a year to guard their crops from the wild life (NCD, 2008). The most common wildlife that raid the crops are wild boar, elephant, bear, porcupine, primates like western Assamese macaque, Indian rhesus macaque, Arunachal macaque, langurs, capped langur, common or gray langur, deer and birds. According to the RNR Census 2008, almost 70% of the households attribute losses on maize followed by paddy (Fig 2). The most direct threats to agro-biodiversity from increasing human wildlife conflicts are abandoning of farming and fallowing of productive agricultural lands in far flung areas prone to wildlife that ultimately leads to the decrease of the farm level diversity and extinction of crops and varieties specifically adapted in that area. Any future conservation action plans for agro-biodiversity have to thus consider the different dimensions of the human wildlife conflicts and its impacts.

Figure 2: Percentage of crop loss to wild animals, RNR Census 2008



5.1.7 Biopiracy

Biopiracy can be explained as the theft of genetic materials, cultural and traditional knowledge particularly related to food and medicinal plants from the rural, marginal communities and state forests for commercial exploitation. Normally the rural communities who are the custodian of the resource are not compensated nor are they able to lay their claim for their share of benefits for lack of adequate legal mechanisms. Although Bhutan has not drastically succumbed to biopiracy at the moment, "Biopiracy" is likely to be more pronounced as our communities and rural areas are increasingly opening up to newer opportunities. Any visitor can freely reach the communities, collect the seeds of interest and utilize the way he or she wants. The communities are least aware of what is being done to their most valuable asset that their forefathers have preserved over the centuries.

Bhutan has in principle adopted the *Sui Generis* System for Plant Variety Protection (PVP). The National Biodiversity Center (NBC) is the authorized institution to facilitate outflow of bio-resources and for bio-prospecting. The Bhutan Food and Agriculture Regulatory Authority (BAFRA) monitors the illegal outflow of any bio-resources through the key check point at the different exit points of the country. The National Policy on Access and Benefit Sharing which is in pipeline for ratification is expected to strengthen the regulation of bio-resources and minimize biopiracy. Other mechanisms to help minimize the illegal outflow of germplasm through the use of Standard Material Transfer Agreement and Prior Inform Consent are at developmental stage. A small start has been made by introducing community seed banks and community biodiversity register in pilot sites as a simple legal basis of ownership of agro-biodiversity resources by the communities.

Piracy of agro-biodiversity resources could be considered minimum because most biopiracy activities are not reported for lack of adequate evidence and awareness on the nature of the illegal act of acquiring seeds and planting materials. It becomes difficult to regulate as quantity

involved may be trivial and because of the unguarded porous border with India. However, the impact of biopiracy could further stretch the depletion of agro-biodiversity as the valued genes could be commercially exploited and patented. The lack of awareness of the communities, limited technical capacity of the regulatory authorities and inadequate inventory of agro-biodiversity further make Bhutan highly vulnerable to piracy and commercial exploitation. Biopiracy infringes on the sovereign right of the local communities on their resources and livelihood.

5.1.8 Climate change and agro-biodiversity

Bhutan's agricultural ecosystems are diverse and fragile and are highly vulnerable to the impacts of climate change that emanates mainly from rise in temperature, changes in the pattern of precipitation and extreme weather events. According to the Sector Adaptation Plan of Action (SAPA) 2013 of the MoAF for climate change, Bhutan is projected to experience a peak warming of about 3.5°C by the 2050s.The surface air temperature will increase with the greatest change in the west, gradually decreasing towards the east. The projected surface warming will be more pronounced during the pre-monsoon than during the summer monsoon season. The temperature increase will be higher in the inner valleys than in the northern and southern parts of the country. With regards to precipitation, the country is expected to experience a significant overall increase in precipitation, but with an appreciable change in the spatial pattern of winter and summer monsoon precipitation, including a 20 to 30% decrease in winter precipitation, over the north-east and south-west parts of Bhutan for the 2050s. This pattern of change is consistent for all months and all time slices.

