Plant Genetic Resources in SAARC Countries: Their Conservation and Management

Bhutan Chapter

by

Mahesh Ghimiray
Renewable Natural Resources Research Centre, Bajo
Council for RNR Research of Bhutan
Wangdue Phodrang, Bhutan.

TABLE OF CONTENTS

1. INTRODUCTION 3

2. STATUS OF PLANT GENETIC RESOURCES 4
   - 2.1 Agrobiodiversity 4
   - 2.2 Rice 4
     - 2.2.1 Rice Environments 5
     - 2.2.2 Traditional Rice varieties 6
   - 2.3 Grain Legumes 8
   - 2.4 Maize 10
   - 2.5 Wheat 12
   - 2.6 Oilcrops 13
   - 2.7 Minor and underexploited crops 14
   - 2.8 Potato 19
   - 2.9 Fruit crops 19
     - 2.9.1 Temperate fruits and nuts 19
     - 2.9.2 Subtropical fruit crops 20
   - 2.10 Vegetables 22
   - 2.11 Medicinal and aromatic plants 23
   - 2.12 Fodder and Grassland Resources 27

3. IMPROVED PLANT GENETIC RESOURCES 30
   - 3. 1 Introduced and adapted germplasm 30
   - 3.2 Utilisation of local germplasm for variety improvement 34

4. PGR CONSERVATION APPROACHES 38
   - 4.1 *In situ* conservation of PGR in Protected Areas 38
   - 4.2 *In situ* conservation of crop genetic resources 39
   - 4.3 *Ex situ* conservation 41

5. INSTITUTIONAL FRAMEWORK FOR MGT OF BIOLOGICAL RESOURCES 52
   - 5.1 National Biodiversity Centre (NBC) 52
   - 5.2 Nature Conservation Division (NCD) 54
   - 5.3 Council for RNR Research of Bhutan (CoRRB) 55

6. POLICY AND LEGISLATION RELATED TO BIODIVERSITY AND PGR 57
   - 6.1 The Forest and Nature Conservation Act 1995 57
   - 6.2 The Seeds Act of Bhutan 2000 57
   - 6.3 Biodiversity Act 2003 58

7. CONCLUSIONS 62

8. REFERENCES 73

1. INTRODUCTION

Bhutan is located in the Eastern Himalayas, landlocked between China and India. It covers an area of 40,076 sq km (LUPP, 1995) and has an estimated population of about 700,000. The physical features of the country are characterized by high, rugged mountains and a network of valleys, ravines and depressions, drainage basins, waterfalls and human settlement. The biotic features as are diverse as its geo-physical elements, broadened further by climatic attributes. Such a natural endowment has given Bhutan its special significance with regard to biological diversity (BAP, 2002). The country is considered as one of the ten biodiversity hotspots of the world.

Bhutan possesses a rich and varied biodiversity, both wild and domestic, which has significance at the regional and global levels. The richness in biological diversity is found at different levels such as the ecosystem, species and genetic levels. Considering its small size, such a diversity is unmatched by many countries of the world. Bhutan also has a strong commitment to conserving its biodiversity. Over 72% of the country is under forest cover, which harbours several species of flora and fauna including rare and endemic species. More than 26% of the country is under the Protected Area Management System, with biological corridors connecting the protected areas. Conservation management covers more than 35% of the total area in the country (BAP, 2002).

At the species level, efforts are still ongoing to completely inventorise the existing diversity. Indications so far are that there are more than 5,500 species of vascular plants, more than 770 species of avifauna and more than 165 species of mammals, with many species being endemic to Bhutan (BAP, 2002).

Bhutan is sparsely populated with about 79% of the people living in rural areas. The cultivated area accounts for about 8% including wetland, dryland, horticulture and fallow rotation. The traditional farming systems integrate crop production, livestock production and use of forest products (Gyamtsho, 1998). The landscape rises from an altitude of 150m to over 7500m, giving rise to a diverse flora and fauna. The natural forest and the traditional farming systems are largely intact, accounting for a wide diversity of plant genetic resources including many endemic cultivated and wild species.

This report is presented in seven sections: following a general introduction in section one, the second section provides an overview of the current status of plant genetic resources, including major and minor cereals, fruits, vegetables, oilcrops, feed and fodder crops and medicinal plants. Section three details on the available improved germplasm, either through introductions or in-country breeding programmes. The PGR conservation approaches and methods presently used in the country are elaborated in section four. Section five describes the major national institutions which are directly involved in the conservation and management of biological resources. The main policy and acts which regulate conservation, use and exchange of bioresources are explained in section six. The paper ends with the concluding section seven by stating that Bhutan has admirably managed its rich biological resources so far but there is a need to continually prepare for emerging challenges in the future.

2. STATUS OF PLANT GENETIC RESOURCES

Agrobiodiversity

Bhutanese farming systems are traditional, largely subsistence and self-sustaining, integrating crops, livestock and forest as renewable resources. Variability in altitudes and climate allows the Bhutanese farmers to cultivate a wide range of food crops, vegetables and fruits. The richness in species and varieties is enhanced through Bhutan's relative isolation from other parts of the continent and through a long and continuous process of natural and human selection. The local crops have considerable genetic diversity and are well adapted to the specific requirements of the areas where they are grown. Table 1 shows the major crops, their area and production in Bhutan.

Table 1: Major agricultural and horticultural crops in Bhutan

Crop species	Area (000 acres)	Production (MT)	Yield (kg/acre)
Rice	111,406	107,877	968
Potato	13,914	43,325	3113
Wheat	23,642	10,747	454
Buckwheat	18,013	6,443	357
Mustard	11,816	3,686	311
Barley	10,887	4,849	455
Maize	137,073	5,380	549
Millet	25,498	9,159	359
Vegetables	14,802	22,257	1503
Legumes	4,070	2,098	515
Chilli	1,688	887	525
Ginger	2,817	4,503	1598
Orange	19,866	77,031	3877
Apple	4,858	9,266	1907
Cardamom	17,231	3,980	230
Arecanut	0.277	1,073	3870

Source: LUPP, 1995

Rice

Rice is the most important food crop of Bhutan and it is grown from tropical lowlands (200 m) in the south up to elevations as high as 2700 m in the north. The native rice varieties possess significant genetic and ecological diversity.

The total rice area in the country is estimated to be around 25,000 ha, almost all of which is irrigated. There are small and isolated pockets in the central and eastern parts where upland rice is grown in the traditional slash-and-burn (*tseri*) system (Ghimiray, 1999). The average national rice yield is about 2.4 t/ha. Rice yields are particularly low in the low-altitude southern foothills because of poor soils, insect pests and diseases. The

overall self-sufficiency in domestic rice production is only about 50%. One of the cherished goals of the Royal Government is to increase the self-sufficiency level in rice food production. The indigenous rice genetic resources play an indispensable role in the crop improvement and food production programme of the Royal Government of Bhutan.

2.2.1 Rice Environments

The rice environments are broadly grouped into four eco-zones according to altitude, temperature and rainfall. These are the Warm Temperate, Dry and Humid Subtropical zones and the Wet Subtropical zone.

Warm Temperate (high-altitude) zone
The warm temperate high altitude zone falls between 1600 m to 2600 m and includes mainly the valleys of Paro and Thimphu, higher altitude areas of Punakha and Wangdue valley and parts of some other districts. Approximately 20% of the total rice area falls in this zone. During the rice crop season this environment has a low-high-low temperature pattern such as in Japan, Northern China and Korea. The climatic conditions allow only one crop of rice in a year. Rice is sown in February-March, transplanted in late May to mid June and harvested in October. Day temperatures during the growing season are generally not a major constraint. However, minimum temperature of below 15^{o}C combined with low water temperature at seedling and tillering stage can cause cold damage.

Dry Sub-Tropical (mid-altitude) zone
The dry sub-tropical zone includes broad valleys of Wangduephodrang and Punakha, hill slopes and narrow valleys of Trongsa, Trashigang, Monggar and Lhuentse districts. This is a mid-altitude zone between 700 m to 1500 m with a lower rainfall. In the lower valley bottoms, low temperature is not a major problem for a single crop of rice. Rice is sown in March-April, transplanted in June and harvested in October-November. Two crops of rice could also be grown. The first crop, transplanted in March by using seedlings raised in a poly-tunnel nursery, can be harvested in July and immediately an early maturing second crop can be planted which is harvested in October.

Humid Sub-Tropical (mid-altitude) zone
The humid sub-tropical zone, falling between 700-1500 m, includes the hill slopes of Tsirang, Dagana, parts of Trashiyangtze, Pemagatshel and Chukha. This is a distinct humid hilly environment with substantially higher rainfall than in the dry sub-tropical zone. Almost all rice is grown under irrigated condition. The rice terraces are carved in hill slopes. Some upland rice is also grown mainly in Zhemgang. The dry and humid subtropical zones account together for about 40% of the total rice area. High rainfall and humid conditions favour disease development and insect infestation.

Wet Sub-Tropical (low-altitude zone)
The wet sub-tropical low altitude zone includes mainly the three foothill districts of Samtse, Gelephu and Samdrupjongkhar and account for about 40% of the national rice acreage. It is a high rainfall environment with high temperatures between altitudes of 200

m to 600 m. Diseases and insect pests are more common due to high humidity and temperatures. Soil conditions are poor compared to other zones. Rice is grown mainly as an irrigated crop. However, in areas where irrigation is not assured, rice is grown under rainfed condition. Yields are generally low and unstable.

2.2.2 Traditional Rice varieties

The traditional rice varieties of Bhutan are grown under diverse agro-climatic conditions and show a high level of genetic diversity. The land races have adapted to the diverse environment and are unique ecologically, genetically and morpho-agronomically. So far, not many systematic studies have been done to unravel the genotypic or phenotypic composition of the local cultivars owing to a paucity of capacity and resources. Traditional varieties are generally heterogeneous for various traits, however quantitative data to illustrate such heterogeneity is generally lacking. Morishima *et al* (1990) reported that Bhutanese land races were highly polymorphic within a field and they also observed "weedy types" associated with high degree of seed shedding and sterility. These weedy types have subsequently been identified as *Oryza sativa* f. *spontanea* (Loresto, 1998).

More than 65% of the total rice area in the country is still planted to traditional varieties (Shrestha, 2004), reflecting the high adaptability and suitability of these cultivars in the traditional farming systems. At higher altitudes, local rice varieties are broadly classified into "Bja Maap" (red pericarp or grain varieties) and "Bja Kaap" (white pericarp varieties). Maaps are predominant in higher elevations usually above 1500 m, while Kaaps are more common in the lower elevations.

The high altitude red rice is favoured for its cooking and eating quality and commands a higher price in the local market compared to the white varieties. Red rice varieties are predominantly japonica types, although many intermediate types have been reported (Chettri, 1992) through introgression and gene flow between indicas and japonicas. The red colour of pericarp is usually controlled by a dominant gene (Rc) which is commonly distributed in wild and weedy types as well as in native cultivars (Oka, 1988).

Bhutanese farmers are known to grow and maintain a diverse range of local varieties in their fields. A single farmer cultivates 2-5 rice varieties in small plots or terraces, exhibiting practical *in situ* conservation at the farm level (Duba *et al*, 1995). The different rice varieties are grown to satisfy the varied needs of the farmers, such as for *tho* (cooked rice), *zaw* (puffed rice), *seep* (beaten rice), *torm* (divine ritualistic figures), *mekhu* (chapatti-like bread) wine distillation and for special religious performances and occasions. On-farm rice diversity is thus an integral part of the tradition, religion and culture of the Bhutanese people. Below is a brief description of the Bhutanese rice varieties found in different altitude regimes.

High-altitude varieties

The high-altitude rice varieties are characterised by cold tolerance at seedling stage, tall stature, long growth duration, medium to low tillering, late leaf senescence, good panicle exsertion, high spikelet fertility, high shattering, fewer grains per panicle, dense grains,

red pericarp, intermediate amylose and a lack of seed dormancy (Chettri, 1992). Some of the popular high altitude varieties especially from the valley of Paro and Thimphu are Naam, Hassey, Kochum, Thembja, Bjanaab, Dumbja, Zhechum, Chumbja, Uzum, Dagozam, Sombja, Khembja, Rey Sakha and Hamzam (Table 2). Many of these cultivars could be the local variants of a major genotypic pool selected over a number of years to suit micro-environments and farmers' needs. No molecular level studies have so far been done.

Some local varieties are cultivated for specific purposes, for instance, Dumbja is used mainly for *seep* making as it is one of the few high altitude varieties with white grains. Red grained varieties do not make good *seep* or *zaw*. Dumbja is also used in a variety of religious festivities. Hamzam is good for making *torm*.

Table 2: Important rice varieties and their traits

Altitude (m)	**Local varieties**	**Major traits**	**Improved varieties**	**Major traits**
1600-2700	Naam, Kochum, Hasey, Thembja, Dumbja, Maap, Zuchem	Cold-tolerant, tall, lodging-prone, good taste, mostly red-grained, blast susceptible	No.11 Khangma Maap Yusirey Maap Yusirey Kaap	Cold-tolerant, tolerance to blast, respond to fertilisers, high grain yield
700-1500 (Dry)	Zakha, Yankum, Ageydogo, Maap, Kaap, Bondey, Salem	Lodging-prone, mainly white-grained, good taste, some are speciality varieties	IR 64, M-54, IR20913, Bajo Kaap-1, Bajo Kaap-2, Bajo Maap-1, Bajo Maap-2	High yielding, good grain and market acceptability, short height and less straw
(Humid)	Attey, Taprey, Masino, Sukhimay Jarjan, Sambara, Verna, Sungsung-bara	Average yield, tall and lodge if fertilised, good grain quality, white-grained	IR 64, IR20913, Bajo Maap-1,2 Bajo Kaap-1,2	Early maturing hence attacked by birds and rodents, high yield, average grain quality
200-600	Kati, Jaswa, Onpaki, Mama, Taule, Mansara, Jeerasari,	Low yielding, susceptible to pest/diseases, good grain quality, good straw yield	BR 153 BW 293	High yielding, more tolerance to pests and diseases, average taste

Mid-altitude varieties

The mid-altitude varieties are mostly characterised by a lack of cold tolerance, early leaf senescence, higher number of spikelet per panicle, slender grains, long seed dormancy,

low to high amylose and mainly white pericarp (Chettri, 1992). Most of these varieties are also susceptible to blast, bacterial blight and sheath rot. In the dry subtropical zone, popularly grown traditional varieties are Zakha, Silekachum, Wangdakam, Botoli, Tantshering, Dawa Yankum, Agey Dogo, Salem, Kathramathra, Chumbja Maap, Olanam, Bondey, Jarey, Thagom, Kongteyrey and Dungchem. Some are specialty varieties, for instance, Olanam is specifically grown for brewing alcohol and Bondey is an aromatic variety for special occasions.

Commonly grown varieties in the humid subtropical areas are Attey, Sukkimey, Choti Masino, Takmaru, Malingay, Bhujungey, Taprey, Rudwa, Champa, Anadi, and Bharlangey. Anadi is grown for *chiura* (beaten rice) and Choti Masino is popular as a fine quality rice.

Low-altitude varieties
Low altitude varieties have generally not been characterised, however they have some affinity to the varieties of the mid-altitude zone. Aijung, Kati, Mama, Jaswa, Mansara, Taule, Katusey, Kalo Nunia, Onpaki, Fudungey, Jeerasary, Ghattey, Bhog (scented) and Abrey are some of the popularly cultivated varieties in the low elevation foothills.

2.3 Grain Legumes

Grain legumes are an important component of the Bhutanese farming systems. They are grown in diverse land use systems such as dryland, wetland, kitchen gardens and *tseri* in different cropping systems and seasons depending on the altitudes and the species. However, over 75% of the national legumes area is on drylands (National Legumes Survey, 1999). The survey of 1999 recorded a total of 16 species grown in the country, including a few unidentified species (Table 3). The most widely grown species across the country are *Glycine max, Phaseolus vulgaris, Pisum sativum* and *Vigna* spp.

Table 3: Legume species cultivated in the country by altitudes

Legume species	**Altitude in m**					**Total no of villages**
	200-600	**600-1200**	**1200-1800**	**1800-2400**	**Above 2400**	
Arachis hypogea	-	-	9*	2	-	11
Cajanus cajan	18	-	-	-	-	18
Dolichus lablab	-	-	3	-	-	3
Glycine max	18	46	183	108	3	358
M. uniflorum	6	-	-	-	-	6
Phaseolus lunatus	21	1	-	-	-	22
Pisum sativum	10	2	28	16	5	61
Psophocarpus tetragonolobus	2	-	-	-	-	2
Phaseolus vulgaris	32	48	170	98	2	350
Phaseolus coccineus	-	-	6	1	1	8
Phaseolus spp	3	-	11	2	4	20

Vigna mungo	30	12	8	3	-	53
Vigna radiate	19	-	12	1	1	33
Vigna umbellate	3	19	69	22	-	113
Vigna unguiculata	-	12	25	3	-	40
Vigna spp	4	2	14	7	-	26
Unidentified spp	3	1	1	-	-	5
Total no. of species	13	9	13	11	6	

* the figures indicate the number of villages in which each species was recorded
Data source: National Legumes Survey, 1999

The grain legumes are known by various names in different languages and dialects in the country (Table 4). The use of the local name, however, is often unclear whether it applies to a specific variety or is simply a general name applicable to all varieties of that species. Most farmers grow traditional varieties and maintain their own seeds. Reasons for growing legumes by the farmers include: food source, income source, availability of land and seeds, fodder for livestock, easy management, improvement in soil fertility, used for religious ceremonies and less damage by wild animals (NLS, 1999).

