COUNTRY REPORT

STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN INDIA (1996 – 2006)

A Country Report

National Bureau of Plant Genetic Resources
(Indian Council of Agricultural Research)
New Delhi - 110 012, India
January, 2007

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Foreword

The Food and Agriculture Organization of the United Nations' (FAO) Report on the State of the World's Plant Genetic Resources (PGR), 1998 has been the first comprehensive world-wide assessment of the state of PGR conservation and use. Representatives of 150 countries and 54 inter-governmental and non-governmental organizations at the Fourth International Technical Conference on PGR in Leipzig in 1996 had welcomed this report and also adopted the Global Plan of Action (GPA) that provides a framework for action for the conservation and sustainable use of PGR for food and agriculture (PGRFA) at local, national, regional and international levels so as to address the needs and priorities expressed in the Report.

The GPA has been recognized as an important contribution of the FAO Global System to the implementation of the Convention on Biological Diversity (CBD). It is one of the supporting elements of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) that addressed the outstanding issues of the Nairobi Final Act. The GPA comprises a framework of 20 priority activities under 4 priority areas, namely, (i) *In Situ* Conservation and Development, (ii) *Ex Situ* Conservation, (iii) Utilization of PGR, and (iv) Institutions and Capacity Building. The intermediate and long-term objectives of GPA cover agreed specific recommendations for action in the fields of policy and strategy, capacity-building, research and technology, and administration and coordination. On the other hand, the Conference of Parties (COP) to the CBD in their Decision II/16 had also welcomed the offer of the FAO to link its information mechanisms to the clearing-house mechanism (CHM) under the Convention.

The GPA also aimed at assisting countries and institutions responsible for conservation and use of PGRFA to identify priorities for action and strengthen their programmes, including education and training. Thus GPA catalyses for priority-setting and also synergizing among activities for the conservation and sustainable use of PGRFA. The signatory countries are committed to implement the plan and the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) monitors the overall progress in its implementation. A periodical assessment of the state of world's PGRFA would facilitate the analysis of changing needs and gaps; and this will help in the adjustment of the rolling GPA. The preparation of the second Report on the State of World's PGRFA has been a further step in this direction.

The ITPGRFA was adopted by FAO Conference in November, 2001, and it came into force on June 29,

2004. The need for periodic reports on the state of world's PGR is reaffirmed by the Treaty, which requires that Contracting Parties shall cooperate with the CGRFA of the FAO in reassessment of the state of world's PGRFA.

The CGRFA at its Ninth Regular Session in October, 2002 considered a proposed outline of the second Report on the State of the World's PGRFA, and steps for its preparation. Consequently countries were requested to prepare for the compilation of the report through a guideline. The Commission also stressed that the preparatory process should be fully integrated with the process of monitoring the implementation of the GPA. As per the time line detailed in the document CGRFA-10/04/5 Add.1, if the second Report is not adopted in 2006, it would be available for adoption by the Commission at its Twelfth Regular Session slated to be held in October 2008.

With the country-driven nature of the preparatory process, we are very pleased that India and other six participating countries of the GCP/RAS/186/JPN project are among the first countries that established a National Information Sharing Mechanism on the Implementation of GPA (NISM-GPA). The data generated under the project and NISM-GPA and the report have already been submitted to FAO. This forms the basis of this country report, which has been supplemented with additional information required as per the guideline.

We recognize the leadership role played by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, one of the four genetic resources bureaux established by the Indian Council of Agricultural Research (ICAR), in the process of establishing the NISM-GPA in India. The achievements of NBPGR in bringing together over one hundred stakeholders from around the country to discuss and share knowledge about the GPA and the purpose and the activities of the NISM-GPA; and in materializing meaningful collaboration with the stakeholders in establishing the mechanism are indeed commendable. The efforts made by the committee constituted to contribute to individual chapters and to bring the comprehensive country report are highly appreciated.

We are pleased over the amount and quality of information on PGR activities in the country gathered and documented in this report. This will aptly set the right direction for the country to sustainably manage its PGRFA for food and nutritional security for its present and future generations; and to share the information with other countries through the mechanisms set out by the FAO and the CBD.