Bhutanese farmers are already experiencing the menace of climate change. The local symptoms of climate change include, Glacial Lake Outburst Flood (GLOF) of 1994, flood, flash floods damaging agricultural lands, property, drought delaying the planting of crops, unexpected outbreak of diseases of sub-tropical areas in the cool and warm temperate agro-ecology such as the rice blast disease in 1995, Gray Leaf Spot in maize in 2007 and Army worm in 2013 and increasing incidences of forest fire (Bhutan Climate Summit, 2011). Bhutanese farmers are sensitive and highly aware (86%) of climate change and its impacts in agriculture (Fig 3). Apart from climate change, other factors posing as threats to cereals diversity include new introductions or exotic varieties, human-wildlife conflicts, farm labour shortage and change in crops and cropping systems (Survey, 2013).

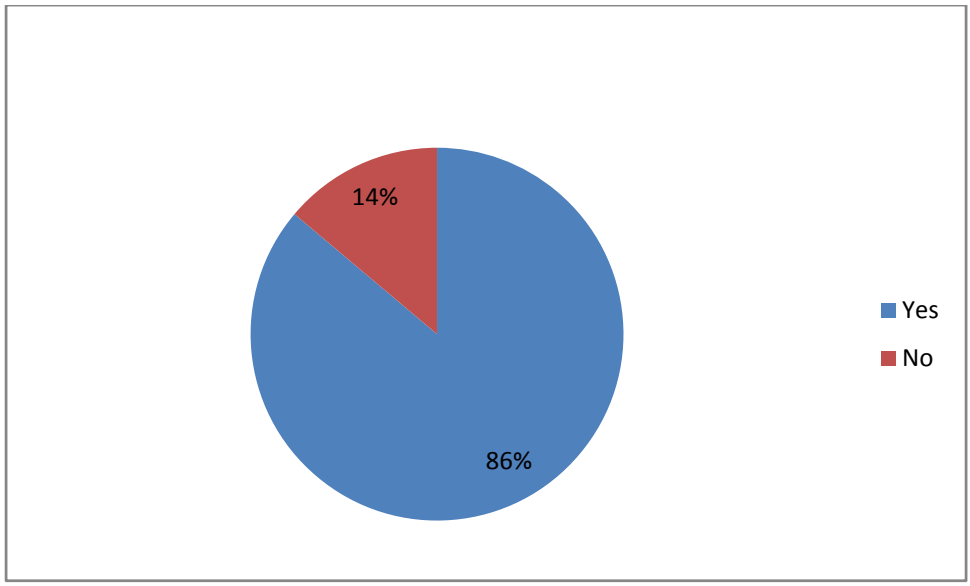


Figure3: Level of awareness on climate change

Climate change will directly affect the agro-biodiversity in many forms. The impact of climate change on different crops and varieties will manifest in the form of distribution and diversity. The primary climatic factors that are most likely to affect agro-biodiversity are the rise in temperature and changes in precipitation which leads to extreme weather events such as flash floods, landslide, seasonal drought, heat stresses, hailstorms, frost and cold spells which in turn could lead to low yield, insurgence of new pests and diseases, and disappearance of traditional varieties and landraces which generally has a much lower inherent immunity to the attack by new pathogens.

The impacts of climate change on agro-biodiversity will be apparent in many direct and indirect ways. Different forms of biotic and abiotic stresses will negatively impact production and increase the risks of crop failures affecting farmers' traditional varieties the most. As a coping strategy to avert crop failures, farmers often resort to planting of a few tolerant varieties decreasing the farm diversity. Dependency on seasonal rainfall for crop production and increasing incidences of drought will lead to the scarcity of water for agriculture, delay the planting of crops and largely encourage farmers to abandon farming. Overtime the higher frequency of extreme weather events will affect farmers' traditional seed system the most. The traditional seed system is the lifeline for seed production and supply, and the most established mechanism of *in situ* conservation of agro-biodiversity in subsistence agriculture. The traditional seed system completely relies on the ambient weather conditions for harvesting, processing, cleaning and storage of seeds. Any anomalies in the weather during the harvest and post production processes influence the quality, storage and viability of seeds.

