COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

PAKISTAN

Country Report on Plant Genetic Resources for Food and Agriculture – Pakistan

Plant Genetic Resources Program
National Agricultural Research Centre
Pakistan Agricultural Research Council
Islamabad, Pakistan

Note by FAO

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FOREWORD

The on-going globalization and high farm productivity trends are threatening the agricultural biodiversity and hence, sustainable agricultural development. Plant biodiversity is also depleting as a consequence of green revolution, hybrid seed, new diets, intellectual property rights (IPRs) and access restrictions. Such developments have prompted the stakeholders to gear up for improved Plant Genetic Resources (PGR) conservation strategies in the interest of their sustainable utilization.

This Country Report on Plant Genetic Resources for Food and Agriculture (PGRFA) is a part of more than 150 countries' global endeavor to contribute to the National Information Sharing Mechanism (NISM) for enabling the conservation as well as sustainable utilization of PGRs. The first country report was published in 1996. Since then, a dramatic progress has been made on conservation, evaluation, legislation, training and other aspects of PGRs, necessitating revisiting of the relevant information to fill gaps and improve efficiencies for sustainable utilization of PGRs for achieving enhanced national food security. This second PGRFA Country Report, produced under the auspices of FAO, is the outcome of multifaceted activities undertaken over the last decade. The reported information has been gathered through extensive consultations and intellectual exchanges amongst stakeholders through series of intensive workshops involving senior and middle level management officials representing provincial, federal and academic institutes and NGOs. Generating and disseminating PGRs information is in line with global agenda for biodiversity conservation and its utilization. The Country Report will serve as a resource for national, regional and international players to promote stronger linkages for collaborative research and exchange of plant germplasm for attaining speedier agricultural development leading to human welfare. The report will also serve as an instrument to identify gaps and inefficiencies still existing at national and international levels, which in turn will help in guiding the policy formulation for future global adjustments for improving the PGR conservation and utilization strategies - ultimately leading to enhanced global food security.

I commend the strenuous efforts by all scientists of Plant Genetic Resources Program (PGRP) and supporting staff led by Dr. Zahoor Ahmad, during the last several months by organizing a series of workshops and bringing the stakeholders under the umbrella of NISM. I hope they will continue expanding their professional, academic and intellectual horizons for more effective conservation of PGRs on the one hand and their sustainable utilization on the other, for a food-secure Pakistan and a hunger-free world at large.

Dr. Abdul Rashid
Director General
National Agricultural Research Centre

PREFACE

The conservation and sustainable utilization of plant genetic resources is key to improving agricultural productivity, thereby contributing to national development, food security and the relief from poverty. Recognizing the importance of Plant Genetic Resources for Food and Agriculture (PGRFA), an international process on the preparation of Country Report was initiated in 1992 under the auspices of FAO. FAO's first report on the State of the World's Plant Genetic Resources, prepared in 1996 from more than 150 country reports, identified a number of serious gaps and inefficiencies in the conservation and utilization of these resources. Based upon the country reports, FAO developed the *Global Plan of Action on Conservation and Sustainable Utilization of Plant Genetic Resources* which was intended as a frame work, guide and catalyst for actions at community, national, regional and international levels. The FAO Commission on PGRFA in its 8th regular session held in 1999 reiterated the need to periodically assess the state of the world's plant genetic resources to facilitate the analysis of changing needs and gaps, and also to contribute to the adjustment of the rolling Global Plan of Action. In 2002, the FAO commission on PGRFA in its 9th regular session considered a detailed proposal for the preparation of the second report on the state of world's PGRFA. The Inter-Governmental Working Group in its meeting held in 2003 recommended that FAO prepare guidelines that would draw forth information on changes in national status that have occurred since the first report.

For the preparation of the National Information Sharing Mechanism on PGRFA and of the Country Report, FAO provided financial resources to PARC in 2006. Three workshops of stakeholders belonging to federal, provincial and academic institutions and also NGOs were held in October, December, 2006 and March, 2007 in order to compile information on 20 priority areas identified in Global Plan of Action. In these three workshops, 167 stakeholders participated and provided information on common tables on computer software prepared by FAO.

Based upon the information gathered during this process, the 2nd Country Report on PGRFA has been prepared particularly focusing on the activities under taken after 1995 (First report).

This report comprises of eight chapters on (i) State of diversity, (ii) *In situ* management, (iii) *Ex situ* management, (iv) State of use, (v) National programs, trainings and legislation, (vi) Regional and international collaboration, (vii) Access to genetic resources, sharing of benefits arising out of their use and farmer's rights, and (viii) Contribution of plant genetic resources management to food security and sustainable development.

Mr. Juan Fajardo from FAO Headquarter was deeply involved in the process and participated in two of the workshops and provided tremendous technical guidance. The stakeholders who participated in the workshops and provided information for National Information Sharing Mechanism (NISM) and Country Report, also made valuable contributions to substantiate these vital documents of global interest.

Dr. Zahoor Ahmad
Deputy Director General, IABGR

EXECUTIVE SUMMARY

The present Country Report reviews the current status of Plant Genetic Resources in Pakistan, focusing on (i) State of diversity, (ii) *In situ* management, (iii) *Ex situ* management, (iv) State of use, (v) National programs, trainings and legislation, (vi) Regional and International collaboration, (vii) Access to genetic resources, sharing of benefits arising out of their use and farmers' rights, and (viii) Contribution of Plant Genetic Resources management to food security and sustainable development. Pakistan is endowed with rich resource base of plant genetic resources due to wide variations in soil and climate, its location in proximity to three of the major centres of diversity described by Vavilov (China, Indian subcontinent and Central Asia) and centre of diversity itself of many crop species. The country possesses many species of wild relatives of domestic crops, particularly of cereals and chickpea. There has been a catastrophic loss in agricultural biodiversity during the last three decades due to introduction of improved varieties in major crops like wheat, rice, cotton, chickpea and maize. Due to little varietal improvement work in minor or under utilized crops, there still exists a lot of diversity in mung bean (*Vigna radiata*), mash (*Vigna mungo*), brassicas complex, sorghum, millet and horticultural crops. The awareness created by various public and private organizations about the importance of plant genetic resources has attracted the attention of researchers, planners and NGOs for *in situ* and *ex situ* conservation and sustainable utilization of these resources.

For *ex situ* conservation, the national program on collection, conservation and evaluation are underway but more needs to be done to fill in the gaps in collection from various areas of the country particularly for the wild relatives of crop plants. An important step in *ex situ* conservation of plant genetic resources is the establishment of National Program on Conservation of Plant Genetic Resources at National Agricultural Research Centre, Islamabad which has been able to conserve more than 23 000 accessions of various crops including major, minor and medicinal plants. The national program on PGR has a Genebank along with six laboratories for (i) exploration and collection, (ii) seed conservation, (iii) *in vitro* conservation, (iv) germplasm evaluation & characterization, (v) plant introduction and seed health and (vi) data management. The PGRP has the national mandate on conservation, evaluation and distribution of germplasm. This national program is supported by six Crop Advisory Committees which help to identify the priority areas of collection and germplasm needs for specific purposes. Another step recently taken is the establishment of botanical gardens at Islamabad, Lahore and Peshawar. But unfortunately little has been done so far on on-farm management of plant genetic resources.

Regarding the utilization of these resources, a number of new varieties of wheat, rice, cotton, maize, sorghum, millet and horticultural crops have been developed which have contributed significantly in food security and sustainable development. Besides high yields, the introduction of these varieties has considerably supported the sustainable management of diseases like the rust in wheat, *Aschochyta* blight in chickpea, cotton leaf curl virus in cotton and mungbean yellow mosaic virus in mung and mash, as well as better quality in basmati rice. Approximately 2 000 to 3 000 accessions are distributed annually from the collections of the national Plant Genetic Resources Program to scientific community. The information collected from stakeholders during the implementation of the National Information Sharing Mechanism has revealed that the breeders need the germplasm mainly to address a range of biotic and abiotic stresses. In particular, tolerance to drought and salinity are the most demanded characters.

Various universities have included courses on Biodiversity Conservation in their syllabi for graduate and post graduate students. Regarding legislation on access to genetic resources, benefit sharing, farmers' rights, much has to be done yet as few national workshops have been held during the last 4-5 years. A draft on access and benefit sharing has been developed and is being considered at the appropriate fora.

The National Information Sharing Mechanism on Plant Genetic Resources for Food & Agriculture has been developed and available on PARC website (www.parc.gov.pk). For international collaborations, Pakistan has signed a memorandum of understanding on germplasm exchange with many countries.

COUNTRY REPORT ON PLANT GENETIC RESOURCES OF PAKISTAN

1. Introduction

Pakistan with a land area of 79.61 million ha. is located at the western end of South Asian subcontinent and is characterized to contain the major archaeological sites of Indus civilization. From the coast of Arabian Sea and the mouth of Indus near the tropic of Cancer, it extends about 1 700 kilometers northward in great mountain chains of Hindukush, Himalayas and Karakorum. Its flora has the characteristics of both Palaearctic and Indo – Malayan elements. Geographically, Pakistan has a diverse climate ranging from subtropical to temperate and alpine forests. Climatically, it is arid and semi-arid. The altitudinal variations are wide ranging from sea level to 8 000 meters. Annual rainfall varies from 50mm in arid and semi-arid areas to 2 000 mm in moist forests. The temperature influenced by altitude varies from below freezing in northern mountains during winter to 35 – 50 ^{O}C during summer in central and southern plains.

The wide variations in geography, altitude, soil, climate and culture have created a rich floristic diversity and it is estimated that there are about 6 000 species of higher plants (Nasir and Ali, 1970). There are about 400 endemic species and 4 endemic genera (*Douepia, Suleimania, Spiroseris* and *Wendelboa*). The floristic diversity has further widened due to ancient trade route from China to Western Asia, many crop and fruit species from along the entire route were brought here and have been cultivated for thousands of years. The excavations of ancient civilizations of Mohanjo Daro, Harappa and Taxila revealed much about the origin of agriculture for the Indian subcontinent. Many crops including wheat, barley, rice, cotton and sesame were discovered to have been under cultivation in the ancient times.

Pakistan has the world's sixth largest population: the estimation for 2007 is over 169 million inhabitants, and by the next decade the population is expected to exceed 176 million. This will lead to higher demand for food and agricultural products. Also, 24 percent of the population in the country is undernourished and the number of undernourished people has increased in recent years and situation demands increase in productivity per unit area.

Agriculture is the mainstay of Pakistan's economy. Nearly one-fourth of total output (GDP) and 44 percent of total employment is generated in agriculture. Not only that 44 percent of country's work force are employed in agriculture but 67.5 percent of country's population living in rural areas is directly or indirectly linked with agriculture for their livelihood. Due to introduction of new improved and high yielding varieties, and intensive farming systems, there has been catastrophic loss to agricultural biodiversity during the last three decades. Having 23.12m ha. as cropped area, 4.29 m ha. is rainfed. Recently Pakistan has attained self sufficiency in staple crops and major source of earning in foreign exchange is from export of rice and cotton.

Agriculture is the main income generating sector contributing about 25 percent to the GDP. Kharif (summer) and Rabi (winter) are two crop seasons where a number of cereals, legumes, vegetables, sugar crop, oilseeds, fodder, fiber, spices and condiments are grown. Among fruits, a variety of fruits from tropical (mango, guava, citrus, coconut) to temperate fruit and nuts (apple, peach, plum, apricot, grapes, cherry, walnut, pomegranate) etc. are grown on wide areas.

2. Agro-ecological regions of Pakistan

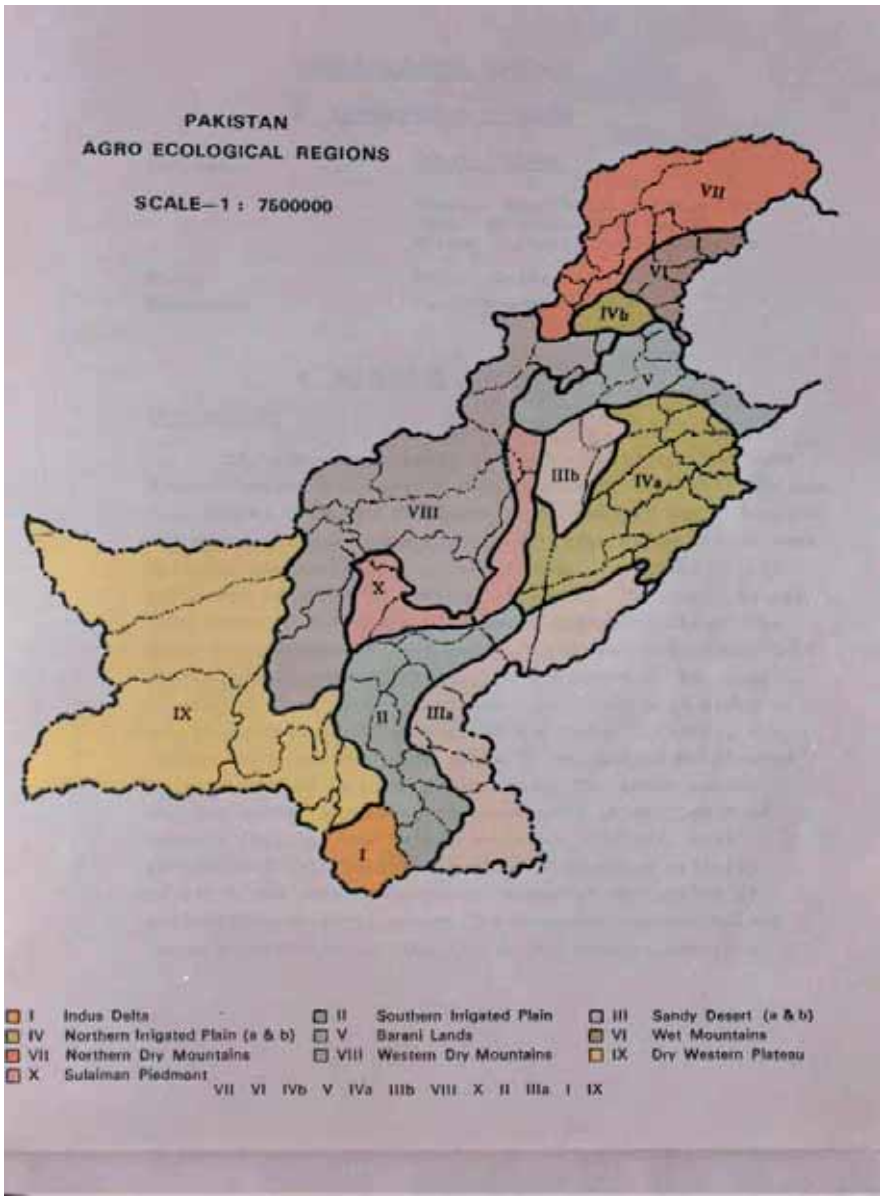
Pakistan Agricultural Research Council (PARC) in 1980 based upon a survey and review of the available literature on physiographic, climate, soil, and other factors affecting agriculture, divided Pakistan in 10 agro-ecological regions and are described briefly as follows:

- **Agro-Ecological Region – I (Indus Delta):** This region comprises of areas from the districts of Thatta, Badin and Hyderabad. Soils of this region are clayey and silty. The climate is arid tropical marine with moderately hot summer and mild winter. The clayey soils are under irrigated cultivation to grow rice, sugarcane, pulses, banana and some other fruits plants. During winter, *Trifloium*, *Lens culinaris* and *Lathyrus sativa* are cultivated.

- **Agro-Ecological Region – II (Southern Irrigated Plain):** It comprises of areas from the districts of Hyderabad, Badin, Tharparkar, Sanghar, Dadu, Khairpur, Larkana, Nawabshah, Jaccobabad, Sukkar, Rahim Yar Khan, Sibi and Shikarpur. The main soils are calcareous, silt loam and silty clays with weak structure and good porosity. The climate is arid sub-tropical continental with hot summer and mild winters. Canal irrigated agriculture is the predominant land use of the region. Cotton, wheat, mustard, sugarcane and clover are the main crops in the left bank of the Indus. Rice, wheat, chickpea and clover are grown on the right bank. In areas with little water, sorghum is grown.

MAP 1

Pakistan agro-ecological regions



- **Agro-Ecological Region – III (A) Sandy Deserts:** This region includes the areas from Tharparkar, Khairpur, Nawabshah, Sanghar, Rahim Yar Khan, Bahawalpur and Bahawal Nagar. Thar and Cholistan desert is a part of the great Indus Desert. The climate is arid (desert) sub-tropical with very hot summer and mild winter. Main land use of the region is grazing but guar, millet and castor are grown. In south-eastern part of the region, where rainfall is about 300mm, wheat is also an important crop on loamy soils and castor on sandy loam soils.
- **Agro-Ecological Region – III (B) Sandy Deserts:** It comprises the sandy deserts from the districts of Muzaffarabad, Mianwali and Sargodha. The climate is arid to semi-arid sub-tropical continental. The northern part of the region,

with a rainfall of 300 to 350 mm is mainly used for chickpea cultivation. Some area is under canal irrigation to grow cotton, sugarcane, guar, millet and wheat.

- **Agro-Ecological Region – IV (A) Northern Irrigated Plain:** Most of the area in the province of Punjab is located in this region. The districts of Peshawar and Mardan in the North West Frontier Province (NWFP) are also included. This region has semi-arid subtropical continental type of climate. This is the major agricultural production area with a number of crops like wheat, maize, rice, sugarcane, barley, cotton and many minor crops. The orchards of citrus and mango are important while in NWFP areas, pear, plums, tobacco and groundnut are also grown.
- **Agro-Ecological Region – IV (B):** The half saucer shaped alluvial valley of Peshawar is drained by Kabul, Swat and Kalapani rivers. This area has semi-arid (Steppe) sub-tropical continental type of climate, with little rain both in winter and summer. The main crops are sugarcane, maize, tobacco, wheat and clover. Sugar beat is recent introduction in the area. Considerable area is under fruit orchards of pears and plums. Some areas in the northern part are dry where wheat, millet, chickpea and groundnut are grown.
- **Agro-Ecological Region – V (Barani Areas):** This region comprises of areas from the districts of D.I. Khan, Bannu, Mianwali, Attock, Abbottabad, Rawalpindi, Jhelum, Gujrat, Gujranwala and Sialkot. The region comprises of salt range, Pothwar Plateau and the Himalayan Piedmont plains. A small narrow belt lying along the foot of the mountains is nearly humid, with hot summer and cold winters while the southern part of the zone is semi arid and hot. A large proportion of the area comprises gullied land. The main crops of the region are wheat, rice, maize, millet, sorghum, oilseeds pulses and fodder.
- **Agro-Ecological Region – VI (Wet Mountains):** This region comprises of areas from Rawalpindi, Murree, Hazara and Mansehra. The region comprises high maintains and plateaus and therefore, the climate is undifferentiated. Approximately 25% of the area is under rainfed cultivation, the main crops being maize, wheat and rice. Fruit orchards of apple, plum, peach, apricots are abundant in this area.
- **Agro-Ecological Region – VII (Northern Dry Mountains):** The region comprises of Gilgit, Baltistan, Chitral, Dir and areas of Swat valley. Karakorum Mountains and spurs of Hindukush border the syntaxical bend. Enclosed by high mountains, the valleys are characterized by extreme aridity. The summer is mild and winter is cold. Maize, wheat, rice, finger millet, barley, buckwheat, and a number of temperate fruits and nuts are characteristic of this area. This area is rich in crop, fruit and nut genetic resources.
- **Agro-Ecological Region – VIII (Western dry Mountains):** This area lies to the south of Safed Koh and to the west of Indus including districts of Kohat, Bannu, Tribal Areas, Zhob, Loralai, Kalat, Sibi, Quetta and Kacchi. The greater part of the area can be described as semi arid, high land, with mild summer and cold winter. Wheat, maize, alfalfa and temperate fruits are the major agricultural crops.
- **Agro-Ecological Region – IX (Dry Western Plateau):** The region comprises mountainous areas with inter-mountain basins and plateau from the districts of Karachi, Dadu, Makran, Kharan, Chagai and Lasbella. The region has arid (desert) tropical type of climate with constantly dry season. The soils of the plain areas are deep, strongly calcareous silt loams. The lower parts of the hills and higher parts of the plains have gravelly soils. Fruits, vegetables and wheat are grown wherever water is available from springs or kareezs. The other crops are sorghum, millet, castor bean, etc.
- **Agro-Ecological Region – X (*Sulaiman Piedmont*):** It comprises the piedmont plains of the Sulaiman Range, sloping towards the Indus River. The climate of the region is arid, hot and subtropical continent. Torrent – watered cultivation is the main land use, under which wheat, sorghum, millets and chickpeas are grown. Rice is grown in a narrow strip forming the junction of piedmont and river plains.