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New Delhi
22nd February, 2007

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EXECUTIVE SUMMARY

India is located to the North of equator between 8^0 4′ to 37^0 6′ N latitude and 68^0 7′ to 97^0 25′ E longitude. India is the second most populated nation in the world next only to China. The country can be broadly categorized into three geological regions: the Himalayas and eastern Hills, the Indo-Gangetic plains and the Peninsular shield. The Indian subcontinent is very rich in biological diversity, harbouring around 49,000 species of plants, including about 17,500 species of higher plants. A rich crop diversity is avialable in India in terms of both number of species and within the species. The net sown area in the country was 141.03 m ha in 2000-01. The present cropping intensity is 136%. Agriculture is the largest private enterprise in India (>100 million farm holdings) and is the lifeline of Indian economy. It contributes nearly 22% of the national GDP and sustains livelihood of about two-thirds of its population.

Presently, the Indian diversity is composed of rich genetic wealth of native as well as introduced types. Crop diversity is well represented as developed cultivars, landraces or as folk varieties in different phytogeographical regions of India.

In situ conservation of Plant Genetic Resources (PGR) forms an integral part of the biodiversity conservation programmes in India. Fourteen Biosphere Reserves have been designated of which four are included in the World Network of Biosphere Reserves. There are 92 National Parks and 500 wildlife sanctuaries in the country covering an area of 15.67 m ha. Several difficult areas were explored during last five years and rare/endemic/ endangered species were collected. Efforts have been made for documentation and protection of indigenous technical knowledge and also the germplasm of the local landraces/ farmers' varieties.

Realizing the importance of collecting and conserving PGRFA, India has taken strategic steps for their *ex situ* conservation using appropriate approaches. Major part of this work has been carried out under Indian Council of Agricultural Research (ICAR) by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, with its 10 regional stations/base centres/quarantine centres' over different phyto-geographic zones of the country and active collaboration and linkages with over 40 National Active Germplasm Sites (NAGS). The National Genebank of NBPGR has three types of storage facilities - seed genebank, cryogenebank and *in vitro* genebank and has 3,49,020 germplasm

accessions currently, of nearly 1,187 species. Stock inventorization and monitoring of viability is performed regularly in most of the accessions.

There exists a mechanism of 'Single Window System of Germplasm Supply' to the users in the country. NBPGR is the nodal organization supplying genetic resources to different breeding programmes through its network. There have been a number of success stories in crop improvement programmes resulting in development/genetic improvements of a number of cultivars/ hybrids that have helped in enhancing the national production demonstrating the contribution in increasing the productivity. Most of the crop species have been evaluated for morphological and agronomic traits. A total of 4,618 cultivars have been released in 162 crops. However, 10 crops including cereals, millets, cotton and chickpea contribute towards 50% of the total cultivars released so far.

Realising the increasing importance of activities related to PGR, NBPGR in collaboration with Indian Agricultural Research Institute (IARI) started Master's and Ph.D. programmes in PGR. The level of public awareness on the importance of PGRFA conservation in the country is satisfactory, however, literacy about various international agreements and national legislations with regard to plant genetic resources needs strengthening. Aspects related to PGRFA are being integrated into the pre-secondary and secondary educational curricula.

Over the past fifteen years, several management action plans have been undertaken to maintain or enhance exchange of PGR, through workplans, MoU's and collaborative/bilateral research programmes with different countries. Various crop germplasm were exchanged under the provision of these work plans. However, after the International Treaty on Plant Genetic Resources for Food and Agriculture comes into force, access to PGRFA for utilization, conservation, research, breeding and training would be facilitated.

In India important legislations have been enforced in response to international developments. These are the "Biological Diversity Act 2002", "Protection of Plant Varieties and Farmers' Right Act 2001" (PPV & FRA) and "Geographical Indications of Goods (registration and protection) Act 1999". In addition, amendments have been made in the "Patents (Amendment) Act 2005" and the "Plant Quarantine Regulation of Import into India Order 2003" which have a bearing on PGR management.