It is therefore imperative and compelling to conserve both *in situ* and *ex situ* the broadest possible genetic diversity as an insurance against risks posed by climate change to prevent the

loss of country's rich agro-biodiversity (Bhutan Climate Summit, 2011). Farmers suggest a number of ways that they would like the government to intervene in the face of changing climate (Table 6). These suggestions have been incorporated in the Strategic Action Plan.

Table 6: Farmers' suggestions to mitigate impacts of climate change in farming.

At Farmer's level	At Government level
❑ Continue putting effort in farming of diverse crops.	❑ Support Farm Mechanization
❑ Timely Management of the crops.	❑ Facilitate availability of inputs
❑ Improve soil fertility	
❑ Effective use of the resources	❑ Improve Market Facilities
❑ Maintain seed quality	❑ Provide quality seeds
❑ Control of pest and diseases	❑ Address human wildlife conflict
❑ Try improved crop production technologies	❑ Disseminate improved production technologies
❑ Exchange of seeds amongst communities	❑ Encourage youth to take up farming
❑ Group farming	❑ Support trainings on crop management
❑ Exposure and access to new techniques	

5.2 Opportunities

Notwithstanding the above discussed threats to cereals diversity in the country, there are several opportunities for its conservation. Despite its small size, the country has a diverse agro-ecology due to the large altitudinal variation where different crops and cropping systems can be practiced within short distances. Despite rapid modernization, religion, culture, tradition and the respect for nature and environment are still central to the Bhutanese people. Rituals and traditional ceremonies are very common and most of these ceremonies remain incomplete, local deities unappeased and prayers unfulfilled without the offerings of the nine different cereals (*dru-na-gu*) and the different processed products from these cereals. The integrated and subsistence nature of farming, a vibrant traditional seed system, strong traditional and cultural values and enabling policy support for organic farming offers immense opportunities for conservation of cereals diversity.

5.2.1 Integrated and subsistence farming

Although the contribution of agriculture as a whole to the GDP is declining, it continues to be the mainstay of the people engaging over 69% of the population. Majority of the Bhutanese farmers continue to practice self-sustaining, integrated and subsistence agricultural production system, with small land holdings where a variety of crops livestock are raised to meet household food security. It is in this context that the diversity of crops is very important. Multiple cropping is a common feature of the small holder Bhutanese farmers where different cereals, legumes and vegetables are grown as intercrop, mixed crop or rotated in order to meet household needs and maximize production per unit area.

Although there is a strong drive for commercial farming, large scale commercialization and farm mechanization is difficult and nearly impossible in most parts of the country. Small farm size, poorly developed irrigations systems, terrain and remoteness, and poor socio-economic status of farmers are key constraints to commercial farming. These factors, however, favour multiple cropping, thus promoting crop diversification. One of the primary benefits of crop diversification is that it promotes sustainable in situ conservation of agro-biodiversity.

5.2.2 Traditional seed systems

Seed is the basic input for crop production which is the primary means of subsistence of the small holder Bhutanese farmers. For subsistence Bhutanese farmers, food security hinges on the consistent and assured access to seed. Over 95% of the seed requirement of farmers is still met from farm saved seeds produced in the traditional seed system. Seeds that are produced by farmers in their fields are selected and preserved in their homes and passed to fellow farmers and to the next generation. The existing reciprocal seed exchange system among the farmers and the neighbouring communities is the most assured, proven and stable seed production and supply mechanism. Even the formal seed sector has to fall back on the farmers' seeds to supply seeds

and seedlings of many crops. Farmers' traditional seed systems are well established but are deficient of scientific skills of selection and management and hence need to be reviewed and refined. At present there are no interventions to improve and recognize the traditional seed system. Informal seed system is threatened by outbreak of new pest and diseases, poor storage, lack of market and increasing dependence on the formal seed sector. Many private seed enterprises are already venturing into commercial seed business which could easily undermine the advantages of traditional seed system as well as exploit the farmer's existing seed system to make an easy profit by involving them and infringing into their sovereign rights to produce, save and sell seeds whenever there is an opportunity.