CHAPTER 1

THE STATE OF DIVERSITY

Pakistan is situated in proximity to three of the major centres of diversity described by Vavilov (China, Indian subcontinent and Central Asia) and holds many plant species. The diversity of genetic resources provides the sustainable basis for food supply and security. A variety of crops like wheat, rice, maize, barley, sorghum, millet, cotton, brassicas, sunhemp, tobacco, sugarcane, chickpea, mung, mash, lentil, groundnuts, sesame, chilies, onion, garlic, coriander, turmeric and various other vegetables and fruits are cultivated in Pakistan. The average of last five years in area, production and yield of most of the crops is given in Table 1.

TABLE 1
The area, production and yield of some of the important crops 2000-2005

Crop	Species	Area (000 ha.)	Yield (kg/ha)	Production (000 t)
Wheat	*Triticum aestivum*	8 307	2 196	18 238
Rice	*Oryza sativa*	2 334	1 922	4 487
Maize	*Zea mays*	945	1 658	1 566
Sorghum	*Sorghum color*	384	601	231
Millet	*Panicum miliaceum*	389.1	456	177.4
Barley	*Hordeum vulgare*	149.4	1 009	151
Sugarcane	*Sacharum officinarum*	1 030	47 000	48 371.2
Cotton	*Gossypium hirsutum*	3 002	557	9 837 (Bales)
Sunhemp	*Crotealaria juncea*	3.16	661	2.1
Jute	*Corchorus capsularis*	0.026	1 115	0.029
Tobacco	*Nicotina tabaccum*	52.4	1 857	97.3
Sugar beet	*Beta vulgaris*	6	26 800	150
Guar	*Cyamopsis tetragonoloba*	158	954	151
Gram	*Cicer arietinum*	1 074	615	661
Mung	*Vigna radiate*	198	459	91
Mash	*Vigna mungo*	51	518	26.3
Lentil	*Lens culinaris*	62.5	575	36
Peas	*Pisum sativum*	134	587	82
Other Summer legumes	-	10	536	5.2
Other Winter legumes	-	3.4	499	1.7
Rapeseed & mustard	*Brassica spp*	335	843	282.2
Groundnut	*Arachis hypogaea*	101	1 079	109
Sesame	*Sesamum invicum*	85.6	454	38.9
Sunflower	*Heliamthus annuus*	149.5	782	191.4
Soybean	*Glycine max*	0.64	173	3.7
Safflower	*Carthamus tinctorius*	0.06	1 500	0.04
Linseed	*Linum usitatissimum*	7.92	585	4.63
Castor	*Ricinus communis*	7.41	752	5.57
Onion	*Allium cepa*	87.1	14 000	1 218.3
Garlic	*Allium sativum*	8.8	9 000	79.5
Chillies	*Capsicum annuum*	87.9	1.5	133.6

Crop	Species	Area (000 ha.)	Yield (kg/ha)	Production (000 t)
Coriander	*Coriandrum sativum*	6.8	0.5	3.3
Turmeric	*Curcuma domestica*	4.3	9.2	39.4
Ginger	*Zingiver officinale*	0.077	0.351	0.027
Potato	*Solanum tuberosum*	97.9	14.6	1 426.3
Vegetables		218.0	-	2 889.3
Tomato	*Lycopersicon esculentum*	29.3	10.6	311.6
Fodder crops		2 649.9	22.7	60 215.1
Citrus	*Citrus* spp	195.8	-	1 961.0
Mango	*Mangifera indica*	92.1	-	918.6
Banana	*Musa paradisiaca*	26.0	-	95.7
Apple	*Malus* spp	45.5	-	532.3
Guava	*Eugenia* spp	57.4	-	461.4
Apricot	*Prunus armenica*	12.1	-	175.8
Peach	*Prunus* spp	4.4	-	43.7
Pears	*Pyrus communis*	2.8	-	36.2
Plum	*Pryus domestica*	6.7	-	74.4
Grapes	*Vitis* spp	9.0	-	67.3
Pomegranate	*Punica granatum*	6.5	-	96.7
Dates	*Pheonix* spp	75.2	-	581.2
Almonds	*Prunus* spp	10.7	-	46.0

Besides the crops mentioned above, a number of other minor crops like buckwheat, foxtail millet, faba bean, common bean and various medicinal plants are being grown particularly in northern mountains or tribal areas for a very long period and rich genetic diversity is found in these crops. The main popular fruits of the country are citrus, mango, banana, grapes, apple, peach, plum, apricot, pomegranate, dates and some nuts. The various native crops of the region and introduction during the period of time are given in Table 2.

TABLE 2

Crop species native or introduced in the region

Plant Group	Native	Introduced
Cereals	Bread wheat, rice, barley	Maize, millet, sorghum
Food legumes	Mungbean, moth bean, pigeon, pea, cowpea, mashbean	Chickpea, lentil, peas, faba bean, common bean
Sugar crops	Sugarcane	Sugar beet
Vegetables	Brinjle, okra, melons, cucurbits	Carrot, radish, turnip, tomato, cabbage, cauliflower, pumpkin, bottle gourd, potato
Oilseeds	Sesame, mustard, castor, safflower	Groundnut, soybean, sunflower, linseed
Fiber plants	Desi cotton, sunhemp, tree cotton, kenaf	American cotton, jute
Spices & condiments	Turmeric, black mustard	Ginger, mint, fennel, coriander, cumin
Fruit plants and nuts	Mango, citrus, jujube, guava, pomegranate, apricot, walnut	Apple, peach, plum, grapes, banana, date palm, papaya, almond, cherry, mulberry

Besides the variety of crops under cultivation, a large number of wild relatives to many crop species are found in Pakistan which is mainly distributed in northern mountains or in Balochistan. The various wild relatives and minor fruit plants distribution is presented in Table 3.

TABLE 3
Wild relatives of crop plants in Pakistan

Wild relatives of	Scientific Name	Distribution
Wheat	*Aegilops squarrosa* *A. triuncialis* *Elymus borianum* *E. kuramensis* *E. nodosus* *E. stewarti* *E. longearistatus* *E. russelli* *E. jacquemontii*	Mountain areas of Pakistan - Endemic to Swat Endemic to Kurram Kurram Endemic to Kashmir High alpine areas of Hidukush, Himalaya & Karakorm Endemic to Karakorm Endemic to Kashmir
Barley	*Hordeum bogdanii* *H. spontaneum* *H. murirum*	Karakoram, Ziarat & Horbi range North Balochistan NWFP and Muree Hills
Rice	*Oryza coarctata*	Indus delta
Sorghum	*Sorghum nitdum* *S. halepense*	Hazara and Muree Common weed through out Pakistan
Millet	*Pennisetum flaccidum*	High alpine slopes of Himalya, Karakorm
Cotton	*Gossypim stocksii*	Northern Sindh
Mustard	*Brassica juncea* *B. deflexa*	Western Balochistan Western part of Balochistan
Kenaf	*Hibiscus caesius* *Hibiscus micranthus* *H. lobatus*	N.Pujab, NWFP and Kashmir Sind and Balochistan Salt range, Sindh, Kuram valley
Chickpea	*Cicer macranthum* *Cicer microphyllum* *Cicer nuristanicum*	Northern mountains
Pome fruits	*Pyrus pashia, Malus demestica, Cydonia oblonga, Sorbus lanata, Sorbus tianshanica, Cartaegus songarica, Cotoneaster offinis, Cotoneaster nummulria, C. integersima*	Northern areas of Pakistan and Balochistan
Stone fruits	*Prunus cerasioides* *Prunus jacquemontii,* *Prunus prostrota,* *Prunus cornuta,* *Prunus cerasus* *Prunus mahaleb* *Prunus tomentosa* *Prunus cerasifera*	Northern areas of Pakistan and Balochistan
Other fruit tree species	*Diospyros lotus* *Ficus carica* *Olea ferruginea* *Zizyphus spp*	Swat, Karakorum & Northern Mountains Swat Widely distributed
Tree nuts	*Corylus jacquemortii* *Pistacia atlantica* *Pistacia chinensis* *P.khinguih* *Psunus bucharica* *Psunus kuramica*	Kalam Northern Mountains of Balochistan Northern areas Endemic to Kurram
Small fruits	*Duchesnea indica* *Fragaria nubicola* *Ribes alpestre* *Ribes Orientale* *Rubus anatolicus* *Rubus ellipticus* *Rubus hoffmeisterianus* *Rubus irritons* *Rubus macilantus* *Rubus nivens*	Widely distributed in Mountain areas Swat, Kurram and Northern of Pakistan

The crop biodiversity for some of the crops is discussed below:

1.1 Cereals

Wheat is the major food crop of Pakistan grown over an area of 8 million ha. scattered over a wide range of ecological regions. Presently most of the area is occupied by improved varieties but local land races still exist in Balochistan and Northern Mountains due to local preferences or non-availability of improved varieties suitable for these areas. The local land races of wheat and barley are of great importance for quality and their tolerance to drought and salinity.

Rice is another important cereal crop. This part of world is considered to be the habitat of Basmati rice. Due to use of Basmati rice in religious and social ceremonies, the house wives maintain the old land races for specific uses while due to its commercial importance, these land races are being mostly replaced by improved varieties. Coarse and glutinous rice is also grown in many areas. At high mountain areas like Chitral and Dir, the farmers still grow only local land races because of their adaptability to cold water. In addition to wheat and rice, maize, sorghum, finger millet foxtail millet, buckwheat, barley etc. are grown in Pakistan. Different barley races (covered and naked), foxtail millet and finger millet races are cultivated by communities in northern Pakistan. Although maize, sorghum and millet are introduction in this part of world, but long history of their cultivation, natural selection and local preferences have created a wide genetic diversity in these crops. The women are playing key role for maintaining the biodiversity of these crops, as they are involved in selection of cultivars and maintaining for further propagation.

1.2 Food legumes

The area under pulses is 1.48 million ha. and it is an important group of food crops providing proteins. Among food legumes, the chickpea, lathyrus, lentil mung bean, mash bean, pigeon pea, cowpea, moth bean, broad bean, and common bean constitute important gene pools of various legumes. Diversity occurs in plant type, days to maturity, pod size, shape, grain colour etc. Some of the germplasm has been identified to be resistant to biotic and a-biotic stresses. The green revolution during the late 1960's increased the cereal production while the production of food legumes either decreased or remained static. Presently, due to concerted efforts by various research institutes in the country, the release of high yielding varieties in chickpea, lentil, mung and mash have resulted in the erosion of various local races/cultivars from the farmer's field. Due to lesser attention on the pigeon pea, cowpea, moth bean and the broad bean, the rate of genetic erosion is comparatively less than conventional food legumes, like chickpea, lentil, mung and mash.

1.3 Oil Seed crops

The main oil seed crops of Pakistan are rape and mustard, sesamum, linseed and castor. The sunflower, soybean and groundnut are introductions. Most of the oil seed crops are grown on marginal areas. Although the extent of genetic diversity in introduced oil seed crops is low but the indigenous crops express a wide diversity in morphological traits and response to various stresses.

1.4 Horticultural crops

A wide range of fruit species like mango, guava, citrus, banana, jujubar (ber), Eugenia (Jaman), apple, peach, plum, apricot, grapes, and nuts like almond and walnut are grown. These possess wide genetic variability in fruit size, shape, colour, maturity time and quality etc. These fruit species have been diversified through human selection over hundreds of years. There are more than 150 clones/local cultivars of apricots grown in northern areas of Pakistan with characteristics of early bloom and sweetness. Wide variation exists in fruit size, shape, colour, taste, seed size, quality of kernel etc. The recent introduction of hybrid varieties of apricots has posed a serious threat of genetic erosion to the local cultivars. The local varieties like Halman and Morghulam are famous for their taste and sweetness.

The local pears and peaches are also diverse in terms of fruit size, shape and time to maturity. The grapes grown in Pakistan include land races of *Vitis vinifera,* V *jacquemontii* and *V. parvifolia*. The adaptation pattern of different species varies from the arid dry to the humid regions. *Vitis vinifera* demonstrates great diversity in Skardu, Hunza, and Gilgit. *V. jacquemontii* is adapted to the

high rainfall areas in Swat and Kashmir. The wild species of *V. parvifolia* are distributed sparsely in the Chickar area of Kashmir.

Mango is one of the most delicious fruit in Pakistan and more than 150 varieties have been documented but many of the trees are unselected seedlings which are very diverse due to cross pollination. The most famous varieties are Sindri, Malda, Dosari, Chonsa, Anwar Retole etc. The maturity time of mango varieties varies from early June to late August or early September indicating wide diversity, which is a desirable character. Similar patterns of variability exist in citrus and guava etc.

More than 45 species of vegetables are grown in Pakistan. Due to market demand and non-availability of local seeds, the rate of genetic erosion has been very high in major vegetables like tomatoes, onions, peas, okra, brinjals, cauliflower, carrots, radish and turnips etc. The indigenous diversity is still found in cucurbits, bitter gourd, spinach, Lufa, *Brassica* spp., etc. Turmeric is indigenous to this region.

1.5 Fiber crops

The cotton (*Gossypium arboreum, G. herbasium*), sunhemp**, r**oselle, kenaf are the main indigenous fibre crops, the cotton having the dominant position with the introduction of *hirsutum* group. Cotton being the major cash crop is cultivated on a vast area and about 99% area is occupied by improved varieties. Some of the farmers grow on very small area the local landraces for their domestic use. Most of these cultivars have small fiber length and the lint is in different colours. As very little improvement work has been conducted in sunhemp, kenaf, and roselle, so most of the local land races are under cultivation. Jute is purely an introduction in Pakistan so most of the improved varieties have been acquired from Bangladesh.

1.6 Sugar crops

Sugarcane is the major sugar crop. At present, most of the indigenous cultivars have disappeared from farmers' field but under the National Coordinating Programme, more than 200 accessions either local or exotic are being maintained in field genebank. Two wild relatives' species of sugar cane (*Saccharum munja* and *S. spontaneum*) are fairly distributed as wild species in waste lands or along the water channels. All the sugar beet grown in Pakistan is exotic and improved varieties.

1.7 Fodder/underutilized crops

A variety of fodder crops belonging to *Poaceae* and *Fabaceae* are grown possessing a wide genetic diversity particularly for yield potential, ratooning ability and digestibility. The major fodder crops are maize, sorghum, millet, oat, clover, medics, cowpea, moth bean etc. Wherever there is agricultural land, fodder crops are also grown. Sometimes, grasses and legumes are inter-cropped. Some of the wild relatives to these crops are also available in various ecologies.

1.8 Minor crops

The minor or underutilized crops make an important contribution to the life of local communities and play an important role in alternative cropping systems, crop diversification, and development of value added products. Mostly these underutilized crop species are adapted to marginal lands. The genetic resources of these indigenous underutilized species face rapid destruction owing to erosion of traditional farming culture, change of traditional food habits and the introduction and adaptation of high yielding crops. Some of the minor crops include; Guar (*Cyamopsis tetragonoloba*), Mothbean (*Vigna acontifolia*), Grasspea (*Lathyrus sativus*), Fenugreek (*Trigonella foenum-graecum*), Liquorice (*Glycycyrrhiza glabra*) etc. As very little crop improvement work has been conducted, so most of the local landraces are available expressing a significant genetic diversity. The local selections by farmers and environmental adaptations have created superior genotypes.

1.9 Minor fruits

The Hindu-Kush Himalayan region of Pakistan is very rich in fruit and nut biodiversity as a result of the wide range in climate. The major fruit species cultivated include apples, apricots, peaches, plums, and walnuts. Besides these, there are a number of other minor or neglected species and wild relatives of many fruit species. Some species may have less significance in the present economy of the region, but genetically could be very important for future breeding programmes.

1.9.1 Pome fruit diversity

The minor pome fruit species growing in the region are listed in Table 4. They include *Pyrus pashia*, *Malus domestica*, *Cydonia oblonga*, *Sorbus lanata*, *S. tianshanica*, *Crotaegus songarica*, *C. affinis*, *C. intergerrima*, *Cotoneaster lindlegi*, and *C. nummularia*. *Pyrus phasia* (wild pear) occurs at elevations between 750 and 2 500 m together with *Pistacia chinesis* and *Diospyros lotus*. The fruits of wild pear are 1-2 cm long and brown with conspicuous white raised lenticels. The domestic apple (*Malus domestica*) is planted widely and produces small to medium-sized early maturing fruits. *Cydonia oblonga* (quince) is not distributed widely in the region and the type of fruit found in the area is bitter. People use the fruit cooked, boiled and preserved in sugar, and for medicinal purposes. Sorbus (*Sorbus lanata*) occurs at elevations of 2 000 - 3 600 m. The fruit is round, two to four cm in diameter, and orange with a heavy red blush flesh. The soft fruit is edible and sweet. The fruit can be kept for one month after harvesting. Carteagus (*Cartaegus songarica*) is known locally as Cochina in Kohistan, Shinjuli in Kaghan, *Gooni* in Chitral, and *Singjary* in Pushtoo. It is common in cultivated areas of Balochistan, the Kurram Valley, Chitral, Swat, Astore, Gilgit, Hazara, the Murree hills, and Kashmir at elevations of from 925-2 800m. The mature fruit hangs on the tree for several months. As well as being grown for its fruit, *Cartaegus songarica* is also used as root stock for quince and apple. Local knowledge suggests that the root stock is resistant to root rot. The *Cotoneaster genus* is represented in the region by *C. affinis*, *C. integerrima*, *C. lindleyi*, and *C. nummularia*. *C. affinis* is found associated with *Pinus gerardiana*, *Cedrus deodara*, *Ulmus*, and *Pyrus pashia* at altitudes of from 1 100-3 000 m, whereas *C. integerrima* is found at altitudes of from 2 200-4 000 m. All four Cotoneaster species have ornamental value and the fruits are edible.

TABLE 4
Minor fruit crop resources of the Pakistan mountains

Latin Name	English Name	Local Names
Pome fruits		
Pyrus pashia	Wild pear	Batanji, tanchi khapa
Malus domestica	Domestic apple	Chotta, shird
Cudpmoa oblonga	Quince	Behi, chator, charoll
Sorbus lanata	Sorbus	Tameez
Sorbus tianshanica	Sorbus	-
Cartaegus songarica	Cartaegus	Chochina sinjay
Cotoneaster affinis	Cotoneaster	Bedour, kabeshoo
Cotoneaster integerrima	Cotoneaster	-
Cotoneaster nummularia	Cotoneaster	-
Stone fruits		
Prunus cerasioides	Wild cherry	-
Prunus jacquemontii	-	Jikhn, mabheen
Prunus prostrata	-	-
Prunus cornuta	Himalyan bird cherry	Burris, parrt
Prunus cerasus	Pie cherry	-
Prunus mahaleb	Mahaleb cherry	-
Prunus tomentosa	Korean cherry	Shogun
Prunus cerasifera	Myrobalan plum, cherry plum	Alucha
Other fruit tree species		
Diospyros lotus	Date plum	Amlok
Ficus carica	Fig	Anjir
Ficus palmate	Wild fig	Jangli anjir
Morus alba	White mulberry	Toot
Morus nigra	Black mulberry	Shahtoot
Morus serrata	-	Toot
Olea ferruginea	Indian olive	Kao

Latin Name	English Name	Local Names
Zizyphus spp.	Jujube	Ber, anab, markhanay, singli
Tree nuts		
Corylus jacquemontii	Wild Hazelnut	Mazeer, jangli badam
Pistacia atlantica	Wild pistachio	Toke
Pistacia chinesis	Wild pistachio	Shinala, kangar
Pistacia khingjuk	Wild pistachio	Saveer, khakaon
Prunus bucharica	Wild almond	Jangli badam
Prunus macilentus	Wild almond	Jangli badam
Small fruits		
Duchesnea indica	Indian straw	-
Frageria nubicola	Wild strawberry	Magaroos
Ribes alpestre	Asia gooseberry	-
Ribes orientale	Wild currant	-
Rubus anatolicus	Wild blackberry	Kanachi, karwara
Rubus ellipticus	Golden raspberry	Guracha
Rubus hoffmeisterianus	Wild raspberry	Rumu
Rubus irritons	Wild red raspberry	Rutuch
Rubus macilentus	Wild yettlow raspberry	-
Rubus niveus	Black raspberry, mysore raspberry	Buganray, bukaran
Grapes and related species		
Ampelopsis vitifolia	Crow's grape	Kawali yatch, grabuch
Vitis jacquemontii	Wild grape	Gidar kwar (jackal grape)
Vitis parvifolia	-	Kali dhak
Vitis vinifere	Wine grape	Angoor

1.9.2 Stone fruit diversity

Stone fruits in Pakistan mountains are represented by 12 species, excluding almonds. These include four wild and naturally occurring species of cherry (*Prunus cerasioides*, *P. jacquemontii*, *P. prostrata*, and *P. cornuta*). Seven species of *Prun us* apart from sweet cherry (*Prunus avium*), which is a recent introduction, have been introduced into this area at different times in human history. *Prunus cerasioides* is very rare because the region lies at its western limit of distribution. Its distribution (up to 800m) indicates that it has low chilling requirements and is resistant to stone fruit diseases. It produces small, acid fruits and may be useful as a rootstock. *Prunus jacquemontii* is distributed widely from Balochistan to Chitral, Gilgit, and Kaghan at elevations of between 1 250 and 3 700m. Although this species is exposed to heavy grazing, it is still quite common in the wild. Its produces usefully be explored as a dwarfing root stock for cherries. *Prunus prostrata* is a spreading shrub and subjected to heavy grazing. The fruits are very small and inedible. It is found on open, rocky, dry and sunny slopes. It may be a valuable ornamental because its flowers and the nature of its occurrence. The Himalayan bird cherry (*P. comuta*) is common in moist, temperate regions at elevations from 2 100-5 700m. Although frequently lopped, it is found in the Kaghan Valley because the fruits are edible. It has good compatibility as a root stock for sweet cherry. *Prunus cerasus* (pie cherry) and *P. mahaleb* (Mahaleb cherry) are introductions in this area, most probably brought in by the British as a root stock for sweet cherry or as ornamentals. Both these species are rare. *Prunus tomentosa* (Korean cherry) is cultivated for both ornamentation and for its edible fruits. *Prunus cerasifera* (Myrobalan plum) is distributed widely throughout northern Pakistan at altitude of from 500 - 2 300 m. It is called alucha everywhere. The fruits are edible, 2 - 2.5 cm in diameter, and available in the market from May to mid-July. Other species of stone fruit such as *Prunus salicina* (Japanese plum), *Prunus persica* (peach), and *Prunus armeniaca* (apricot) are considered as the major fruit tees in this area.