Table 4: Legume species and their local names

Latin name	**Dzongkha**	**Sharchopkha**	**Lhotshamkha**
Arachis hypogea	Batha semchum	Badam	Badam
Cajanus cajan	Tyeu	Rahari	Rahari dal
Dolichus lablab	Semchu karp	-	-
Glycine max	Semkarp	Libi	Bhatmas
Pisum sativum	Beysem, Thachem semchu	Bray changmo Brashangmo	Matar
Phaseolus vulgaris	Pata semchum Moram, Bogola	Broktang oray Nakmay	Bori, kanchi bori, ghew bori
Phaseolus spp	Batha semchum Guma semchum	Semchum	Hiudey bori, singvi
Vigna mungo	Semchu	Shakpu	Kalo dal
Vigna radiate	Huchum	Mosum, Shakpu dal	Moong dal
Vigna umbellate	Semchu kaap	Gakpu, Shengje	Bori
Vigna unguiculata	Semchu	Senji, Guibee	-

Data source: National Legumes Survey, 1999

Data on the area and production of grain legumes are often incomplete and fragmented. The National Legumes Survey of 1999 estimated 32,990 ha (Table 5) of land under legumes cultivation, which is about 11% of the national arable area. Some other sources cite lower figures. By region, the eastern and west-central regions have the greatest percent of land under legumes. The most important legume species in terms of cultivated area are *Glycine max,* different *Phaseolus* spp and *Pisum sativum*. The average yields of grain legumes are around 497 kg/ha (NLS, 1999) under monocropped conditions and

slightly lower when intercropped (457 kg/ha). The total annual production of legumes would be around 14,000 tonnes.

Table 5: Estimates of area grown to legume species by altitudes

Legume species	**Altitude in m**					**Total (ha)**
	200-600	**600-1200**	**1200-1800**	**1800-2400**	**Above 2400**	
Arachis hypogea	-	-	91.6	14.3	-	106
Cajanus cajan	32	20.6	-	-	-	52.6
Dolichus lablab	-	-	86.6	-	167.6	254.2
Glycine max	124	1490	5280	2944.5	34	9874
Pisum sativum	-	192	1172.5	225.5	2055	3969
Phaseolus vulgaris	269.2	721.9	2909	361.5	186.2	4448
Phaseolus coccineus	-	-	56.3	9.3	16.2	81.8
Phaseolus spp	278.1	541.3	2571.2	1576	351.8	5319
Vigna mungo	72.9	64	234.8	-	-	372
Vigna radiate	40	-	590.3	647	3.2	1286
Vigna umbellate	-	355.5	1504.5	1625.1	-	3485
Vigna unguiculata	61.5	262.3	889.9	352.2	-	1566
Vigna spp	120.2	971.2	847	-	12.2	1950
Unidentified spp	48.6	164	14.6	-	-	227
Total no. of species	1047	4783	16249	7756	3155	32990

Data source: National Legumes Survey, 1999

2.4 Maize

Maize is the most important cereal in terms of area under cultivation. No information exists on how and when maize was introduced in Bhutan (Roder and Gurung, 1990). However, the presence of maize had been noted by George Bogyle during his visit to Bhutan in 1774. Maize could have been in the region even prior to the discovery of the New World. The trade links between Europe and the East could possibly explain the entry of maize in the country (BAP, 2002).

Maize is today grown throughout the country up to an altitude of around 3000 m. The main growing areas are concentrated in the eastern parts of the country. Maize is grown as a rainfed crop on unterraced slopes. A small portion however is also grown in the wetlands prior to rice. Local maize includes dent, flint and popcorn types. Maize is grown as a single crop or intercropped or relay-cropped with beans, soybeans, potato, amaranths and pumpkin. There are several local landraces or varieties which are recognizable by their distinctive morphological traits. Farmers have different names for the local cultivars which have adaptation to micro-climate, soil types, time of sowing, nutritive value and other properties. Such landraces are genetically diverse, although they may be similar phenotypically. However, detailed studies at the genetic or molecular level are lacking. RNRRCs, in close collaboration with NBC, are currently engaged in collecting and

characterizing the local varieties. Table 6 provides a list of the important local varieties and their main characteristics.

Table 6: Local maize varieties and their major traits

Dis-trict	**Varieties**	**Positive Characteristics**	**Negative Characteristics**
Pema-gatshel	Tekharpa	Good yielder	Prone to lodging, hard grain, susceptible to pests & diseases
	Bartshampa	Soft and suitable for making Tengma	-
	Gangkhapu	Has good taste	-
	Barma Ashom	High yield and good taste	Late and prone to lodging
	Bema (yellow)	High yield and good taste	Late and prone to lodging
	Local	Good taste	Prone to lodging and susceptible to pest and disease
	Yomzorpa (yellow)	High yield, good taste	Prone to lodging, susceptible to pest and diseases
Pema-gatshel	Naktseripa (White)	Low yield, late and prone to lodging	Low yield, late and prone to lodging
	Yengkharpa	Good taste, resistant to lodging, resistant to pest and diseases	Late, low yield
	White maize	Resistant to lodging	Low yield, late, susceptible to pest and disease
	Kanglungpa (yellow)	Resistant to lodging	Low yield, late
	Baipo	Good taste	Low yield, prone to lodging
	Uzrongpa		Low yield
	Vethpu		Low yield
Trashi-yangtse	Khallingpa	High yield, good taste	Prone to lodging
	Balingmo	High yield	Prone to lodging
Trashi-gang	Baipo	Good taste	
	Sharpa	Good taste	
	Bepo Ashom	Early	
	Kanglungpa		
	Ashom Tshelu	Good taste	
	Ashom balingmo		Tall and prone to lodging
	Yangtsipa	High yiled	
	Sharpa Ashom	Popcorn	
	Baipo (yellow)	Soft Kharang, good taste, Good Tengma	
	Baipo (white)		
Mong-gar	Baipo Ashom		Tall, heavy lodging
	Theksumpa		Tall, heavy lodging, low yield

	Kanglungpa	Stable Yield	Late
	Yangtsipa		
Lhuen-tse	Yangtsipa cross	Good taste and resistant to lodging	
Bum-thang	Asham	High yield, good taste, resistant to lodging	
	Chokor local	Good taste, resistant to pest and diseases	
	Yangtsipa	High yield, good taste	
	Kaptibikhar	Good taste	Susceptible to pest and diseases
	Thridangbi	Good taste	
	Samcholing	Good taste	
Trong-sa	Taksumpa	Good taste, resistant to pest and diseases	Low yield
	Kidum	Good taste, high yield, resistant to lodging and pest and diseases	
	Charkharpa	Good taste, high yield	Susceptible to pest and diseases
	Chadam	Good taste, high yield, resistant to lodging and pest and disease	Late
Sar-pang	Pailey	High yield, resistant to lodging and pest and disease	Late
	Bhalay	-	
	Seti	High yield, good taste, resistant to lodging	
	Murali	Popcorn type	
	Yangtsipa	High yield good taste	

Source: RNRRC Wengkhar

Maize is eaten as a staple in the eastern and some southern parts of Bhutan. It is mainly consumed as maize grits (*kharang*) or as flour (*bokpi*). *Kharang* is a coarse milled granules cooked similar to rice or often mixed with rice. Maize *bokpi* is a finely milled flour and eaten as a dough. A large percentage of maize is also used to make alcoholic beverages.

2.5 Wheat

Wheat is the third most important cereal crop after rice and maize in terms of production. Wheat is grown in almost all the different agro-ecological regions of the country, from about 200 m to locations above 3000 m as a main or secondary crop after maize, rice and potato, and in rotation with buckwheat at higher altitudes.

No records on the introduction of wheat to Bhutan are available. Some speculate that it might have been introduced from Tibet. Records of some early visitors to the country suggest that wheat as a second crop after rice was more important in the last century than today (Roder and Gurung, 1990). A number of other crops such as oilcrops and vegetables have been ontroduced in the rice cropping system now. Low grain yield and subsequently low returns to investment and cheap imports from India are some other

reasons for stagnating wheat cultivation in the country. Wheat, however, is also grown as winter fodder and for hay making at higher altitudes.

Wheat landraces are perhaps the most threatened cereal food crops in the country. Village elders are often nostalgic of their local varieties they used to grow in the past. Many of these local cultivars, according to them, have disappeared from their fields as they are gradually replaced by a few improved varieties (BAP, 2002). It is however likely that some of the varieties may still survive in remote and far-flung areas. Among the improved varieties, three are popularly grown: Sonalika, Bajoka 1 (HD 2380) and Bajoka 2 (BL 1093).

A large proportion of the wheat production in the country goes into alcoholic beverages, locally called *chang* and *ara*. Wheat is also used in the form of a flat bread (*keptang*) or wheat flour from roasted grains is eaten with butter tea as snacks.

2.6 Oilcrops

Oilseeds constitute major agricultural crops in the country next to cereals. Predominant oilseed crops are mustard and rapeseed (*Brassica juncea* and *B. campestris*) grown at altitudes from about 200 m to 3000 m. The acreage under oilseed crop is slowly diminishing because it is not economically viable (BAP, 2002). This is due to the limited choice of cultivars and the high cost of production, thus cheaper imports depress domestic production. In the wetlands there are other competing crops such as wheat and vegetables. In the dryland, mustard is grown as a secondary crop under rainfed conditions.

There is a high diversity of oilcrops in the country, but the local cultivars have not been systematically collected and studied so far. However, RNRRC Bajo is taking some initiatives in this area, including a nation-wide study on the varieties, management practices, processing practices and farmers' perceptions on oilcrops cultivation vis-à-vis cheaper imports from India and elsewhere. In addition to *Brassica* species, there are other oil-bearing crops grown traditionally. Niger seed (*Guizotia abyssinica*) is grown in small areas during summer in the lower hills. Niger is known to do well even under poor fertility and management conditions and competes well with weeds. Sesame (*Sesamum indica*) grows in the southern parts of the country. Two types of sesamum are grown, one with white seed and the other with black seed. Another minor source of vegetable oil is sunflower (*Helianthus annuus*) grown mainly in the cool temperate zone above 2000 m. Soybean (*Glycine max*) and groundnut (*Arachis hypogea*) are other oilseeds species cultivated in the eastern parts of the country. However, their exploitation for quality oil is so far limited by a lack of suitable oil extraction devices.

In addition, there are a number of perennial oil-bearing trees from which seeds are harvested to extract oil. Locally called Pangtsi (*Symplocus paniculata*), is found in abundance in the mid-altitude valleys of Punakha and Wangdue. It contains about 20% edible oil. Yika (*Maduca butyretica*) is found in Eastern Bhutan, and the oil is mostly

used for lamp oil, although the oil and fruits are edible. Karshing or Kadam (*Jatropa curcas*) is widespread in the country and its oil is mainly used for soap making (BAP, 2002). The plants are used as live fence and for erosion control. Shingshe (*Neolitsea* sp) is found in eastern parts and its oil is used for consumption and for lighting lamps.

2.7 Minor and underexploited crops

Bhutan has a number of indigenous crops which are considered minor (Table 7) and are largely underexploited, however the importance of such crops in the sustenance and livelihood of remote and inaccessible communities cannot be underrated. Although major cereals such as rice are generally preferred, the minor crops play a vital role in the overall food basket of the Bhutanese people, especially in the rural areas.

Barley, mostly naked type, is well adapted to the Bhutanese high altitude conditions. It is the only grain crop available for farmers and livestock herders who live above 3500 m (Roder and Gurung, 1990). Barley is grown mainly as a rainfed crop, however it is also irrigated in some areas like Bumthang. Millets are mainly grown in poor soils and management situations as a short duration crop in the drylands. Different species of millets (Table 7) are grown in different parts of the country. Rye is relatively a newly introduced crop grown in winter or spring in high altitude areas, mostly in Bumthang. Amaranths are widely grown but in small areas only, often together with millets, soybean or maize.

Table 7: Minor agricultural crops of Bhutan

Crop	**Botanical name**	**Region**	**Altitude (m)**
Barley	*Hordeum vulgare*	Widespread	1000-4000
Rye	*Secale cereale*	Bumthang	2700-3000
Sweet buckwheat	*Fagopyrum esculentum*	Widespread	300-3000
Bitter buckwheat	*Fagopyrum tataricum*	Widespread	3000-3000
Finger millet	*Eleucina coracana*	Widespread	-2000
Foxtail millet	*Setaria italica*	Widespread	-800
Common millet	*Panicum milliaceum*	Widespread	-2000
Amaranth	*Amaranthus* spp	Widespread	1200-2500
Taro	*Colocasia/Alocasia spp*	Widespread	500-3000
Perilla	*Perilla frutescence*	East and South	200-2000
Niger	*Guizotia abyssinica*	South	-1000
Yam	*Disscorea* spp	South and East	-1500
Tapioca	*Manihot esculenta*	South and East	-1500
Sweet potato	*Ipomea batatas*	Widespread	-1500
Sugarcane	*Saccharum officinalis*	Widespread	-2000
Queensland arrowroot	*Canna edulis*	South and East	-1500
Grass pea	*Lathyrus sativus*	South	-1500
Sorghum	*Sorgum bicolor*	South	-1000

Source: Adapted from Roder and Gurung, 1990

Taro species are important in the southern parts of the country, although small patches can be found throughout Bhutan. Niger is grown in the low-altitude foothills mostly for home-made pickles and occasionally for oil. Sugarcane is cultivated as a backyard or kitchen garden crop by most households, its cultivation linked to its requirement during religious ceremonies.

Both sweet and bitter buckwheats are grown in Bhutan from low to high altitude zones. Being a short duration crop, buckwheat is grown under various cropping patterns, as a second crop after potato, wheat or barley. It is also grown in the wetlands as a pre-rice crop. Systematic collection and study of the local diversity in minor crops is underway at RNRRC Jakar, which has the mandate for these crops. Table 8 provides details of varieties of buckwheats, barley and millets along with important agronomic characteristics.

Table 8: Landraces of buckwheats, barley and finger millet grown in different districts

District	**Crop**	**Variety**	**Agronomic traits**
Trongsa	S/buckwheat	Charay	Good taste, large grain size
	B/buckwheat	Bratma	High yield, early maturing
	Finger millet	Makom	Good taste, small grain, low yield
		Guenthum	Moderate yield, easy to thresh
		Kongpu	Good for alcohol production, no shattering, long spike
Zhemgang	S/Buckwheat	Charay	Good taste, low yield, early maturing, lodging
	B/buckwheat	Bratma	Moderate yield, lodging, bitter taste, wild animal damage
	Barley	Tongsola	-
	Finger millet	Kongpu	Good taste, high yield
Bumthang	Barley	Prokto	High yield, disease susceptible, wild animal damage, hooded awns
		Ranat	Insect and disease susceptible, high yield, less damage by wild animal, long awns on two opposite rows and no awns on the centre rows
		Manat/Janat	High yield, good taste, insect tolerant, less damage by wild animals, long awns
	S/buckwheat	Charay	Good taste, insect/disease susceptible
	B/buckwheat	Bratma	Large grain size, high yield
		Jarkobo	Moderate yield, bitter taste
		Gongkobo	Moderate yield, insect susceptible
		Yorphra	-
		Korpa	-

Sarpang	S/buckwheat	Mithrey Phapar	Good taste, lodging, low yield, difficult to thresh
	B/buckwheat	Titey Phapar	Good yield, bitter taste
	Finger millet	Thangray	Moderate yield
		Kalo	Good taste, difficult to thresh, high yield, early maturing
		Jumkay	Easy to thresh
		Baganay	High yield, tall, red/brown seeds, lodging
		Mungsiray	Semi-open/closed spike, brown seeds, no lodging, short fingers, late
		Katikay	Open spike, no lodging, small seeds, black colour
Samtse	Finger millet	Kodo	High yield, lodging, good taste
	S/buckwheat	Mithrey Phapar	Good taste
	B/buckwheat	Titey Phapar	-
Tashi Yangtse	Finger millet	Chakray	Good taste, high yield
	Barley		-
Tsirang	Finger millet	Dolley	High yield
		Jhumkay	Good taste, no lodging, easy to thresh, early maturing
		Murkay	Good taste, early maturing
		Kalo	Good taste, black seeds, cold tolerant
		Seto kodo	Semi-open spike, no lodging, white seeds, high yield
		Katikay	Good taste
	Barley	Naat	Good taste, awned
	S/buckwheat	Mithey phapar	Good taste, more husk

Source: Wangda, 2005

Traditional recipes from minor crops include noodles, cooked dough, pancakes and bread particularly from buckwheats. Bitter buckwheat is traditionally used also to treat livestock ailments (Roder and Gurung, 1990). Millet grains are widely used to make alcoholic beverages, called *bangchang* or *tongba*, which are popular beer-like drinks. Amaranth leaves are eaten as vegetable. Seeds of amaranths are used in various forms, often as additives to improve the taste or cooking quality of foods. Sprinkling seeds before rice is fully cooked is said to improve the rice texture. Amaranth seeds are commonly added with puffed rice (*zao*) for better popping effect.

There are many wild plant genetic resources collected from the forests which are used as food for consumption (Table 9). Wild yams are used as staple during times of food shortages. Oil is extracted from seeds of many trees grown in the periphery of fields or in

bunds. A wide range of orchids, ferns, bamboo shoots, banana inflorescence, canes and mushrooms are eaten as delicious vegetables. Similarly, many wild fruits are harvested for consumption. Such wild crops satisfy specific primary needs of isolated populations of subsistence farmers. However, many of these crops are also sold in the local markets as niche produce.