There are several ancillary advantages of the traditional seed systems. Farmers' traditional seed system has been an established and proven strategy for *in-situ* conservation of agro-biodiversity resources for centuries. This system produces large volume of seeds of several commercial and rare crops at a much lower cost and seed is abundantly available. A formal sector often overlooks the seed production of crops that are economically not viable due to low volume of demand. In the first ever agro-biodiversity fair for farmers conducted by the National Biodiversity Center (NBC), some farmers displayed upto 48 different varieties of cereals, legumes and vegetable which are maintained to meet their subsistence, social and cultural needs (Katwal *et al.* 2011).

Currently, there are no proactive interventions or efforts to support the traditional seed system. The propagation of community seed banks, seed clubs, seeds fairs and seed exchange and marketing are some of the approaches that could be used to rejuvenate and improve the traditional seeds system. Four Community Seed Banks have been initiated in Sarpang, Bumthang and Samdrup Jongkhar to strengthen traditional seed systems and promote custodian farmers' ownerships. The traditional seed systems have to be linked and accredited by the formal sector for long term sustainability. If such initiatives are not forthcoming the danger of further depletion of existing agricultural biodiversity is inevitable.

5.2.3 Strong traditional values and culture

Bhutan's unique development philosophy of Gross National Happiness (GNH) recognizes the preservation and promotion of cultural, traditional values and spiritual heritages as one of four main pillars of GNH. The preservation of culture and traditional values is known as *Driglamnamza* (etiquette) and is strongly observed in offices, places of religious significance and official functions. Most important ceremonies and official functions normally begin by a *Marchang* ceremony where the offering of *banchang*, a local drink brewed from wheat and barley is a must. The government's emphasis on preservation of culture and traditional values indirectly supports the promotion and conservation of traditional crops as they are a part of the cultural necessity.

Bhutan is a multi-ethnic society and to some extent there is a certain ethnic diversity in the food and farmers conserve and grow crops that are required for special preparation and occasions. For

instance, many local communities grow finger millet to prepare a local drink to serve to a lactating mother as it is known to enhance milk production to feed the young baby. Wheat and barley are grown to prepare *banchang* while the flour is used in all religious ceremonies. There are many different local festivals in different parts of Bhutan. During such local festivals, communities take a strong pride in preparing and eating traditional food. Coinciding with local festivals, food and seed fairs are organised to encourage farmers to conserve and continue growing traditional crops.

A holistic development approach and effort of the government to preserve and prevent the loss culture and traditional values provide an enabling environment for promotion of traditional crops as they are central to culture and religion. The National Biodiversity Center is already exploring these opportunities and has designed programs to enhance and upscale the conservation of cereals that is central to Bhutanese culture and traditions.

5.2.4 Promotion of organic farming

The government has a long term vision to make Bhutanese agriculture fully organic and has accorded a high priority towards the development of organic agriculture. The formulation of a National Organic Framework was started in 2002 and the policy was officially announced in 2007 (Duba, *et, al*. 2008). The National Organic Program (NOP) of the DoA is mandated to coordinate, implement and promote activities related to organic farming. Bhutanese farming by default is largely organic due to the insignificant access and use of external inputs, remoteness of the farming areas, and cultivation of a variety of crops to meet household needs. Organic agriculture is seen as a potential opportunity for conservation of on-farm cereal diversity as the emphasis is on the adoption of sustainable agricultural practices including local crops and varieties (Katwal, 2013). The demand for local products including that of cereals is presently high and the local varieties command a higher price in the market. This is encouraging farmers to produce more. There is a strong support from the National Organic Program for farmers to produce more and diversify their products. Farmers are organized into groups for increasing the scale of production and enhance marketing.

6. Agro-biodiversity Strategic Action Plan

The overall development concept of GNH is the basis and essence of this Action Plan. It seeks to contribute to the economic growth, food security and poverty alleviation through the use agro-biodiversity as an asset for socio-economic development. It is guided by the following principles:

1. That the agro-biodiversity is the ultimate basis for food security and livelihood of the Bhutanese people
2. That the protection of agro-biodiversity is the responsibility and sacred duty of all citizens of the country
3. That all citizens have the right to understand, value, appreciate and participate in agricultural bio-resource conservation and use
4. That it is vital to prevent further loss of agro-biodiversity for the future well being of the Bhutanese people
5. That science and technology plays a central role in exploitation, conservation and utilization of agro-biodiversity
6. That the respect for knowledge, persistence and practices of indigenous people and farming communities is sacrosanct in biodiversity management.
7. That plant genetic diversity is crucial for increased resilience to emerging challenges due to climate change.