1.9.3 Tree nuts

Walnuts and almonds (*Prunus dulcis*) are cultivated tree nuts of economic importance to local communities. In addition to these, three species of Pistacia, two species of wild almond, and the hazelnut *Corylus jacquemontii* all grow in this area. Three wild species of Pistacia (*P. atlantic*, *P. chinesis*, and *P. khinjuk*) grow on dry rocks, in rock clefts, and in places inaccessible to people. *Pistachia chinensis* is mostly found in graveyards together with wild olives. The two species of wild almond are *Prunus bucharica* and *P. kurminica* (almond). *Prunus bucharica* is very rare, *P. kuramica* grows in the Kurram Valley and in Chitral on dry slopes. Because these species have small trees and are found in areas where there is extreme drought, they may be valuable as root stock for cultivated almonds. Filberts or hazelnuts (*Corylus jacquemontii*) are found in the moist forests of the Kalam Valley, but trees are rare.

1.9.4 Diversity and importance of other fruit tree species

Other minor fruit species occurring in the northern mountain area of Pakistan are list in Table 4. These species have significant economic importance to local people, either for income or as food. Two species of mulberry (*Morus*) are found widely distributed in the area. *Diospyros lotus* (date plum) is cultivated widely by villagers in the hills at altitudes of between 750 to 2 100 m. Small fruits are dried and sold in the market and seedlings are also used as root stock for *D. kaki* cultivars. The wild fig, *Ficus palmate*, is also common in hill areas. These trees produce small fruits that are edible. This species also has good attributes as a root stock for commercial figs.

Among the small fruits, there are two wild species of strawberry, three species of gooseberry, one species of blackberry, and five species of raspberry native to the area. However, the diversity of these species is threatened by overgrazing of their habitats.

1.9.5 Diversity of grapes and their wild relatives

There are three wild grape species in the area: *Ampelopsis vitifolia*, *Vitis jacaquemontii*, and *Vitis parvifolia*. *Ampelopsis vitifolia* is found in Chitral, Swat, Kohistan, Hazara, and Muzaffarabad at elevations of from 900 to 2 400 m growing either in moist gullies or in regions with substantial rainfall. *Vitis jacquemontii* is found in Swat, Hazara, and Azad Kashmir at elevations of between 600 and 2 400 m. The vines are vigorous and climb up trees or hang over river banks. The fruits are edible. *Vitis parvifolia* is found growing in gullies in Swat, Hazara, and Azad Kashmir.

1.10 Future needs and priorities

The meet the local demands and competitiveness in international trade, there is need to diversify crops with major emphasis on high value crops like fruits, vegetables, medicinals and oilseed, etc. the exploitation of under-utilized crops particularly adopted to marginal lands need serious consideration, It demands creating awareness of under-utilized crops in human nutrition, but also their role in sustainable agriculture and their role in international trade.

The under-utilized species may be local staples or collected (wild) but are considered as minor species but have high potential. They mitigate seasonal shortages of major crops and are used in inter cropping or mixed cropping systems, and require little inputs. These are less susceptible to biotic and aboitic stresses. Despite the important role of underutilized crops in the life of local communities, there have been little efforts in preserving their germplasm and crop improvement. The Plant Genetic Resources is presently executing two projects funded by Southampton University and Agriculture linkage Program of Pakistan Agricultural Research Council mainly with collection and characterization of their germplasm. More efforts are needed to expand germplasm collections, crop improvement, appropriate production technologies, open marginal lands for cultivation and diversify present cropping patterns. The Government of Pakistan is keen to improve to conserve that valuable germplasm and minimize their genetic erosion as is evident from the list of projects being executed and present in Annexure of the report.

The Biodiversity Action Plan (BAP) for Pakistan was approved by the Government of Pakistan in 1998 which was prepared by Ministry of Environment, IUCN, WWF involving various other stakeholders. This action plan sets out a strategy for action under 13 main components which includes planning and policies, legislation, identification and monitoring, *in situ* conservation, *ex situ* conservation, sustainable use, incentive measures, research and training, public education and awareness, environmental impact assessment, access issues, exchange of information, and financial resources. For each component, the issues relevant to Pakistan have been identified and list of objectives and corresponding actions

are recommended to deal with the identified issues. Slowing the rate of biodiversity loss in Pakistan requires institutional strengthening to better understand the elements of biodiversity and the effective means for ensuring the conservation and sustainable use of these elements. The active participation and support of the local communities will be essential for *in situ* conservation.

CHAPTER 2

THE STATE OF *IN SITU* MANAGEMENT

Plant genetic resources for food and agriculture need protection to sustain mankind and environment. Some of these resources belong to wild plant species that are used by human communities for direct food production and other to wild relatives of crop species which are an important source of genes for crop improvement. One of the best ways for their conservation is to protect segments of a particular ecosystem so that various species in them are preserved *in situ*. Establishing and managing a network of protected areas is the key element in conservation of wild relatives of cultivated plants. Many important species could not survive in their natural environments without these protected areas. In Pakistan, there are 233 protected areas; 19 national parks, 98 wildlife sanctuaries, 102 game reserves and 14 unclassified (private, proposed or recommended.) The total protected areas in Pakistan are 7.24 million ha. which is 9% of the total land area. There is one Biosphere Reserve (Lal Sohanra National Park). Nine wetlands have been designated under the Ramsar Convention. The composition of protected areas system in Pakistan is as follows:

TABLE 5
Composition of protected areas system in Pakistan (WCMC 1998)

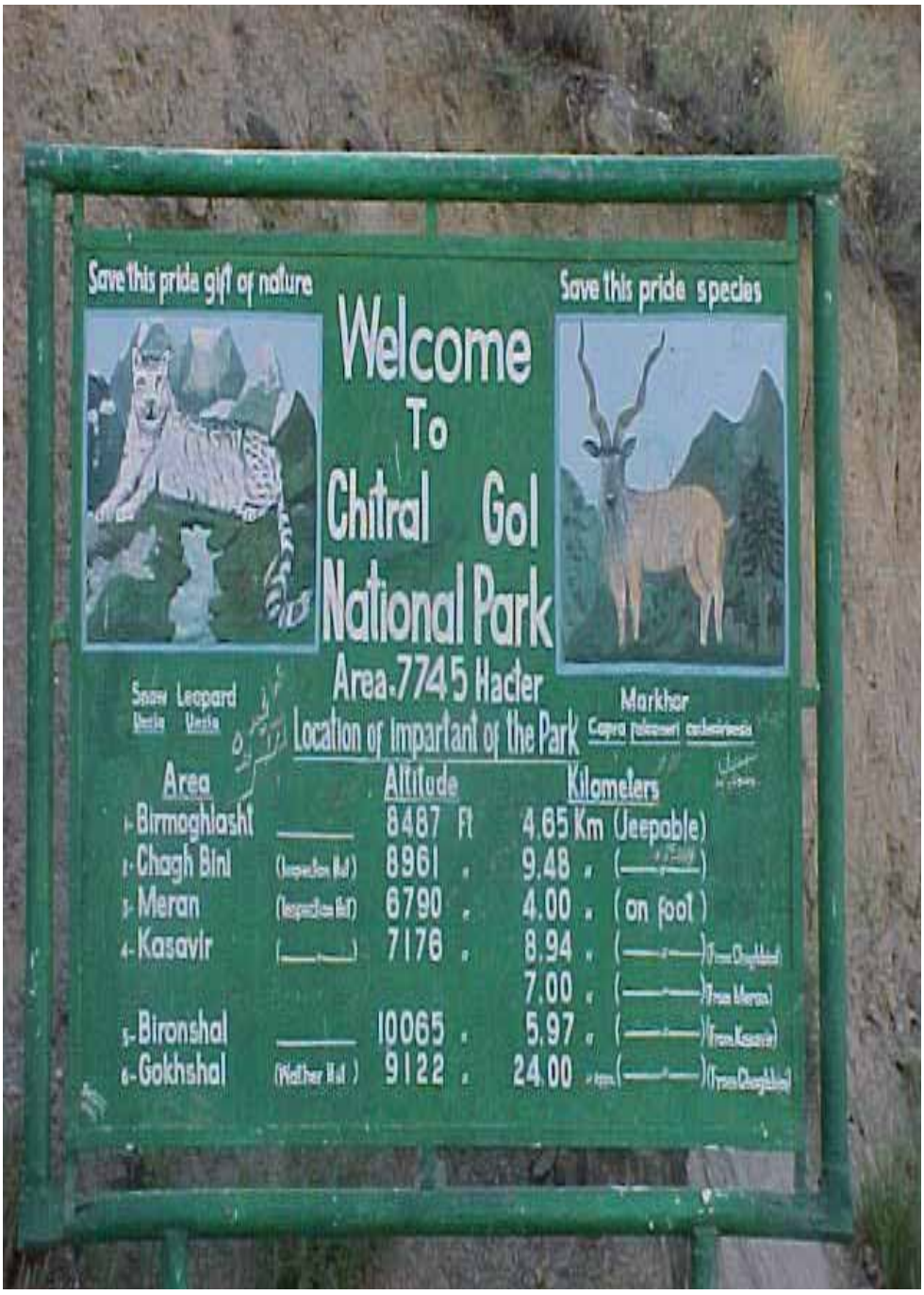
Category	Number	Area (ha)	Percentage of total area
National Parks	19	954 246	1.2
Wild Life Sanctuaries	98	2 749 054	3.4
Game Reserves	102	3 535 284	4.4
Unclassified	14	-	-
Total Protected Areas	**233**	**7 238 584**	**9.0**

Due to more awareness and their importance in conservation of biodiversity, 10 national parks out of 19 have been established during 1993 to 2006. Now Hazara University located at Dudial in North West Frontier Province is planning to establish a biosphere reserve in the vicinity of the University.

- **National Parks:** A national park is an area set aside by the Government for the protection and preservation of its outstanding scenery, flora, and fauna in a natural state. It is accessible to public for recreation, education and research. To facilitate public use and recreation, access roads, construction of rest houses, and hostels are permitted. Forests and other flora in national parks may be managed and forest products obtained provided these activities do not damage natural ecosystem. Firing of any firearm, polluting water, cleaning of land for cultivation, disturbance of wild life or their breeding places is prohibited in national parks which help in the conservation of biodiversity including wild relatives of crop plants.
- **Lal Sunhara Park** was the first national park of Pakistan which was established in district Bahawalpur of Punjab province. The main purpose of the park was to protect the flora and fauna of Cholistan desert, a home of many desert species.
- **Khirtar National Park** was created in 1974 near Karachi in Sindh Province. This park provides protection to wildlife as well as flora in coastal areas.
- **Khunjerab National Park** was created in 1975 in Northern Areas of Pakistan near border with China. This area is a place for many native species particularly wild relatives of crops and some minor fruits. This area is characterized to have temperate flora. Management plan of this park has been developed with the help of WWF- Pakistan for the better protection of wild species. In this plan, incentives have been proposed for the local people to reduce the pressure on natural flora and fauna.
- **Margalla Hills National Park** was established in 1980 near the Federal Capital, Islamabad. This area has a mixed vegetation of subtropical and temperate type. It is one of the best managed parks and flora of the area is well protected.
- **Hazaraganji Chiltan National Park** established in 1980 near Quetta in Balochistan Province to preserve the

biodiversity of cool deserts. This area is characterized to have two wild relatives' species of wheat namely *Aegilops squarrosa* and *A. tricuncialis* and many other species of importance.

- **Ayubia National Park** has been established in 1984 in district Abbottabad of NWFP province. The area has moist temperate vegetation and serving as an important spot for *in situ* conservation of flora and fauna. This park is rich in floristic diversity.
- **Chitral Gol National Park** was also established in 1984 near Chitral in NWFP with an area of 49 480 ha. The particular flora of dry temperate forest in preserved along with other wild life. This area provides a habitat for the conservation of many wild fruit species including grapes, walnuts, Rubus, Prunus spp. etc.
- **Chinji National Park** was established in 1987 in district Attock of Punjab. The area is characterized to have sub tropical vegetation with many plant species of significance.
- **Shiekh Buddin National Park** was established in 1993 in NWFP with an area of 15 537 ha. aiming to protect the flora and fauna of the ecosystem.



- **Handerab – Shandur National Park** was established in 1993 over an area of 51 800 ha. in Northern areas. It is located between Gilgit and Chitral and is a place of important flora and fauna. Temperate vegetation is characteristic of the area.
- **Deosai National Park** was also established in Northern Areas over an area of 363 600 ha. in 1993 in Deosai Plateau between two of the major mountain ranges of the world i.e. Karakoram and Himalayas at an elevation ranging from 3 400 to 4 300 m, with some points reaching to 5000 m.
- **Central Karakoram National Park** was established in 1993. K-2 the second highest peak of the world (8611 m) is the central point of the park. Spreading over an area of 10 000 sq.km, the park encompasses many peaks and glaciers.
- **Machiara National Park** was established in 1996 in district Muzaffarabad of Azad Jamu and Kashmir. It covers an area of 13 355 ha. conserving the biodiversity.
- **Hingol National Park** was established in 1997 in Balochistan which is spread over the districts of Lasbela, Awaran, and Gwader, covering area of 6, 19 043 ha. Hingol river runs through the park and forms estuary at the point of entrance in the sea providing habitat to a number of species.
- **Saiful Maluk National Park** has been established in 2003 in NWFP Province with an area of 4 867 ha.
- **Laluser National Park** has also been established in 2003 in NWFP Province over an area of 30 375 ha.
- **Toli Pir National Park** was notified in 2005 in AJK with an area of 1 000 ha.
- **Pir Lasura National Park** was also notified in 2005 in AJK with an area of 1 580 ha. Necessary infrastructure is being developed for these two parks.

On-farm conservation of landraces of crop plants is another approach for *in situ* conservation which is difficult to manage in case of annual crops as new and improved varieties are a continuous threat for their erosion. In remote valleys of northern areas, NWFP and Balochistan, where improved varieties have not been developed for these particular ecologies (low temperature, cold water and drought), the farmers yet grow local land races of rice in Chitral and drought resistant wheat in Balochistan and Northern Areas.

Regarding the *in situ* conservation of fruit plants, the situation is much better due to cultural, socio-economic factors and few incentives. The Horticulture Department/Board organizes exhibitions for various fruit plants like mango, dates, citrus, etc. These exhibitions encourage the farmers to conserve maximum number of clones. During mango shows, more than 250 varieties/clones are displayed. The number of clones/cultivars in dates and citrus are not less than 150. In northern areas, the farmers have selected promising clones of apricot, grapes, peach and walnuts. The awareness created by various government agencies/NGOs is also playing a vital role for *in situ* conservation of crops, fruit and nut genetic resources in Northern Areas. During our phyto-geographic survey of northern areas for fruit and nuts, the information on the extent of diversity available was collected. The local communities were found keen to preserve the genetic resources due to their local preferences and adaptability.

The preparation of inventories and surveys of plant genetic resources and associated biodiversity is essential for better management of *in situ* and *ex situ* conservation. The Herbaria located at National Agricultural Research Centre; University of Karachi; Quaid-e-Azam University, Islamabad; Pakistan Forest Institute; Pakistan Museum of Natural History are deeply involved in preparation of inventories on floral biodiversity. An "Annotated Catalogue of the Vascular Plants of Pakistan" has been published. The above mentioned herbaria are regularly surveying and monitoring the floral biodiversity. During 2006 and 2007, the Higher Education Commission has provided necessary funds to University of Peshawar and University of Khairpur to establish botanical gardens and herbaria. These institutes will also be involved in surveying and preparation of inventories.

The on-farm management of crop genetic resources is difficult to handle as there is need of incentives for farmers, creation of awareness about the role of biodiversity in their daily life. It could only be achieved by participation of local communities, creating interest in local genetic resources and organizing exhibitions at regional level. Although at present on-farm participatory plant breeding does not exists but some of the crop commodity programmes have started thinking on it. Local or small scale seed production systems are important for *in situ* conservation of crop biodiversity. Although there are not well established systems but small farmers particularly women are playing an important role. They want to have the cultivars of their interest due to social and cultural preferences particularly in minor and under-utilized crops. The Ministry of Food, Agriculture and Livestock is implementing a development project to establish markets for these species and their products particularly of medicinal plants. The *in situ* conservation of wild relatives of crop plant has been identified as a priority which is partly being managed through the establishment of National parks, and forest reserves. At present the major limitation is the non-availability of trained manpower and resources to manage these parks.

CHAPTER 3

THE STATE OF *EX SITU* MANAGEMENT

3.1 The state of collections

The systematic collection and conservation activities in Pakistan were started in early seventies with the approval of a small project under PL480 "Collection of rice germplasm". The need for genetic conservation and plant exploration was strongly felt during this period due to the introduction of improved varieties and changes in the agricultural land use etc. In 1978, Pakistan Agricultural Research Council initiated a program entitled "Exploration, Collection, Conservation and Evaluation of Plant Genetic Resources". Under this programme, a small genebank for short-term storage and a laboratory was established at National Agricultural Research Centre (NARC), Islamabad. In 1993, a decent facility for germplasm storage and associated research was established at NARC with the financial support from Japan International Cooperation Agency (JICA). This facility comprises of genebank for active and base collections and six laboratories for Exploration & Collection, Seed Conservation, *In vitro* Conservation, Germplasm Evaluation, Plant Introduction & Seed Health and Data Management. All laboratories are well equipped with very sophisticated equipments. In addition to the above there are six glass houses, seed threshing/processing room, soil sterilizer, plant incinerators/pesticide store and two standby electric generators.

The Plant Genetic Resources Institute (PGRI) of PARC/NARC has undertaken fifty seven plant collecting expeditions in different agro-ecological region of the country in collaboration with national coordinated commodity programmes and International Agricultural Research Centres (IARC) (Annexure-I). The genebank maintains more than twenty three thousand accessions of which about 80% are of local origin (Table 6). Asexually propagated crops are being preserved using *in vitro* techniques and recently *Cryo-preservation* is being initiated for long-term preservation of vegetative crops. At present collection of vegetables and oilseed crops for preservation prior to extinction is main focus of PGR Programme. With the recognition of importance for underutilized/minor and medicinal crops, these have also been included recently in collection and preservation agenda. The major crops, i.e., wheat, rice, chickpea, maize, sorghum, oilseeds and millets have been intensively collected from areas with high genetic diversity. Along with local cultivars, the wild relatives of wheat (*Aegilops squarrosa* and *A. triuncialis*), chickpea (*Cicer macranthum* and *Cicer microphyllum*), barley (*Hordeum spontaneum*) and various wild relatives of pomes, stone fruits and tree nuts have been collected. Since1996, significant progress has been made in collection and conservation of germplasm. Almost 6 000 accessions of different crops and medicinal plants have been added in the entire gene pool.