Table 9: Wild plant genetic resources used for consumption

Crop/local names	**Botanical name**	**Altitude range (m)**	**Uses**
Wild yam	*Dioscorea* spp	200-1600	Staple
"Patey"	*Angiopteris lygodiifolia*	1100-1500	Staple
"Yankari"	*Entada spp*	-1000	Staple
"Tamphie"	*Verbascum* spp	2000-3500	Staple
"Guli"	*Persea spp*	1000-2000	Fruit
"Pangtsi"	*Symplocus* spp	800-1800	Oil
"Shingmar"	*Lindera* spp	-1500	Oil
"Yika"	*Diplonema butyracea*	-1500	Oil
"Gantey"	*Gynocardia* spp	-1000	Oil
"Chara"	*Prasiola formosana*	2000-3000	Vegetable
Orchids	*Cymbidium* spp	1500-2000	Vegetable
"Nakwe"	*Osmunda* spp	1500-2000	Vegetable
"Pankwe"	*Petridium* spp	1000-2600	Vegetable
"Paktsa"	*Calamus* spp	1000-2000	Vegetable
Banana (inflorescence)	*Musa* spp	500-1500	Vegetable
"Marip"	*Elaegnus parviflora*	2400-3000	Fruit, alcohol
"Amla"	*Emblica officinalis*	-1500	Fruit, pickle
"Baykhe"	*Capsella* spp	2500-3000	Vegetable
Stinging nettle	*Urtica* spp	-3000	Vegetable, livestock feed
"Lam rum"	*Alium* spp	3000-3500	Vegetable
"Phareth"	*Polygonum* spp	2000-2600	Vegetable
Bamboo shoots	*Several species*	-2000	Vegetable
"Nyakhachung"	*Asparagus* spp	-1500	Vegetable
Mushrooms	Many species	-3500	Vegetable

Source: Roder and Gurung, 1990

In the past, animal fibres from sheep and yak, plant fibres from different species (Table 10) and endi silk provided raw materials for clothes used by the subsistence communities of Bhutan (Roder and Gurung, 1990). Wild nettle was widely used in earlier days for cloth fibre, however its use has long declined due to cheaper imports from India. The cultivation of cotton, likewise, has been discontinued since decades. Rearing of silk worm for endi silk has also declined rapidly. However, small scale silk production still continues.

Table 10: Local fibre crops of Bhutan

Crop	Main districts/region	Status/importance
Cultivated		
Cotton (*Gossypium* sp)	Pemagatsel, Zhemgang Trashigang	Not cultivated any more
Hemp (*Crotolaria* sp)	Gelephu	Rarely cultivated
Castor (*Ricinus* spp)	Trashigang, Monggar	Used as feed for silk worm
Wild		
Nettle (*Girardinia palmate*)	Widespread in subtropical areas	Used to some extent
Heteropanax fragrans	Trashigang, Monggar	Used as feed for silk worm
Edgeworthia gardeneri	Subtropical	Used for paper making
Daphne spp	Temperate	Paper making

Source: Roder and Gurung, 1990

Bhutan is renowned for its fine textiles. Even today, spinning, dyeing and weaving of wool, cotton and endi silk are important activities done in almost all rural households. The government also promotes such activities for enhancing rural incomes and to provide continuity to age-old practices and traditions. Local plants are a source of most dyes for colouring textiles (Table 11). The lac insect, *Tachardia lacca*, provides the most important red colour. In the olden days, dyes were important traditional export items to India (Roder and Gurung, 1990).

Table 11: Dye crops used in the country

Dye plants	Colour
Strobilanthus cusia	Blue (indigo)
Curcuma domestica	Yellow
Rubia manjitha (Madder)	Red
Rubia wallichiana	Red
Symplocus theaefolia	Yellow
Symplocus ramose	Yellow
Butea monsperma	Red – lac insect

Source: Roder and Gurung, 1990

A variety of plants are also a source of ingredients that are needed in traditional religious ceremonies. *Cupressus corneyana*, *Juniperus recurva* and *Taxus baccata* are important plant species which are used for incense by all Buddhists. Different parts of banana plant and several grass and tree species such as *Ficus religiosa* and *Prunus* sp are essential for Hindu ceremonies. Thus, plants provide sustenance and spiritual comfort for the Bhutanese.

2.8 Potato

Potato was introduced into the country in the late sixteenth century (Roder and Gurung, 1990), but it remained a minor crop until late nineteenth century when Bhutan began constructing roads providing access to the Indian market. Today, it is a major cash crop and export earner for the country. The bulk of the potatoes are sold in the Indian border towns at lucrative prices.

The major potato growing areas are located in the mountainous western and eastern regions of the country between altitudes of 1500 m to 3000 m. A small area in the lower regions of the South is also under potato cultivation, mainly for household consumption. The cool climate and high hills of Bhutan are ideal for potato cultivation and farmers can maintain their own seeds for years without significant degeneration in quality.

Predominant potato varieties are Kufri Jyoti, Desiree, Yusikaap (CIP 720088) and Khangma Kewa (CIP 378015.13), which have been tested and released by the Ministry of Agriculture through research. Farmers prefer Desiree, a short duration, red skinned Dutch variety, for its wide adaptability and better market price.

2.9 Fruit crops

The wide diversity of agro-climatic conditions prevalent in the country favours cultivation of different fruits and nuts. These fruits and nuts are an important source of essential vitamins and minerals, thus playing a role in improving nutrition and health of the rural communities. Among various fruit crops grown in the country, apple and citrus enjoy a special importance due to favourable growing conditions and available export markets in India and Bangladesh (Dorji, 1999). The Royal Government of Bhutan promotes increased cultivation and diversification of fruit and nut crops to enhance household nutrition and cash incomes. The major approaches used are through *in situ* conservation and utilization of landraces and their wild relatives and through introduction of germplasm to increase the diversity of existing crops.

2.9.1 Temperate fruits and nuts

Apple is the most important temperate fruit, however, not much is known about its first introduction and cultivation in the country. Now it is grown between altitudes ranging from 2000 m to 3000 m asl. Thimphu, Paro, Haa and Bumthang are the major apple growing districts in the country. Commercial varieties popularly grown are Red and Golden Delicious, which are preferred by the growers, consumers and exporters for their sweetness, size and fruit colour. Recently, many other apple varieties have also been introduced mostly from Europe, Japan and India.

Besides apple and peaches, Chinese pear (*Pyrus pyrifolia*) is an important traditional fruit crop. Chinese pear was traditionally more important than apple because it did better at higher altitudes than apple. Compared to apple, Chinese pear is also less susceptible to insects and diseases and less demanding on soil fertility (Roder and Gurung, 1990). The

research system has now introduced soft-shell walnut, apricot, peaches, plums, cherry, almonds, pecans and different berries which are grown in the country (Table 12).

Table 12: Available temperate fruit and nut crops and their varieties

Crops	**Varieties**
Apple	Top Red, Red Free, Red Chief, Red Spur, Weel Spur, Hardi Spur, Coop-12, Vance Delicious, Shim Kulu, Crimson Golden, Lobo, Spartan, Ariwa, Anna, Sekaichi, Shuko, Orin, Mutsu, Kitanosachi, Einshimer, Jumbo Orin, Golden Nasphel, Fuji, Nagafu, Starking, Golden Delicious, Red/Royal Delicious, Hanawai, Jonagold
Walnut	Late English, Govind, Tuder, Kashmir Seedling, Henson, Kanthel Selection, Yusipang 1, Kandaghat, Blackmore, Broadview, Buccaneer, Coenen, No 16, Khangma 1, Proslavski
Cherry	Stella, Seneca, Red Heart, Belford Prolific, Black Heart, Makhmali Glass, Thriump Damini, Junifer
Apricot	Sar Doli, Kaisha, New Castle, Nari
Peaches	July Elberta, Crawford Early, Floradasan, Kanto 5, Red Heaven, Shan-e-Punjab, Sun Heaven
Plums	Beauty, Santa Rosa, Stanley, Mari Posa
Pears	William, Max red Bartlett, Nashi, Gola, Tsirang Local, Bagugosha
Almond	Drake, Kagzi, Pathak Wonder, Dhebar Badan, Thinshelled
Hazelnut	Tondo di giffoni, Corbel, EMOA 1, Gunslebert, Gustavi Zeller, Hallesseche Riesen
Red Currants	Tartan, Rovada, Roodneus, Junifer, Jonker van Tets
Gooseberry	Archilles, May Duke
Blackberry	Lochness, Chester Thornless
Raspberry	Autumn Bliss, Marwe

Source: Dorji, 1999

Walnut is another important crop in the temperate areas. The native walnut (*Juglans regia*) is hard-shelled and difficult to crack. It grows in the wild throughout the kingdom at altitudes between 1500 – 3000m. The local walnut also has timber value. Walnut is promoted as a high-value, low-volume cash crop for farmers of remote areas. Besides walnut, other important crops are hazelnuts, apricots, pecan, chestnut, almond, pears, plums and a host of berries.

2.9.2 Subtropical fruit crops

The subtropical fruit zone stretches from about 400 m to above 1600 m, where a number of crops are grown. Among these, mandarin (*Citrus reticulata*) is the most important crop in terms of area grown to it and the cash income that growers derive from it. Bangladesh and India are the most important markets for the fruit, however, a considerable amount is also processed and value added within the country. No information on the year or source of introduction of mandarin into Bhutan is available. However, early visitors (for instance

Turner in 1783) described a garden near Wangduephodrang having a variety of subtropical fruit trees including mandarin and citron.

The diversity of the local mandarin seems to be limited in the absence of any systematic studies done so far. The local mandarin grows very tall (up to 15 m), has thorns and is difficult to harvest. Above 1500 m, it does not do well. The Ministry of Agriculture is therefore providing options through the introduction of different citrus species (Table 13), mostly from Europe, Japan, USA and Australia.

Table 13: Subtropical fruit crops and their varieties in Bhutan

Crops	**Varieties**
Citrus - Mandarin	Kishu, Oota Ponkan, Freemont, Encore, Clementine Nules, several local cultivars
Satsuma	Miyagawa wase, Ichifumi wase, Okitsu wase, Matshuda Unshui
Tangelo	Minneola, Seminole, Murcott
Tangor	Iyo, Miyauchi Iyo
Orange	Navel Late, Lane Late, Valencia, Onlinda, Washington Navel
Sour Orange	Gonton, Bouquet de Fleur
Lime	Bearss, Locals
Lemon	Meyer, Limoniera
Grape Fruit	Rio Red, Star Ruby
Pumello	Ortoblanco, Langthel Local
Kumquat	Marumi
Limquat	Evstis
Grapes - Table	Muscat of Alexandria, Calmera, Ruby Seedless, Sultana M12, Waltham, Portlands Early
Wine	Perlette, Chardonny, Chasselas, Pinot Noir, Cab Franc, Mondeusa, Gamay N
Avocado	Zufano, Hass, Bacon, Pinkerton, Fuerte
Mango	Langra, Dasheri, Chausa, Himsagar, Amrapali
Guava	Thai Giant, Alahabad Safedi, Locals
Pomegranate	Bedhana, Amar Shurin, Nellis, Western Schley, Mahan, PS-75-K5, Burkett, Kiowa, Wichta
Banana	Williams, Bhur Dwarf, Zapari, Authia, Malbhog, Dhusrey, Manohar, Chinichampa, Harichat, Ghuikola
Cardamom	Ramshai, Bharlangey

Source: Dorji, 1999

Besides citrus, other subtropical fruits such as avocado, mango, guava, banana, grapes and pomegranate are also introduced and popularized. Among these, mango has a potential for large scale cultivation and sale. The Renewable Natural Resources Research Centres (RNRRCs) under the Council for RNR Research of Bhutan (CoRRB) of the Ministry of Agriculture maintain the genetic materials of the fruits and nuts as *in situ* collections. However, the possibility of *in vitro* storage needs to be explored as well (Dorji, 1999).

2.10 Vegetables

Given the diversity of agro-climatic conditions, a wide array of vegetables are grown in different parts of the country. A lot of these vegetables are relatively new for Bhutan, having been introduced and promoted by the Ministry of Agriculture from the 1970s. Some of the traditional vegetables, however, are chili, radish, turnip, pumpkins, squashes, leafy greens and different gourds (Table 14). The relatively recent introductions include carrot, tomato (excluding cherry types), cole crops, asparagus etc.

Table 14: Commonly grown vegetables in the country

Local name	**English name**	**Botanical name**
Ema	Chili	*Capsicum* spp
Dolom	Brinjal	*Solanum melogena*
Kakur	Pumpkin	*Cucurbita pepo*
Gyen	Cucumber	*Cucumis sativus*
-	Bottle gourd	*Lagenaria* spp
-	Ridge gourd	*Luffa acutangula*
-	Sponge gourd	*Luffa cylindrical*
-	Snake gourd	*Trichosanthes anguina*
-	Ash gourd	*Benincasa hispida*
Khagten	Bitter gourd	*Momordica charantia*
Lambenda	Tomato	*Lycopersicon esculentum*
Iscus	Chayote	*Sechium edule*
Shing-gi-lambenda	Tree tomato	*Cyphomandra betacea*
Buensum	Pea	*Pisum sativum*
Semchung	Beans	*Phaseolus* spp
-	Lady's finger	*Hibiscus esculentus*
Meto kopi	Cauliflower	*Brassica oleracia*
Ngakhagchung	Asparagus	*Asparagus officinalis*
Dama kopi	Cabbage	*Brassica oleracia*
-	Spinach	*Spinacea oleracia*
Eusii	Coriander	*Coriandrum sativum*
Lafu	Radish	*Raphanus sativus*
Aendo	Turnip	*Brassica rapa*
Gop	Onion	*Allium cepa*
Chagop	Garlic	*Allium sativum*
Ngakay	Fern shoots	*Dryopteris* spp
Lafu Maap	Carrot	*Daucus carota*
Kewa	Potato	*Solanum tuberosum*
Semagi kewa	Yams	*Dioscorea* spp
Hentsey	Sag	*Brassica* spp
Olachoto	-	*Cyclanthera pedata*
Olachoto	Orchids	*Cymbidium* spp
Saga	Ginger	*Zingiber officinale*
-	Turmeric	*Curcuma domestica*

All households in Bhutan maintain vegetable gardens in their backyards to grow a mixture of vegetables and herbs to meet their daily requirements. Such indigenous gardens are a repository of genetic diversity for vegetables, spices and condiments. Gardens differ from household to household, community to community and region to region, depending on climate, soils, diet and history (Gurung, 1999). They contain variety of crops that serve different purposes. Some may provide food, others medicine or craft materials, and some may be grown for aesthetic values. In addition to meeting household needs, these gardens are also used to grow vegetables for the local markets. Some farmers have even gone further to produce vegetables in a commercial scale for the internal as well as outside markets.

Bhutanese also harvest several plants from the wild and consume them as vegetables. Such vegetables are collected from the forests, in addition to the cultivated species and varieties. These include wild edible mushrooms, bamboo shoots, ferns, orchids, cane shoots, wild asparagus, wild onion, stinging nettle and different yams or wild potatoes.

Complete and systematic collection, characterization and evaluation of the vegetables have not been possible so far given the lack of expertise and manpower. However, the recently established National Biodiversity Centre (NBC) is taking initiatives in this direction.

2.11 Medicinal and aromatic plants

Bhutan was known as "Lholong Menjong" or the land of medicinal herbs, in the ancient times. This name reflects the rich diversity of medicinal plants available in the country in those days and even to this day.

The traditional medicinal system in Bhutan, known as "Gso.ba.rig.pa" was officially recognized and included in the National Health Care System by the Royal Government of Bhutan in 1967. Today the traditional medicine has grown into three distinct divisions consisting of National Traditional Medicine Hospital with its branches all over the country, National Institute of Traditional Medicine (NITM) as the premier institute awarding degree and diploma in Traditional Medicine, and Pharmaceutical and Research Unit responsible for production of Traditional Medicine and further research. The traditional medicine system enjoys an equal status as that of the modern system and Bhutanese have a choice to be treated by either of the systems.

The medicinal and aromatic plants of Bhutan are categorized into two groups of *sgno-sman* (high altitudes above 2600 m) and *khrog-sman* (low altitudes below 2600 m) according to the traditional medicine system (Tshitila, 1999). A partial listing of the medicinal and aromatic plants is provided in

Table 15 with the *Gso-ba-rig-pa* as well as the botanical names. It is worthwhile to note here that the present inventory of medicinal and aromatic plants is incomplete and more work needs to be done.

There are more than 600 plant species mentioned in the Bhutanese traditional medicine texts which can be used for therapeutic purposes. However, the Institute of Traditional Medicine currently uses 264 plant species, mostly from high altitudes, to produce about 106 products. The average annual raw materials used were about 9.484 tonnes of dried materials between 1990 to 1995 (Tshitila, 1990).

There are some rare and valuable species which are reported to be illegally harvested. These species are *Cordyceps sinensis, Fritillaria delavayi, Picrorhiza kurroa* and *Sassurea gossipiphopra*. Recently the collection and sale of *Cordyceps sinensis* has been legalized with issue of harvest permits within designated pockets and sale of the produce through open auction markets.

Apart from streamlining collection and harvesting procedures following sustainable and scientific principles, the Ministry of Agriculture is also involved in the domestication of some the medicinal and aromatic plants, which would supplement the collections from the wild and also diversify the source of cash income for the farmers in remote areas. Some of the species that are already under cultivation include *Inula recemosa, Carum curvi, Sassurea lappa, Abelmochos muchatos* and *Aloe vera*. Several herb gardens have also been established in the high altitude areas for domestication trials, characterization and evaluation of medicinal plants (Tshitila, 1999). The RNR Research Centre in Yusipang is involved in *in vitro* culturing of rare and difficult to propagate species such as *Asparagus recemosa, Crocus sativus* and *Dracoaephalum tanguiticum*.

Most of the medicinal plants are collected from the Protected Areas and National Parks spread throughout the country and are managed by the Nature Conservation Division (NCD) of the Department of Forestry. Some of the current collection procedures and pratices (Tshitila, 1999) are described below.

- Collection/harvesting of medicinal plants is allowed, but only with a permit issued by the Park authorities. The collected materials are used mostly in formulation of traditional medicines.
- The park management has the right to regulate and monitor the harvesting and collection of plants within the park, including enclave zones, buffer zones and seasonal grazing areas.
- The park management has the right to rescind with good cause the harvesting permits within their jurisdiction.
- The park management acts as a facilitator and liaise with the local communities, user groups and governmental and non-governmental organizations to develop and promote sustainable harvesting practices.
- All organizations, governmental or non-governmental, require that they consult the NCD and park management on any plans and practices that pertain to collection and processing of medicinal and aromatic plants.