6.1 Goal and objectives

The overall goal of this Action Plan is to conserve and sustainably use Bhutan's agro-biodiversity for agricultural development, farmers' livelihood and income generation for the present and future generations. The objectives are grouped into the following five categories.

1. Provide an enabling policy and legal framework for conservation and sustainable utilization of agro-biodiversity (***Policy and Legislation***)
2. Strengthen research, development, extension and documentation on agro-biodiversity (***Research and development***)
3. Enhance conservation, management and sustainable use of agro-biodiversity resources in the country (***Conservation and Use***)
4. Strengthen capacity building for agro-biodiversity conservation and utilization (***Capacity Development***)
5. Improve the existing information and monitoring and evaluation systems for agro-biodiversity (***IMS and M & E***)

6.2 Strategies and Actions

6.2.1 Strategies and Actions to achieve Objective 1

Objective: Provide an enabling policy and legal framework for conservation and sustainable utilization of agro-biodiversity

Strategy 1: Ensure that legislative, administrative, fiscal or other regulatory mechanisms are put in place for the sustainability of agricultural biodiversity

Action 1.1 Develop a National Policy on agro-biodiversity to address the current gaps and issues related to conservation and use

Action 1.2 Formulate and enforce appropriate regulatory mechanisms, if necessary, to conserve agro-biodiversity and minimize loss of food crops and crop varieties

Action 1.3 Prioritize and support conservation and sustainable utilization of agro-biodiversity in the five year development plans

Action 1.4 Devise suitable mechanisms to recognize and reward farming communities for their contribution to agro-biodiversity conservation and persistence

Action 1.5 Develop a framework for value addition and product development of unique landraces

Action 1.6 Strengthen and support informal seed supply systems through enabling national policies and practices

Strategy 2: Prioritize and secure required financial resources through both internal and external sources for planning and implementation of agro-biodiversity related programs

Action 2.1 Ensure adequate financial resources for planning and implementation of agro-biodiversity programs

Action 2.2 Explore public-private investments through sector partnerships and other innovative measures for agro-biodiversity conservation and utilization

Action 2.3 Develop appropriate project proposals and long term programs and secure funds from donor and partner countries

Strategy 3: Strengthen education, advocacy and awareness programs on agro-biodiversity

Action 3.1 Develop advocacy, education and awareness materials for general public, research academia, extension personnel, policy makers and others on agro-biodiversity

Action 3.2 Integrate agro-biodiversity as part of curriculum for CNR, schools and other training programs

Action 3.3 Conduct awareness programs and campaigns on the importance and value of agro-biodiversity conservation for farmers, students, policy makers and general public

6.2.2 Strategies and Actions to achieve Objective 2

Objective: Strengthen research, development, extension and documentation on agro-biodiversity

Strategy 1: Assess the diversity of local crops, varieties and genetic resources in a comprehensive manner through diversity surveys and inventories

Action 1.1 Deepen the current knowledge on cereals agro-biodiversity resources of Bhutan and carry out documentation

Action 1.2 Define/systematically classify agro-ecosystems diversity in the country in sync with crops and their cultivation

Action 1.3 Continue survey and inventory of cereal genetic resources for food and agriculture

Action 1.4 Conduct studies on genetic erosion, including impact of introductions on agro-biodiversity and systems resilience, and recommend remedial measures

Action 1.5 Conduct agro-morphological characterization and evaluation of cereal crop varieties to validate on-farm diversity on a scientific basis

Action 1.6 Carry out allozyme/isozyme variability studies, isozyme profiling and cluster analysis to reveal genetic relationships among landraces, in addition to agro-morphological studies