TABLE 6

Status of Genebank at Plant Genetic Resources Programme

S. No.	Crops	Accessions	Total
	Cereals:		**10 312**
1-	Wheat (*Triticum aestivum*)	2 767	
2-	Durum wheat (*Triticum durum*)	207	
3-	Wheat (Wild species)	130	
4-	Barley (*Hordeum vulgare*)	1 274	
5-	Oats (*Avena sativa/fatua*)	540	
6-	Rice (*Oryza sativa*)	2 957	
7-	Maize (*Zea mays*)	545	
8-	Sorghum (*Sorghum bicolor*)	866	
9-	Millets (*Pennisetum glaucum*)/related spp.	1 007	
10-	Buckwheat (*Fagopyrum)esculentum*	19	
	Food Legumes:		**5 290**
11-	Chickpea (*Cicer arietinum*)	2 243	
12-	Chickpea (wild cicer)	90	
13-	Lentil (*Lens culinaris*)/its wild relatives	808	
14-	Mungbean (*Vigna radiata*)	643	
15-	Mashbean (*Vigna mungo*)	799	
16-	Cowpea (*Vigna unguiculata*)	212	
17-	*Lobia* (*Phaseolus vulgaris*)	109	
18-	*Vicia* species	172	
19-	Moth (*Vigna acontifolia*)	66	
20-	Matri (*Lathyrus speceis*)	148	

S. No.	Crops	Accessions	Total
	Oilseeds:		**3 139**
21-	Oilseed *brassica*	1 003	
22-	Groundnut (*Arachis hypogaea*)	754	
23-	Soybean (*Glycine max*)	133	
24-	Sunflower (*Helianthus annuus*)	143	
25-	Safflower (*Carthamus Tinctorius*)	362	
26-	Sesame (Sesamum indicum)	073	
27-	Cotton **(**Gossypium hirsutum**)**	671	
	Others:		**4 981**
28-	Fodder & forages	341	
29-	Fibre crops	357	
30-	Vegetables	1 481	
31-	Fruits	1 024	
32-	Medicinal plants	1 778	
G.Total:			**23 722**

For systematic collection of germplasm, carefully designed plans are made in the light of importance of the plant species. In our collection plans, the emphasis is given to remote valleys located away from the main roads. Most of the collections in PGRI are made through coarse grid sampling i.e. by taking random population samples at wide intervals. In certain cases, the collections are made from orchard and kitchen gardens because the genetic diversity here is very high, and has hardly suffered from genetic erosion.

3.2 Storage facilities

Plant Genetic Resources Programme has two types of conservation facilities i.e. Active collection and Base collection. These two types of collection/storage complement each other. Genebank has the capacity to accommodate 60 000 seed samples of 500 g each. The seeds are stored at 5°C and 40 % relative humidity in active collection, at 0°C for mid term storage and -18°C for original samples (base collection).

Most of the Institutes maintain short – term collection for the breeding purpose. However, Central Cotton Research Institute, Multan and Rice Research Institute, Kala Shah Kaku, Lahore maintains short – term seed gene bank of cotton and Rice, respectively.

3.3 *In vitro* conservation

The *in vitro* conservation activities in PGRI are related to conservation of vegetatively propagated crops which cannot be conserved as seed either due to their heterogeneity or recalcitrant behavior. *In vitro* technology is important for conservation as well as for disease elimination, true-to type, large scale production capacity and ease in international exchange. The emphasis is given on slow growth culturing techniques at lower temperature or the application of growth retardant in culture media. The major emphasis is being given on research to develop appropriate methods of conservation for sugarcane, sweet potato, apricot, grapes and banana. Knowledge of basic tissue culture requirements, especially the conditions for highest rate of propagation are very important prior to *in vitro* preservation of any plant species.

In vitro laboratory of PGRP has employed a variety of techniques for conservation of the germplasm of vegetatively propagated species namely grapes, peach, pear, sweet potato, banana and sugarcane that are economically high potential crops for sustainable development in agriculture. It is therefore logical to follow a systematic approach to germplasm conservation that essentially involves collection of plant germplasm from diverse ecologies, safe storage of germplasm under a variety of conditions to ensure longevity and then, revival studies after removal from the storage treatments. Germplasm collection, storage and data on such studies will bear long term and medium term benefits in plant research system of the country. A collection of these species has been acquired from local ecologies and exotic sources for establishment of the field gene bank and then in the *in vitro* gene bank of these clonally propagated species.

3.4 Field genebanks

The majority of fruit plant species cannot be preserved in the genebanks because either the seed cannot be preserved for long term storage or are heterogeneous. So to have true to type plants, fruit plant species are preserved in field

genebanks (clonal repositories) as clones. These field gene banks have a great value as they provide an instant access to the breeders for crossing purposes and selection of promising lines in variety evolution process through routine observations and evaluations of morphological characters based on rich sources of diversity.

Pakistan Agricultural Research Council (PARC) has started a project on the conservation and establishment of field genebanks for grapes, peach and pear. A field gene bank of grapes has been established at NARC comprising 188 accessions collected from different parts of the country. Provincial Agricultural or Horticultural Research Institutes have collected the selected cultivars of various fruit species and are maintaining them as clones in field genebanks. But systematic efforts for collection and conservation are yet too made. Some important field gene banks with selected clones are given in Table 7.

Field Genebanks (clonal repositories) as clones

TABLE 7

Germplasm conservation in field gene banks

Crops	Field gene banks
Dates	Date Palm Research Station, Jhang, Punjab. Date Palm Research Station, Kotdiji, Mirpurkhas, Sindh Date Palm Farm, Turbat, Balochistan. Horticulture Research Station, D.I. Khan, NWFP
Citrus	Citrus Research Station, Sahiwal, Punjab. Orange Research Station, Sargodha, Punjab. Agricultural Research Institute, Tarnab, Peshawar, NWFP.
Mango	Mango Research Station, Sujahabad, Multan, Punjab. Horticulture Research Institute, Mirpurkhas, Sindh
Apple	Agricultural Research Institute, Quetta, Balochistan. Agricultural Research Station, Mangora, NWFP Arid Zone Research Centre, Quetta
Grapes	Arid Zone Research Centre, Quetta. Agricultural Research Station, Sariab, Quetta, Balochistan. Agricultural Research Station, Sakardu, Northern Areas. National Agricultural Research Centre, Islamabad

Crops	Field gene banks
Apricot	Agricultural Research Institute, Sariab, Quetta, Balochistan. Karakorum Agricultural Research Institute for Northern Areas, Juglot, Gilgit.
Peach	National Agricultural Research Centre, Islamabad Karakorum Agricultural Research Isn't. for Northern Areas, Gilgit. Agricultural Research Station, Swat.
Pear	National Agricultural Research Centre, Islamabad Karakorum Agricultural Research Isn't. for Northern Areas, Gilgit Agricultural Research Station, Swat.
Zizyphus jujube	Horticulture Research Station, Bahawalpur. Agricultural Research Station, Tandojam.
Wild Cotton	Central Cotton Research Institute, Multan.
Sugarcane	National Agricultural Research Centre, Islamabad. Sugarcane Research Institute, Thatta. Sugarcane Research Institute, Mardan.
Olive	Barani Agricultural Research Institute, Chakwal.

3.5 Security of stored material

All possible efforts have been made to ensure safety and security of the germplasm stored in the gene bank. There is one backup and standby generator to ensure continuous power supply. The electric supply is routed through automatic voltage regulator to control the power fluctuation and for the safety of Lab. equipments. Fire extinguishers have been placed at various places. The gene bank building has been properly insulated. The construction, insulation and refrigeration standards conform to the design of seed storage facilities for Genetic Conservation to IBPGR 1982 specifications. Once the germplasm arrive at PGRI its health status is monitored and its germination & moisture contents are determined. Seeds are then dried, packed and sealed before it goes to the storage room. All these steps are in accordance with international standards. The PGRP has already duplicated its material for safety e.g. rice germplasm at International Rice Research Institute (IRRI), Philippine, wheat, barley & chickpea at ICARDA - Aleppo, Syria and vegetable, mung & mash germplasm at AVRDC, Taiwan. At present, PGRP do store countries approved varieties seed on behalf of Federal Seed Registration Department. The Program is collaborating with NIBGE, Faisalabad for cotton germplasm conservation. The PGRP collaborate with West Asia & North Africa (WANA) seed network and has accepted the responsibility of conserving all crop reference seed samples.

3.6 Documentation

The documentation of plant Genetic Resources is of paramount importance for utilization and retrieval of information pertaining to crop species and play is a key role in the management of Genetic Resources Information (GRI). The documentation laboratory has computerized genetic resources information/collection data with thirty to forty parameters to establish plant genetic resources information database. Softwares of dBase-IV, FoxPro and Excel were previously used to maintain the current database. Therefore, a Database System was designed and developed (using MS Access) on Plant Genetic Resources Information to maintain the Database properly. Accessions of different crop species preserved in the gene bank have been documented using their passport data.

The following catalogues have been published and distributed to the breeders and libraries.

- Plant Germplasm Catalog – 1997. It gives the passport information on 15 000 accessions preserved in the gene bank.
- Plant Germplasm Catalog-2003. It gives passport information on 19 000 accessions preserved in the gene bank.
- Wheat Germplasm Catalog. It has information on evaluation data for various morphological characters as well as passport information on wheat germplasm in the gene bank.
- Barley Germplasm Catalog. This catalog contains evaluation data along with passport data of barley germplasm.
- Mash Germplasm Catalog. This catalog contains evaluation data of 484 accessions alongwith passport data of 595 accessions.
- Mungbean Germplasm catalogue. This catalog contains evaluation data on 529 and passport data on 672 accessions
- Cowpea Germplasm Catalog. It has information on passport data on 192 accessions.
- Germplasm catalogue on Medicinal Plants: It gives the information on 1700 accessions of medicinal plants collections in the Genebank.

Some of the information on plant germplasm is also available on PARC Website (www.parc.gov.pk).

3.7 Characterization and evaluation

Characterization and evaluation is vital for plant genetic resources activities related to collection and conservation before its utilization. It helps to estimate geographical distribution of genetic diversity to plan future exploration missions. Characterization is important to eliminate duplications, isolate different variants from the same accession and to establish a core collection. The practical feature of germplasm evaluation is its importance in utilization. The extent of genetic diversity in germplasm for morphological, agronomic, biochemical and molecular markers helps in planning breeding programme for crop improvement. Screening of germplasm against various biotic and a-biotic stresses is a pre-requisite to develop plant varieties adaptable to stress conditions.

Almost 70% germplasm of cereals and 95% of legumes have been evaluated for various agro-morphological and genetic traits. Lines moderately tolerant to salt and leaf folder (*Cnaphalocrocis medinalis*) in rice, early maturity and short stature in barley, good quality with 5+10 and 2+12 allelic combination in wheat, powdery mildew resistance in pea, and tolerant to mungbean yellow mosaic virus in mung and mash have been identified for utilization in the breeding prog. Detailed evaluation against biotic and abiotic stresses is being carried out and will remain the major future thrust. SDS-PAGE, Isozyme, and DNA analyses have been used to evaluate genetic diversity in different crop species. Several graduate students have completed their thesis research.

During characterization and evaluation, three steps are performed: (1) Characterization and preliminary evaluation which is a record of characters in the field, viz morphological traits and maturing dates and it is mostly done according to IPGRI descriptors, (2) Detailed evaluation based on agronomic characters viz; resistance to biotic and a-biotic stresses; (3) biochemical evaluation which examines the specific characters required for breeding. Electrophoretic analysis of seed proteins and DNA are the major techniques used for this type of evaluation. Field evaluation and multiplication are often performed at the same time. The germplasm preserved in the gene bank is periodically regenerated. About 15% accessions of different crops need to be regenerated within a year whereas 40% accessions in need of regeneration within next five years.

3.8 Field evaluation

Germplasm characterization is the most important part of any germplasm system. As most of the crops stored in the genebank can be grown is Islamabad either as summer or winter crops, the characterization is mostly conducted at Islamabad (33.40 °N and 73.07 °E). The characterization work is mostly conducted according to IPGRI descriptors of various crops. The main purpose of characterization is to identify the extent of genetic diversity which may be useful to the breeders. During the process of characterization, the isolation of pure genotypes from population samples is also conducted. Evaluation and characterization of medicinal plant species and underutilized crops is another priority area. The characterization and evaluation work conducted for various crops is given in Table 8.

TABLE 8
Characterization and evaluation of genetic resources

S.No.	Crop	No. of Accessions	No. of Traits
1-	*Oryza sativa*	1 374	14
2-	*Sorghum bicolor*	860	18
3-	*Hordeum vulgare*	1 400	12
4-	*Zea mays*	648	13
5-	*Cicer arietinum*	1 004	14
6-	*Triticum durum*	192	21
7-	*Brassica* spp.	121	15
8-	*Triticum aestivum*	2 490	21
9-	*Glycine max*	133	20
10-	*Setaria italica*	50	05
11-	*Pennisetum glaucum*	194	20
12-	*Fagopyrum esculentum*	19	05
13-	*Lycopersicon esculentum*	70	20

S.No.	Crop	No. of Accessions	No. of Traits
14-	*Raphanus sativus*	47	23
15-	*Pisum sativum*	223	23
16-	*Ablemoschus esculentus*	34	33
17-	*Lens culinaris*	423	08
18-	*Vigna mungo*	570	21
19-	*Vigna radiata*	660	18
20-	*Vigna unguiculata*	173	31
21-	*Nigella sativa*	98	05
22-	*Linum usitatissimum*	100	04
23-	*Plantago ovata*	98	14
24-	*Sesamum indicum*	176	14
25-	*Foeniculum vulgare*	98	10
26-	*Cichorium intybus*	46	05
27-	*Trigonella foenum-graecum*	34	08
28-	*Anethum graveolens*	37	06
29-	*Trachyspermum ammi*	60	07
30-	*Ocimum* sp.	27	17
31-	*Ricinus communis*	33	15
32-	*Coriandrum sativum*	33	14
33-	*Vernonia anthelmintica*	43	06

3.9 Molecular/biochemical evaluation

Molecular/biochemical techniques including seed proteins and DNA finger printing etc. are widely used due to validity and simplicity for describing genetic structure of crop germplasm. The genetic resources evaluated using molecular/ biochemical markers are given in Table 9. Genetic diversity based on qualitative and quantitative traits along with molecular markers is useful in gene bank management and planning experiments that facilitates efficient sampling and utilization of germplasm either by identifying and/or eliminating duplicates in the gene stock ultimately resulting in the development of core collection.

TABLE 9
Molecular/biochemical evaluation

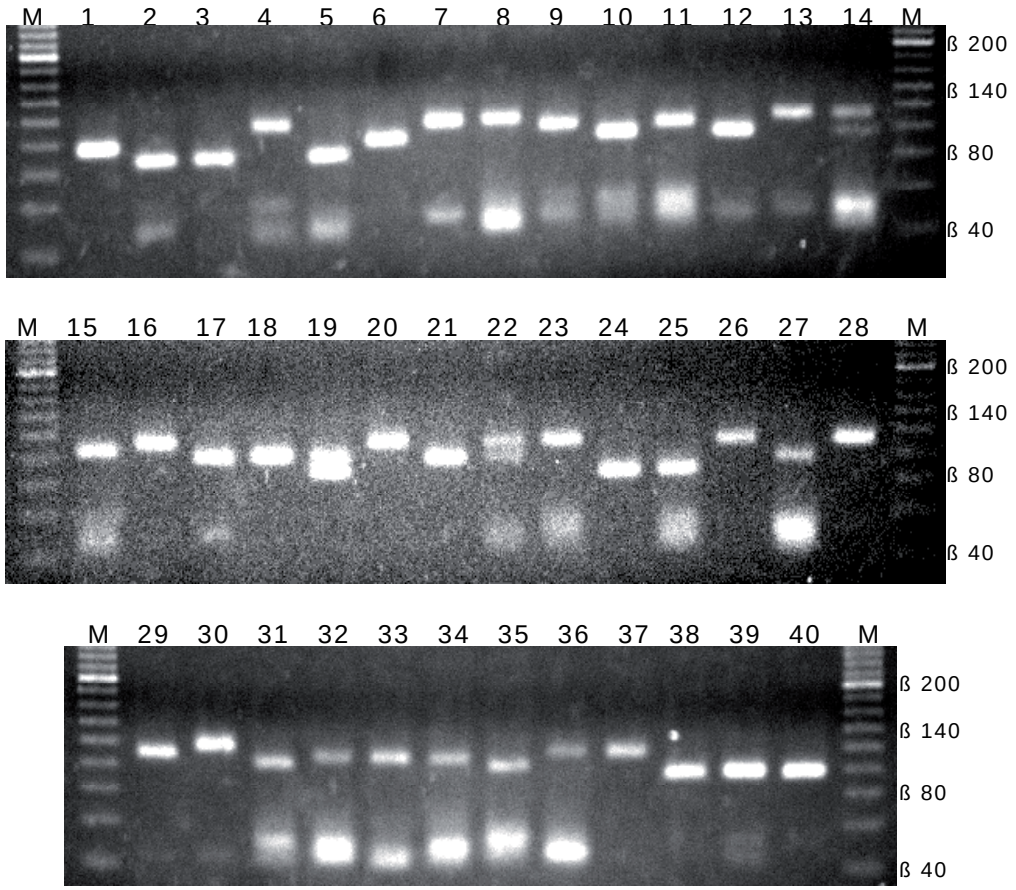
S.#	Crop	No. of Accessions	Technique used
1-	Buck wheat	19	SDS-PAGE
2-	Chickpea	10	Isozyme
3-	Cotton	13	Isozyme
4-	Cowpea	138	SDS-PAGE
5-	Lentil	166	SDS-PAGE (120), Isozyme (36), DNA-RAPD (10)
6-	Mash	321	SDS-PAGE (311), 2-D Protein Analysis (10)
7-	Matri	12	SDS-PAGE
8-	*Medicago* spp.	168	SDS-PAGE
9-	Okra	39	SDS-PAGE
10-	Peanut	151	SDS-PAGE
11-	Peas	73	SDS-PAGE
12-	Rice	440	SDS-PAGE (350), RAPD(50), SSR (40)
13-	Soybean	161	SDS-PAGE
14-	Vetch	12	SDS-PAGE

S.#	Crop	No. of Accessions	Technique used
15-	*Vigna* spp.	300	SDS-PAGE
16-	Wheat	443	SDS-PAGE (418), 2-D Protein Analysis (5), RAPD (20)
17-	Wild wheat	42	SDS-PAGE
18-	Kalongi	34	DNA-RAPD
19-	Methray	34	SDS-PAGE
20-	Sowa	37	SDS-PAGE
21-	Tulsi	10	SDS-PAGE
22-	Arind	33	SDS-PAGE

The SDS-PAGE conducted for various crops indicated that 7.5% acrylamide gel concentration gave high resolution in banding patterns of cereal, whereas for most of the legumes (*Cicer, Lens, Vigna, Pisum, Glycine,* etc.) 11.25% gel exhibited high resolution. Some of the medicinal plant species were also subjected to SDS-PAGE analysis. Molecular characterization studies carried out in Pakistan on some important crops have provided insight into the extent and distribution of genetic diversity. Figure 1 presents genetic variation among rice (*Oryza sativa)* cultivars using microsatellite markers. The SDS-PAGE has been conducted for studying genetic diversity in wheat, rice, sorghum, mungbean, blackgram, cowpea, peas, *Nigella sativa*, *Trigonella foenum-graceum*, *Ocimum sanctum*, *Anethum graveolens* and *Ricinus communis* that revealed low to medium levels of genetic diversity for seed proteins. Specific protein subunits for identification of various species have been identified to resolve taxonomic issues. Varying degrees of association of markers with agronomic characters were observed in blackgram.

FIGURE 1

SSR banding pattern of 40 traditional and improved cultivars of Pakistani rice generated by primer pair RM-310. The lanes represent M-20bp molecular size marker; 1 to 40 represent rice cultivars



3.10 Germplasm distribution

The distribution of germplasm to plant breeders and the scientists for research is an important activity of the genebank. During the last 10 years, efforts were made to meet the demands of scientists and others. A total of 13 055 accessions of different crop germplasm were supplied to various national and provincial research institutions. A total of 5 217 accessions also have been distributed to international research organizations.

3.11 Role of botanical gardens

The botanical gardens are responsible for the maintenance and conservation of endangered plant species. In addition to their role in plant genetic resources conservation, the botanical gardens offer unique opportunities in creating public awareness of the need and methods of conservation of plant resources. At present four botanical gardens are being established in Pakistan. They are located at University of Agriculture, Faisalabad; University of Kharpur (Sindh); Pakistan Forest Institute; Peshawar; Morgha Biodiversity Park, Rawapindi; Capital Development Authority; botanical Garden, Islamabad. The major purpose of these gardens is to display diversity of beautiful and rare plants specially those that could be used in horticulture, agriculture, forestry and landscaping.

A large number of plants have been used in traditional medicine for centuries. Therefore, collection, conservation, and propagation of this germplasm are important to protect these species. At present there are six medicinal plant gardens in Pakistan which are located at National Agricultural Research Centre, Islamabad; Arid Zone Research Institute, Quetta; Qarshi Industry, Hattar; Islamic University, Bahawalpur and Hamdard University, Karachi, Karakorum Research Institute for Northern Areas, Gilgit. The propagation and cultivation of medicinal plants are carried out in these gardens.