Table 15: List of medicinal and aromatic plants of Bhutan

Name transcript	**Botanical names**
High altitude species	
Bdu-rtsi-lo-ma	*Aconitum laciniatum*
Bong-nga-dkarpo	*A. orochryseum*
Bong-nga-marpo	*A. violacium*
Snya-lo-mchog	*Aconogonum tortuosum*
Ri-sgog	*Allium macranthum*
Klung-sgog	*Allium walachi*
Sga-tig-nagpo	*Androsace stigilossa*
Srub-ka	*Anemone rivularis*
Ske-matshe	*Arabidopsis himalaica*
Rtsva-a-krong	*Arenaria kansuensis*
Dva-gyung	*Arisaema jacquimontii*
Lug-mig	*Aster flaccidus*
Srad-ser	*Astragalus floridus*
Skyer-pa-nag-po	*Barberis aristata*
Spang-ram	*Bistorta macrophylla*
Sgong-thog-pa	*Brassica juncea*
Sngo-zi-ra	*Bupleurum candolli*
Co-ga-pa	*Capsella bursa-pastoris*
Bya-kang	*Delphinium drepanocentrum*
Pri-yang-ku	*Dracocephalum tangtuiticum*
Byi-rug-smug-po	*Elshoutia eriostachya*
Mtshe-ldum	*Ephedra gerardiana*
Spang-mtshan-spu-ru	*Eriophyton wallichiana*
Dur-byid	*Euphorbia grifithii*
Thar-nu	*Euphorbia* spp
Zhim-thig-le-karpo	*Euphrasia himalaica*
Bri-rta-sa-dzin	*Fragaria* spp
Dkar-po-chig-thub	*Fritillaria delavayi*
A-bhi-kha	*Fritillaria gardneri*
Zang-rtsi-karpo	*Galium aparine*
Zang-rtsi-nagpo	*Gallium* spp
Spang-rgyan-sngon-po	*Gentiana algida*
Spang-rgyan-dkarpo	*Gentiana* spp
Gangga-chung	*Gentiana umula*
Gla-sgang	*Geranium* spp

Li-ga-dur	*Geranium tuberaria*
Spru-ma-dkarpo	*Heracleum candicans*
Ol-mo-se	*Podophyllum hexandrum*
Lug-mnye	*Polygonatum singalilensis*
Gro-lo-sa-dzin	*Potentilla peduncularis*
Shang-dril-ser-po	*Primula muaroi*
Sga-tshva	*Ranunculus brotherusi*
Ga-bra	*Rubus ellipticus*
Bri-mog	*Onosma hookeri*
Lug-ru-serpo	*Pedicularis longiflora*
Tha-ram	*Plantago erosa*
Gser-gye-me-tog	*Herpatospermum caudigerum*
Star-bu	*Hippophae rhamnoides*
Ma-nu	*Inula recemosa*
Pa-yag	*Lancea tibetica*
Yu-mo-mdeu-byin	*Mecanopsis primula*
Dbyar-rtsva-dgun-bu	*Cordyceps sinensis*
Bya-rgod-spos	*Delphinium brunonianum*
Bya-rgod-sug-pa	*Saussrea gossipyphora*
Srol-gong-ser-po	*Soroseris hookeri*
Idum-nag-dom-mkhris	*Veronica himalensis*
Thang-phrom-nag-po	*Scopolia lurida*
Yu-gu-shing-dkarpo	*Sambucus adnata*
Khur-mong	*Taraxacum officinale*
Low altitude species	
A-ga-ru	*Aquilaria agalocha*
Shu-dag-nag-po	*Acorus calamus*
Khrog-ba-sha-ka	*Adhatoda vasica*
Bilba	*Aegele marmlos*
Dam-bu-ka-ra	*Aaletris pauciflora*
Sgog-skya	*Allium sativum*
Mdog-lden	*Althea rosea*
Ka-ko-la	*Amomum subulatum*
Go-yu	*Areca catechu*
Ba-le-ka	*Aristolochia griffithii*
Pad-ma-ge-sar	*Bombaz ceiba*
Ma-ru-tse	*Butea buteiformis*
Jam-bras	*Caesalphinia crista*
Gur-gum	*Carthamus tinctorius*
La-la-phud	*Carum copticum*
Dong-ga	*Cassia fistula*
Thal-ka-rdo-rje	*Cassia tora*
Bse-yab	*Choenomeles lagenaria*
Ga-bur	*Cinnamomum camphora*
Shing-tsha	*Cinnamomum tamala*

Gu-gul	*Commiphora mukul*
Dre-bzang	*Crocus sativa*
Zi-ra-dkar-po	*Cuminum cyminum*
Yung-ba	*Curcuma longa*
Re-rel	*Dryopteris fragrans*
Sug-smel	*Elettaria cardamomum*
Sa-bras	*Eugenia fruticosa*
She-ri-mkhan-tra	*Euphorbia royleana*
Shing-kun	*Ferula foetida*
Ka-bed	*Luffa aegyptiaca*
So-ma-ra-dza	*Malva verticillata*
Am-bras	*Mangifera indica*
Ba-spru	*Mirabilis himalaica*
Seng-ldeng	*Morus macroura*
Dza-ti	*Myristica fragrans*
Zi-ra-nag-po	*Nigella sativa*
Skyu-ru	*Emblica officinalis*
Pi-pi-ling	*Piper nigrum*
Sar-pa-ganda	*Rauvolfia serpentine*
Dan-rog	*Ricinus communis*
Rgun-brum-dkar-po	*Withania somnifera*
Rgya-tig	*Swertia chirata*
Tsan-dan-kar-po	*Santalum album*
Til-snum	*Sesamum indicum*

Source : Tshitila, 1999

2.12 Fodder and Grassland Resources

Bhutan has over 1,000,000 acres of registered grazing land (Fodder Handbook, 2002). Such grazing lands are locally called *tsadrog* and are important for livestock farmers. The most extensive areas of natural grasslands are found in the alpine and scrubland above the tree line at altitudes between 4000 m to 5000 m in the northern districts of Haa, Paro, Thimphu, Gasa, Wangdue and Bumthang. Districts with large areas of *tsadrog* with winter grazing areas under forest cover include Zhemgang, Trashigang and Chukha.

Permanent grasslands or rangelands are those lands on which the indigenous vegetation is predominantly grasses, grass-like plants, forbs, or shrubs and are managed as a natural ecosystem (Fodder Handbook, 2002). Trees are also a part of the rangelands. The existing vegetation in the rangelands is a result of environmental factors and the influence of human interventions, wild life and domestic animals. Other important factors are elevation, aspect, rainfall and soil conditions. The knowledge of grassland vegetation and species distribution is still rudimentary. Grass species dominate the vegetation at lower elevation, with sedges and broadleaf species gaining importance as elevation increases.

Major native grasses and sedges in the rangelands include *Chrysopogon gryllus, Cymbopogon bhutanicus, Apluda mutica, Arundinella nepalensis, Schizachyrium delavayi, Arundinella hookerii, Agrostis* spp, *Helictotrichon virescens, Brachypodium sylvaticum, Clamaagrostis* sp, *Poa* spp. *Elymus* sp, *Bromus* sp, *Tristum* sp, *Kobresia* sp and *Carex* sp. Among broadleaved species, *Desmodium* sp, *Artemesia* sp, *Euphorbia* spp, *Lespedeza* sp, *Potentilla* sp, *Taraxacum* sp, *Saussurea* sp and *Saxifraga* spp are predominant.

The RNR research centres and other agencies of the Department of Livestock have been introducing, evaluating and adapting exotic feed and fodder species to in order to raise the productivity of livestock in the country. Table 16 provides a list of the most important and popularly grown grasses and legumes crops for animals.

Table 16: Important grasses and legumes crops for livestock

Common name	**Botanical name**	**Environment**
Grasses		
Cocksfoot	*Dactylis glomerata*	Temperate
Italian ryegrass	*Lolium multiflorum*	Temperate -subtropical
Tall fescue	*Festuca arunidnacea*	Temperate –subtropical
Napier grass	*Pennisetum purpureum*	Tropical-temperate
Molasses grass	*Melinis minutiflora*	Tropical
Ruzi grass	*Brachiaria ruziziensis*	Tropical
Oat	*Avena sativa*	Temperate –subtropical
Guinea grass	*Panicum maximum*	Subtropical
Setaria	*Setaria sphacelata*	Subtropical-temperate
Paspalum	*Paspalum atratum*	Subtropical
Sudan grass	*Sorghum sudanense*	Tropical –temperate
Sugar cane	*Saccharum officinalis*	Subtropical
Legumes		
White clover	*Trifolium repens*	Temperate
Greenleaf desmodium	*Desmodium inortum*	Subtropical
Stylo	*Stylosanthes guianensis*	Subtropical
Fodder peanut	*Arachis pintoi*	Subtropical
Lucerne	*Medicago sativa*	Tropical-temperate
Velvet beans	*Mucuna pruriens*	Subtropical
Wynn cassia	*Cassia rotundifolia*	Subtropical-temperate

Besides grasses and legumes, there are many local trees and shrubs used as fodder for domestic animals (Table 17). Both tender and mature parts of leaves and soft stems are commonly fed to the animals. Most of the tree fodders are fed through cut-and-carry system except in a few cases where animals feed directly on lopped parts in the field (Timsina and Sherpa, 2005). Tree fodders are important in winter when there is a shortage of green biomass to feed to animals.

Table 17: Palatable tree or shrub species used as fodder

Local name	Botanical name	Altitude range (m)
Amlisoo	*Thysonalena maxima*	200-1800
Baar	*Ficus benghalensis*	200-1200
Badahar	*Artocarpus lakoocha*	300-1600
Bains	*Salix babylonica*	1000-3000
Barkaulo /Phakri	*Casearia glomerata*	1200-2200
Bhatmase	*Desmodium oblongum*	800-1200
Bohori	*Cordia dichotoma*	200-1500
Chamlayo	*Ulmus lanceifolia*	300-600
Chiewri	*Aesandra butyraceae*	300-1500
Chuletro	*Brassiopsis hainla*	800-2000
Dabdabe	*Garuga pinnata*	300-1300
Debre lahara	*Butea parviflora*	300-600
Khirro	*Sapium insigne*	300-600
Dudhilo	*Ficus nerifolia*	900-2000
Dumri	*Ficus glomerata*	300-1200
Faledo	*Erithrina indica*	300-3000
Gayo	*Bridelia retusa*	300-1200
Ginderi	*Premna integrifolia*	300-1200
Gogun	*Saurauria napaulensis*	600-1800
Gueyloo	*Eleaegnus parvifolia*	300-1200
Jamuna	*Syzygium cumini*	300-1600
Kabra	*Ficus lacor*	600-1600
Kaijal	*Bascofia javanica*	300-1200
Katahar	*Artocarpus heterophyllus*	200-1700
Kawlo (Lali)	*Persea odoratissima*	300-1300
Khamari	*Gmelina arborea*	300-1200
Khari	*Celtis australis*	700-2000
Khasreto	*Ficus hispida*	600-1100
Khanyu	*Ficis semicordata*	300-2000
Khasru	*Quercus grifithii*	600-2000
Kimboo	*Morus alba*	1200-2400
Koiralo	*Bauhinia variegata*	300-1500
Kubinde	*Kydia calycina*	300-1200
Kutmero	*Litsea monopetala*	300-1450
Lute khanyu	*Ficus montana*	600-1200
Malata	*Macarnaga postulata*	550-1000
Nebara	*Ficus auriculata*	600-1800
Parari	*Sterrespermum tetragonum*	300-1200
Musere Katus	*Castonopsis tribuloides*	600-2100
Phaledo	*Erythrina indica*	300-1400
Phalant	*Quercus glauca*	1100-3100
Pipal	*Ficus religiosa*	300-1200
Pipli	*Ex Bucklandia populnea*	1000-1800

Rai khanyu	*Ficus montana*	300-1200
Sindure	*Malatus phillipinensis*	300-1000
Siyal fusre	*Grewia tilaefolia*	300-1000
Somi	*Ficus benjamina*	600-1400
Taki	*Bauhinia purpurea*	300-1400

Source: Timsina and Sherpa, 2005

3. IMPROVED PLANT GENETIC RESOURCES

Systematic and organized agricultural research started in Bhutan only in 1982 when the Centre for Agricultural Research and Development (CARD) was established at Bajo, Wangduephodrang, to undertake research on cereals and vegetables. CARD is now upgraded into a Renewable Natural Resources (RNR) Research Centre. There are three other RNR Research Centres now at Wengkhar (Monggar), Jakar (Bumthang) and Yusipang (Thimphu) with specific national research mandates on horticulture, livestock and forestry respectively. Apart from their national mandates the RNRRCs also carry out research on food crops and horticulture to cater to local and regional needs.

Introduced and adapted germplasm

Initially, the RNRRCs relied more on introducing and adapting new crop varieties and related technologies from outside, for instance rice varieties from IRRI and wheat and maize from CIMMYT, but such an approach is inadequate and often times new varieties bred elsewhere do not match local agro-environments. The RNRRCs are now actively pursuing improvement of local crops and their varieties through cross breeding and selection programmes. The focus is on important food crops such as rice and maize.

Table 18 provides a recent list of improved germplasm of cereals, vegetables, fruits, oilseeds and grain legumes. Most of these improved genetic resources have been introduced and adapted to the local environments.

Table 18: List of Released Crop Varieties

Variety	**Variety/breeding line name/original**	**Year of release**
RICE		
IR 64	IR 64	1988
Milyang 54	Milyang 54	1989
IR 20913	IR 20913-B-26-1-2-2-3	1989
No 11	No 11	1989
BR 153	BR 153-2B-10-1-3	1989
BW 293	BG293-2	1990
Barket	K-78-13	1992
Khangma Maap	Chummro	1999
Bajo Maap 1	CARD21-10-1-1-3-2-1	1999

Bajo Maap 2	CARD21-14-1-1-3-2-1B	1999
Bajo Kaap 1	IR61331-2-148-B	1999
Bajo Kaap 2	IR61328-1-136-2-1-2-3	1999
PP4-8-1-1 (red)	Yusi Ray Maap	2002
PP3-31-2-1 (white)	Yusi Ray Kaap	2002
Khumal-2	Khumal-2	2002
MAIZE		
Yangtsipa	Suwon 1	1992
Khangma Asom 1	Palmirah8529	1999
Khangma Asom 2	Suwon8528	1999
WHEAT		
Sonalika	Sonalika	1988
Bajoka 1	HD 2380	1991
Bajoka 2	BL1093	1994
MINOR CEREALS		
Finger Millet		
3459	Limithang Kongpu-1	2002
5459	Limithang Kongpu-2	2002
OILSEEDS		
Mustard		
Type-9	Type-9	1989
M-27	M-27	1989
Bajo Peka 1	BSA	1994
Bajo Peka 2	PT 30	1994
Mustard green	Khangma Petche-1	2004
Mustard Green	Khangma Petche-2	2004
SOYBEANS		
One Daughter	One Daughter	1994
GC 86018-427-3	Khangma Libi-2	2002

HORTICULTURAL CROPS

Vegetable		
Potato		
Yusikap	Cultivar-720088	1988
Kufri Jyoti	Kufri Jyoti	1989
Desiree	Desiree	1989
CIP 378015.13	Khangma Kewa Kaap	2002
Beans		
Borloto	Borloto	1990
Pusa Parvati	Pusa Parvati	1990
Kentucky Wonder	Kentucky Wonder	1990
Brothbone	Brothbone	1990
Top Crop	Top Crop	1990
Rasma	Rasma	1994
Long John	Long John	1994

Mungbean	KPS 2	2002
Mungbean	Barimung	2002
Cabbage		
Copenhagen Market	Copenhagen Market	1990
Golden Acre	Golden Acre	1990
Baldura	Baldura	1994
Pride of India	Pride of India	1994
Cauliflower		
White Top	White Top	1990
White Summer	White Summer	1990
Progress	Progress	1990
Snow Ball-16	Snow Ball-16	1994
Chilli		
Sha Ema	Sha Ema	1990
Hot wax	Hot wax	1990
Capsicum		
California Wonder	California Wonder	1990
Carrot		
Early Nantes	Early Nantes	1990
Chantaney Improved	Chantaney Improved	1990
Radish		
Spring Toknashi	Spring Toknashi	1990
Minowase	Minowase	1990
Milaysige	Milaysige	1990
Shogoem Shon	Shogoem Shon	1990
Hongkong White	Bajo Laphu 1	2002
Tomato		
Roma	Roma	1990
Helfruch	Helfruch	1990
Nozomi	Nozomi	1990
Fusi'3	Fusi'3	1990
Rattan	Bajo Lambenda 1	2002
Turnip		
PTWG	PTWG	1990
Local Purple	Local Purple	1990
Greens (Saag)		
Him Beauty	Him Beauty	1990
Takama	Takama	1990
Neguna	Neguna	1990
Taisai	Taisai	1990
Bulb Onion		
Senshu Yellow	Senshu Yellow	1990
Nasik Red	Nasik Red	1990
Senshu Red	Senshu Red	1994
Red Creole	Bajogop 1	2002

Cardamom		
Bharlangey	Bharlangey	2002
Golsey	Golsey	2002
Lettuce		
Great Lake	Great Lake	1990
Sunny	Sunny	1994
Cucumber		
Shabigenchu	Shabigenchu	1990
Santon No. 1	Santon No. 1	1990
Spinach		
All Green	All Green	1990
Chinese Cabbage		
Kyoto 1	Kyoto 1	1990
Pumpkin		
Ramthang Brumsha	Ramthang Brumsha	1990
Tetsu Kabuta	Tetsu Kabuta	1990
Utsuki Red	Utsuki Red	1990
Brinjal		
Paro Local	Paro Local	1990
Big Round	Big Round	1990
Pusa Purple Long	Pusa Purple Long	1990
Pea		
JI 1050	JI 1050	1994
Snow pea	Snow pea	1990
Garlic		
Local Selection	Local Selection	1990
Celery		
Sort Lake	Sort Lake	1990
Parsley		
Paramount	Paramount	1990
Okra		
Blue Bell	Blue Bell	1994
Pusa Sawani	Pusa Sawani	1994
Broccoli		
Desico	Desico/Deccicco	1994
Summer Squash		
Zucchini (green)	Zucchini (green)	1994
FRUITS AND NUTS		
Melon		
Honey Dew	Honey Dew	1990
Almonds		
Texas		2004
Drake		2004
Dhebhar Badhan		2004
Kagzi		2004

Walnut		
Kanthel	Kanthel	2004
Yusipang 2	Yusipang-2	2004
Water Melon		
Asahi Yamato	Asahi Yamato	1990
Grapes		
Muscat of Alexandria		2004
Perlette		2004
Lime		
Bearrs		2004
Rangpur lime (as rootstock)		2004
Peach		
Flordasun	Bajokham 1	2002
July Elberta	Bajo Kham 2	2004
Pear		
Flemish Beauty	Bajo Lea 1	
Apricot		
New Castle	Bajo Khamchung 1	
Apple (Scion)		
Red Delicious	Red Delicious	1994
Royal Delicious	Royal Delicious	1994
Golden Delicious	Golden Delicious	1994
Jonathan	Jonathan	1994
Rich Red	Rich Red	1994
Lobo	Lobo	2002
Red chief	Red Chief	2004
Red Free	Red Free	2004
Root Stock		
MM-106	MM – 106	1994

Source: CoRRB, 2005

Utilisation of local germplasm for variety improvement

Hybridisation 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 programme is to assimilate desirable genes for high yield, adaptability, grain quality and disease resistance from various sources. Among diseases, breeding for blast resistance in the cold high-altitude environments is a priority. The assistance of IRRI in the generation of crossbred materials and technical backstopping has been indispensable.