Action 1.7 Initiate molecular (DNA polymorphism) diversity studies of landraces for a scientific analysis of genetic variability to enhance the efficiency of crop breeding programs

Strategy 2: Institute research on climate change and its impacts on agro-biodiversity using scientific tools and techniques

Action 2.1 Institute and conduct research on impacts of climate change on agro-biodiversity and food security of the affected farmers

Action 2.2 Conduct climate change scenario analysis and identify climate analogue sites for major crops and major growing areas through the use of latest GIS tools

Action 2.3 Identify appropriate germplasm and source germplasm from identified analogue sites for use in targeted areas to enhance climate change resilience and enable farmers' adaptation to climate change

Action 2.4 Analyze potential vulnerability of cereal based cropping system to climate change and how it can be reduced by improving resilience through the use of agro-biodiversity

Action 2.6 Identify efficient measures to support farmers' adaptation strategies to climate change

Strategy 3: Mainstream participatory plant breeding and participatory varietal selection methods in the formal plant breeding systems

Action 3.1 Standardize and integrate participatory plant breeding (PPB) and participatory varietal selection (PVS) in the national research system

Action 3.2 Develop the capacity of farmers in meaningful engagement in PPB and PVS through training programs

Action 3.3 Increase the utilization of unique landraces in breeding programs to develop varieties that have higher acceptability among farmers

Action 3.4 Broaden the genetic base of food crops as a risk aversion strategy from emerging pest and disease outbreaks

Action 3.5 Classify diverse micro-environments to develop varieties specific to local domains (diverse germplasm for diverse environments)

Action 3.6 Promote genetic enhancement of valued landraces through seed selection, seed rehabilitation and purification methods, apart from cross breeding

Action 3.7 Develop crop production packages for local varieties for use in extension demonstrations and promotion campaigns

Strategy 4: Improve and promote research and development on post harvest, processing, value addition and product development of under-utilized crops

Action 4.1 Strengthen the technical capacity for post-production/post-harvest research on cereals at the National Post Harvest Center

Action 4.2 Identify and promote special traditional varieties of rice and maize that have higher processing value in niche areas for household income and sustainable conservation

Action 4.3 Analyze and document the nutrient status of important traditional varieties of rice, maize, buckwheat, millet and other underutilized cereals

Action 4.4 Support and strengthen markets that deal with traditional crops and products

Action 4.5 Actively advocate and promote the consumption of traditional cereals like millets, buckwheat, barley and other minor cereals through value addition, developing recipes and making products readily available in the market

Action 4.6 Support and promote farmers and women's groups focused on conservation of underutilized cereals in potential areas for conservation and promotion of traditional cereals through sustainable incentives

6.2.3 Strategies and Actions to achieve Objective 3

Objective: Enhance conservation, management and sustainable use of agro-biodiversity resources in the country

Strategy 1: Strengthen *in situ* conservation of agro-biodiversity

Action 1.1 Initiate community biodiversity register to record, inventorize local crop diversity and associated knowledge at the Gewog level

Action 1.2 Document and map genetic diversity of cereals in the country

Action 1.3 Identify priority areas and crops for targeted *in-situ* conservation of agro-biodiversity

Action 1.4 Strengthen local capacity of communities to implement on-farm conservation strategies

Action 1.5 Sensitize communities and organize biodiversity fairs to locate diversity and custodian farmers and promote exchange of seeds and knowledge

Action 1.6 Institutionalize diversity fairs in national agricultural extension programs

Action 1.7 Carry out zonation and declare heritage sites of significance for local crops, varieties and wild relatives

Action 1.7 Put in place monitoring mechanisms to keep track of increase or decrease of the number of landraces and modern varieties and their distribution patterns

Strategy 2: Strengthen *ex situ* conservation of agro-biodiversity

Action 1.1 Identify collection gaps and prioritize crops and areas for collection

Action 1.2 Support targeted collecting of plant genetic resources for food and agriculture

Action 1.3 Sustain and expand *ex situ* conservation of germplasm

Action 1.4 Regenerate and multiply *ex situ* accessions

Action 1.5 Institutionalize depositing of all released crop varieties in the genebank