3.12 An assessment of major *ex situ* needs

- There have been significant achievements in the collection and conservation of PGR. However, the emerging threats to biodiversity and changing global scenario towards restricted access to germplasm, requires emphasis on trait specific explorations.
- There is a need to strengthen the network of germplasm conservation by including all the stakeholders.
- Repeat collections in areas that exhibited large or useful diversity in the past, filling gaps on collections.
- More emphasis needs to be given in collecting wild germplasm of different crop species. The availability of improved gene transfer across species or genera suggest that demand for wild germplasm will increase in the years to come.
- Need to organize expeditions for underutilized/ minor crops and medicinal plants
- Pakistan is rich in wild and local fruit germplasm; there is a need to establish clonal repositories of different fruit crops.

CHAPTER 4

THE STATE OF USE

4.1 The importance of utilization

The plant genetic resources have been collected and preserved in Pakistan systematically for more than four decades. Many of these have been preserved in duplicate to provide a backup for the users, whereas some have been preserved at only one location/country. Without utilization of genetic resources, the human resources and scientific skills along with expenses employed on this noble activity could not be fully exploited and justified. The best option is to collect the genetic resources along with acquisition preferably from the centre of diversity and then prior to conserve it is important to characterize and evaluate. After collection, evaluation and characterization, if the volume of data and genetic resources permits, it is wise to establish a core for ready use by the breeders and researchers that will ultimately save time and labour. The material is usually evaluated most of the time by the specific institute at their respective areas that may mislead for agronomic performance although highly heritable plant descriptors could provide taxonomic information. For preliminary evaluation, mostly the IPGRI descriptors are followed with some modifications. Sometimes the inputs from different crop commodity program and researchers are also incorporated.

4.2 Utilization of conserved plant genetic resources and major constraints to their use

Prior to utilization, germplasm characterization and evaluation is imperative. Keeping in view the importance of utilization, the researchers have evaluated various crop germplasm under the field condition for different numbers of characters. Maximum accessions of wheat, barley, rice, chickpea, cotton, pea, lentil, mungbean and mash have been evaluated for important characters by the respective institutes. It is important to note that most of the germplasm of self pollinated crops have been evaluated rather than cross pollinated crops except maize that has been evaluated by Maize and Millet Research Institute, Yousafwala that is almost a mono crop institute working on maize. Various germplasm catalogues have been published by the researchers for reference to the breeders working on specific crop/crop group. A high degree of genetic variation has been reported in local germplasm for most of the crops. During a survey on characterization of germplasm by the various research institutes, it was observed that almost all the institutes have characterized and evaluated most of the germplasm for various traits.

The germplasm has also been evaluated for biotic and abiotic stresses, but few reports were available on biochemical and molecular characterization. Some of the stakeholders pointed out the lack of expertise and resources in term of economics and manpower. All the stakeholders either in the research institutes or universities have high level of expertise for characterization and evaluation of crop germplasm including cereals, legumes, fibres, oilseeds and vegetable germplasm. It was noticed that only few institutes (Nuclear Institute for Agriculture and Biology, Plant Genetic Resources Program) had the capacity and capabilities for biochemical and molecular evaluation of crop germplasm.

Access to plant genetic resources is the second important step for utilization. Plant Genetic Resources Program is the only centralized facility for *ex situ* preservation and the evaluation data for crop germplasm is provided to the genebank that entertains the requests of germplasm from national and international scientists as and when needed. So far, more than eight thousands accessions of cereals, food legumes, fruits and oilseeds have been supplied to the researchers in the country and abroad for experimentation and utilization in the crop improvement programs.

Accordingly more than five thousand samples of different crops were obtained from abroad for their utilization by plant scientists that strengthened the scope of utilization.

Table 10 presents the summary of PGR collected, preserved and distributed among the researchers during last 25 years. Among various crops species, chickpea, barley, lentil, rice, millets, sorghum, wheat, black gram, mungbean, cowpea and maize have been frequently requested by the researchers, whereas some other crops were least requested. Similarly vegetables and medicinal plants have recently attracted the attention of researchers to start their work on these crops.

TABLE 10
Plant Genetics Resources of various Crops Collected, Preserved and Distributed among Researchers during last two Decades

Crops	Accessions in genebank	Area of collection	Accessions distributed
Arachis hypogea	754	Exotic	750
Avena sativa and A. fatua	540	N.A., Punjab	848
Brassica spp.	1 003	All over the country	308
Carthamus tinctorius	362	Balochistan	362
Cicer arietinum	2 243	All over the country	2 865
Fagopyrum esculentum	19	N.A.	24
Fibre Crops	357	All over the country	91
Fodder and Forage	341	All over the country	73
Fruits	1 024	N.A.	305
Glycine max	133	N.A.	730
Helianthus annuus	143	N.A., Balochistan	40
Hordeum spp.	1 274	All over the country	3 282
Lathyrus spp.	148	Punjab, Sindh	33
Lens spp.	808	All over the country	2 423
Medicinal and Aromatic Plants	1 202	All over the country	1 624
Oryza sativa	2 957	All over the country	4 273
Pennisetum spp.	1 007	All over the country	1 520
Phaseolus vulgaris	109	N.A., NWFP, Balochistan	32
Sesamum indicum	73	NWFP, Sindh	39
Sorghum spp.	866	All over the country	3 132
Triticum aestivum	2 767	All over the country	8 341
Triticum durum	207	N.A., NWFP	
Vegetables	1 481	All over the country	3 251
Vicia spp.	172	NA, NWFP, Sindh	111
Vigna aconitifolia	66	All over the country	110
Vigna mungo	799	All over the country	3 897
Vigna radiate	643	All over the country	3 934
Vigna unguiculata	212	All over the country	1 170
Wild Cicer spp.	90	N.A.	355
Wild species of wheat	130	N.A., Balochistan	390
Zae mays	545	All over the country	1 719
Total	**22 475**		**46 032**

NA- Northern areas, NWFP- North Western Frontier Province

4.3 Utilization activities (characterization, evaluation, pre-breeding, genetic enhancement, seed supply) and deployment of genetic diversity (breeding for pest and disease resistance and other traits, crop diversification)

Although genebank of Plant Genetic Resources Program (PGRP) has widely distributed germplasm of various crops in last three decades, but due to poor feedback information system, there was no data available on actual situation on evaluation and utilization. Under a study with the collaboration of IPGRI–CWANA, we reported the contribution of different patterns of germplasm utilization in Pakistan. Among various crops species, chickpea, barley, lentil, rice, millets, sorghum, wheat, black gram, mungbean, cowpea and maize were requested frequently by the researchers during the last two to three decades. Most of the researchers evaluated the germplasm for crop improvement programs and were of the view that data should be accessible to other researchers. The germplasm has been used frequently for more than one purpose including molecular markers and genetic engineering along with screening against biotic and abiotic stresses. Basic studies on fingerprinting and

genomics have been widely conducted during last one decade, especially on cotton, wheat and rice. Tolerant germplasm to various diseases along with elite lines have been identified and available on request for utilization in crop improvement. Agronomic traits and DNA markers exhibit high genetic diversity in most of the crops evaluated, whereas seed proteins indicated a low level of genetic diversity for almost all the crops except wheat and peas. Effective use of crop genetic resources demands a stronger germplasm management system including establishment of regional germplasm multiplication and distribution centers to make germplasm distribution and exchange more accessible nationwide and even worldwide.

Table 11 presents results on the data on use of genetic resources. It is important that the germplasm has been utilized for research and development purposes along with academic nature. Thirty one post graduate students have completed their research on the germplasm distributed by the genebank. Many respondents had multiple choices and they used germplasm for more than one purpose. Seventy two respondents used germplasm for their applied research and nine for both basic and applied. With the emergence of new techniques of biotechnology during the recent past some researchers have used germplasm for genomics and genetic studies. This might be because of establishment of new research institutes especially on molecular and genetic engineering and better funding facilities to the universities in the recent past. About half of the researchers used germplasm for breeding purpose either for yield potential or other characters depending upon the crop. Breeding for biotic and abiotic stresses is very important aspect and 66 researchers worked on viral diseases (mostly on legumes), 111 on fungal diseases, 39 on bacterial and 60 researchers worked on screening for insect resistance. Screening for biotic and abiotic stresses was conducted mostly by federal research institutes. Thirty two respondents worked on various abiotic stresses including salinity and drought.

TABLE 11

Use of plant genetic resources by the recipients to various research institutes and University for academics and research purposes*

Academics	Frequency
Reports	27
Catalogue	9
Multiplication	22
Research paper	18
Paper presented	4
Not yet published	27
M. Sc thesis	7
M. Phil thesis	17
Ph. D thesis	7
Blank	276
Research purpose	
Applied research	72
Applied and basic research	9
Basic, biotechnology and genetic research	117
Basic biotechnology, genomics and applied research	12
Basic genetic research	44
Genetic research	38
Genetics and applied research	5
Breeding programs	
Breeding for yield and yield traits	36
Other characters	12
Yield characters specific	149
For biotic and abiotic stresses	
Viral diseases	66
Fungal diseases	111
Bacterial diseases	39
Insect pests	60
Abiotic stresses including salinity and drought	32

* The report is based on 476 recipients of PGR

Direct and indirect use may be regarded as two patterns of germplasm utilization. Direct use refers to germplasm materials that are sown as cultivars in crop production while indirect use refers to involvement of germplasm as parents in improvement program. The direct use has made less contribution and it is not expected to increase in near future due to less information available on the germplasm or data provided from Genebank for most of the crops. A large number of varieties for various crops have been developed by the researchers that are summarized in the Table 12. Among various crops, twenty seven varieties were developed in chickpea, 73 for cotton, twenty in maize, 18 in mungbean, 34 in rice, 33 in sugarcane and one hundred varieties have been developed in wheat. Among the varieties developed for various crops it is important to note that a large number of varieties have been developed during last one decade. Wheat and cotton are important crops of Pakistan and almost half of the varieties have been developed during last one decade that indicated the maximum use of plant genetic resources during this era. All the six varieties of apple had been developed during last ten years because exploration and utilization of fruit germplasm has been visualized recently in Pakistan. It was observed that the breeders cannot easily access germplasm although a wide range of genetic diversity is theoretically available to them. One basic reason for limiting germplasm utilization is too little availability of useful germplasm that is well characterized and evaluated. This was found during the survey related to global plan of action indicating that desirable germplasm is not accessible to the researchers for ready use.

TABLE 12

Number of varieties developed by the national researchers for various crop species

Sr.No.	Crop	Number of total varieties	Varieties developed after 1996
1-	Alfalfa	01	01
2-	Apple	06	06
3-	Barley	07	04
4-	Barseem	02	0
5-	Chickpea	27	16
6-	Cotton	73	35
7-	Cowpea	03	03
8-	Guar	02	01
9-	Lentil	09	05
10-	Maize	20	05
11-	Mashbean	05	02
12-	Millet	06	01
13-	Mungbean	18	10
14-	Oats	04	01
15-	Rice	34	11
16-	Sorghum	04	03
17-	Sugarcane	33	24
18-	Vetch	01	01
19-	Wheat	100	50

The rate of loss in biodiversity has been studied thoroughly and tried to minimize by preserving in the gene banks, material maintained by breeders, biologists, in herbariums and on-farm. Table 13 gives the summary for evaluation and pattern of genetic diversity on various crops. It was observed in most of the crops that seed protein profiles could not be used to investigate intra-specific variation rather it could be more likely used to resolve inter-specific or inter-generic phylogenic relationship in crop plants. The unique example for probing bread making quality associated with high molecular weight glutenin subunit in wheat is accepted worldwide. The data on genetic diversity for various crop germplasm revealed that quantitative traits and RAPD markers were able to explain high genetic variation in all the crops, whereas SDS-PAGE indicated a low level genetic diversity for most of the crops except wheat and peas where high level of diversity was observed, whereas lentil exhibited medium level of diversity. Due to simplicity in measurement and importance of qualitative traits for plant description, these are suggested to study as a first step in crop germplasm evaluation.

TABLE 13
Genetic diversity in indigenous plant genetic resources of various crops based on characterization, evaluation and biochemical markers

Crop	Evaluated	Traits	Qualitative traits	Quantitative traits	Protein	RAPD
Triticum aestivum	700	21	Medium	High	High	High
Oryza sativa	620	18	High	High	Low	High
Zea mays	173	13	High	High		-
Sorghum	423	20	High	High	Low	-
Brassica juncea	125	21	Low	High	Low	High
Raphanus sativus	27	14	-	High	Low	High
Millets	182	21	High	High	Low	-
Hordium vulgare	397	15	High	High	Low	-
Sesamum indicum	105	9	High	High	Low	-
Glycine max	71	15	High	High	Low	-
Len culinaris	345	15	High	High	Medium	High
Vigna mungo	550	21	Low	High	Low	High
Vigna radiata	620	18	Low	High	Low	-
Vigna unguiculata	173	31	High	High	Low	-
Cicer arietinum	423	17	High	High	Low	-
Pisum sativum	182	31	High	High	High	High

4.4 Pre-breeding, genetic enhancement

It is the main responsibility of researchers to develop varieties of particular crop on which they work. Most of scientists agreed that genetic resources are the building blocks for any crop improvement program, and the researchers intend to have as many germplasm accessions as they could. It is desired by the researchers that the germplasm they are receiving should have been evaluated and characterized and if possible, resistant lines be identified. Depending upon the national needs some of the elite germplasm lines and disease tolerant lines against various diseases have been identified and published (Table 14). All of these studies were conducted by experts using standard techniques for evaluation and screening, hence these results could be used for improvement of various crops. The identified lines are predominantly pure-lines in case of self pollinated crops; therefore these are suggested to be tested under wide range of agro-climatic conditions to select the best ones for general cultivation. The biotic and abiotic stresses are the most important threat to crop production and tolerant germplasm have been identified for potential use. *Aschocyta* blight is the most devastating disease that causes serious damage to chickpea crop all over the world. In Pakistan during last three decades chickpea crop has damaged twice up to 70%. Screening against chickpea blight under field as well as green house conditions was carried and resistant sources have been identified. Three varieties (Dasht, NIFA 88, Balkasar) developed from the indigenous PGR were resistant to blight. Similarly Mungbean Yellow Mosaic Virus (MYMV) is very important but high level of resistance has been identified. A resistant source against Blackeye Cowpea Mosaic Virus (BICMV) that is a serious disease in cowpea growing areas has been identified and powdery mildew resistant germplasm of *Pisum sativa* has been reported. These sources have been provided to the researchers working on these commodities for utilization in crop improvement program.

Response to the capability to perform breeding for specified crop groups by the various institutes gave interesting results and the institutional capacity was decreasing for summer legumes including mungbean and blackgram, increasing for wheat, chickpea, canola and sugarcane. Similarly response to crop breeding programme carried out by institution, few responded and most of the germplasm have been evaluated and utilized in crop improvement for food security. Specific institutes are working on particular crops for various cropping systems. Among crops for food security, potato, wheat, chickpea, mungbean, rice, mash, groundnut, rapeseed, mustard, barley, lentil, vetch and maize were high ranking as described by the stakeholders. Cotton and Barley were recognized with limited scope in food security, whereas some of the stakeholders considered cotton, sugarcane, tomato, onion, peas, brinjal, canola, chickpea, mungbean, black gram, lentil and maize as the crop with medium potential in food security. Although participatory

breeding approach is very important and is being adopted by most of the countries but in Pakistan, most of the institutes involve farmers for setting breeding priorities. Central Cotton Research Institute,Vegetables Research Institute, Nuclear Institute for Food & Agriculture, Rice Research Institute, Kala Shah Kaku, National Sugar Crops Research Institute, Thatta, Wheat Research Institute, Faisalabad, Arid Zone Research Center, Quetta, Cholistan Institute of Desert Station Islamia, University Bahawalpur do work for assessing diversity and have reported various degrees of diversity in crop germplasm. Some of the stakeholders highlighted the needs and constraints to implementation, opportunities for further action at national or sub-regional level, and actions or support needed from regional and/or international organizations.

TABLE 14
Utilization of PGR for development of varieties and parental lines

Crop	Characters of interest	Accession No. / Parental lines
Rice	Varieties (quality)	3767, 3769
	Plant type	0000335
	Yield potential	0003358
	Early ness	0003058
Maize	Early ness	0071103, 0071557, 0071058
Wheat	Drought tolerance	0018170, 0018188
Chickpea	Yield potential	Punjab 2000, 54281, 54289
	Blight	54289, 54291, 019791, 54298, 97047, 924043
Mungbean	Yield potential	NCM 209
	ULCV	98-CMH-016, NM-2, BRM-195
Black gram	High yielding, resistant to MYMV	45923, 45920, 45921
	Dual season cultivar	45921
	Charcoal rot	45718, 45719, 45721, 45731
	ULCV	VH 9440039-3, ES- 1
Lentil	Yield potential	40688, 40757, 40787
Cowpea	Yield potential	27003, 27009, 27044, 27082, 27097, 27123, 27147, 27167, 27171
	BICMV	27168, 27192
Pea	Yield potential	10603, 10607, 10610, 10645, 10646
	Powdery mildew	10603, 10628

4.5 Assessment of needs to improve utilization

The germplasm catalogues have been published on passport data (all the germplasm) and evaluation catalogues (wheat, barley, mungbean, black gram, cowpea, pea). For better utilization of PGR, all information related to germplasm collection, preservation, characterization, evaluation, research and utilization, should be disseminated to breeders as print material or online. Similarly with the advancement in the field of bioinformatics, the data generated through evaluation/screening should be available online as in the case of many gene banks of developed world. The advances and experience of germplasm utilization by breeders should also be fed back to curators and shared online. Electronic access to information in the future will facilitate such exchange. Most of the institutes have evaluated almost all the crop germplasm for morphological and agronomic traits, whereas very few reports are available on molecular and biochemical traits. The institutes include Federal Research Institutes, Provincial Research Institutes and Universities, whereas the crop groups were cereals, legumes, oilseeds and vegetables. Few reported fruit and fodder crops. The researchers involved in various crop commodities have high levels of capacity to evaluate the crop germplasm for morphological traits, agronomic traits, abiotic and biotic stresses. This includes fiber crops, sugar crops, major cereals, minor cereals, oilseeds, legumes, vegetables and others. It was observed that there is potential for utilizing minor cereals and legumes for various abiotic stresses.

The Rice Research Institute, Kala Shah Kaku has 1 435 accessions of rice and all of these accessions have been distributed at least once either within the country or abroad. National Focal Point (NFP) observed the obstacles to establishing core collections in the country relating to lack of trained personnel, need for core collection is not recognized, limited number of accessions available, inadequate available information on accessions and the methodology too complex.

Mostly data is recorded on field note book which is very old method that needs improvement. Therefore, there is need of a computer software and training for its operation for maintaining the germplasm data on scientific grounds. Similarly few stakeholders experienced lack of facilities and trained manpower for molecular characterization.

The Arid Zone Research Center, Quetta is working on development of varieties through mutation breeding against yellow rust resistant in local wheat cultivar for Balochistan. The researchers of Barani Agricultural Research Institute, Chakwal intend to characterize and evaluate under-utilized crops or species. Similarly Cholistan Institute of Desert Studies, Islamia University of the Bahawalpur investigated socio-economic improvement of Cholistan desert dwellers through exploitable genetic potential of xeric grasses and identification of under-utilized crops or species. The scientists of Maize & Millet Research Institute, Yousaf Wala worked on Pearl Millet Breeding Program that is a potential under-utilized crop for the area.

Most of the stakeholders were involved in seed production and distribution for various crop species. Federal Seed Certification & Registration Department is the public organization that deals with variety registration, a legal requirement in the country. The procedure adopted by them is based on International Seed Testing Association (ISTA) standards including Distinctness, Uniformity and Stability (DUS) and Value for Cultivation and Use (VCU). Similarly the same is responsible to ensure seed quality standards which are also based on ISTA rules and these are being ensured for most of the crops, especially wheat, cotton, rice and sunflower. Low seed purity and cost of required production inputs was also highlighted. Central Cotton Research Institute, Multan indicated that markets are well established and expanded in cotton and they have fourteen varieties in the market at present. Vegetables Research Institute, Faisalabad has five varieties of potato and is making attempts to develop new markets. Markets of rice are well established and expanded. At the same time existing markets have been expanded and some new markets developed by Rice Research Institute, Kala Shah Kaku with eight varieties at present. Nuclear Institute of Agricultural & Biology is working on chickpea, cotton, mungbean and lentil with various varieties in market for which markets are well established and expanded.