Mechanisms for benefit sharing have been put in place in the form of different legislations listed above. International agreements that are relevant to the implementation of Farmers' Rights, viz. Convention of Biological Diversity, Global Plan of Action, International Treaty on Plant Genetic Resources for Food and Agriculture have been subscribed. The PPV&FRA has been enacted as a national legislation to achieve or enhance the implementation of Farmers' Rights.

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We gratefully acknowledge the support of Food and Agriculture Organisation (FAO) of the United Nations and the Government of Japan, for their generous financial and technical assistance given to GCP/RAS/186/JPN project "Implementation of the GPA for the Conservation and Sustainable Utilization of PGRFA in Asia and the Pacific". We also thank the Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India for giving National Bureau of Plant Genetic Resources (NBPGR) the responsibility of executing this project.

The compilation of this report in India was carried out under the consistent guidance of Dr. Mangala Rai, Secretary, Department of Agricultural Research and Education, Government of India and Director General, Indian Council of Agricultural Research (ICAR)

Dr. S.P. Tiwari, Deputy Director General (Education and Crop Science), ICAR has been a source of inspiration and guidance right from the inception of this project. We sincerely thank him for his contribution in preparation of this report. Dr. N.D. Jambhale, Assistant Director General (Seed) and Dr. Sudhir Kochhar, Principal Scientist, ICAR, deserve a special mention of their help in critical evaluation of the report.

Special thanks are also due to Drs. N. Quat Ng and Stefano Diulgheroff for their keen interest, critical comments and technical support to the project.

We also wish to thank all Heads of Divisions and staff of NBPGR for their full support and help in successful compilation of this report. Last but not the least, all the contributors deserve to be appreciated for their invaluable contribution in making this comprehensive report.

Introduction

India is located to the North of equator between 8^0 4′ to 37^0 6′ N latitude and 68^0 7′ to 97^0 25′ E longitude. It is the seventh largest country in the world with a total land area of 3,287,263 sq km. India is the second most populated nation in the world next only to China with its population of 1,027,015,284, as per 2001 census, and estimated as 1,103,371,000 for 2005. The average density of the population is ranked 31st in the world with about 329 persons/km^2.

The country can be broadly categorized into three geological regions: the Himalayas and eastern Hills, the Indo-Gangetic plains (alluvial tract) and the Peninsular shield (metamorphosed rocks). Geographically six regions can be outlined: the great plains; the mountain zone; the North-western gangetic North-eastern region comprising of Brahmaputra and Surma valleys; the desert region; the central and southern Plateau region; and the western and eastern peninsular region. Further, based on physiographic climate and cultural features, India is reported to be divided into 20 agro-climatic regions- i) Arid ecosystem, representing three agroclimatic regions in the country; one in the cold arid zone of western Himalayas and two in hot arid zones in the western India and Deccan Plateau; ii) Semi-arid Ecosystem comprising of five hot semi-arid eco-regions of northern plains and central highlands with alluvial derived soils, central (Malwa) Highlands, Gujarat Plains and Kathiawar with medium black soils, Deccan (Telangana) plateau with shallow and medium black soils, Deccan (Karnataka) plateau with Red loamy soils; iii) Sub-humid ecosystem representing five hot and one warm sub-humid eco-region in the northern central and eastern parts of the country; iv) Humid, prehumid Ecosystems comprising 3 agro-ecological regions in the north eastern India including Bengal; v) Coastal Ecosystem covering two regions of western and eastern ghats and vi) Island Ecosystem covering Andaman-Nicobar and Lakshadweep.

The forest cover in India has been assessed as 678,333 km^2 as per "State of Forest Report of the Government of India" (2003), which constituted 20.64% of the country geographical area.