To date, over 150 crosses have been made (Table 19) 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, Zuchem, Bjanaab and Attey. The hybridisation programme has generated over 5000 breeding lines and bulks for testing in different parts of the kingdom. Several breeding lines have shown excellent performance in terms of suitability to local conditions, higher productivity, quality and pest resistance. Many lines with superior yield and desired grain characteristics such as the red pericarp have been identified and formally released for high and mid-altitude rice valleys.

Table 19: Crosses, parents and the number of lines/bulks generated, 1986-2000.

Cross designation	**Parents**	**Number of lines/bulks**
CARD20	Local Kaap/IR64	107
CARD21	Local Maap1/IR64	235
CARD22	Ugey Maap/IR36	50
CARD24	Local Kaap/IR60	20
CARD25	Local Kaap/Selewah	27
CARD26	Ugey Maap2/IR36	94
CARD27	Ugey Maap3/IR36	34
CARD28	Local Maap/IR58	45
CARD29	Local Maap/IR56	40
IR56346	Wangdue Kaap(L)/BG90-2	175
IR56347	Wangdue Kaap(L)/CO25	140
IR56350	Wangdue Kaap(L)/IR24	214
IR56354	Wangdue Kaap(E)/CO25	226
IR56357	Wangdue Kaap(E)/IR24	187
IR56359	Wangdue Kaap(E)/IR52	135
IR58545	Bja Naab/B2982B-	22
IR58559	Bja Naab/BG94-1	53
IR58566	Bja Naab/China 1039	15
IR58567	Bja Naab/IR9202-	41
IR58568	Bja Naab/IR9758-	33
IR58569	Bja Naab/IR15636-	15
IR58570	Bja Naab/JKAU450-	26
IR58571	Bja Naab/RPKN2-	60
IR58606	Bja Naab/IR31386-	9
IR58615	Bja Naab/IR10041-	34
IR60016	Bja Naab/IR31868-	12
IR60018	Paro Maap/IR31868-	120
IR60019	Th. Dumbja/IR31868-	51
IR60020	Th. Maap/IR31868-	44
IR60021	Bja Maap/IR32429-	66

IR60023	Paro Maap/IR32429-	53
IR60025	Th. Dumbja/IR32429-	39
IR60026	Th. Maap/IR32429-	-
IR60035	Paro Maap/Milyang 54	30
IR60036	Th. Dumbja/M 54	65
IR60037	Th. Maap/M 54	85
IR60063	Bja Naab/85-3504	45
IR60068	Paro Maap/85-3504	37
IR60072	Th. Dumbja/85-3504	45
IR60073	Th. Maap/85-3504	138
IR61328	Bja Naab/IR41996-	274
IR61331	Paro Maap/IR41996-	293
IR61333	Th. Dumbja/IR41996-	191
IR61334	Th. Maap/IR41996-	177
IR61375	Th. Dumbja/Diamante Inia	40
IR61376	Th. Maap/Diamante Inia	9
IR61380	Paro Maap/N. Inia	45
IR61383	Th. Dumbja/N. Inia	40
IR61384	Th. Maap/N. Inia	20
IR61388	Bja Nab/Suweon 332	229
IR61390	Paro Maap/Suweon 332	229
IR61391	Kuchum/Vary Lava	4
IR61392	Paro Maap/Vary Lava	9
IR62448	Semtokha Maap2/IR43450-	65
IR62467	Attey/Suweon 358	149
IR62470	Punakha Maap/Suweon 358	154
IR62471	Semtokha Maap2/Suweon 358	-
IR62472	Sukhimey/Suweon 358	-
IR62473	Zakha/Suweon 358	99
IR62476	Semtokha Maap2/Suweon 359	80
IR62478	Zakha/Suweon 359	55
IR62734	S 353//No.11/Th. Dumbja	48
IR62744	S 359//IR41996/Paro Maap	38
IR62745	S 359//IR41996/Th. Dumbja	84
IR62746	S 359//IR41996/Th. Maap	-
IR63332	Zakha/Akihikari	86
IR64237	Zakha/IR39739-	32
IR64429	Akihikari//Akihikari/Pun.Maap	-
IR64430	Akihikari//Akihikari/Sem.Maap	29
IR65222	Attey/Akihikari	-
IR65239	Attey/YR3825-	135
IR65892	No.11/Chummro	37
IR66408	Chummro/IR55259-	74
IR66412	Chummro/IR60060-	152
IR66068	YR3825//YR3825/Barket	86

IR68136	Barket/Kochum	7
IR68142	IR64/Zawa Bondey	7
IR68146	JP5/Gyembja	9
IR68147	JP5/Kochum	7
IR68149	JP5/Zuchein	8
TOTAL		***5,740***

Source: Ghimiray, 2000

The importance of blast resistance in high altitude rice varieties has been underscored by the blast outbreak of 1995. The disease devastated about 712 ha of rice area leading to an estimated loss of 1099 tons of paddy or an equivalent Nu 11 million. Not a single traditional rice variety possessed appreciable blast resistance. Breeding for blast resistance is hence accorded high priority (Ghimiray, 1999).

The RNRRC at Wengkhar is currently involved in collecting, characterizing and evaluating local maize cultivars for use in crop improvement programmes. Large-scale exotic introductions have been curtailed to avoid marginalizing local varieties. Nonetheless, three improved varieties, Yangtsipa, Khangma Ashom 1 and Khangma Asom 2, which were released in the 1990s are widely grown by farmers. The collected local varieties from Eastern Bhutan have been crossed with the released varieties, particularly Yangtsipa, and superior lines are under selection now. Such lines and varieties having Bhutanese genes will be promoted in the future.

4. PGR CONSERVATION APPROACHES

The two major conservation strategies of *ex situ* (''away from site" or storage in gene banks under artificial conditions) and *in situ* ("on site/on-farm" or in farmers' fields through sustained use) for plant genetic resources are used in the country. These strategies are not mutually exclusive, but are complementary and Bhutan advocates their simultaneous use. *In situ* conservation is dynamic allowing for genetic evolution and biotic interactions; and it is fortunate that Bhutan still provides a textbook example of on-farm conservation in the Himalayas.

In situ conservation of PGR in Protected Areas

The policy of the Royal Government of Bhutan is to maintain at least 60% of the total land area under forest for all times to come. Conservation also gets precedence over exploitation of natural resources merely for economic gains. Bhutan has an extensive system of Protected Areas for conservation of ecosystems, its biodiversity and genetic resources. Currently there are four national parks, four wildlife sanctuaries and one strict nature reserve covering all altitude zones in the country (Table 20). The total area covered represents more than 35% of the country. These protected areas contain huge diversity of plants, besides wild crop relatives.

Table 20: Protected areas of Bhutan.

Name of protected area	Size (sq km)	Districts
Royal Manas National Park	1022.84	Zhemgang, Sarpang
Jigme Singye Wangchuck National Park	1400	Zhemgang, Trongsa, Sarpang, Wangdue, Tsirang
Jigme Dorji National Park	4349	Gasa, Thimphu, Paro, Punakha
Bomdiling Wildlife Sanctuary	1486.75	Monggar, Lhuntse, Trashiyangtse
Thrumshingla National Park	768	Bumthang, Monggar, Lhuntse, Zhemgang
Phibsoo Wildlife Sanctuary	278	Sarpang
Sakten Wildlife Sanctuary	650	Trashigang
Khaling-Neoli Wildlife Sanctuary	273	Samdrupjongkhar
Toorsa Strict Nature Reserve	650.74	Haa, Samtse

Source: BAP, 2002

Management of forest genetic resources outside the protected area network is carried out within a system of Forest Management Units (FMUs). The Department of Forest is responsible for preparation of plans for FMUs. The main purpose of FMUs is to provide sustained supply of forest produce to fulfill the needs of end-users without compromising the environmental and ecological stability of the forest (Norbu, 1999). Protection of forest ecosystems, biodiversity and genetic resources is an overriding objective.

In situ conservation of crop genetic resources

Bhutan's agricultural system is still in an initial phase of modernization. Bhutanese farmers primarily cultivate traditional crop varieties and also depend upon forest resources for their livelihood. Major crops grown are rice, maize, wheat, barley, buckwheat, potato, apple, cardamom, mandarin, and a wide range of minor crops including amaranths, millets, vegetables, pulses and oilseeds. Subsistence farming, based on traditional practices by local farmers, has helped to preserve diversity in field and vegetable crops (BAP, 2002). Indigenous agro-forestry maintains trees and other woody perennials in fields and pastures needed for construction purposes, tools, firewood, medicine, livestock feed and human food. Home and kitchen gardens hold indigenous germplasm as old and obsolete varieties, land races and rare species. Farmers still continue to grow and maintain local varieties, even when they experiment with and adopt some improved varieties. The reasons for this are diverse; some are based on storage properties, nutritional and processing quality, cooking ease, traditional, religious and cultural values and uses, and niche markets. Agronomic reasons include better adaptation to farmers' conditions and practices and greater resistance to local biotic and abiotic stresses.

The Ministry of Agriculture is consciously promoting *in situ* conservation of agro-biodiversity. One such on-farm conservation programme is the Biodiversity Use and Conservation in Asia program (BUCAP) which supports on-farm PGR conservation and management in the country. The programme is funded primarily by the Development Fund of Norway through the South East Asia Regional Initiative for Community Education (SEARICE), an NGO based in the Philippines. The overall objective of the project is to support the initiatives on conservation, development and utilization of agricultural biodiversity by focusing on on-farm conservation. The project is implemented under the national leadership of NBC and through the existing research and extension network. The lead in field planning and implementation is taken by the RNRRCs with the support of the district agriculture extension. For focus and visible impact, activities are undertaken in selected sites by forming farmers' PGR groups using the Farmers Field School (FFS) approach.

The various initiatives of the programme have provided insights on the different aspects of on-farm conservation and utilization of different crops, particularly maize and rice. The participatory FFS approach has also provided continuous learning among farmers, extension and researchers on *in situ* conservation. This on-farm PGR programme complements the *ex situ* conservation efforts of the RNRRCs and NBC.

The BUCAP programme has been very instrumental in creating awareness on the importance of PGR conservation, capacity building of the various stakeholders particularly on PGR management besides strengthening the knowledge on Participatory Plant Breeding (PPB) and participatory variety selection (PVS) and strengthening linkage among NBC, Research, Extension and Farming communities. Seed selection and improvement activities led to yield increase in local rice varieties (i.e. Apadogo, Dawa Yangkum, Nabja, etc.) thereby promoting conservation of landraces through use.

The first phase of the programme, which ends in 2005, has identified several weaknesses:

- Lack of clear roles and responsibilities for stakeholders.
- Weak participatory planning processes.
- Lack of clarity on strategies for implementation frame-work
- Inadequate sharing of experiences ad information among partner countries.
- Activities not well integrated with research and extension plans.

Therefore, in view of the wide experiences acquired in the first phase, continuation of the various activities initiated on on-farm PGR management has been agreed. This new phase will fulfil the following objectives:

Conservation, development and utilization of PGR of important food crops of Bhutan
Rice and maize were the focus crops in the first phase; second phase will encompass the other equally important food crops for subsistence farmers such as millets, buckwheat, barley, grain legumes etc. Based on the learnings so far, the programme will make a concerted effort to collect, conserve and promote utilisation of these crops.

Broadening of genetic base through PPB and PVS
The project will focus on diversifying agro-biodiversity, through provision and access to new genetic materials to the farmers through PVS and PPB. Researchers, extensionists and farmers are familiar with PVS and PPB concept, which needs to be scaled up to other sites and crops to broaden the plant genetic base for food self-sufficiency and security.

Support organic agriculture and sustainable farming systems
Given that Bhutanese farming system is largely organic and realising the ecological and potential benefits from it, the Ministry of Agriculture (MoA) actively promotes organic farming. The programme will pilot the approaches and applications of Sustainable Agriculture (SA) and encourage growing traditional crops and crop varieties.

Linking PGRCDU with better livelihood opportunities
To sustain and encourage *in situ* conservation efforts it is essential that communities are provided with economic opportunities for their endeavours. The project will promote local products and explore niche market in collaboration relevant agencies of the Ministry thereby linking conservation to better livelihood opportunities.

Policy Advocacy on PGR
Although an enabling policy on PGR is in place, there is limited general awareness and education. Creating awareness on PGR, its conservation and use at different levels is an important activity of the programme.

***Ex situ* conservation**

The national gene bank at NBC in Thimphu has been completed and awaits to be inaugurated shortly. The gene bank has facilities for short, medium and long term storage for about 12000 accessions. Prior to this, the facilities for conservation were limited to a few deep freezers at the RNRRCs for short term storage. As part of their crop improvement programme, the RNRRCs collected varieties of different crops and maintained them as working collections at the centres. NBC now collaborates with the RNRRCs in organizing collection expeditions to areas not covered so far.

In the past, there were a few germplasm collection expeditions organized with the assistance of outside expertise in the absence of trained local manpower (Norbu, 1999). One such expedition was in 1981 in collaboration with the then IBPGR (now IPGRI) which collected accessions of different crops (Table 21).

Table 21: Plant genetic resources collected by IBPGR in 1981

Species	**No of accessions**
Oryza sativa	61
Zea mays	47
Triticum aestivum	24
Hordeum vulgare	30
Eleusine coracana	14
Setaria italica	11
Panicum meliaceum	3
Sorghum bicolor	2
Polygonum esculentum	48
Amaranthus spp	17
Phaseolus spp	37
Glycine max	16
Vigna spp	10
Pisum sativum	9
Lablab spp	5
Sinapsis alba	23
Perilla frutescence	6
Capsicum annum	18
Brassica campestris	16
Raphanus sativa	11
Cucurbita pepo	10
Cucumis sativus	7
Lycopersicon esculentum	1

Beta vulgaris	1
Solanum melongena	1
Momordica sativum	1
Coraindrum sativum	7
Prunus persica	5
Musa spp	1
Alium sativum	14
Alium cepa	9

Source: Norbu, 1999

IRRI collectors were in the country in 1976 and 1984 and collected 217 rice accessions. More recently in 1996 to 1998, IRRI was involved in training the research and extension staff of the Ministry of Agriculture to undertake germlasm exploration and collection. Several training programmes were organised with expert trainers from IRRI-SDC project, which combined actual field collections as part of the training. These collections, totaling 356 accessions from all districts of Bhutan, are currently conserved in IRRI (Table 22). The germplasm will be repatriated once the gene bank in NBC is ready to receive them.

Table 22: Number of traditional Bhutanese rice varieties conserved at IRRI

District	**Altitude range (m)**	**No. of varieties**
Punakha	1240-2380	44
Wangdue	1300-2025	37
Tsirang	800-1530	13
Dagana	900-1500	14
Thimphu	1600-2300	43
Paro	2000-2570	50
Tashigang	1220-2250	24
Mongar	950-2150	15
Zhemgang	1200-1740	13
Lhuntse	1250-1800	10
Tongsa	1000-2360	10
Samtse	900-1400	11
Sarpang	115-610	12
Chukha	600-2440	17
Samdrup Jongkhar	400-500	6
Pemagatshel	820-1650	30
Haa	1450-1800	4 (**Total : 356**)

Source: Ghimiray, 1999

As the national centre for rice research, RNRRC Bajo has been collecting, characterizing and maintaining accessions of local varieties at the centre. The total number of accessions so far is 394 (Table 23). These accessions will form a part of the national collection at NBC.

Table 23: Traditional Rice Varieties of Bhutan.