In fact, the reason that breeders cannot obtain and use germplasm of interest is among the major constrains. The usefulness of collections largely depends on whether the range of genetic diversity is ecologically and geographically representative and whether there are genes of interest to breeders located in certain accessions. Weak links between breeders and curators have also limited the use of germplasm resources in crop breeding. The varieties have been developed from genetic resources along with germplasm utilization effectively in crop improvement and it is expected more in future along with research on stresses (biotic and abiotic) tolerance. Due to narrow genetic base coupled with low level of genetic variation between and within accessions as reported by respondents, it is required to collect germplasm from unexplored areas that are expected to have high level of variation/landrace. Most of the germplasm have not been evaluated in detail, especially for abiotic stresses that is needed to be strengthened by involving subject matter specialist for exploitation of desirable genes for crop improvement. For comprehensive analyses, a feedback system is required and for this pre–request information consisting of basic questions on use is suggested to get at the time of seed supply or a strong linkage between researchers, gene bank and crop advisory groups (crop based) is suggested.

Seed supply in crop germplasm is mainly divided into two broader categories, the germplasm is either distributed from the genebank curators to the researchers who are the end users of plant genetic resources. It is obvious that germplasm has been distributed frequently to the researchers upon their request and most of the varieties developed in the country have been the resultant of utilization of these genetic resources. Most of the research institutes have a limited seed production and supply system but it is only confined of their jurisdiction either for the commodity or provincial territory. To keep pace for seed production and supply for general cultivation, especially for major crop, i.e., wheat, cotton, chickpea, rice, the Sindh seed supply cooperation and Punjab seed supply cooperation are operative in the respective provinces. Although with infrastructure for seed production, cleaning, processing and supply, these could not meet the full requirements of the farmers. It is estimated that about 20 percent of the farmers are able to get certified seed for planting. All the seed business is controlled by the National Seed Registration and Certification Department with research and establishment infrastructure throughout the country. The experts follow the ISTA rules for seed production, processing and distribution.

CHAPTER 5

THE STATE OF NATIONAL PROGRAMS, TRAININGS AND LEGISLATION

The Plant Genetic Resources Program (PGRP) is the main National Program that is functioning for overall management of PGRs including exploration, collection, exchange, safe storage on long, medium and short term basis, evaluation, documentation and distribution to other research institutes for sustainable utilization of plant genetic resources of crops and wild relatives within the country and abroad. Other research and educational institutes both at Federal and Provincial level are also handling conservation and use of plant genetic resources of selected crop commodities or groups of plant species. Some of the private herbal medicinal companies such as Qarshi and Hamdard have established herbal gardens at their premises and regularly seek assistance from PGRP and other organizations for strengthening their germplasm collection for biodiversity conservation. Attock oil refinery in Rawalpindi has also developed a biodiversity park as an environment improvement strategy for compensating the pressure on biodiversity due to industrial processing in the nearby vicinity. PGRP is a component of the Institute of Agricultural Biotechnology and Genetic Resources (IABGR) which is itself one of the nine institutes that are involved in research and development activities of several crop commodities, livestock sector and social sciences. Although the history of development of plant genetic resources conservation and use is long, but in its present form, it was established with the financial assistance of the Japan International Cooperation Agency (JICA) in 1993 and has received additional financial support again in 2003 from JICA for strengthening of the activities related to plant genetic resources for food and agriculture. PGRP is regularly funded by the government of Pakistan and additional financial support is received from other projects sponsored by Agricultural Linkages Program (ALP), Generation Challenge Program, Pakistan Science Foundation (PSF) and National Biotechnology Commission (NBC) and several other organizations.

A newly funded project on establishment of the genomics and agricultural biotechnology (NIGAB) has been initiated and is being executed with financial support of federal government. It will assist foster the collaboration with field crop commodity research programs at NARC and other national and provincial research institutes culminating in effective utilization of plant genetic resources. Conservation, utilization of plant genetic resources of medicinal herbs is being pursued under a mega project funded from MINFAL. Collection and conservation of underutilized crops of the country has also been fortified with the financial assistance of international agencies namely International Center for underutilized crops, Southampton University, UK.

Financially, there has been no dearth of resources for research on conservation of plant genetic resources in PGRP since its inception, with a few crunches for some times in the past but human resource development has several weaknesses and many young scientists have either left or at present under long term study programs. Therefore the program is presently understaffed and consequently under utilized. Financial commitments have by and large increased over the past several years, reflecting the interest of public sector and other stakeholders in the PGRs but much more needs to be done yet for streamlining the mandated activities. More coordination needs to be developed among the environment, and biodiversity related programs. More international support is required in the area of training, infrastructure development, collection missions to areas which have not been explored yet for germplasm collection and germplasm exchange among distant and nearby regions. Networking among other provincial and local organizations needs to be strengthened especially with civil society organizations, universities in order to fully materialize the stated objectives and goals of the national program.

5.1 PGRP: A Focal Point for National Information Sharing Mechanism (NISM)

For an effective utilization of data and information that is continuously growing in volume as a result of research on evaluation and characterization of collected germplasm both at PGRP, elsewhere in the country and overseas, the information/ data base system has been developed. Now, with the assistance of FAO, NISM will be in place to further fortify the magnitude of conservation of PGRs and their sustainable utilization by establishing interaction with users,

breeders and other scientists for germplasm improvement and management across the country and regions. The computer software programs used in the mechanism allow the user flexible and multifaceted retrieval of information that will go a long way in sustainable utilization of PGRs and related downstream issues such as access and benefit sharing. Furthermore, priority needs to be laid on strengthening feed back information among the users of PGRs and dissemination of such information for effective utilization of genetic resources at national and international levels in sustainable food production, thus helping in enhancement of global food security.

5.2 Trainings

Senior scientists at the PGRP are well qualified in their respective fields and are contributing to train young scientists and university students in diverse disciplines of conservation of plant genetic resources and their utilization such as biochemical evaluation, plant seed health monitoring and management, *in vitro* conservation and cryopreservation, data management and gene bank management. A number of training courses were held in the recent past for imparting training to the provincial and university scientists for management of plant genetic resources.

A large number of internees who have recently graduated form universities have been inducted at the national agricultural research center and other research institutes under the national internship program (NIP). They are being trained in different research programs including plant genetic resources for food and agriculture to make them useful in collecting, evaluating and utilizing the PGRs for food and agriculture. However, they will be more useful if program for their regular induction in research programs are planned simultaneously.

Some of the universities namely University of Agriculture, Faisalabad, University of Arid Agriculture, Rawalpindi, Hazara University, Agriculture University Tandojam, Sindh and others offer regular courses in plant genetic resources to graduate and post graduate students. Yet there is no regular training module developed for on job training of the young scientists in the area of plant genetic resource conservation. Some international agencies such as JICA offer regular training to the PGR scientists but these are not adequate and have shrunken during the last several years. There is a need to explore additional options for training the scientists to perpetuate the conservation, evaluation and germplasm improvement. The major obstacle to providing training is the lack of linkages with international cooperation and development agencies, which need to be strengthened for exchange of personnel and expertise, through multilateral research projects. Higher education commission is one of the sources that can fund only educational programs abroad and it is mostly university oriented education. Training at overseas research institutes has no or little priority for higher education commission. Thus separate training and education programs may need be evolved with the assistance of international and national donor agencies specifically targeting the plant genetic resources conservation and use.

5.3 National legislation

There is an inherent tension between the conservation of plant genetic resources and their use. This is because developed countries use them for commercial exploitation whereas their conservation is concerned with century's long labor and hard work of poor countries' farming community in saving and nurturing the seed and acquiring traditional knowledge about them. In order to develop a consensus between the conservation approach and use of plant genetic resources for commercial purposes and to facilitate continued access and benefit sharing, a legal framework has to be structured at national level on ethical grounds, as a binding to the international regulatory regimes. A lot has yet to be done in Pakistan although some initial work has been done here to govern the conservation and granting access to plant genetic resources.

Department of Plant Protection working under the Ministry of Food and Agriculture and Livestock (MINFAL) is mandated to regulate the cross border movement of germplasm and to set out quarantine rules for entry and exit of plant and seed material at all the ports of entry of the country but enforcement and implementation of these rules has severe impediments due to lack of full capacity. Governance of trans-boundary movement of plant genetic resources needs to be fortified with capacity building in the plant protection department by strengthening the staff and empowerment for strict vigilance as leakages of infected plant material has been reported in the past that had resulted in severe epidemics in some of the crops such as cotton and banana. The draft on Plant breeders' rights has been wetted by the all provinces and is being currently wetted for approval by the legislators of Pakistan in the near future. Similarly Intellectual rights organization has been established that is working on the development of the IPS legislation in the country and a considerable progress is soon expected. The discussion on international instrument on genetic resources and traditional

knowledge is being initiated among the stakeholders and sensitization for framing the domestic laws on protection of genetic resources and traditional knowledge is being highlighted at the IPO Pakistan.

Biosafety rules (Biosafety rules 2005) have been recently enacted by the government of Pakistan to govern the handling, development, release or commercial use and transboundary movement of Genetically Modified Organisms (GMOs) that are considered to be a likely threat to biodiversity but also hold a great promise for enhancing food security. The National Biosafety Cell (NBC) has been established at the Pakistan Environment Protection Agency (PEPA) of the Ministry of Environment of Government of Pakistan to regulate GMOs in the country. Biosafety guidelines have also been approved that will streamline the development and release of the GMOs for commercial release. There is still a gap in implementation of the biosafety guidelines and rule enacted by the government of Pakistan since institutional biosafety committees are yet not fully functional and appointment of biosafety officers has not been made. Activating the IBCs will safeguard the development of GMOs and minimize the ill effects, if any, of GMOs on PGRs and protect them for securing the food security for future and present generations, yet promoting the development of GMOs for sustainable food production.

A project on strengthening of IPRs has been recently initiated at the Ministry of Food, Agriculture and Livestock (MINFAL) with its components at PGRP and FSCRD to streamline the governance of access to PGRs and equitable benefit sharing and for facilitation of legislation for protection of new plant varieties and for protection of genetic resources and associated traditional knowledge. With these developments, Pakistan is expected to soon emerge at the world map of institutionalized conservation and utilization of plant genetic resources through networking of IPRs, access and benefit sharing and variety protection regulatory regimes operating as a binding to the international regulatory regimes.

The public awareness about plant genetic resources regarding its roles and values is more common in rural communities and among the elite class of urban communities but a concerted approach has to be adopted to create a wide spread general awareness among the masses. On special occasions such as world food day and also silver jubilee celebrations of PARC, popular articles and pamphlets are written to highlight the value of genetic resources. T.V productions are also telecast occasionally for mass awareness and students from schools, colleges and universities commonly visit PGRP to get acquaintance about the PGRs. Civil servants, officers from forces and other governmental departments and civil society are also briefed about the plant genetic resources but there is a need to arrange more regular visits for general public and CDs and videocassettes may be helpful in generating greater interest in PGRs and their conservation among the masses.

CHAPTER 6

THE STATE OF REGIONAL AND INTERNATIONAL COOPERATION

It is well realized now that no single country or region can be self sufficient in its needs on genetic diversity. It is estimated that average interdependence between all regions of the world is more than 50 percent and for some regions it may even be more than 90 percent. International collaboration played a paramount role for the establishment of Plant Genetic Resources Programme at National Agricultural Research Centre, Islamabad under the auspices of Pakistan Agricultural Research Council. In collaboration with international organizations a considerable number of exploration missions were sent to different parts of Pakistan for collection of crop diversity, which was consequently conserved in the genebank for future use of researchers. Crop germplasm was exchanged with international research organizations universities and researchers for crop improvement.

Different aspects of international collaboration and cooperation are discussed as below:

6.1 Collaboration with USA through PL-480 Scheme

The germplasm conservation activities were started in Pakistan though a research project on "Rice Germplasm Collection & Evaluation" implemented for period of five years, under the PL-480 scheme. Under this project about 940 accessions of rice were collected and evaluated for different agro- morphological and genetic traits.

6.2 Collaboration with JICA

In 1993, a decent facility for germplasm storage and associated research was established at NARC under a project "Genetic Resources Preservation and Research Laboratory (GRP&RL)" with the financial support from Japan International Cooperation Agency (JICA). This facility comprises of Genebank for Active and Base Collections, and six laboratories for Exploration & Collection, Seed Conservation, *In vitro* Conservation, Germplasm Evaluation, Plant Introduction & Seed Health and Data Management. All laboratories are well equipped with very sophisticated equipments. After the completion of the GRP&RL, the JICA funded "Project Type Technical Cooperation on GRP&RL" which started in May 1993 and ended in May, 1998. Under this cooperation, JICA provided four long term experts and a number of short term experts, training of PGRI scientists in Japan, spare parts of equipments and chemicals. In August, 2001, JICA funded an "Aftercare Project on GRP&RL" which was completed in August, 2003.

6.3 Collaboration with regional networks on plant genetic resources

As a consequence of collaboration with regional networks as CWANA and SAARC, in addition to crop germplasm exchange, seminars on different aspects of PGR were conducted to disseminate PGR information to researchers in the world for future planning. A national survey was conducted under the auspices of CWANA to ascertain the utilization of conserved PGR in the National Genebank at NARC, Islamabad at different national research institutes in Pakistan.

6.4 Collaboration with international centers for development of research projects on under-utilized crops

The under-utilized crop groups including traditional and non-traditional species show very large amounts of genetic variability at intra-specific and inter-specific levels, and as a result, their identification and description is either inadequate

or information about them is missing. Keeping in view the importance of under-utilized crops like amla (*Phyllanthus emblica*) and Imli (*Tamarindus indica*), a project has been developed in collaboration with International Center for Under-utilized Crops (ICUC) for identification of useful land races of these crops, which may be used as foundation material for the development of cultivars with desired traits.

6.5 Collaboration with different countries for exchange of germplasm

Realizing the importance of crop genetic diversity, Pakistan has signed Memorandum of Understanding (MOU) with China, Afghanistan, Yemen, Algeria, Syria, Sri Lanka, Uzbekistan and many other countries for exchange and conservation of crop germplasm.

6.6 Exploration and collection of crop germplasm in collaboration with international organizations

So far, the Plant Genetic Resources Program (PGRP) has accomplished 58 plant collecting expeditions in the different agro-ecological regions of the country. The plant collecting expeditions were organized in collaboration with international research organizations.

As a consequence of exploration and collection, the Plant Genetic Resources Program (PGRP) has conserved more than 23 000 accessions of orthodox seed species in the genebank out of which 11032 accessions (Annexure-I) were collected in collaboration with international organizations.

6.7 International Agreements in respect of biodiversity conservation

In order to fulfill the international obligations towards the conservation of crop genetic diversity, Pakistan has become member of several international agreements and conventions. The agreements and conventions include the following:

- Plant Protection Agreement, Rome, 1956.
- International Union for the Protection of New Varieties of Plants, 1961 (UPOV).
- Convention Concerning the Protection of the World's Cultural and Natural Heritage, Paris, 1972.
- Convention on International Trade in Endangered species and Wild Flora and Fauna, Washington, D, C., 1973.
- Convention on Biological Diversity, Rio-De Janeiro, 1992.
- International Technical Conference on Plant Genetic Resources, Leipzig, June, 1996.
- World Food Summit, Rome, November, 1996.
- International Treaty on Plant Genetic Resources for Food and Agriculture. Rome, 2001.

Besides the above International agreements the Government of Pakistan through Pakistan Agricultural Research Council is engaged in the collections, conservation and evaluation of agriculture biodiversity. The policies of Pakistan on conservation of Biodiversity are concentrated on *in situ* wild life conservation. The country still has to go a long way to frame laws and Policies to conserve all its plant genetic material, multilateral exchange of material, farmer's rights etc.

In preview of the CBD and International Treaty on Plant Genetic Resources, the national biodiversity strategy will be the centerpiece to fulfill the Convention's obligations, including the integration of sectoral and cross sectoral plan's programmes and policies called for in article 6(B). Primary function is to make specific recommendations for national action on conserving biological diversity and sustainability using its components. The Government of Pakistan has already prepared National Conservation Strategy. Similarly the draft for endorsement of Biodiversity Action Plan of Pakistan with the support from IUCN/WWF and financed by World Bank / GEF have been prepared and approved by Ministry of Environment.

6.8 Germplasm acquisition

In response to requests from researchers working in different research organizations in Pakistan, requests were made to various international research organizations for supply of desired germplasm to be used in crop improvement activities. In this regard a total of 4 022 accessions belonging to 24 different crop species were acquired from 40 countries (Annex-II).

6.9 Germplasm distribution

Distribution of germplasm is the responsibility of genebank and to fulfill its role of service facility to the users community, a total of 5 217 accessions were supplied to researchers of 16 countries. This material was comprised of 33 different crop species (Annex-III).

6.10 Training of PGRP scientists through international cooperation

Scientists working in Plant Genetic Resources program received long term and short term trainings in the field of PGR collection strategies, conservation, management of genebank, morphological and biochemical evaluation and data management. The details of training received are given in Table 15.

TABLE 15
Training of PGRP Scientist through international Collaboration

Training/Degree	Sponsoring organization	No of scientists
Ph.D.	JICA – Japan	04
M.S.	IBPGR	02
Short term trainings	JICA, IRRI, ICARDA, ICBA	30

6.11 Future strategic directions to improve regional and international collaboration

There is a strong need to improve regional and international collaboration for conservation of plant genetic resources which is being looked through:

- Establishing networking on various crop groups for exchanging information on germplasm status, evaluation data and priority areas for collection.
- Develop joint projects on characterization, evaluation and utilization of germplasm.
- Having memorandum of understanding (MOUs) with various countries.

CHAPTER 7

ACCESS TO PGRFA AND SHARING OF BENEFITS ARISING OUT OF THEIR USE AND FARMER'S RIGHTS

Earlier, the crop germplasm was considered as the common heritage of mankind. The germplasm was collected without restrictions by scientists and utilized as raw material in breeding programs throughout the world. During the last decade four major international developments have affected the regulatory mechanism in the various countries as regard to conservation of PGR. These include CBD, FAO Global Plan of Action and International Treaty on Plant genetic Resources for Food & Agriculture and the Trade Related Aspects of Intellectual Property Rights System (TRIPS). These developments have lead to the paradigm shift towards the sovereignty of states over their genetic resources.

Pakistan is a party to the convention of biological Diversity (1992), ITPGRA (1995), and International Technical Conference on Plant genetic Resources, Lipzig (1996).Therefore, the country grant access to PGR on mutually agreed terms subjected to prior informed consent of the contracting parties providing such resources. Further, it requires the contracting parties to share in a fair and equitable way the results of research and development and the benefit arising from the utilization of such resource.

Access to PGR is an important step for utilization. So far more than eight thousand accessions of cereals, food legume, fruits and oilseeds have been supplied to various research institutes in the country and abroad for utilization in their breeding programs. Similarly, more than five thousand samples of different crop species were acquired from abroad for utilization. In Pakistan, the use of PGR has contributed significantly to achieve food security and sustainable development. The utilization of sources for leaf rust resistant in wheat, blight resistant in chickpea and root rot resistant in chillies has resulted in the development of resistant varieties.

An important component of the CBD is that of the equitable benefit sharing of biological resources. This aspect of the CBD has not yet been fully addressed in Pakistan. The country has to go a long way to establish the mechanism for sharing the benefits arising out of the use of PGR. In Pakistan, draft Biodiversity Law 2005 for Access to Biological Resources and Community Rights has been prepared by the Biodiversity Working Group in the Ministry of Environment. This draft was circulated to all stakeholders and many inadequacies were identified as:

- The Bonn Guidelines have been ignored altogether
- While there are adequate provisions on procedures for access to genetic resources there is no provision on the safeguard of Traditional Knowledge (TK)
- Sharing of benefit with the holders of TK
- There is no clarity on who the indigenous communities are and how the benefits would be shared.

Among the NGO's only SDPI has the exposure to deal the complex issues of Bonn Guidelines. They organized several workshops on access and benefit sharing. The final draft of biodiversity Act 2006 on Access and benefit sharing is in the process of preparation.

7.1 Implementation of Farmers' rights

Pakistan has not yet allowed patenting of plant varieties. The draft Plant Breeders Rights Act has been prepared by the Federal Seed Certification Department and is going to be presented for approval in the Cabinet meeting soon. The country has to go a long way to frame laws and policies to conserve genetic material, multilateral exchange and farmers' rights.

CHAPTER 8

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

The value of both traditional farmers' varieties and wild relatives of cultivated plants in crop improvement and agricultural development cannot be ignored. There are many examples which demonstrated the enormous importance and economic value of plant genetic diversity and plant germplasm which have formed the basis of improving agricultural production and have played crucial role to manage a number of national crises that occurred in agriculture over past 50 years. The use of plant genetic resources has contributed significantly to achieve food security and sustainable development.