Strategy 3: Promote minor, neglected and under-utilized crops and varieties to exploit their nutritive and food security potential in the country

Action 3.1 Evaluate, identify and promote promising landraces and neglected crop varieties in the country

Action 3.2 Assess the nutritional value of identified landraces and varieties

Action 3.3 Create awareness on the value of local food crops (nutrition, organic, health) among general public, consumers and tourists through food fairs and linkages with tourism

Action 3.4 Promote development and use of under-utilized food crops through facilitation and access to markets (local, regional, international) and product diversification

Action 3.5 Synergize with the National Organic Program to explore the potential of under-utilized crops as health food in the national and international food markets

Strategy 4: Support, recognize and mainstream informal or farmers' traditional seed systems for increased access to local seeds and their use

Action 4.1 Reform seed regulatory framework to ensure recognition and promotion of local seeds and seed sources

Action 4.2 Propose popular local varieties for release and notification in compliance with the law for large scale production and sale of seeds

Action 4.3 Improve and strengthen farmers' seed systems using scientific techniques to improve seed quality and productivity

Action 4.4 Explore the possibility of including valued local varieties in the agriculture extension and development programs and projects, instead of promoting only high yielding modern varieties

Action 4.5 Form a network of local seed producers and link them to the formal seed system

Action 4.6 Develop and strengthen seed banks at the local levels

Strategy 5: Mitigate human wild-life conflicts

Action 5.1 Reduce impact on household food security by supporting crop intensification and diversification programs of the DoA

Action 5.2 Support and promote government approved incentives on appropriate fencing materials for crop protection in key conservation areas

Action 5.3 Support seed rehabilitation and seed supply of cereals to interested and affected farmers

Action 5.4 Contribute to potential crops insurance interventions promoted by MoAF

6.2.4 Strategies and Actions to achieve Objective 4

Objective: Strengthen capacity building for agro-biodiversity conservation and utilization

Strategy 1: Plan and provide for optimal skilled human resources for full time engagement in the conservation, management and utilization of agricultural biodiversity

Action1.1 Develop a human resource master plan for effective deployment of skilled manpower for agro-biodiversity conservation

Action 1.2 Operationalize the master plan

Action 1.3 Identify gaps in skills and knowledge and propose appropriate training programs

Action 1.4 Strengthen the regional research centres with additional manpower and skills for biodiversity management of crops

Strategy 2: Plan and provide for optimal facilities and infrastructure, both centrally and regionally, for agro-biodiversity conservation and management

Action 2.1 Develop basic infrastructures and facilities for research, development and utilization of agro-biodiversity at local and national levels

Action 2.2 Develop institutional capacity at NBC to measure and characterize genetic resources at the DNA level

Action 2.3 Establish molecular laboratory and biotechnological facilities to take up germplasm characterization and molecular level studies of local genetic resources

Action 2.4 Provide requisite facilities at the local and community level for agro-biodiversity conservation and use

Strategy 3: Build and strengthen national, regional and international collaboration with relevant organizations for sourcing and exchange of technical expertise, scientific information and genetic materials

Action 3.1 Establish links with regional/international centres of excellence for biodiversity, gene banks for exchange of information, expertise and genetic resources under mutually agreed terms and condition

Action 3.2 Streamline and facilitate exchange (outflow and inflow) of crop genetic resources using standard procedures and norms

Action 3.3 Strengthen cross-sectoral coordination and linkages among stakeholders for agro-biodiversity program planning and implementation in the country

6.2.5 Strategies and Actions to achieve Objective 5

Objective: Improve the existing information and monitoring and evaluation systems for agro-biodiversity

Strategy 1: Strengthen agro-biodiversity information management system

Action 1.1 Strengthen the current information management system for agro-biodiversity

Action 1.2 Promote information sharing among stakeholders/users

Action 1.3 Identify required investments and resources to strengthen information management system

Strategy 2: Put in place an effective Monitoring and Evaluation system

Action 2.1 Strengthen the current Monitoring and Evaluation system for agro-biodiversity