SNo	Variety name	Altitude (m)	Village	District
1.	Kochum	2570	Drugyal Dzong	Paro
2.	Thaemja	2450	Phubana	Paro
3.	Hasay	2440	Ngoba	Paro
4.	Janaab	2410	Nabesa	Paro
5.	Khemja	2400	Dophu	Paro
6.	Kaap	2400	Longona	Paro
7.	Gyamo Kap	2400	Misi	Paro
8.	Naam	2380	Joshilo	Paro
9.	Kam	2350	Jagathang	Paro
10.	Dumbja	2300	Acho	Paro
11.	Somja	2300	Nabesa	Paro
12.	Hatsey	2300	Jagathang	Paro
13.	Zamsa Kaap	2300	Zamsa	Paro
14.	Kochum Map	2300	Phondo	Paro
15.	Gangju Kochum	2288	-	Paro
16.	Janam	2230	Changkha	Paro
17.	Themja	2150	Kempa	Paro
18.	Dumja	2150	Kempa	Paro
19.	Zhechum	2140	Kharapji	Paro
20.	Machem	2100	Issuna	Paro
21.	Dumbja	2010	Changkha	Paro
22.	Khemjya (awned)	2010	Chongkha	Paro
23.	Kochum	2010	Chongkha	Paro
24.	Chumbja	2440	Dechencholing	Thimphu
25.	Dangrey	2440	Chapcha	Thimphu
26.	Bjanam	2385	Simtokha	Thimphu
27.	Zeychum	2379	Chalumanfe	Thimphu
28.	Punakha Cupo	2379	Chalumanfe	Thimphu
29.	Uzum	2360	Taba	Thimphu
30.	Zhuchum	2330	Gaynekha	Thimphu
31.	Dumbja Kap	2300	Zamto	Thimphu
32.	Hamzam	2260	Chalumaphey	Thimphu
33.	Kurtepja	2260	Chalumaphey	Thimphu
34.	Bjanam	2250	Lutey	Thimphu
35.	Dumja	2200	Drumo	Thimphu
36.	Ray Sakha	2200	Kabjisa	Thimphu
37.	Ray Naab	2100	Sisina	Thimphu
38.	Ngaja	1730	Mendegang	Thimphu
39.	Guenja	1700	Mendegang	Thimphu
40.	Dagozam	1600	Mindegang	Thimphu
41.	Kambja	1600	Mindegang	Thimphu
42.	Zakha Kaap	1600	Mendegang	Thimphu
43.	Zakha Maap	1600	Mendegang	Thimphu
44.	Chumja	1600	Mendegang	Thimphu
45.	Dorilo Maap	1800	Tomji	Haa
46.	Rey Naab	1600	Rabji	Haa

47.	Rey Maap	1450	Shabji	Haa
48.	Rey Kaap	1450	Shabji	Haa
49.	Bjarey	2440	Chapcha	Chukha
50.	Kaley	1220	Tala	Chukha
51.	Thosar	-	Pachutar	Chukha
52.	Jirasari	-	Toribari	Chukha
53.	Kartikay	-	Modina	Chukha
54.	Assamay	-	Modina	Chukha
55.	Duelhay Marsi	-	Modina	Chukha
56.	Krishnabhog	-	Malbassay	Chukha
57.	Pakhey Dhan	-	Dhan Dara	Chukha
58.	Marsi	-	Dhan Dara	Chukha
59.	Botay Dhan	-	Gurung Goan	Chukha
60.	Shayto-buzuri	-	Beach Soureni	Chukha
61.	Maelingayne	-	Beach Soureni	Chukha
62.	Par Rottay	-	Gurung Goan	Chukha
63.	Guenja	1840	Chotenipo	Punakha
64.	Ow-map	1830	Jangnabu	Punakha
65.	Macha	1750	Shengosa	Punakha
66.	Zakha	1700	Lunakha	Punakha
67.	Gembja	1700	Lunakha	Punakha
68.	Kap Terin	1700	Lunakha	Punakha
69.	Chinangkam	1650	Jashika	Punakha
70.	Hinsum	1650	Jashika	Punakha
71.	Kachum	1650	Jashika	Punakha
72.	Zakha	1650	Jashika	Punakha
73.	Tshelap	1650	Tshelukha	Punakha
74.	Chumjya	1500	Thara	Punakha
75.	Toebi Hamjim	1500	Lunakha	Punakha
76.	Wangda Kam	1500	Thara	Punakha
77.	Nabaysoso	1500	Yebesa	Punakha
78.	Ondeykam	1500	Yebesa	Punakha
79.	Toli	1500	Yebesa	Punakha
80.	Yangkum	1400	Manikha	Punakha
81.	Jarey	1400	Zomi	Punakha
82.	Ray Jajey	1400	Sopsokha	Punakha
83.	Ray Kongtshey	1400	Sopsokha	Punakha
84.	Dawasum	1372	Chukulungchu	Punakha
85.	Tebay Machum	1372	Chukulungchu	Punakha
86.	Dungchem	1365	Yebesa	Punakha
87.	Tan Tshering	1365	Yebesa	Punakha
88.	Wangkum	1360	Tana	Punakha
89.	Bondey	1354	Yebesa	Punakha
90.	Shagi Toli	1345	Sherigang	Punakha
91.	Toli Map	1345	Awkha	Punakha
92.	Bja-naam	1345	Papchu	Punakha
93.	Bondey Sap	1345	Joshi	Punakha
94.	Olanam	1280	Khuru	Punakha
95.	Zaga shochu	1250	Jara	Punakha

96.	Gyemza maap	1245	Jara	Punakha
97.	Nobza-white	1245	Jara	Punakha
98.	Botoli (white)	1240	Khawchara	Punakha
99.	Botoli (red)	1240	Chekha	Punakha
100.	Beybukap	1240	Jara	Punakha
101.	Jajey maap	1220	Khawakha	Punakha
102.	Chumza (red)	1220	Gubzee	Punakha
103.	Dawa Wangkum	1220	Gubzee	Punakha
104.	Botoley	1220	Gubzee	Punakha
105.	Jarey kap	1220	Gobzee	Punakha
106.	Chumjey	1200	Laikha	Punakha
107.	Zakha (Maap)	1150	Hebesa	Punakha
108.	Wangda kam	-	Nobri	Punakha
109.	Phulisu	-	Shengosa	Punakha
110.	Pamja	-	Changchina	Punakha
111.	Pasakachum	1880	Changkha	Wangdue
112.	Hamzom	1800	Y.Nawang	Wangdue
113.	Kachumm	1800	Jagatokha	Wangdue
114.	Bomteling	1770	Kangsuma	Wangdue
115.	Silekachum	1680	Khamena	Wangdue
116.	Kamnam	1660	Khamena	Wangdue
117.	Bomdilip	1600	Nawang	Wangdue
118.	Lhamjim	1550	Tikena	Wangdue
119.	Zakha	1500	Gogona	Wangdue
120.	Hemjam	1500	Gogona	Wangdue
121.	Tan Tshering	1400	Khengna	Wangdue
122.	Bjena Maap	1400	Titokha	Wangdue
123.	Thagom	1400	Thamakha	Wangdue
124.	Kongtey Rey	1350	Tagkha	Wangdue
125.	Mabphokhum	1350	Tagkha	Wangdue
126.	Jajey Kap	1350	Lankena	Wangdue
127.	Lhamzalma	1330	DorjiPoktor	Wangdue
128.	Sepja	1300	Lopokha	Wangdue
129.	Khanaam	1300	Lopokha	Wangdue
130.	Zakha	1300	Lopokha	Wangdue
131.	KatraMathra	1120	Hikhakha	Wangdue
132.	Zakha	750	Jangarey	Wangdue
133.	Rabe Machu	-	Choba	Wangdue
134.	Chalep	-	Jangsabu	Wangdue
135.	Takmaru	1530	Gopini	Tsirang
136.	Thimah	1460	Burichu	Tsirang
137.	Botey Dhan	1400	Suntaley	Tsirang
138.	Sukhimey	1400	Mithun-	Tsirang
139.	Malingey	1300	Beteni	Tsirang
140.	Bhujungey	1300	Sallery	Tsirang
141.	Kali Dhan	1300	Sallery	Tsirang
142.	Taprey	1290	Lamidara	Tsirang
143.	Sukhimey	1290	Lamidara	Tsirang
144.	Rudwa	1290	Lamidara	Tsirang

145.	Champa	1200	Pataley	Tsirang
146.	Attey	1200	Salami-	Tsirang
147.	Anadi	1090	Lobsebote	Tsirang
148.	Chiurey Dhan	1080	Lobsebote	Tsirang
149.	Choti Masino	800	Pataley	Tsirang
150.	Thapa Chini	800	Pataley	Tsirang
151.	Timmurey	800	Pataley	Tsirang
152.	Baghey	-	-	Tsirang
153.	Botey Dhan (R)	1500	Goshi	Dagana
154.	Taprey	1300	Sallery	Dagana
155.	Bhujungey	1220	Suntaley	Dagana
156.	Attey	1220	Suntaley	Dagana
157.	Bharlangey	1200	Suntaley	Dagana
158.	Guruley	1200	Tashidin	Dagana
159.	Kutka	1200	Namchela	Dagana
160.	Barkey Dhan	990	Tashidin	Dagana
161.	Kati	990	Tashidin	Dagana
162.	Anandi	915	Jashidin	Dagana
163.	Kalami	915	Tashidin	Dagana
164.	Choti Masino	900	Tashidin	Dagana
165.	Rayka	2250	-	Trongsa
166.	Aulum	2250	-	Trongsa
167.	Gembray	2080	Kebetakpa	Trongsa
168.	Gunja	1850	Samcholing	Trongsa
169.	Bokarmo	1800	Refe	Trongsa
170.	Chonam	1800	Refe	Trongsa
171.	Semkap	1800	Phokchey	Trongsa
172.	Nemshongpa	1750	Faychung	Trongsa
173.	Tshinangka	1700	Pepchegang	Trongsa
174.	Jarjan	1150	Namthel	Trongsa
175.	Sindhi	1150	Namthel	Trongsa
176.	Kamshing	1740	Buli	Zhemgang
177.	Shungpa	1740	Buli	Zhemgang
178.	Zakhor	1430	Shobling	Zhemgang
179.	Korphokpa	1430	Shobling	Zhemgang
180.	Khangmala	1200	Goling	Zhemgang
181.	Leh	1200	Goling	Zhemgang
182.	Bidungpa	2250	Chekhov	Tashigang
183.	Chalangpa	2150	Dauling	Tashigang
184.	Shangyipa	2150	Dauling	Tashigang
185.	Aaring Bara	2140	Theraphu	Tashigang
186.	Dagpa Bara	2100	Tsenkharla	Tashigang
187.	Pashingdeb	2050	Chachong	Tashigang
188.	Verna	2050	Asom della	Tashigang
189.	Khalingpa Bara	2000	Baenung	Tashigang
190.	Khoptang Chalu	2000	Yanten	Tashigang
191.	Ngurmlingbo	2000	Dauling	Tashigang
192.	Masop	1990	Theraphu	Tashigang
193.	Aaring Bara	1980	Kangpara	Tashigang

194.	Pang Bara	1875	Toksinang	Tashigang
195.	Thumsampu	1830	Kanglung	Tashigang
196.	Zu Bara	1820	Chema- khesheng	Tashigang
197.	Sung Sung Bara	1800	Thrimshing	Tashigang
198.	Zubara	1800	Yangkhar	Tashigang
199.	Bartshampa	1800	Chortenkora	Tashigang
200.	Bumdelingpa	1800	Chortenkora	Tashigang
201.	Verna	1790	Toksinang	Tashigang
202.	Sorbang Bara	1790	Tokshengnang	Tashigang
203.	Wangdi Karmo	1790	Orpong	Tashigang
204.	Catsalo	1775	Kheshing	Tashigang
205.	Verna	1760	Resingma	Tashigang
206.	Phongmepa	1760	Pang thang	Tashigang
207.	Rangshikharpa	1760	Pang thang	Tashigang
208.	Kamdep	1750	Rijigang	Tashigang
209.	Kamsa Teckpa	1750	Rijigang	Tashigang
210.	Khalingpa	1740	Kheshing	Tashigang
211.	Rashu Bara	1720	Chema-khesheng	Tashigang
212.	Thongramgpu	1710	Pang thang	Tashigang
213.	Kham Dangpa	1680	Langting	Tashigang
214.	Wangdi Karmo	1678	Packaling	Tashigang
215.	Namnang Bara	1675	Pha kha	Tashigang
216.	Owling Bara	1670	Tangphrang	Tashigang
217.	Aaring Bara	1660	Pasaphug	Tashigang
218.	Takulung Bara	1650	Shing gom	Tashigang
219.	Bomdilingpa	1647	Beling	Tashigang
220.	Gasha Bara	1640	Muetangkhar	Tashigang
221.	Baypu Asu	1640	Muetangkhar	Tashigang
222.	Karma Wangda	1600	Yab rang	Tashigang
223.	Sorbang	1600	Radhi Sangkhar	Tashigang
224.	Sung Sung Bara	1600	Lamyoung	Tashigang
225.	Kardungpa	1600	Chekhov	Tashigang
226.	Phobara	1600	Dekaling	Tashigang
227.	Shungbara	1600	Echhur	Tashigang
228.	Verna	1600	Manthung	Tashigang
229.	Kham Nangpa	1590	Yab rang	Tashigang
230.	Mebra	1580	Manthung	Tashigang
231.	Galingkharpa	1500	Lamyoung	Tashigang
232.	Ngera Bara	1500	Tsenkharla	Tashigang
233.	Pang Bara	1500	Radhi	Tashigang
234.	Phobara	1420	Dekeling	Tashigang
235.	Sarbhang Bara	1300	Zomgang	Tashigang
236.	Jamkharpa	1300	Richen dung	Tashigang
237.	Wangda Karo	1220	Khidung	Tashigang
238.	Asu Bara	900	Zomgang	Tashigang
239.	Bepu Bara	850	Nadonggone	Tashigang
240.	Wangdi Karmo	750	Khenri	Tashigang
241.	Tongling pu	750	Khenri	Tashigang
242.	Jamkharpa	750	Redang Beksa	Tashigang

243.	Bidungpa Bara	700	Lungtenzampa	Tashigang
244.	Bulizamo	1900	Lungkanchu	Mongar
245.	Gayabzamo	1800	Tormasong	Mongar
246.	Tsherang Zamo	1800	Tormashong	Mongar
247.	Naglong Bar	1750	Bazor	Mongar
248.	Rangshing Kharpa	1750	Bazor	Mongar
249.	Verna	1750	Bazor	Mongar
250.	Pangbra	1700	Tokari	Mongar
251.	Sung Sung Bara	1666	Wengkhar	Mongar
252.	Saychum	1656	Shaphang ma	Mongar
253.	Balingmi	1650	Ngachang	Mongar
254.	Tongsarpa Bara	1600	Wengkhar	Mongar
255.	Botpa bara	1600	Tetang Ridaga	Mongar
256.	Wangddi Karmo	1600	Chali	Mongar
257.	Sung Sung Bara	1580	Seynakhor	Mongar
258.	Wangchu Bara	1580	Seynakhor	Mongar
259.	Bomdelingpa	1550	Teling	Mongar
260.	Karang Chalu	1540	Yadi	Mongar
261.	Kurtoezamo	1500	Takhambi	Mongar
262.	Kambra Pheza	1500	Takhambi	Mongar
263.	Kambra	1500	Petshongbi	Mongar
264.	Wangdi karmo	1500	Seynakhor	Mongar
265.	Asu	1500	Gomchu	Mongar
266.	Kurtey Zamung	1400	Chaskar	Mongar
267.	Karang	1250	Chahainang	Mongar
268.	Pang Bara	1200	Waichur	Mongar
269.	Khaja	1150	Chali	Mongar
270.	Kurto jamo	1080	Dungshingmo	Mongar
271.	Kambara	1070	Chali	Mongar
272.	Wangdi Karma	1050	Pam	Mongar
273.	Tshering Zangmo	1000	Salling	Mongar
274.	Sung sung bara	1000	Yadi	Mongar
275.	Serpazangmo	1000	Yadi	Mongar
276.	Serpazangmo	1000	Yadi	Mongar
277.	Chirang Zangmo	950	Thidangbi	Mongar
278.	Jubara	950	Phishing	Mongar
279.	Pang Bara	700	Resa	Mongar
280.	Chenamo	550	Masang daja	Mongar
281.	Wangdi Karmo	500	Galikhar	Mongar
282.	Tsherang zam	500	Jang dung	Mongar
283.	Bara Dama	500	Karbi	Mongar
284.	Golipang Bara	-	Bamjar	Mongar
285.	Sang Sung Bara	820	Khar	Pemagatshel
286.	Brong Kolapa	820	Khar	Pemagatshel
287.	Yadu Bara	820	Khar	Pemagatshel
288.	Sam Bara	1660	Labor	Pemagatshel
289.	Bara Tshalu	1650	Khuminang	Pemagatshel
290.	Yurungpa Bara	1580	Yomzone	Pemagatshel

291.	Bara Tshalu	1500	Denang	Pemagatshel
292.	Sam Bara	1130	Pangthang	Pemagatshel
293.	Sun Sung Bara	1120	Mongnadang	Pemagatshel
294.	Yadu Bara	1100	Chortenra	Pemagatshel
295.	Betpu Bara	1550		Pemagatshel
296.	Shilangpa	-		Pemagatshel
297.	Khangpa	-		Pemagatshel
298.	Wangdi Karmo	-		Pemagatshel
299.	Dagpa Mras	1800	Khompang	Lhuntse
300.	Bochola	1750	Bamedangsa	Lhuntse
301.	Dakpa	1750	Bamedangsa	Lhuntse
302.	Madasherpo	1750	Bamedangsa	Lhuntse
303.	Asu	1650	Bamedangsa	Lhuntse
304.	Dagpa Zamo	1650	Bamedangsa	Lhuntse
305.	Masarirpo	1650	Bamedangsa	Lhuntse
306.	Dakpa	1450	Bartopang	Lhuntse
307.	Karateckpa	1250	Fagidung	Lhuntse
308.	Khopthang Salu	2000	Bamther	Trashiyangtse
309.	Karma Tekpa	1950	Bamther	Trashiyangtse
310.	Khopthangla	1850	Jangfutse	Trashiyangtse
311.	Pasgingdeb	1850	Jangfutse	Trashiyangtse
312.	Phakpa Deb	1850	Jangfutse	Trashiyangtse
313.	Sung Sung Bara	1800	Yangtheng	Trashiyangtse
314.	Chalangma	1800	Berthangla	Trashiyangtse
315.	Dhakpa Bara	1800	Yoermachen	Trashiyangtse
316.	Pangbra	1800	Lower Dubti	Trashiyangtse
317.	Mabra	1800	Kenmungshong	Trashiyangtse
318.	Sonala	1750	Yangtheng	Trashiyangtse
319.	Khemdeb	1750	Yangtheng	Trashiyangtse
320.	Mobzangmobra	1700	Rabthey	Trashiyangtse
321.	Lamshu	1700	Omba	Trashiyangtse
322.	Gonbara	1650	Serpang	Trashiyangtse
323.	Sung Sung Bara	1640	Yoermachen	Trashiyangtse
324.	Zubra	1620	Chenmung	Trashiyangtse
325.	Bidungpa	1610	Yarphey	Trashiyangtse
326.	Negpa	1600	Gangkhar	Trashiyangtse
327.	Yengtshangbra	1580	Lamthel	Trashiyangtse
328.	Bumdilingpa	1580	Neshing	Trashiyangtse
329.	Pashingdeb	1560	Baney	Trashiyangtse
330.	Tshangnapa	1530	Lalam	Trashiyangtse
331.	Karma Tekpa	1520	Wangla	Trashiyangtse
332.	Asu (khamdangpa)	1520	Phungyang	Trashiyangtse
333.	Bartsampa	1500	Shadhi	Trashiyangtse
334.	Tshalu Zubara	1500	Dongkhar	Trashiyangtse
335.	Bapa Amshu	1370	Pam	Trashiyangtse
336.	Shungshung Bara	1370	Pam	Trashiyangtse
337.	Baypo	1320	Bhagshag	Trashiyangtse
338.	Kalu Malu	1300	Dhorbhu	Trashiyangtse