Exploitation and utilization of dwarfing genes from the primitive Japanese winter wheat variety Norin-10, introduced into Pakistan in 1961, had played a key role in the genetic improvement of wheat during "Green Revolution". A number of high yielding, semi-dwarf wheat varieties have been developed and released in Pakistan since 1 965. Pakistan wheat harvest (kg/ha) during 2004-05 was 57% greater than the harvest in 1980-81. Similarly, there was a steady rise in rice production after the development of high-yielding semi-dwarf varieties in Pakistan. Rice yield increased from 1 616 kg/ha in 1980-81 to 1994 kg/ha in 2004-05 showing an overall increase of 23% in yield potential. At the same time, rice export raised from 0.18 million tones in 1970 to 1.82 million tones in 2003-04.

Substantial increase in the production and yield potential has also been recorded in the food legumes and non-conventional oilseed crops due to the development of high yielding and short duration varieties in mung and mash, and hybrid development in sunflower in Pakistan. Similarly, a significant level of yield increase has been noted in all other crops due to the use of plant genetic resources after green revolution. A large number of high yielding, biotic and abiotic stresses tolerant, and better adapted varieties of various crops have been developed through the management and utilization of plant genetic diversity in Pakistan, which ultimately contributed significantly to the food security and sustainable development in the country (Table 16). The cultivation of landraces and cultivars of underutilized crops like sesame, *Vigna* species, coriander, fennel, etc. are also contributing significantly in the livelihood of small farmers as they provide additional income to them. Likewise, growing of local landraces of cold-tolerant rice is playing a critical role in ensuring food security and substantial incomes for small farmers in the northern areas (especially Chitral) of Pakistan.

TABLE 16

Development of improved varieties of various crops through use of genetic resources in Pakistan

Sl. No.	Name of crop	Varieties developed	Yield (kg/ha) in 1980-81	Yield (kg/ha) in 2004-05	% age increase
1.	Wheat	107	1 643	2 586	57
2.	Barley	09	667	1 009	49
3.	Rice	40	1 616	1 994	23
4.	Maize	21	1 262	2 849	126
5.	Sorghum	04	584	601	03
4-	Cotton	75	339	760	124
5-	Sugarcane	37	39.2*	48.9*	27
6-	Sunflower	10	1 090**	1 241	14
7-	Rapeseed & Mustard	22	607	839	38
8-	Chickpea	27	400	794	99
9-	Mung	20	475	577	21
10-	Mash	05	497	491	-01
11-	Others	113	-	-	-

*Yield per ha. in tones
**Yield per ha. in 1986-87.

Plant genetic resources have played a significant role in managing the crisis and sustainable agriculture in Pakistan. Few examples of them are highlighted below:

- In 1978, leaf rust epidemic in wheat resulted in crop failure causing a loss of Rs.5.1 billion ($861M) to the national economy. The development of rust screening system and utilization of leaf rust resistant sources has resulted in the development of leaf rust resistant varieties in the country.
- Chickpea blight outbreak during 1979-81 destroyed the standing crop in Pakistan and resulted in a production loss of more than 50% in the country. Resistant sources to blight were discovered in the local genetic resources through screening program which helped in the production of resistant varieties of chickpea in Pakistan.
- Similarly, in 1989 epidemic of root rot caused heavy loss to chili crop in Pakistan. After the identification and management of resistance sources against root rot disease provided foundation for yield stability of chilli in Pakistan.
- The occurrence of banana bunchy top virus (BBTV) disease in 1990-91 destroyed the banana crop, which resulted in reduction of 75% production causing a loss of Rs.971 million to national economy. The virus and its vector were characterized and identified, which ultimately helped in the development of disease free banana suckers through tissue culture technique by utilizing local germplasm resources.
- Likewise, a loss of 2 million cotton bales was noted in Pakistan during 1991-93 due to failure of crop by cotton leaf curl virus (CLCV) disease. The identification and utilization of resistant sources in cotton has resulted in developing disease resistant varieties in the country.

In conclusion, plant biodiversity represents the primary source for food, feed, shelter, medicine, and many other products and means that make life on earth possible and enjoyable. Plants are the basis of our food supply, and provide many other daily necessities. Today's rapid loss of plant genetic resources puts our future in jeopardy. Conservation of plant genetic resources is the only means to ensure that their potential for improving the living standard of the human beings can be achieved.

At present more than 23 000 accessions of cereals, oilseeds, food legumes, etc. have been preserved in PGRP gene-bank. However, very limited information is available regarding their detailed evaluation and characterization especially for specific trait of economic importance like new plant type (rice), quality, biotic and abiotic stress. Future priority will be required to characterize and identify the elite germplasm with superior quality and enhanced tolerant to diseases, insect-pests and environmental stresses and made it available to the breeders for utilization in breeding programs.

ACKNOWLEDGEMENTS

This report is the product of experiences of a large team comprising of researches, research managers and other officials belonging to many national and international organizations. We are profoundly grateful for their preparedness to share their knowledge that has been documented in this report for a wider spectrum of readers to benefit. The end users of the information assembled herein include researchers, planners, policy makers, students, NGOs, environmentalists and farmers all of who are working on the plant genetic resources to enhance food security on sustainable basis. This report is second in the series to update the information about a decade long endeavors of Pakistan for collecting, conserving, evaluating the plant biodiversity and its use in increasing food security and has been produced ten years after 1997 when the first country report on the subject was produced.

The contributions from scientists of provincial and Federal research institutions are also profoundly acknowledged, who shared their experiences with global community for a better use of PGRs. The work of Juan Fajardo Vizcayno is highly valued as he reviewed and commented on early drafts of the all chapters of the report to bring out a final outcome.

We extend full appreciation to Food and Agriculture Organization (FAO) of the UN for its consistent support, both in the form of technical and financial entities, that enabled us to assemble all the information from national programs after organizing several workshops on the subject to enable the stakeholders in contributing to the contents of the report.

Despite all the efforts to bring out a comprehensive report after several reviews of earlier drafts, the authors accept the responsibility for any errors, omissions and deficiencies which still may exist in the report.

ANNEXURE 1

PLANT COLLECTING EXPEDITIONS IN PAKISTAN

Sr. No.	Expedition name	Collaboration	Year	Area	No. of samples
1-	Fodder & Forages	JICA-Japan	1997	Punjab (Cholistan)	21
2-	Maize Germplasm	JICA-Japan	1997	Kaghan (NWFP)	43
3-	Seabuckthorn	PGRI-PARC	1997	Northern Areas	38
4-	Wheat, Barley & Vegetables	PGRI-PARC	1999	Punjab, NWFP	70
5-	Sorghum, Millet & Vegetables	PGRI-PARC	2000	Punjab, NWFP, Sindh, Balochistan	219
6-	Sorghum, Millet & Vegetables	PGRI-PARC	2000	Punjab, NWFP, AJK	120
7-	Wheat & Barley	Japan	2001	Punjab, NWFP,	292
8-	Wheat, Barley & Oilseeds	JICA-Japan	2002	Northern Areas, NWFP, Punjab, Sindh, Balochistan	286
9-	Vegetables Collection	JICA/PARC	2002	Northern Areas, AJK, NWFP, Punjab	424
10-	Fruits & Vegetables	JICA/PARC	02-03	Northern Areas, NWFP, Punjab	416
11-	Vegetables, Grapes & Underutilized Crops	PGRP/PARC	2003	AJK, Northern Areas, NWFP, Punjab	344
12-	Grapes & Peach Collection	PGRP/PARC	03-04	AJK, Northern Areas, NWFP	83
13-	Collection of Sesame & Peas	PGRP/PARC	03-04	Punjab	105
14-	Vegetables Collection	PGRP/PARC	2004	Sindh	269
15-	Vegetables Collection	PGRP/PARC	2004	Balochistan	63
16-	Grapes Collection	PGRP/PARC	2005	Balochistan	64
17-	Vegetables Collection	PGRP/PARC	2005	Balochistan	87
18-	Medicinal Collection	PARP/PARC	2003-05	Punjab, Balochistan, Sindh NWFP, Northern Areas, AJK,	1 872

ANNEXURE 2

GERMPLASM ACQUISITION FROM COLLABORATING COUNTRIES

S.No.	Country	Crop species	# Accessions
1-	Afghanistan	*Pisum sativum*	21
2-	Algeria	*Pisum sativum*	4
3-	Australia	*Pisum sativum*	3
4-	AVRDC, Taiwan	*Lycopersicon esculentum*	28
5-	Canada	*Pisum sativum*	1
6-	Canada	*Lathyrus sativus*	18
7-	China	*Hordeum vulgare*	1
8-	China	*Phaseolus* sp.	1
9-	China	*Vigna ungiculata*	1
10-	China	*Linum usitatissimum*	4
11-	China	*Oryza sativa*	8
12-	China	*Pisum sativum*	5
13-	China	*Sorghum bicolor*	3
14-	China	*Triticum aestivum*	41
15-	China	*Zea mays*	16
16-	Cyprus	*Pisum sativum*	2
17-	Cyprus	*Hordeum vulgare*	4
18-	Cyprus	*Triticum aestivum*	2
19-	Czech	*Pisum sativum*	2
20-	Ecuador	*Pisum sativum*	2
21-	Egypt	*Oryza sativa*	5
22-	Egypt	*Triticum aestivum*	8
23-	Egypt	*Pisum sativum*	2
24-	Ethiopia	*Pisum sativum*	9
25-	France	*Pisum sativum*	2
26-	Greece	*Pisum sativum*	1
27-	Hungary	*Pisum sativum*	2
28-	ICARDA, Syria	*Pisum sativum*	25
29-	ICARDA, Syria	*Pisum sativum*	24
30-	ICARDA, Syria	*Aegilops* spp	3
31-	ICARDA, Syria	*Cicer arietinum*	85
32-	ICARDA, Syria	*Hippocratea unisiliquosa*	5
33-	ICARDA, Syria	*Hordeum vulgare*	389
34-	ICARDA, Syria	*Lathyrus cicera*	58
35-	ICARDA, Syria	*Lens culinaris*	89
36-	ICARDA, Syria	*Medicago aculeata*	25
37-	ICARDA, Syria	*Scorpiurus muricatus*	5
38-	ICARDA, Syria	*Trigonella foenumgraecum*	5
39-	ICARDA, Syria	*Triticum aestivum*	210
40-	ICARDA, Syria	*Vicia ervilia*	66
41-	India	*Pisum sativum*	11
42-	Iran	*Pisum sativum*	2

S.No.	Country	Crop species	# Accessions
43-	Iran	*Hordeum vulgare*	10
44-	Iran	*Triticum aestivum*	25
45-	Iraq	*Pisum sativum*	1
46-	Iraq	*Oryza sativa*	273
47-	Japan	*Oryza sativa*	1
48-	Japan	*Avena sativa*	3
49-	Japan	*Hordeum vulgare*	2
50-	Japan	*Triticum aestivum*	2
51-	Japan	*Glycine max*	20
52-	Japan	*Sorghum bicolor*	6
53-	Japan	*Zea mays*	60
54-	Japan	*Pisum sativum*	619
55-	Japan	*Triticum aestivum*	76
56-	Japan	*Hordeum vulgare*	70
57-	Japan	*Phaseolus vulgaris*	4
58-	Japan	*Triticum aestivum*	20
59-	Japan	*Vigna unguiculata*	8
60-	Jordan	*Pisum sativum*	2
61-	Kazakhstan	*Pisum sativum*	5
62-	Korea	*Lycopersicon esculentum*	27
63-	Lebanon	*Pisum sativum*	1
64-	Libya	*Triticum aestivum*	5
65-	Mexico	*Triticum aestivum*	20
66-	Mexico	*Zea mays*	11
67-	Morocco	*Pisum sativum*	3
68-	Nepal	*Pisum sativum*	2
69-	Netherlands	*Pisum sativum*	99
70-	North Korea	*Glycine max*	37
71-	North Korea	*Oryza sativa*	103
72-	North Korea	*Sorghum bicolor*	12
73-	OUJ/JWC	*Hordeum vulgare*	118
74-	Philippines	*Oryza sativa*	12
75-	Portugal	*Pisum sativum*	1
76-	Rome, Italy	*Allium cepa*	14
77-	Rome, Italy	*Triticum aestivum*	6
78-	Russia	*Pisum sativum*	1
79-	Spain	*Pisum sativum*	1
80-	Syria	*Pisum sativum*	5
81-	Syria	*Triticum aestivum*	6
82-	Tajikistan	*Pisum sativum*	3
83-	Turkey	*Pisum sativum*	2
84-	UK	*Allium cepa*	14
85-	UK	*Pisum sativum*	2
86-	USA	*Hordeum vulgare*	4
87-	USA	*Triticum aestivum*	3
88-	USA	*Cicer arietinum*	486
89-	USA	*Hordeum vulgare*	1
90-	USA	*Lens culinaris*	246
91-	USA	*Pisum sativum*	1
92-	USA	*Brassica campestris*	168
93-	USA	*Avena sativa*	201
94-	Uzbekistan	*Pisum sativum*	2
Total			**4 022**

ANNEXURE 3

GERMPLASM DISTRIBUTION WITHIN COUNTRY

S.No.	Year	No. of Accessions
1-	1997	1 952
2-	1998	0827
3-	1999	0985
4-	2000	0970
5-	2001	0321
6-	2002	1 292
7-	2003	0915
8-	2004	0661
Total		**13 075**

ANNEXURE 4

GERMPLASM DISTRIBUTED TO INTERNATIONAL RESEARCH ORGANIZATIONS, UNIVERSITIES AND INSTITUTIONS

S.No.	Organization/Country	Crop species	No. of accessions
1-	Argentina	Cowpea	8
2-	Argentina	Lentil	10
3-	China	Wheat, Lentil, etc.	230
4-	Germany	Barley	5
5-	Germany	Onion	21
6-	Germany	Wheat	5
7-	ICARDA, Syria	*Aegilops*	42
8-	ICARDA, Syria	Barley	67
9-	ICARDA, Syria	Chickpea	509
10-	ICARDA, Syria	Faba Bean	10
11-	ICARDA, Syria	Groundnut	2
12-	ICARDA, Syria	*Lathyrus*	28
13-	ICARDA, Syria	Lentil	151
14-	ICARDA, Syria	Maize	4
15-	ICARDA, Syria	Medics	21
16-	ICARDA, Syria	Miscellaneous	24
17-	ICARDA, Syria	Oats	16
18-	ICARDA, Syria	Onion	2
19-	ICARDA, Syria	Safflower	1
20-	ICARDA, Syria	Sesame	1
21-	ICARDA, Syria	Secale	8
22-	ICARDA, Syria	*Trifolium*	4
23-	ICARDA, Syria	*Vicia*	13
24-	ICARDA, Syria	Wheat	818
25-	India	Millet	30
26-	India	Safflower	25
27-	Iran	*Kala Zeera*	29
28-	Iraq	Mungbean/Mashbean	200
29-	Japan	*Brassica*	1
30-	Japan	Minor cereals	250
31-	Japan	Peas	160
32-	Japan	Rice	339
33-	Japan	Safflower	40
34-	Japan	Vegetable	19
35-	Japan	Wheat	47
36-	Japan	Miscellaneous	129
37-	Korea	Wheat	50
38-	Korea	*Amaranthus*	1
39-	Korea	Barley	30
40-	Korea	Chick pea	15
41-	Korea	Cow pea	3

S.No.	Organization/Country	Crop species	No. of accessions
42-	Korea	Lablab bean	1
43-	Korea	Lentil	15
44-	Korea	Maize	15
45-	Korea	Mash	6
46-	Korea	Millet	5
47-	Korea	Ming	2
48-	Korea	Paper bean	3
49-	Korea	Pigeon pea	1
50-	Korea	Rice	30
51-	Korea	Rice bean	4
52-	Korea	Sord bean	1
53-	Korea	Sorghum	8
54-	Korea	Wheat	30
55-	Mexico	Maize	53
56-	Mexico	Wheat	266
57-	Netherlands	Barley	50
58-	Nepal	Barley	100
59-	Rome	Wheat	23
60-	Sri Lanka	Cowpea	19
61-	Sri Lanka	Lentil	20
62-	Sri Lanka	Mash bean	19
63-	Sri Lanka	Mung bean	46
64-	Sri Lanka	Rice	43
65-	Sri Lanka	Chickpea	10
66-	Taiwan	Legumes	200
67-	Taiwan	Mungbean	2
68-	USA	Barley	144
69-	USA	Chickpea	18
70-	USA	*Dacus* Spp.	5
71-	USA	Fruit	227
72-	USA	Lentil	154
73-	USA	Maize	56
74-	USA	Medics	21
75-	USA	Miscellaneous	24
76-	USA	*Moru* Spp.	20
77-	USA	Oats	6
78-	USA	Pisum	2
79-	USA	Secale	8
80-	USA	*Trifolium*	4
81-	USA	*Vicia*	13
82-	USA	Wheat	175
		Total	**5 217**

ANNEXURE 5

SEMINARS/WORKSHOPS/TRAININGS ORGANIZED

S.No.	Name of training courses
1-	Seminar on "Plant Genetic Resources for food security in South & West Asia". November 3-6, 1997.
2-	Tissue culture and biotechnology, 1997.
3-	Tissue culture and biotechnology, 1998.
4-	Seminar on "Underutilized crops of Pakistan". May 22-29, 1998.
5-	Seminar on "Medicinal Plants of Pakistan", December 2-3, 1998.
6-	Tissue culture and biotechnology, 1999.
7-	Seminar on "Sustainable Utilization of Plant Genetic Resources for Agricultural Production". December 17-19, 2002.
8-	Medicinal Plants: Linkages Beyond Boundaries. September 7-9, 2004.
9-	Production and post harvest processing of medicinal herbs. 2004.
10-	Plant molecular genomics. 2005.
11-	Production and post harvest processing of medicinal herbs. 2005.
12-	Production and post harvest processing of medicinal herbs. 2006.