India figures among the bio-diversity rich countries in the world, having about 7.5% of the identified biological species. The Indian subcontinent is very rich in biological diversity, harbouring around 49,000 species of plants, including about 17,500 species of higher plants. It possesses about 11.9% of world flora

with 5,725 endemic species of higher plants belonging to about 141 endemic genera and over 47 families. The Indian gene centre holds a prominent position among the 12 mega-gene centres of the world. It is also one of the Vavilovian centres of origin and the diversity of crop plants. Two out of the 25 global hotspots of biodiversity, namely the Indo-Burma and Western Ghats / Sri Lanka, occur here. About 166 species of crops including 25 major and minor crops have originated and / or developed diversity in this part of the world. Further, 320 species of wild relatives of crop plants are also known to occur here. A rich crop diversity is avialable in India in terms of both number of species and within the species. Landraces, traditional cultivars and farmer's varieties in several agricultural and horticultural plant species are abundant but a decreasing trend is noted in areas moving towards advanced agricultural practices. Crops in which rich diversity occurs in the country include rice, wheat, maize, barley, pigeonpea, chickpea, minor millets, mungbean, urdbean, horsegram, mothbean, ricebean, clusterbean, sesame, forage grasses, okra, eggplant, cucumber, melons, citrus, banana and plantains, jackfruit, mango, tamarind, *jamun*, jute, cotton, ginger, turmeric, pepper, cinnamon and cardamom. Among tuberous crops, rich variability exists in sweet-potato, taros and yams. Native resources are also available in *Coleus* species, sword-bean, velvet-bean and several minor fruits, such as berries and nuts; and several species of *Rubus*, *Ribes*, *Juglans*, *Pyrus* and *Prunus*.

India is the largest producer in the world of cashew nut, coconut, tea, ginger, turmeric and black pepper. It also has the world's largest cattle population (193 million) and is the largest producer of milk also. India ranks second worldwide in farm output. It is the second largest producer of wheat, sugar, groundnut and inland fish and the third largest producer of tobacco and rice. India accounts for 10% of the world fruit production with first rank in the production of banana and sapota.

The net sown area in the country increased from 118.75 m ha in 1950-51 to 141.03 m ha by 2000-01. The present cropping intensity of 136 % has registered an increase of only 25% since Independence. Broad cropping pattern indicates that foodgrains occupy a major share in gross cropped area as compared to non-foodgrains. The per caput availiability of the land is on the decline, signaling permanent ceiling on the horizontal expansion of cultivable area. Further, the vast area in the country has degraded due to salinity, waterlogging, acidity, erosion, which can be put to productive use through appropriate technological interventions. Broad cropping pattern indicates that though foodgrains have a preponderance in gross cropped areas as compared to non-foodgrains, their relative share came down from 76.7 % during 1950-51 to 65 % during 2000-2001. According to the Agriculture Census, the area operated by large holdings (10 ha and above) has declined to 14.8 % in 1995-1996 compared to 17.3 % in 1990-91. Similarly, the area operated under marginal holdings (less than one hectare) indicated that land is getting fragmented.

Water has been prioritized to be the most crucial resources. Agriculture uses almost 85% of the total water available in the country, while technological potential exists to raise it to about 90%. Inequity in access or availability of water, its spatial/temporal variability, public/private investments and participatory management are some of the issues for research, development and policy paradigms. India supports 16.8% world's poplulation with 4.2% world's water resources and 2.3% global land. Per caput availability of resources is 4 to 6 times lesser compared to world average. Foreseably, this will further decrease due to increasing demographic pressure and consequent diversion of land for non-agricultural use. Over years, in the quest for development serious damages have been caused to natural resources, soil, water, climate and biodiversity, challenging the very sustainability of agriculture.

SOURCE

1. FAO. 1996. India: Country Report to the FAO Technical Conference on Plant Genetic Resources. FAO, Rome, Italy.

2. ICAR. 2006. Handbook of Agriculture. Indian Council of Agricultural Research, New Delhi, India.

THE STATE OF DIVERSITY 1

THE MAIN VALUE OF PLANT GENETIC RESOURCES

Important crops and their products

The Indian subcontinent is very rich in biological diversity, harbouring around 49,000 species of plants, including about 17,500 species of higher plants. The Indian gene centre holds a prominent position among the 12 mega-gene centres of the world. It is also one of the Vavilovian centres of origin and diversity of crop plants. Two out of the 25 global hotspots of biodiversity, namely the Indo-Burma and Western Ghats / Sri Lanka, are located here[1]. India possesses about 12 per cent of world flora with 5,725 endemic species of higher plants belonging to about 141 endemic genera and over 47 families. About 166 species of crops including 25 major and minor crops have originated and/or developed diversity in this part of the world. Further, 320 species of wild relatives of crop plants are also known to occur here[2, 3].