Action 2.2 Adopt M & E as an integral part of the strategic action plan and its implementation in the field

Action 2.3 Carry out baseline surveys/bench mark studies to measure the effects and impacts of the interventions over a period of time

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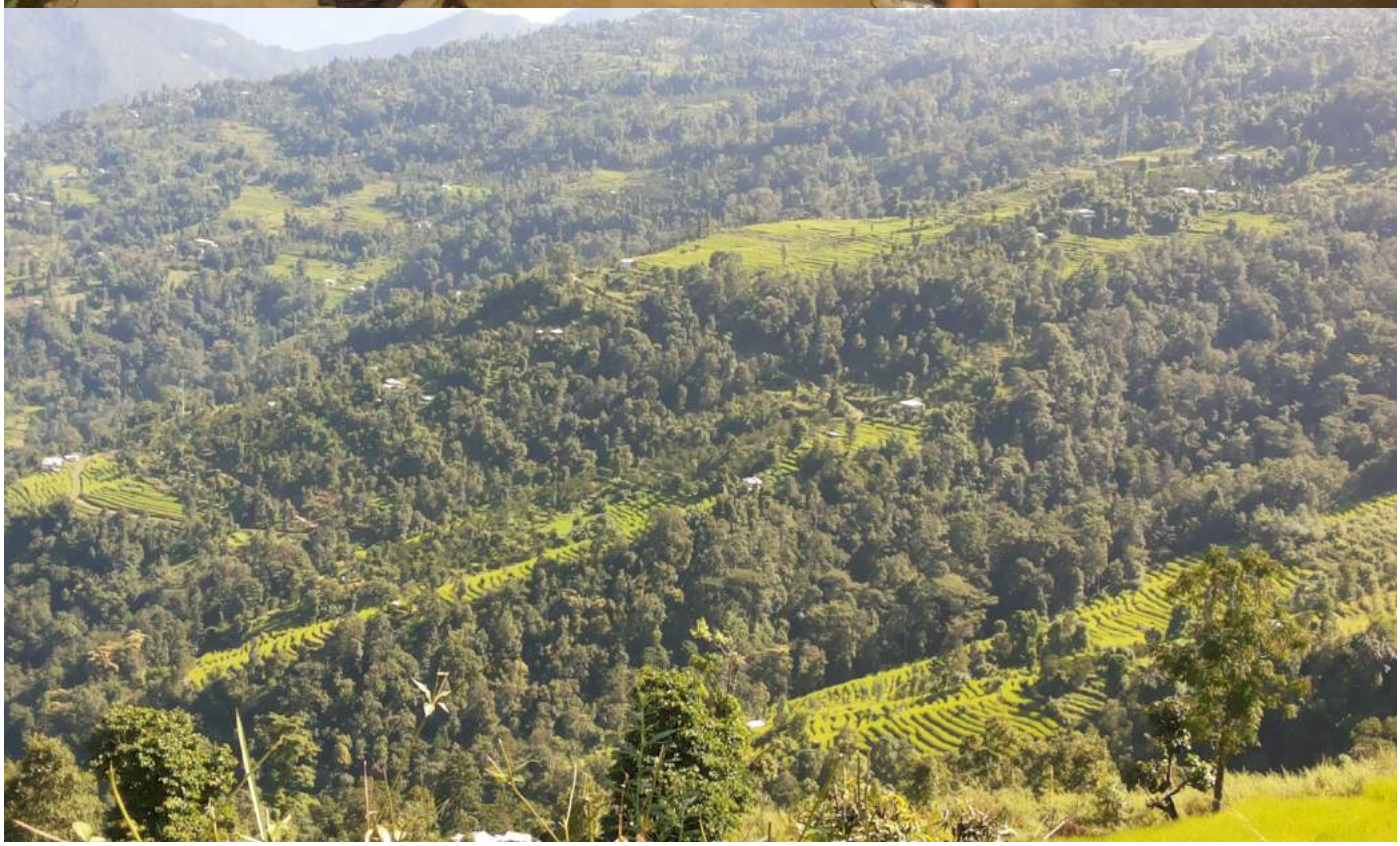

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