ANNEXURE 6

RESEARCH THESES SUPERVISED AND COMPLETED AT PLANT GENETIC RESOURCES PROGRAM

S. No.	Name of University	Research title	Degree
1-	Quaid-i-Azam University	Effect of modified developmental stages on yield and yield components in maize (*Zea mays* L.)	Ph.D.
2-	Quaid-i-Azam University	Gene-action for some important morpho-physiological traits in wheat (*Triticum aestivum* L.) under field conditions	Ph.D.
3-	Quaid-i-Azam Univ.	Assessment of genetic diversity in chickpea (*Cicer arietinum* L.) germplasm based on morphological and biochemical gene markers	Ph.D.
4-	Quaid-i-Azam Univ.	Genetic diversity in *Lens culinaris* for morphological, biochemical and molecular markers	Ph.D.
5-	Quaid-i-Azam Univ.	Inheritance and breeding methods in *Vigna mungo*	Ph.D.
6-	Quaid-i-Azam Univ.	Biodiversity in Black Cumin (*Nigella sativa* L.) for morpho–physiological, agronomic and biochemical markers	Ph.D.
7-	Quaid-i-Azam Univ.	Biodiversity in Tomato	Ph.D.
8-	Quaid-i-Azam Univ.	Genetic diversity and inheritance in *Pisum sativum* L.	Ph.D.
9-	Quaid-i-Azam Univ.	Genetic diversity in local and exotic cowpea [*Vigna unguiculata* (L.) Walp.] germplassm based on plant traits and SDS-PAGE	M. Phil.
10-	Quaid-i-Azam Univ.	Phylogenetic relationship among *Vigna* spp. for morphological traits and biochemical markers	M. Phil.
11-	Quaid-i-Azam Univ.	Evaluation and characterization of local and exotic peas germplasm based on morphological traits and SDS-PAGE markers	M. Phil.
12-	Quaid-i-Azam Univ.	Effect of diethyl sulphate on okra (*Abelmoschus esculentus*)	M. Phil.
13-	Quaid-i-Azam Univ.	Phylogentic relationships in *Vigna* species based on morphological traits, seed proteins and quality characters	M. Phil.
14-	Quaid-i-Azam Univ.	Genetic diversity in local and exotic pea germplasm	M. Phil.
15-	Quaid-i-Azam Univ.	Diversity in *Pisum sativum* for SDS-PAGE markers and agronomic traits	M. Phil.
16-	Quaid-i-Azam Univ.	Genetic diversity in chickpea(*Cicer arietinum* L.)	M. Phil.
17-	Quaid-i-Azam Univ.	Genetic diversity in local and exotic germplasm of *Pisum sativum* for SDS-PAGE markers and agronomic traits	M. Phil.
18-	University of Arid Agriculture	Morphological and Biochemical evaluation of wheat germplasm collected from various parts of Pakistan	Ph.D.
19-	University of Arid Agriculture	Characterization and morphological/biochemical evaluation of landrace genotypes of barley	Ph.D.
20-	Quaid-i-Azam Univ.	Taxonomic and biochemical studies of medicinally important Speciec of family *Solanaceae* from Pakistan	Ph.D.
21-	University of Arid Agriculture	Genetic diversity for morpho-physiological and biochemical traits in Indian mustard [*Brassica juncea* (L.) Czern. & Coss]	Ph.D.
22-	Gomal University, D.I. Khan	Inheritance and genetic variability of wheat (*Tritium aestivum* L.) germplasm from NWFP, Pakistan determined by morphological traits and bio-chemical markers	Ph.D.
23-	Quaid-i-Azam Univ.	Morphological and biochemical evaluation of landrace genotypes of rice.	M.Phil.
24-	Quaid-i-Azam Univ.	Germplasm Evaluation, Morphomolecular Diversity and Fertilizer Response in Castor (*Ricinus communis*)	M.Phil.
25-	Quaid-i-Azam Univ.	Germplasm Evaluation of *Trachyspermum ammi* (L.) Sprague Based on Morpho-Physiological and Biochemical Markers.	M.Phil.
26-	Univ. of Arid Agriculture	Characterization of Local Fennel (*Foeniculum vulgare* Mill) for oil contents and Genetic Variability.	Ph.D.
27-	Univ. of Arid Agriculture	*In vitro* culture of sugarcane	M.Sc.
28-	Univ. of Arid, Agriculture	*In vitro* culture of grape	M.Sc.
29-	NWFP Agri. Univ., Peshawar.	*In vitro* morphogenesis under various hormonal regimes in sugarcane.	M.Sc.
30-	Quaid-i-Azam University	Genetic diversity in *Ocimum basilicum* and *O. sanctum* and their mycoflora in germplasm collections from Pakistan.	M.Phil.
31-	University of Arid Agriculture	Genetic diversity in wheat	M.Sc. **Internship**

S. No.	Name of University	Research title	Degree
32-	University of Arid Agriculture	Genetic diversity in barley	M.Sc. **Internship**
33-	Quaid-i-Azam Univ.	Artificial seed ageing and callgenic response in wheat (*Triticum aestivum* L.) seeds	M.Phil.
34-	University of Arid Agriculture	Report writing on research methods in genebank management	B.Sc. **Internship**
35-	Univ. of Arid Agriculture	Inter and intra-specific variation in SDS-PAGE electrophoresis of total seed protein in chickpea germplasm	M.Sc. **Internship**
36-	Univ. of Arid Agriculture	Inter and intra-specific variation in SDS-PAGE electrophoresis of total seed protein in rice germplasm	M.Sc. **Internship**
37-	Quaid-i-Azam Univ.	Screening of rice Germplasm for salt tolerance	M.Phil
38-	Quaid-i-Azam Univ.	Studies of high-molecular weight glutenin sub-unit polymorphism in wheat	M.Phil
39-	Quaid-i-Azam Univ.	Morpho-physiological and biochemical analysis of genetic diversity of rice form Pakistan	M.Phil
40-	Quaid-i-Azam Univ.	Morpho-physiological and biochemical analysis of genetic diversity of barley from West Asia and North Africa	M.Phil
41-	Quaid-i-Azam Univ.	Geographical diversity in local wheat germplasm based on morphological and biochemical traits	Ph.D.
42-	Univ. of Arid Agriculture	Morphological and Biochemical evaluation of wheat Germplasm collected form various parts of Pakistan	Ph.D.
43-	Univ. of Arid Agriculture	Characterization and morphological/biochemical evaluation of landrace genotypes of barley	Ph.D.
44-	Quaid-i-Azam Univ.	Taxonomic and biochemical studies of medicinally important species of family *solanaceae* from Pakistan	Ph.D.

ANNEXURE 7

LIST OF PROJECTS

Name of project	Coordinating Institutions
Acceleration of pulses research and production in Punjab for its import substitution.	Pulses Research Institute, Faisalabad
Acquisition, distribution and evaluation of wheat and barley germplasm	Cooperative Research Programme on Wheat & Barley, NARC, Islamabad
Acquisition, Screening and Utilization of Peas Germplasm for Development of Superior Cultivars.	Plant Genetic Resources Institute, NARC
Acquisition, Screening and Utilization Germplasm of Pearl Millet for the Development of dual purpose Cultivars.	Millet Research Station, Rawalpindi
Application of DNA finger printing for drought tolerance in wheat	National Institute for Biotechnology & Genetic Engineering, Faisalabad
A survey of germplasm resources and phtosociology, ecotype variations inmorphological, anatomical,bio-chemical chertarization and phytoremeditation potential of two aromatic grasses- Vetiveria zizanioides & Cymbopogon jwarancusa- with special reference to Sothern Punjab.	Cholistan Institute of Desert Station, Islamia University, Bahawalpur
Bread wheat improvement for drought tolerance and high yield potential.	Nuclear Institute for Food & Agriculture,Peshawar
Breeding for Synthetic Maize	Maize & Millet Research Institute, Yousaf Wala
Cereal Crop Improvement Programme	Cereal Crops Research Institute, Pirsabak
Characterization & Evaluation of Crop Germplasm & Crop Improvement for Rainfed Areas	Barani Agricultural Research Institute, Chakwal
Characterization of pathotypes/races of ascochyta rabiei in chickpea varieties	Nuclear Institute of Agricultural & Biology, Faisalabad
Cholistan desert ecosystem monitoring for future management and awareness.	Cholistan Institute of Desert Station, Islamia University, Bahawalpur
Collection, Conservation, Evaluation and Documentation of Horticultural Crop Germplasm And Its Wild Relatives.	Plant Genetic Resources Institute, NARC, Islamabad
Collection, Conservation and Evaluation of Plant Genetic Resources	Plant Genetic Resources Institute, NARC, Islamabad
Collection of Cotton Germplasm	Central Cotton Research Institute, Multan
Collection of Desert Plants, Trees, Shrubs & Grasses	Aid Zone Research Institute, Bahawalpur
Combating desertification in Cholistan desert through exploitable genetic potential of *Prosopis cineraria* L. Druce.	Cholistan Institute of Desert Station, Islamia University, Bahawalpur
Conservation and Sustainable Utilization of Agro-biodiversity of under Utilized crops	Plant Genetic Resources Institute, NARC, Islamabad
Crop Genetic Improvement	Department of Plant Breeding & Genetics, UAF, Faisalabad
Crop Improvement programme	Nuclear Institute of Agricultural & Biology, Faisalabad
Development & screening of Sugarcane & Sugarbeet germplasm.	Sugar Crop Research Institute, Mardan
Development of better Oilseed Varieties/Hybrids Enhance the Oilseed Production	Oilseeds Research Institute, Faisalabad
Development of canola quality mustard genotypes	Nuclear Institute for Food & Agriculture, Peshawar
Development of heat tolerant early maturing & high yielding mungbean genotypes.	Nuclear Institute for Food & Agriculture, Peshawar
Development of Heat Tolerant wheat varieties	Wheat Research Institute, Faisalabad
Development of high yielding and well adaptive indigenous canola hybrids.	Cooperative Research Programme on Oilseeds, NARC
Development of high yielding groundnut varieties	Barani Agricultural Research Institute, Chakwal
Development of Local Sunflower Hybrids	Cooperative Research Programme on Oilseeds, NARC, Islamabad
Development of wheat Varieties & package of production technology	Wheat Research Institute, Faisalabad
Development of techniques for the commercial scale propagation of medicinal plants	Botany Department, UAF Faisalabad
DNA-based genetic characterization of cotton germplasm	National Institute for Biotechnology & Genetic Engineering, Faisalabad
DNA based genetic characterization of maize germplasm	NWFP Agriculture University, Peshawar
DNA marker for wilt resistant genes in Chickpea	University of Agriculture, Faisalabad
Establishment of Cultivar Adaptability, Testing and Registration System	Federal Seed Certification & Registration Department, Islamabad
Establishment of National Variety Data Bank	Federal Seed Certification & Registration Department, Islamabad
Establishment of Seed Testing Laboratories to Meet WTO Requirements	Federal Seed Certification & Registration Department, Islamabad
Establishment & maintenance of Botanical Gardens	Botany Department, UAF Faisalabad

Name of project	Coordinating Institutions
Evaluation, Characterization & improvement of Oilseeds Crops.	Cooperative Research Programme on Oilseeds, NARC, Islamabad
Evaluation of wheat varieties for low water requirements using conventional and mutation breeding techniques	Nuclear Institute for Food & Agriculture, Peshawar
Exploitation of Forage Legume Diversity Endemic To Salt Range In Soon Valley of The Punjab.	University of Agriculture, Faisalabad
Genetic Improvement of *Brassica* Oilseed By Integrative Use Of Conventional	NWFP Agriculture University, Peshawar
Genetic Improvement of Crops	Arid Zone Research Institute, Bahawalpur
Genetic improvement of pulse crops	Pakistan Agricultural Research Council, Islamabad
Germplasm Evaluation, selection and dissemination of Lentil under the environment of highland Balochistan	National Agricultural Research Centre, NARC, Islamabad
Germplasm Evaluation and selection against prevalent biotic and abiotic stresses in highland Balochistan	National Agricultural Research Centre, NARC, Islamabad
Haploidy breeding and *in vitro mutageneisis* for drought tolerance in wheat	Nuclear Institute for Food & Agriculture, Peshawar
Hybrid Maize Breeding Program	Maize & Millet Research Institute, Yousaf Wala
Hybrid Seed Production of Rice	Rice Research Institute, Kala Shah Kaku
Improvement of drought tolerance in desi chickpea through induced mutations.	Nuclear Institute for Food & Agriculture, Peshawar
Increasing Production of Kabuli Chickpea For Its Import Substitution.	Pulses Research Institute, Faisalabad
In situ evaluation of indigenous walnut	Agricultural Research Station, Mingora
Integration of Biotechnology with Plant Breeding for crop improvement.	Center of Agricultural Biotechnology & Biochemistry, Faisalabad
Introduction and yield improvement of under exploited pulses in NWFP	Agricultural Research Institute, Tarnab, Peshawar
In Vitro Conservation and Cryopreservation of Plant Germplasm of Vegetatively Propagated Crops.	Plant Genetic Resources Institute, NARC, Islamabad
Irrigated Wheat Improvement Program	Nuclear Institute for Food & Agriculture, Peshawar
Molecular Breeding of Kabuli Chickpea For Ascochyta Blight Resistance and High Yield Potential	Cooperative Research Programme on Pulses, NARC, Islamabad
Molecular characterization of rice germplasm using RAPD analysis	Plant Genetic Resources Institute, NARC, Islamabad
Mutation breeding for high grain yield, improved quality and earliness in non-aromatic rice	Nuclear Institute for Agriculture, Tandojam
Pearl Millet Breeding Program	Maize & Millet Research Institute, Yousaf Wala
Production of doubled haploids of Wheat by using wheat x maize crosses technique	Barani Agricultural Research Institute, Chakwal
Production of Fruit and Vegetable Project Punjab	Barani Agricultural Research Institute, Chakwal
Production of Jojoba through Research and Extension	Oilseeds Research Institute, Faisalabad
Quality characterization of oilseed crops through NIRS	Nuclear Institute for Food & Agriculture, Peshawar
Screening of citrus cultivars	University of Agriculture, Faisalabad
Seed Production of Rice Hybrids	Rice Research Institute, Kala Shah Kaku
Socio-economic improvement of Cholistan desert dwellers through exploitable genetic potential of xeric grasses	Cholistan Institute of Desert Station, Islamia University Bahawalpur
Sorghum Breeding Program	Maize & Millet Research Institute, Yousaf Wala
Strengthening of Coordinated Research Programmes of PARC	Cooperative Research Programme on Wheat & Barley, NARC, Islamabad
Studies on breeding biology and post natal development and control trails against rodent damaging date palm orchards	University of Karachi, Govt. of Sindh
Studies on Viral Diseases of Major Pulse Crops And Identification of Resistant Sources.	Cooperative Research Programme on Pulses, NARC, Islamabad
Sustainable approaches toward	Barani Agricultural Research Station, Kohat
To Develop Drought Resistant Wheat (*Triticum aestivum* L.) Genotypes Under Water Stress Condition.	Nuclear Institute for Agriculture, Tandojam
Utilization of genetic variation in yield response to drought stress for the development of improved wheat germplasm	Cooperative Research Programme on Wheat & Barley, NARC, Islamabad
Varietal Improvement in Vegetables	Vegetables Research Institute, Faisalabad

ANNEXURE 8

FIRST NATIONAL WORKSHOP OCTOBER 30, 2006

Establishment of a National Information Sharing Mechanism for Monitoring the Implementation in Pakistan of the Global Plan of Action for Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture and Preparation of a PGRFA Country Report

AGENDA

8:30 – 9:15am	Registration
9:30 – 9:35am	Recitation from Holy Qura'an
9:35 – 9:55am	Welcome Address by *Dr. Zahoor Ahmad* Objectives of the Workshop Introduction of participants Presentation of the Agenda
9:55 – 10:10am	Inaugural Address and Opening Remarks by *Dr. M. Afzal*, Director General, NARC.
10:10 – 10:20am	Opening remarks by *Mr. Memed Gunawan*, FAO Representative
10:20 – 10:25am	Vote of Thanks
10:25 – 10:45am	Tea break
10:45 – 11:20am	The Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture: the 20 priority activity areas and those particularly relevant to the PGR Program. *Dr. Zahoor Ahmad*
11:20 – 11:45am	Presentation of the activities in the PGR Program. *Dr Shahid Masood.*
11:45 – 12:30pm	General context – Monitoring the implementation of the Global Plan of Action and Preparation of the Second State of the World's Report. *FAO*
12:30 – 13:00pm	Overview of the indicators and reporting format for monitoring GPA implementation. *FAO*
13:00 – 14:00pm	Lunch break
14:00 – 14:45pm	Demonstration of an established National Information Sharing Mechanism on PGRFA. *FAO*
15:15 – 15:30pm	The strategy for the establishment in Pakistan of the national information sharing mechanism and for the preparation of a Country Report of the state of PGRFA. Activities and tentative work plan; timeframe; national focal point and stakeholders' roles and responsibilities. Dr. Zahoor Ahmad, Dr. Shahid Masood
15:30 – 16:00pm	Tea break
16:00 – 16:15pm	Revision of information in Common Tables. *Mr. Abdul Qayyum*
16:15 – 16:45pm	Discussion and agreement on the strategy and adoption of the work plan.
16:45 – 17:00pm	Closing

Workshop documents

1. **Working documents**
   - Statement on role and responsibilities of National Focal Point and Stakeholders
   - Work plan for the project activities with expected milestones and timeframe
   - Template for completing information of Common Tables

2. **Background documents**
   - Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture
   - Indicators and Reporting Format for monitoring the Implementation of the Global Plan of Action
   - Pakistan Country Report to the FAO International Technical Conference on Plant Genetic Resources. Leipzig, 1996

ANNEXURE 9

SECOND NATIONAL WORKSHOP DECEMBER 18 - 19, 2006

Establishment of a National Information Sharing Mechanism for Monitoring the Implementation in Pakistan of the Global Plan of Action for Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture and Preparation of a PGRFA Country Report

AGENDA

Day 1: Monday, 18th December, 2006

8:30 – 9:15am	Registration
9:30 – 9:35am	Recitation from Holy Qura'an
9:35 – 9:55am	Welcome address by *Dr. Zahoor Ahmad* Objectives of the Workshop Presentation of the Agenda Introduction of participants
9:55 – 10:10am	Inaugural address and Opening Remarks by Director General, NARC.
10:10 – 10:20am	Opening remarks by *Mr. Memed Gunawan,* FAO Representative
10:20 – 10:45am	Tea break
10:45 – 11:05am	Plant Genetic Resources and Global Plan of Action By *Dr. Zahoor Ahmad*
11:05 – 11:50am	General context – Monitoring the Implementation of the Global Plan of Action and Preparation of the Second State of the World's Report. By FAO
11:50 – 12:20am	Overview of the indicators and reporting format for monitoring GPA implementation. By FAO
12:20 – 12:45pm	Demonstration of the Computer Application of the National Information Sharing Mechanism. By *Abdul Qayyum* and *Muhammad Kashif*
12:45 – 13:00pm	Introduction to the work plan. Activities and expected outputs. By *Abdul Qayyum* and *Muhammad Kashif*
13:00 – 14:00pm	Lunch break
14:00 – 15:30pm	Practical Session-1 Installation; User Registration; Documents; Backing-up data
15:30 – 16:00pm	Tea break
16:00 – 17:00pm	Practical Session-2 Working with the Common Tables

Day 2: Tuesday, 19th December, 2006

9:00 – 10:30am	Practical Session-3 The Questionnaire; recording and displaying answers
10:30 – 11:00am	Tea break
11:00 – 13:00pm	Practical Session-4 Exporting/Importing data to/from Excel; Exporting data to the National Focal Point
13:00 – 14:00pm	Lunch break
14:00 – 15:30pm	Practical Session-5 Questions and Answers; Review of main issues
15:30 – 16:00pm	Tea break
16:00 – 16:45pm	Discussion and agreement on the work plan
16:45 – 17:00pm	Closing

ANNEXURE 10

THIRD NATIONAL WORKSHOP APRIL 10, 2007

Establishment of a National Information Sharing Mechanism for Monitoring the Implementation in Pakistan of the Global Plan of Action for Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture and Preparation of a PGRFA Country Report

AGENDA

Tuesday 10th April, 2007

9:00 – 9:30am	Registration
9:30 – 9:35am	Recitation from Holy Qura'an
9:35 – 9:45am	Welcome address by *Dr. Zahoor Ahmad* Objectives of the Workshop Presentation of the Agenda Introduction of participants
9:45 – 10:00am	Inaugural address and Opening Remarks by Director General, NARC.
10:00 – 10:10am	Opening remarks by *Mr. Memed Gunawan,* FAO Representative
10:10 – 10:40am	Tea break
10:45 – 12:30pm	Demonstration of information on Common Tables responses from stakeholders and discussions *Mr. Abdul Qayyum & Mr. M. Kashif*
12:30 – 1:30pm	Lunch and Prayer Break
1:30 – 3:30pm	Presentation of Country Report and discussions
3:30 pm	Closing

ANNEXURE 11

LIST OF PARTICIPANTS

S.No.	Name and Addresses	City
1	Dr. Kausar Nawaz Shah, Cytgenetics, BARI, Chakwal. Knshah786786@yahoo.co.uk	Chakwal
2	Dr.Muhammad Aqil, Director, Wheat Research Institute, AARI, Faisalabad. Dr_aqil@yahoo.com	Faisalabad
3	Dr. Abdul Rashid, Director, Vegetable Research Institute, Faisalabad. Director_vegetable@yahoo.com	Faisalabad
4	Dr. Asif Ali, Associate Professor, Deptt. of PBG, UAF, Faisalabad	Faisalabad
5	Mr. Azeem Iqbal Khan, Assistant Prof. CABB, UAF, Faisalabad. ranaazeemiqbal@yahoo.com	Faisalabad
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15	Mr. Babar Manzoor, Senior Scientist, Mutation Breeding Division, NIAB, Faisalabad. Babar_niab@hotmail.com	Faisalabad.
16	Mr. Muhammad Saeed Iqbal, Cotton Botanist, CRI, AARI, Faisalabad	Faisalabad.
17	Mr. M. Shafiq Alam, Statistician, Vegetable Res. Institute, AARI, Faisalabad	Faisalabad.
18	Mr. M. Shafiq, Assistant Botanist, Pulses Res. Institute, Faisalabad	Faisalabad.
19	Dr.Rash Khan, Director KARINA, Juglote, Gilgit	Gilgit
20	Mr. Mohammad Azam Khan, ASO, KARINA, Juglote, Gilgit	Gilgit
21	Mr. Saeed Iqbal, Sees Analyst, FSCD, Islamabad. Saeediqbal65@hotmail.com	Islamabad
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23	Syed Mahmood Nasir, Director Biodiversity, Ministry of Environment, Islamabad	Islamabad
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27	Dr. G.M. Sajid, SSO, PGRP, NARC, Islamabad	Islamabad
28	Dr. Ghulam Jillani, CSO/DDG, CDRP, NARC, Islamabad	Islamabad
29	Dr. Hamid Rashid, SSO, ABP, NARC, Islamabad	Islamabad
30	Dr. M. Akram, PSO, Rice Program, NARC, Islamabad	Islamabad
31	Dr. M. Ashraf Tajammal, Dy. Director, FSCD, Islamabad	Islamabad
32	Dr. M. Salim, National Coordinator Rice, NARC, Islamabad	Islamabad
33	Dr. M. Shahid Masood, CSO, IABGR, NARC, Islamabad	Islamabad
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S.No.	Name and Addresses	City
39	Dr. Saddar uddin Siddiqui, SSO, PGRP, NARC, Islamabad	Islamabad
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45	Mr. Ayub Khan, SSO, Oilseed Program, NARC, Islamabad	Islamabad
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53	Mr. Shakeel Ahmad, SO, Vegetable Program, NARC, Islamabad	Islamabad
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