Presently, the Indian diversity is composed of rich genetic wealth of native as well as introduced types, that is India is a primary as well as a secondary centre of diversity for several crops, and has also rich regional diversity for several South/Southeast Asian crops as described below:

i) **Primary centre of diversity for crops**: Rice, black gram, moth bean, pigeonpea, cucurbits (like smooth gourd, ridged gourd and pointed gourd), tree cotton, capsularis jute, jackfruit, banana, mango, *Syzygium cumini*/jamun, large cardamom, black pepper and several minor millets and medicinal plants like *Rauvolfia serpentina* and *Saussurea costus*.

ii) **Secondary centre of diversity for African crops**: Finger millet, pearl millet, sorghum, cowpea, cluster bean (transdomesticate), okra, sesame, niger and safflower; tropical American types such as maize, tomato, muskmelon/*Cucumis* species, pumpkin/*Cucurbita* species, chayote/chou-chou, chillies and *Amaranthus*; and

iii) **Regional (Asiatic) diversity for crops**: Maize, barley, amaranth, buckwheat, proso millet, foxtail millet, mungbean/green gram, chickpea, cucumber, bitter gourd, bottle gourd, snake gourd and some members of Tribe *Brassicae*.

Crops of Indian origin are listed in Table 1.1. Other important crops grown in India include onion, groundnut, rapeseed-mustard, soybean, tea, coffee, sunflower and among horticultural crops - banana, citrus, grapes, cashew and vegetables of European origin. The indigenous plant wealth has been supplemented by introduction of species and forms that have greatly enriched the local flora. These introduced species also diversified in India due to isolation over time and space, and diversity in climate and human intervention. The geographical proximity with the Indo-Chinese-Indonesian, the Chinese-Japanese, the Central and West Asian centres of diversity has helped in considerably augmenting our crop plants resources. The influx of genetic material from the Mediterranean, African centre, the European and American regions in the past has also resulted in accumulation and diversification of enormous genetic variability. The ancient travellers, traders and religious missionaries contributed significantly towards enriching the agro-biodiversity in the Indian gene centre. Presently, India has more than 480 species of agricultural crops as native and introduced species [4].

Major share of food comes from cultivated species viz. rice, wheat, maize, sorghum, barley, sugarcane, sugarbeet, potato, sweet potato, cassava, beans, groundnut, coconut, banana, oils, etc. Crops like chickpea, pigeonpea, pearl millet and other minor millets, cotton, sunflower, soybean, sugarcane, rapeseed-mustard, vegetable and horticultural crops have their regional importance (from the social and economic security view point) for the farming community. Vegetables and fleshy fruits are of perishable nature and consumed locally or in processed form. Besides, spices and condiments and beverages are obtained from cultivated and wild plant resources. The area, production and yield of major groups of crops showing relative importance of different crops are indicated in Table 1.2. The major crops and processed items exported as principal agricultural commodities are given in Table 1.3.

Table 1.1: Major crop species of Indian Origin[2]

Crop groups	Crops (Botanical name)
Cereals and millets	Rice (*Oryza sativa*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scrobiculatum*)
Grain legumes	Black gram (*Vigna mungo*), moth bean (*V. aconitifolia*), pigeonpea (*Cajanus cajan*), horse gram/kulthi (*Macrotyloma uniflorum*), velvet bean *(Mucuna utilis*)