339.	Khopthang Salu	1300	Dhorbu	Trashiyangtse
340.	Hunda	1300	Ninda	Trashiyangtse
341.	Ngalongbra	1270	Ninda	Trashiyangtse
342.	Radhang Salu	1250	Maydung	Trashiyangtse
343.	Wangdue karmo	1210	Kheni	Trashiyangtse
344.	Chuphalopa	1200	Yoermachen	Trashiyangtse
345.	Karma Wangdi	1200	Khamdang	Trashiyangtse
346.	Asu	1200	Khamdang	Trashiyangtse
347.	Nera Bara	1200	Khamdang	Trashiyangtse
348.	Zakha	1200	Khamdang	Trashiyangtse
349.	Chadep	1200	Kheni	Trashiyangtse
350.	Zhungkha Bara	1200	Kheni	Trashiyangtse
351.	Baypo	1200	Manam	Trashiyangtse
352.	Desingbra	1200	Yallang	Trashiyangtse
353.	Teakpu	1050	Kesor	Trashiyangtse
354.	Prangpo Yartey	1050	Zampa	Trashiyangtse
355.	Bapa Bara	1000	Yoermachen	Trashiyangtse
356.	Asu Balingmu	820	Wangringmo	Trashiyangtse
357.	Pang Bara	1425	Zangthy	S/Jongkhar
358.	Mongar Bara	1295	Zangthy	S/Jongkhar
359.	Sharpa Bara	1140	Louri	S/Jongkhar
360.	Tsho Bara	1130	Junmey	S/Jongkhar
361.	Wangdi Karma	1120	Moumola	S/Jongkhar
362.	Sung Sung Bara	1100	Louri	S/Jongkhar
363.	Chotomosino	1020	U.Hastinapur	S/Jongkhar
364.	Monggarpa	540	Khandrophung	S/Jongkhar
365.	Tengbar	400	Khangkharwoog	S/Jongkhar
366.	BR 153	350	Khangkharwoog	S/Jongkhar
367.	Khamte	300	Bakuli	S/Jongkhar
368.	Chotimasino	300	Kawaipani	S/ Jongkhar
369.	Nagakhaly	118	Daisam	S/Jongkhar
370.	Kolomeya	112	Daisam	S/Jongkhar
371.	Tingrey	112	Daisam	S/Jongkhar
372.	Ijung	100	L.Hastinapur	S/Jongkhar
373.	Ghattey	200	Singhi	Sarpang
374.	Mansara	200	Singhi	Sarpang
375.	Sanukatikey	200	Singhi	Sarpang
376.	Jeerasari	115	Kalikhola	Sarpang
377.	Naura	115	Kalikhola	Sarpang
378.	Moibara	-	Leopani	Sarpang
379.	Champasari	1372	Ronitan	Samtse
380.	Rudhuwa	1372	Panbari	Samtse
381.	Attey	1200	Denchuka	Samtse
382.	Abri	1200	Denchuka	Samtse
383.	Farangay	1200	Denchuka	Samtse
384.	Onepaky	1200	Denchuka	Samtse
385.	Fudungey	1200	Denchuka	Samtse
386.	Setorudhuwa	1200	Denchuka	Samtse
387.	Taule	1200	Denchuka	Samtse

388.	Timburey	1200	Denchuka	Samtse
389.	Katusey	915	Shimjee	Samtse
390.	Kalo Nunia	250	Khucidiana	Samtse
391.	Mansara	200	Nainital	Samtse
392.	BR-153	200	Chengmari	Samtse
393.	Nepalay	200	Sibsoo	Samtse
394.	Jaswa	250	Nainital	Samtse

Source: Ghimiray, 1999

Characterisation and evaluation

Not much work is done in the field of characterisation and evaluation of the collected germplasm. However, a decent beginning has been made at RNRRC Bajo and other Centres in simple recording of morpho-agronomic traits of the different crop accessions. RNRRC Bajo has so far recorded phenotypic traits for over 200 accessions of rice. Proper evaluation for pest resistance and other traits remains largely unaccomplished as requisite facilities are still to be created. Nonetheless, some work has been made by Bhutanese scholars as part of their post-graduate dissertations. In a study of 70 Bhutanese landraces to understand their reaction to different blast isolates, a high level of heterogeneity in resistance was detected within and among varieties (Thinlay, 1998). The study showed that varieties of different altitudinal origin reacted differently to isolates of different origins.

The NBC, in collaboration with the RNRRCs, is the process of characterizing the collected germplasm and making databases in standard formats. The descriptors for different crops are also being identified and developed.

5. INSTITUTIONAL FRAMEWORK FOR MANAGEMENT OF BIOLOGICAL RESOURCES

At the strategic level, the National Environment Commission (NEC), the Biodiversity Management Board (BMB) and the Policy and Planning Division of the Ministry of Agriculture (MoA) have the responsibility for overall policy, legislation and policy directives within the Royal Government of Bhutan (BAP, 2002). The NEC is the focal point for environment policies and for undertaking the responsibilities outlined in the Convention on Biological Diversity (CBD) and other related international conventions, which Bhutan has ratified. The MoA, better known as the RNR (renewable natural resources) sector, encompasses agriculture, livestock and forestry, and is charged with the long-term planning and development of policies and proposals related to the RNR sector. The BMB, comprising of department and agency heads of MoA and presided by the Minister of Agriculture, is charged with advising, reviewing or reforming national policies, projects and actions taken regarding the nation's biological resources.

At the coordination level, the National Biodiversity Centre (NBC) is charged with coordinating the RGoB's actions to conserve biodiversity. It is an autonomous, non-departmental agency, intended to fulfill the RGoB's commitment to conservation and sustainable use of biological resources.

At the implementation level, there are several agencies involved: the Nature Conservation Division (NCD) of the Department of Forestry, the Council for RNR Research of Bhutan (CoRRB) through its RNR research centres, Bhutan Trust Fund, the Institute for Traditional Medicine Services (ITMS), and the Forest Development Corporation (FDC).

Below is a brief description of the important institutions involved in management of biological resources.

5.1 National Biodiversity Centre (NBC)

The National Biodiversity Centre (NBC) was formally established as a non-departmental agency under the Ministry of Agriculture in 1997. The primary purpose of its establishement 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. With its recognized vision and mission of integrating the efforts of RNR sector in conservation activities, NBC provides a collective instrument for advancing sustainable development in the country. The human capacity and physical infrastructural facilities have vastly been improved with the assistance of several donors, notably the Dutch Sustainable Development programme. The institutional setup of NBC is depicted in **Error! Reference source not found.**.

Vision

Effective conservation and sustainable utilization of the rich biological resources; and equitable sharing of benefits arising from the conservation and the sustainable use of these resources.

Mandate

- Co-ordinate Bhutan's biodiversity related activities and serve as a national focal institute for biodiversity.
- Facilitate national decision-making on biodiversity concerns, cutting across sectors, divisions and institutions.
- Guarantee a national balance between conservation and sustainable utilization of biological resources in general, and between *in situ* and *ex situ* conservation.
- Assure a participatory approach to building national consensus on biodiversity around complex issues and resolving conflicting situations.
- Facilitate sub-regional, regional and international cooperation.
- Assure continuity of biodiversity related activities over time.

Objectives

Long term

- To identify and meet national needs through rational, sustainable, effective, and equitable approaches to the conservation and use of biological resources in natural and agricultural ecosystems for the benefit of the present and future Bhutanese people and sustain environmental well-being of the country.

- To ensure adequate national capacity to participate in global efforts to conserve and use biodiversity resources for food, agriculture, industry and environment and to share the benefits arising from their use.

Intermediate

- To give high priority to establishing the essential elements of an integrated national program with a recognized national status for the Biodiversity Conservation; and thereby improve institutional and sectoral linkages and strengthen integration of institutional and community efforts.

- To develop appropriate policy and institutional framework, including mechanisms for coordinated planning and action and a program strategy.

- To develop national capacity in the technical, managerial and policy areas of biodiversity.

Strategies

- Institutionalization and establishment of interdisciplinary programmes.
- Link conservation with utilization by identifying and overcoming constraints.

- Promote institutional collaboration and operational linkages with appropriate institutes and different levels and farming communities for integrating complementary activities to achieve maximum effect.
- Effective co-ordination of the biodiversity activities within the country and linking with regional and international organisations.
- Enhance capacity at all levels through education and training within and outside the country to promote institutional development, program human resources, strengthen co-operation, and devise financial mechanisms.
- Enhance the capacity of farmers and communities through on-farm management of agro-biodiversity based on equal participation and ownership of responsibilities.
- Establish gene banks, botanical gardens, herbarium and zoological parks for *ex-situ* collection to facilitate the conservation and sustainable utilization.
- Resource survey, inventory and documentation.

Long-term strategies for sustainability

- Bioprospecting and utilization
- Formation of functional Board of Trustees
- User fees and memberships for Biological gardens, Gene banks, National Herbarium and Zoological garden
- Linkages with other global programmes in biodiversity and the Bhutan Trust Fund (BTF) for environment conservation in Bhutan.

5.2 Nature Conservation Division (NCD)

The Nature Conservation Division (NCD) of the Department of Forestry under the Ministry of Agriculture plays a vital role in the conservation and management of biological resources of the country. Its mandates are to:

- Manage the wild biodiversity of Bhutan
- Develop and implement management plans for Protected Areas
- Formulate nature conservation policy
- Identify potential additional Protected Areas
- Prioritize inputs from conservation related agencies

There are seven strategic operational principles as part of NCD's strategy. These principles have general applicability for programmes, projects or activities carried out by NCD and its partners. The operational principles reflect the integrated nature of biological conservation in the country. These include participation and multidisciplinarity, adaptive management, integrating conservation and development, recognizing conflicting interests, scaling up and sustainability. The main strategic components include:

- Management of Protected Areas, Buffer Zones and Biological Corridors
- Integrated Conservation Development programmes
- Environmental Education

- Research, Survey and Monitoring

The NCD consists of its head office in Thimphu and the parks in different parts of the country. Both have their own organizational structures. NCD has three sections and six units with specific roles and responsibilities. These are:

Section 1: Management Planning and ICDP
Units: Protected Area Management Unit
Integrated Conservation and Development
Section 2 : Inventory and Data Management
Units : Biodiversity Inventory
Data and Mapping
Section 3: Species Conservation, Research and Monitoring
Units: Species Conservation
Monitoring and Research

5.3 Council for RNR Research of Bhutan (CoRRB)

The Council for RNR Research of Bhutan (CoRRB) coordinates renewable natural resources research programmes throughout the country. Such programmes aim at improving the overall productivity and sustainability of agriculture, horticulture, forestry and livestock enterprises. The research programmes are implemented through four integrated research centres, known as Renewable Natural Resources Research Centre (RNRRCs) located at Yusipang (Thimphu), Bajo (Wangdue), Jakar (Bumthang) and Wengkhar (Monggar). Each of the centres has a national mandate for coordination of research in one of the four major fields of research: forestry at Yusipang, field crops at Bajo, livestock at Jakar and horticulture at Wengkhar (BAP, 2002). Besides the national mandates, the RNRRCs also have a regional mandate to cater to the research and development needs in all the four major fields in a geographically defined area. The RNRRCs have a multi-disciplinary team of scientists.

The organogram of CoRRB is shown in **Error! Reference source not found.**. Its vision, mission and mandates (Draft CoRRB Strategy, 2003) are described briefly below.

Vision

- To be a premier organisation undertaking quality research and technology dissemination in the RNR sector that contributes to peace, prosperity and happiness of the nation
- To strive to become an autonomous and self-sustaining research and technology dissemination organisation with requisite legal basis

Mission

- To make available better RNR technological options for the farmers to contribute to the improvement of their livelihood and living standard through sustainable natural resource management

Mandates

- To formulate RNR research policy and strategy
- To support departments in defining extension policy and strategy
- To plan, undertake and coordinate RNR research, including PGR
- Package and make available RNR technologies to the departments and act as a clearing house of research and general information relating to the RNR sector
- To provide policy advice to the RNR sector development
- To undertake consultancy on research and technology transfer in the RNR sector
- To maintain and strengthen RNR integration concept in research and technology dissemination
- To forge linkages and networking with national, regional and international institutions
- To ensure a sound financial base through fund mobilisation and generation

Features

CoRRB is a policy-making body that links to the policymakers, farmers' representatives and other interest groups. The council is supported by technical committees and a secretariat. The technical committees provide technical support to the governing council. There are three main committees:

- Research Management Committee
- Extension Coordination Committee
- Variety Release Committee

6. POLICY AND LEGISLATION RELATED TO BIODIVERSITY AND PGR

The overall policy objectives of the RGoB for biodiversity are:

- Biodiversity issues to be integrated into the economic development plans and programs
- Information on biodiversity to be developed for conservation and sustainable utilization of biodiversity resources
- Fair and equitable sharing of the benefits arising out of biological resources

There are a number of policies, strategies, acts and by-laws governing biodiversity. Some important ones are:

- Biodiversity Act 2003
- Forest and Nature Conservation Act 1995
- Environmental Assessment Act 2000
- Regulation for the Environmental Clearance 2002
- Arable Agricultural Development Policy and Strategy 2002
- Biodiversity Action Plan of Bhutan 2002
- Plant Quarantine Act 1993
- Seeds Act 2000

The Forest and Nature Conservation Act 1995

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 (Tshering, 2002). It emphasizes biodiversity conservation, particularly through *in situ* conservation, along with protection of all habitats, including grasslands and aquatic and alpine ecosystems.

The Seeds Act of Bhutan 2000

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 will:

- 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.

As stipulated in the Act, the Ministry of Agriculture is in the process of framing and adopting the Rules and Regulations in order to administer the Act and implement the provisions contained therein.

Biodiversity Act 2003

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 pertinent sections of the act are extracted below.

Purpose and objectives

- 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, including the building of scientific and technological capacity relevant to the conservation and sustainable use of biological diversity.
- 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 prevent illegal access to genetic and biochemical resources and associated Traditional Knowledge.
- To recognize and protect the farmers' and breeder's rights.
- To make plant varieties subject to property rights.
- To ensure that plant breeders are able to recover the cost from useful improvements and innovations, and continue to do so.

- To provide legal recognition of varieties which are not protectable under the internationally existing patent and/or plant breeders rights laws and thereby recognize farmers' plant variety improvements and innovations and provide a means of sharing benefits derived from the use of farmers' or traditional varieties as breeding material for commercial purposes.
- To promote access to foreign sources of improved plant varieties to Bhutanese farmers.

Access to Genetic Resources and Benefit Sharing

Prior Informed Consent

- Access covered by this Act shall be subject to the prior informed consent of the Competent Authority of Bhutan, representing national interests and the interests of the local communities harbouring, cultivating, developing and maintaining the biological diversity concerned.
- In case of access to Traditional Knowledge, innovation and practices of local communities, the procedure and conditions set out in this Act shall also apply.
- In both cases, the Authorized Agency is responsible for processing the applications and monitoring the Permits granted.

Conditions for the Grant of Access

Competent Authority, through the Authorized Agency, may grant access if the following minimum requirements are satisfied:

- The applicant agrees to bear all costs relevant to the collection, including costs of participating staff identified by the Competent Authority.
- The applicant agrees to deposit with the Authorized Agency duplicates of each sample collected and the associated information on collection sites of collected materials gathered from farmers' field or government forest.
- The applicant agrees to inform the Competent Authority, through the Authorized Agency, of all findings from subsequent research and development on the collected samples in accordance with the terms of the Material Transfer Agreement or Contract signed between both.
- The applicant shall not transfer the resources accessed or associated Traditional Knowledge to any third party without the authorization of the Competent Authority.
- The applicant shall notify the Competent Authority prior to applying for intellectual property rights relating to the collected material or intellectual property rights relating to an invention, which is based on associated Traditional Knowledge obtained in Bhutan.
- The applicant agrees to benefit sharing conditions negotiated in accordance with the provisions of this Act.
- The applicant agrees to submit a full report to the Authorized Agency on completion of the collection activity, including sites of collection, number of samples collected and associated information gathered.

- During collection, the collector should systematically record common passport data and describe plant populations, its diversity, habitat and ecology in detail.
- The applicant agrees that, the acquisition of germplasm must not deplete populations or farmers' seed stocks, in order to avoid genetic erosion.
- If appropriate, the applicant agrees to bear the cost of environmental impact assessment and abide by the Environmental Assessment Act, 2000 of Bhutan.
- The applicant shall abide by the relevant laws of the country, local customs, traditions and values.

Conditions for Benefit Sharing

Upon fulfilment of all the conditions prescribed, the Competent Authority may grant access if one or more, when relevant, of the following minimum conditions for benefit sharing, which are to be included in the Material Transfer Agreement or Contract Agreement to be signed between the Competent Authority and the Applicant. These conditions may also be considered in any Material Transfer Agreement or Contract Agreement to be signed between the applicant and any other relevant stakeholder.