Fruits	Mango (*Mangifera indica*), banana (*Musa* spp.) jamun (*Syzygium cumini*), jackfruit (*Artocarpus heterophyllus*), *Citrus* group, lime and others, karonda (*Carissa congesta*), khirni (*Manilkara hexandra)*, phalsa (*Grewia asiatica)*, bael (*Aegle marmelos)*, wood apple (*Feronia limonia*), kokam (*Garcinia indica*)
Vegetables	Eggplant (*Solanum melongena*), ridged gourd and smooth gourd (*Luffa* spp.) round gourd/tinda (*Praecitrullus fistulosus*), pointed gourd/parval (*Trichosanthes dioica*), taro/arbi (*Colocasia esculenta*), yam (*Dioscorea* spp.), jimikand (*Amorphophallus campanulatus*), kundri (*Coccinia indica*), cucumber (*Cucumis sativus*), rat tailed radish/mungra (*Raphanus caudatus*)
Oilseeds	Rai, sarson and toria types (*Brassica* spp.)
Fibres	Jute (*Corchorus capsularis*), cotton (*Gossypium arboreum*), sunnhemp (*Crotalaria juncea*)
Medicinal and aromatic	*Rauvolfia serpentina*, *Saussurea lappa*, Indian belladonna (*Atropa acuminata*), Indian barberry (*Berberis aristata*), *Commiphora wightii*
Spices and condiments	Turmeric (*Curcuma domestica*), ginger (*Zingiber officinale*), cardamom (*Elettaria cardamomum*), Bengal/large cardamom (*Amomum aromaticum*), long pepper (*Piper longum*), black pepper (*Piper nigrum*), betle leaf (*Piper betel*), cinnamon (*Cinnamomum* spp.)
Other crops	Sugarcane (*Saccharum officinarum*), bamboos (*Bambusa arundinacea, Dendrocalamus hamiltoni, Sinocalamus giganteus*), *Sesbania sesban,* tea (*Camellia sinensis*)

DIVERSITY WITHIN AND BETWEEN CROPS

Diversity in major crops

Crop diversity is well represented as developed cultivars, landraces or as folk varieties in different phytogeographical regions of India among diverse crop(s)/ crop-group(s). The western Himalayan region (including cold arid tracts) comprising Kinnaur, Lahul and Spiti and Pangi vallies, Ladakh and adjoining areas of Jammu and Kashmir and Uttarakhand hold rich diversity in wheat, maize, barley (hull-less types), proso millet, buckwheat, amaranth, chenopods, field peas, lentil, rice, French bean, *Cicer*, leafy Brassicae, pome, stone and nut fruits, medicago/clover, medicinal and aromatic plants.

Cereal crops are mostly grasses cultivated for their edible grains. The most extensively cultivated grains in the country are rice, wheat and maize. In rice both annual and perennial types occur particularly in the eastern and the central peninsular region including North-eastern plains. *Oryza nivara, O.perennis, O. officinalis, O.granulata, Porteresia coaractata* species and wild forms of *O. sativa* are fairly distributed[5]. Diversity in scented, deep water, cold and salt tolerant paddy types occur in various parts of the country. Considerable polymorphism is still found to exist in crops like wheat (*Triticum aestivum, T. dicoccum* and *T. durum*) and barley (*Hordeum vulgare*) in northern states in Himalayan region. Maize has rich diversity in the peninsular tract, western Himalayas and north eastern states. Fifteen distinct races and 3 sub races of maize were recognized in India. *Chionachne, Polytoca, Trilobachne* and *Teosinte* are also occurring in this region.

Millet crops have been dominant components of rainfed agriculture on a regional basis in India. Millets are small grained, annual, warm weather cereals of grass family that includes 8,000 species within 600 genera, of which 35 species comprising 20 genera have been domesticated. Millets used to be cultivated in an area of 35-37 m ha in India and are reduced to 20-22 m ha during the past decade[6]. The word millets was used to connotate the following eight crops Great millet (*Sorghum bicolor*), Pearl millet (*Pennisetum typhoides*), Finger millet (*Eleusine coracana*), Fox tail millet (*Setaria italica*), Proso millet (*Panicum miliaceum*), Little millet (*Panicum miliare*), Barnyard millet (*Echinochloa colona*) and Kodo millet (*Paspalum scrobiculatum*). Their adaptation to harsher environments and diverse cultural and agro-climatic situations is well known. The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) located in India maintains 44,822 accessions of Sorghum, 21,191 accessions of pearl millet and 3,460 accessions of small millets.

In the India's agricultural sector, oilseeds occupy a distinct position after cereals sharing 13% of the country's gross cropped area and accounting for nearly 3% of the gross national product and 10% of the value of all agricultural products[7]. India ranks first in castor and safflower production and it is the second largest producer of groundnut and sesame and ranks third in linseed and rapeseed, fifth and ninth in soybean and sunflower, respectively. India is blessed with diverse agro-ecological conditions ideally suited for growing nine annual oilseed crops viz., groundnut, rapeseed-mustard, sunflower, sesame, soybean, safflower, castor, linseed and niger and two perennial oilseed crops (coconut and oil palm). In addition to the above, more than 100 tree species of forest origin which have the potential to yield about one million tonnes of vegetable oil are grown in the country. The oilseeds scenario in the country has undergone a sea change in the last 18 years. India has emerged from a net importer in 1980's to a net exporter status during the early 1990's. Again it has become

a net importer accounting more than 40% annual edible oil needs.

The tribal dominated areas of North-eastern region and the Eastern Himalaya such as Mizoram, Meghalaya, Tripura, Manipur, Arunachal Pradesh, parts of Nagaland, north Bengal and Sikkim are extremely rich in variability in rice, maize (including primitive popcorn), barley, wheat, buckwheat, *Chenopodium*, amaranth, soft shelled form of *Coix,* foxtail millet, finger millet, rice bean, winged bean, adzuki bean, sem, blackgram, sword bean, soybean, peas, vegetables (cucurbits like *Cucurbita, Cucumis, Momordica, Cyclanthera, Luffa, Lagenaria, Benincasa*), fruits (*Citrus, Musa*, pineapple), oilseeds (*Brassica* spp., *Perilla*, niger, sesame), fibre crops (tree cotton, jute, mesta and kenaf), tuberous/ rhizomatous types as taro/yam, and bamboos.

Eastern peninsular region particularly the tribal belt of Orissa and Chhotanagpur plateau holds rich crop diversity in rice, sorghum, finger millet, foxtail millet and proso millet, *Dolichos bean*, rice bean, chickpea, pigeon pea, horsegram/ kulthi, brinjal, chillies, cucurbitaceous crops, mango, niger, sesame, linseed, Brassicae and castor. These areas hold tremendous variability in rice.

Western arid/semi-arid region including Rajasthan, Gujarat as well as Saurashtra region, which possesses rich diversity for pearl millet, sorghum, wheat (drought and salinity tolerant types), guar, mothbean, cowpea, blackgram, mungbean, Brassicae, sesame, chilli, cucurbitaceous vegetables, minor vegetables and fruits (*Capparis aphyla, C. deciduas* ber), *Citrus*, forage grasses/legumes and spice crops (coriander, fenugreek, ajwain, garlic).

Central tribal region covering Madhya Pradesh and adjoining tract of Maharashtra are rich in diversity of crops like wheat, rice, sorghum, small millet, grain legumes (chickpea, pigeon pea, black gram, green gram, cowpea), oilseeds (niger and sesame, Brassicae), chilli and cucurbitaceous vegetables. Western peninsular region including the Western Ghats has enormous diversity in tuber crops like *Dioscorea*, *Colocasia*, okra, eggplant, chilli and cucurbits, banana and rhizomatous types like *Curcuma,* ginger, spice crops (black pepper, cardamom, nutmeg), forage legumes and grasses, and arecanut.

Many of the landraces and primitive cultivars have already vanished and some are on the verge of it due to their abandonment by farmers in lieu of high yielding varieties. The remaining ones are genetically deteriorating gradually due to hybridization, selection or genetic drift. It is, therefore the immediate requirement to assess, collect and maintain them in suitable environments and conserve in National Gene Bank. Attention needs to be paid on the vanishing landraces in crops native to the Indian region with regard to their availability and those that are most vulnerable to modern agricultural practices.