- A flat fee and upfront payments.
- The sharing of the research results and relevant information.
- Royalties.
- Milestones payments.
- Recognition as a partner in intellectual property ownership of products derived from the supplied material.
- Joint research activities.
- Concessionary rates or free supply of commercial products derived from the resources provided.
- Transfer of technologies.
- Training and capacity building.
- The acknowledgment of the origin of the genetic resources in any publication resulting from the research activities.
- Donation of equipment to national institutions.
- Other benefits, monetary or non-monetary.

Sui Generis System for the Protection of Plant Varieties

Conditions of Protection

Novelty

The variety is novel if at the date of filing of the application, the material of the variety has not been sold with the consent of the applicant or her/his successor in title, for purpose of exploitation of the variety:

- For longer than one year for commercial varieties.
- In case of varieties bred and developed by farmers and only cultivated within limited areas of the country for longer than 10 years.

Distinctness
The plant variety is distinct if it is clearly distinguishable from any other variety whose existence is a matter of common knowledge at the time of filing of the application.

Uniformity/Stability/Identifiability
Uniformity: The variety is uniform if, subject to the variation that may be expected from the particular features of its propagation and reproduction, it is sufficiently uniform in relevant characteristics**.**
Stability: The variety is stable if its relevant characteristics remain sufficiently unchanged after repeated propagation.
Identifiability: The variety is identifiable if it can be identified by a person skilled in the art of such identification, recognized by the Competent Authority.

Protection of Traditional Knowledge

Conditions for Protection

Applicability
This applies to Traditional Knowledge that was in existence before the commencement of this Act or is created on or after the commencement of this Act.

Customary uses
The customary use of Traditional Knowledge among the local communities does not give rise to any criminal or civil action for liability under this Act.

Rights owners
The owners of Traditional Knowledge are the holders of the rights in the Traditional Knowledge.

Material form not required
The rights exist in Traditional Knowledge whether or not the Traditional Knowledge is in material form.

Duration
Rights conferred by this Act continue in force in perpetuity and are inalienable.

Additional rights
The Rights in Traditional Knowledge are in addition to and do not affect, any rights that may subsist under any intellectual property laws.

7. CONCLUSIONS

Bhutan is blessed with a rich and varied biodiversity, which is largely intact owing to a combination of factors: prudent policies of the Royal Government of Bhutan and a strong commitment to conservation, traditional and inherent reverence of the Bhutanese people to nature and environment, and the geo-political setting and relative isolation of the country until recently. However, there should not be any room for complacency and Bhutan needs to gear up for new and ever emerging challenges. There are also several policy and technical lacunae that require attention and redressal measures.

On the policy front, the formulation of the Biodiversity Act in 2003 is an important milestone in paving ways of effective conservation and management of biological resources. However, the rules and regulations for its implementation remain to be framed. Appropriate modalities and protocols for exchange and sharing of germplasm need to be developed. No single nation can be fully self-sufficient in PGR, no matter how rich and diverse its resources are. It thus becomes unavoidable to collaborate and share bioresources following agreed regulatory mechanisms. The Seeds Act of Bhutan, 2000 is another vital instrument for regulating safe movement of germplasm. The rules for its implementation, again, require to be formalized on a priority basis.

While Bhutan is rightly proud of its conservation policies and their efficient implementation in the field, there are criticisms that protection sometimes overrides utilization and impinges on the livelihoods of rural communities. This reflects the spiral debate on conservation versus utilization with equally emphatic points and counterpoints. However, efforts need to be doubled wherever feasible to utilize natural resources for the benefit of people without, of course, compromising the long-term value and subsequent reuse. The ongoing initiative of the Ministry of Agriculture in exchanging protected forest lands for agriculture with degraded and marginal farm lands which can revert back to forests is a pragmatic approach to development.

In the PGR technical arena, the collection and conservation of plant genetic resources will have to be continued to cover inaccessible and remote areas, as well as minor and under-exploited crops. The gaps in the collected accessions have to be reviewed and filled. In addition, the collected germplasm need to be characterized and evaluated for meaningful utilization by crop improvement programmes. Databases have to be created and shared among users of the germplasm. To do so, the skills of the staff need to be enhanced, at the same time procuring facilities and evaluation tools including molecular and biochemical techniques for the country, preferably at NBC.

Bioprospecting is another area where policy and technical capacities are deficient and need to be quickly built. The potential use of the wide array of medicinal and aromatic plants of the country for pharmaceutical and industrial purposes remains to be exploited. In sum, much more remains to be done than what we have achieved so far.

Figure 1: Organizational Set-up of NBC

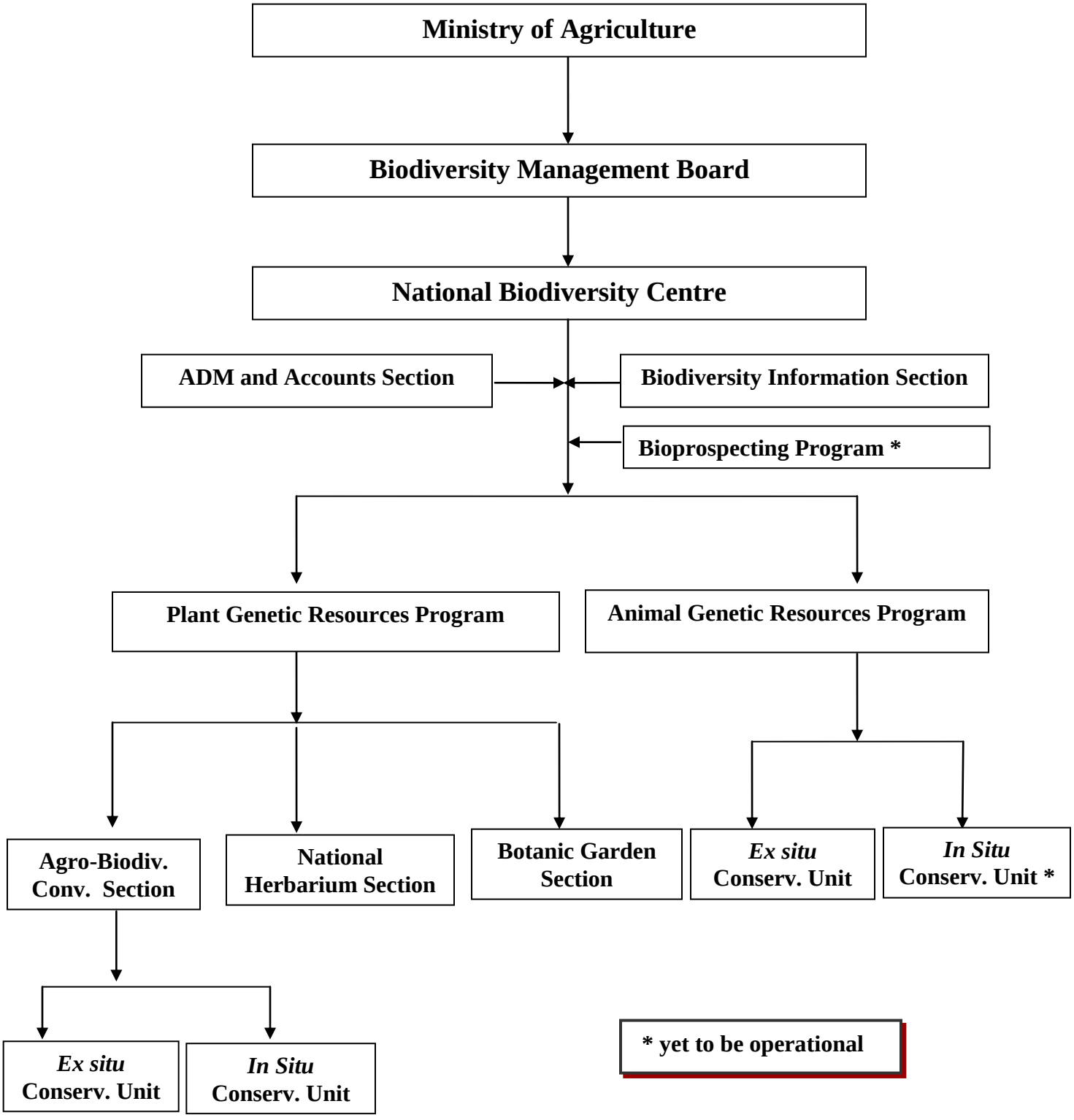

Figure 2: Organogram of CoRRB

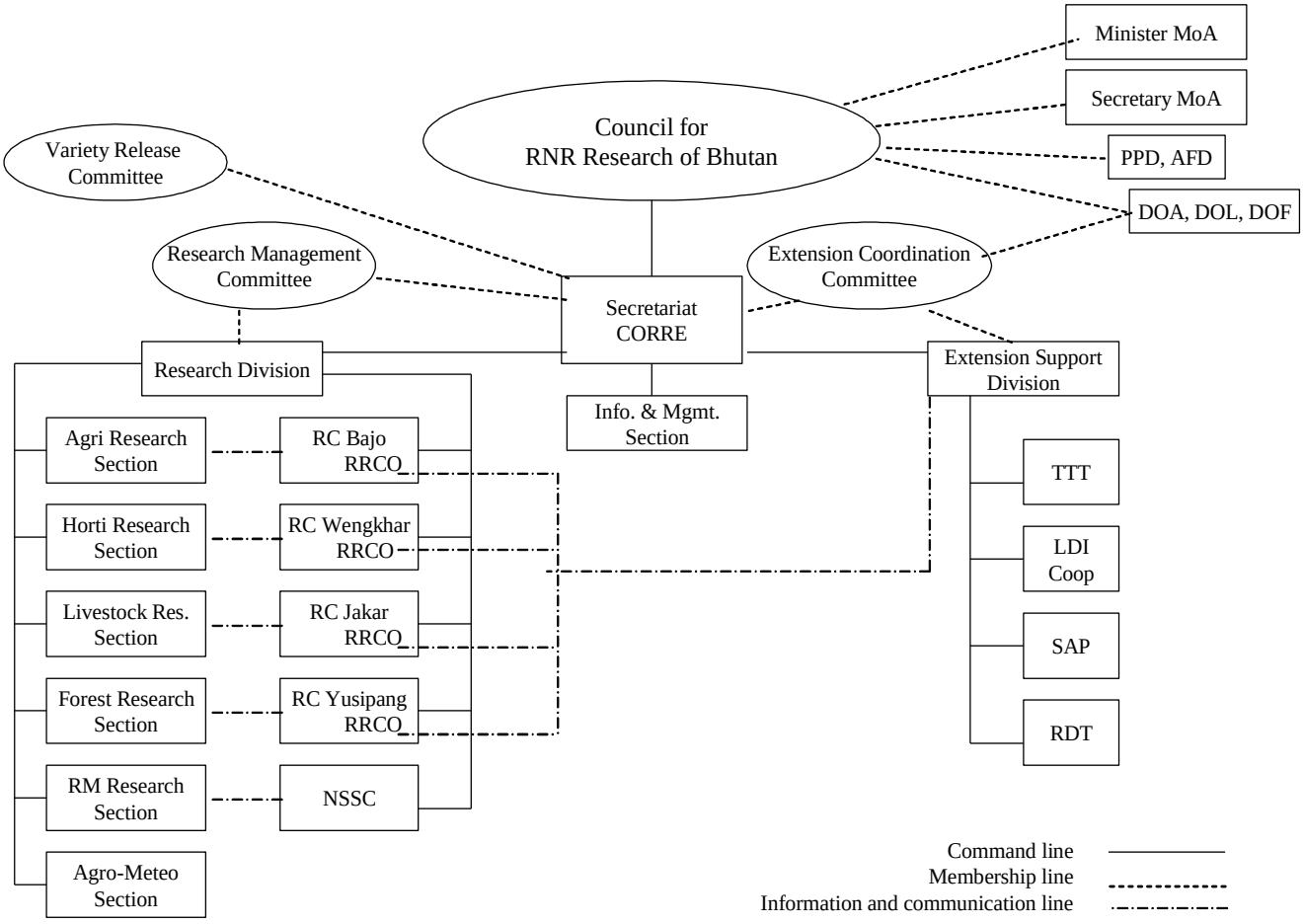

Photo 1: Rice fields in western Bhutan (under theme 2.2.1)

Photo 2: A local rice variety (under theme 2.2.2)

Photo 3: Diversity of beans (under theme 2.3)

Photo 4: Local popcorn variety (under theme 2.4)

Photo 5: Local millet variety in farmer's field (under theme 2.7)


Photo 6: Local barley variety (under theme 2.7)

Photo 7: An improved orange tree (under theme 2.9.2)


Photo 8: Flowers and pods of winged bean (under theme 2.10)

Photo 9: An orchid in full blossom (under theme 2.11)

Photo 10: Improved grasses and legumes fodder species (under 2.12)


Photo 11: An improved rice variety bred at RNRRC Bajo (under theme 3.1)


Photo 12: An improved peach variety in flowering (under theme 3.1)

Photo 13: Natural grasslands and yaks grazing on them (under theme 4.1)


Photo 14: In situ rice conservation threatened by land slips (under 4.2)

Photo 15: Urbanisation is a threat to PGR loss (under theme 4.0)

Photo 16: A top view of RNRRC Bajo (under theme 5.0)

REFERENCES

Chettri, GB. 1992. *An Analysis of Morpho-agronomic Traits, Isozyme Polymorphism and Cross Compatibility of Traditional Rices of Bhutan*. MSc Thesis submitted to the University of the Philippines, Los Banos, Philippines.

Dorji. 1999. *National Perspective on Horticultural Crops: Current Status of Fruits and Nuts Genetic Resources Conservation and Use.* Proceedings of the first National Workshop on PGR. NRTI, Lobesa, Bhutan.

Duba, S., M. Ghimiray, and Y. Dorji. 1995. *Rice Post Harvest Management Systems in Paro and Wangdue-Punakha Valleys*. RNRRC Technical Paper No. 2. Bajo.

Ghimiray, M. 1999. *Conservation and Utilisation of Bhutanese Rice Genetic Resources, in Plant Genetic Resources: Bhutanese Perspective*. Proceedings of the first National Workshop on PGR. NRTI, Lobesa, Bhutan.

Gurung, T.R. 1999. *National Perspective on Horticultural Crops: Vegeetables, Spices, Condiments Genetic Resources Conservation and Use*. Proceedings of the first National Workshop on PGR. NRTI, Lobesa, Bhutan.

Gyamtsho, P. 1998. *Status of Biodiversity Conservation in Bhutan, in Ecoregional Cooperation for Biodiversity Conservation in the Himalayas*. Proceedings of a workshop, UNDP.

Loresto, G.C. 1998. *Report on the Exploration of Farmers' Fields in Paro and Thimphu Valleys*. International Rice Research Institute. Los Bano, Philippines.

Morishima, H., Y. Shimamota, T. Sato, H. Yamagishi and Y.I. Sato. 1990. *Observtion on wild and cultivated rices in Bhutan, Bangladesh and Thailan : Report of study tour in 1989-90*. National Institute of Genetics, Mishima, Japan.

Norbu, N. 1999. *Timber Genetic Resources Conservation and Sustainable Utilization in Bhutan.* Proceedings of the first National Workshop on PGR. NRTI, Lobesa, Bhutan.

Norbu, S. 1999. *Conservation and Utilization of Plant Genetic Resources in the East Central Region of Bhutan*. Proceedings of the first National Workshop on PGR. NRTI, Lobesa, Bhutan.

Oka, H.I. 1988. *Origin of cultivated rices*. Japanese Scientific Societies Press, Elsevier.

RGoB. 1999. *Report on a National Legumes Survey*. Sustainable Soil Fertility and Plant Nutrition Management Project, National Soils Services Centre. Semtokha. Ministry of Agriculture, Royal Government of Bhutan.

RGoB. 2000. *The Seeds Act of Bhutan*. Ministry of Agriculture, Royal Government of Bhutan.

RGoB. 2003. *The Biodiversity Act of Bhutan*. Ministry of Agriculture, Royal Government of Bhutan.

RGoB. 2002. *Biodiversity Action Plan for Bhutan.* Ministry of Agriculture, Royal Government of Bhutan.

RGoB. 2004. *Bhutan Biological Conservation Complex*. Nature Conservation Division, Ministry of Agriculture, Royal Government of Bhutan.

RGoB. 1995. *Area and Production of Major Crops*. LUPP, Ministry of Agriculture, Royal Government of Bhutan.

RGoB. 2002. *Fodder Production in Bhutan: A Handbook for Extension Agents*. National Livestock Research Programme, RNRRC Jakar. Ministry of Agriculture.

RGoB. 2004. *Bhutan Biological Conservation Complex: A Landscape Conservation Plan*. Nature Conservation Division, Ministry of Agriculture.

RGoB. 2003. *Operationalization of CoRRB : A Draft Working Group Report*. Ministry of Agriculture.

Roder, W and Gurung, P.R. 1990. *Mountain Crop Resources of Bhutan in Retrospect and Prospect.* Agriculture Research Centre, Yusipang. Ministry of Agriculture.

Shrestha, S. 2004. *An Economic Impact Assessment of the Rice Research Program in Bhutan.* International Rice Research Institute. Los Banos, Philippines.

Timsina, M.P. and Sherpa, D.L. 2005. *A Survey Report on Local Tree Fodder and Shrub Species in West-Central Region of Bhutan.* RNR Research Centre, Bajo. Ministry of Agriculture.

Thinlay. 1998. *Rice Blast, caused by Magnaporthe grisea, in Bhutan and Development of Strategies for Resistance Breeding and Management*. A PhD dissertation submitted to the Swiss Federal Institute of Technology, Zurich.

Tshering, D. 2002. *Public Biodiversity Policy Analysis in Bhutan*. A PhD dissertation submitted to the Swiss Federal Institute of technology, Zurich, Switzerland.

Tshitila. 1999. *Status of Medicinal Plants Genetic Resources Conservation and Sustainable Utilization in Bhutan*. Proceedings of the first National Workshop on PGR. NRTI, Lobesa, Bhutan.