A study undertaken in Western Himalaya (Uttarakhand) showed a decline in area under cultivation of traditional crops [*Fagopyrum* spp., *Eleusine coracana*, *Echinochloa frumentacea*, *Vigna umbellata*, *Perilla frutescens*, *Glycine max* (black seeded), etc.] by 42-92 %[8]. The major factors responsible were change in cropping pattern, population/ demographic changes, land fragmentation, change in food habit, irrigation/low rainfall, policy issues, lack of R&D, promotion of new cultivars/ High Yielding Varieties (HYV) by public distributors. Best methods to conserve landraces are through home gardens, on-farm conservation, *ex situ* and community participation[8, 9].

Table 1.2: Production and productivity in agriculture during last 8 years

(Production: million t, Yield: Kg/ha)

Crop		1995-96	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04*
Rice	Production	76.98	82.53	86.08	89.68	84.98	93.34	72.65	87.00
	Yield	1797	1900	1921	1986	1901	2079	1804	2051
Wheat	Production	62.10	66.35	71.29	76.37	69.68	72.77	65.10	72.06
	Yield	2483	2485	2590	2778	2708	2762	2619	2707
Oilseeds	Production	22.11	21.32	24.75	20.72	18.44	20.66	15.06	25.14
	Yield	851	816	944	853	810	913	710	1072
Sugar	Production	281.10	279.54	288.72	299.32	295.96	297.21	281.57	236.18
cane	Yield	67787	71134	71203	70935	68577	67370	64562	59119
Pulses	Production	12.31	12.98	14.91	13.42	11.08	13.37	11.14	15.24
	Yield	552	567	634	635	544	607	556	623
Coarse	Production	29.03	30.40	31.34	30.33	31.08	33.38	25.30	37.76
cereals	Yield	940	986	1068	1034	1027	11.31	962	1228

Source: Agricultural Statistics at a Glance. 2004. Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.

By introduction of HYV in major crops (rice, wheat, maize), local landraces of many coarse grain cereals (particularly minor millets) are under cultivation only on limited scale or have disappeared from their native habitats[8, 9]. Although rice diversity at local level appears to have sustained owing to food preferences and social security of the farmers growing rice, diversity in major cereals/millet crops like wheat, pearl millet, sorghum is decreasing at local level.

Diversity in minor crops and underutilized species

There is an increasing focus on exploring opportunities to tap the potential of minor and underutilized species to meet the demand of an ever-increasing population. Pseudocereals like amaranth, buckwheat and chenopods are rich sources of protein and amino acids. Minor millets like ragi, foxtail millet and barnyard millet have high minerals and vitamins. Thus, the role of minor crops/underutilized species in enlarging the food basket and nutritional security has now become a global issue. The diversity rich pockets are located in the neglected/socio-economically weaker/tribal dominated areas with concentration of diversity in this group. In India and other developing countries which are diversity rich and hold enormous indigenous knowledge, research and development in underutilized species is gaining momentum because of their adaptability to local agro-ecosystems, farming systems, and degraded and marginal lands. Besides, minor crops have high genetic diversity, low pest-risk, multi-purpose uses and scope for value addition. Moreover, they are well-tuned to native/traditional farming practices with low inputs, and provide food and nutritional security to rural communities. Minor millets and coarse grains like amaranth, buckwheat and chenopods and minor fruits and vegetable have considerable diversity in Himalayan region, tribal pockets of eastern and peninsular India. Direct correlation between use, culture, cultivation and conservation has been observed in this group.

Home gardens and traditional agro-forestry systems with complex structure and multiple functions are the important sites for *in situ*/ on-farm conservation of land races, wild potential species and wild relatives of crops. Inventorying the wild and domesticated plants valued for human use has been done in different parts of the country[10].

Diversity in wild relatives of cultivated plants

The wild relatives of cultivated plants constitute a rich reservoir of genetic variation in the gene centre and this diversity is of immense value to breeders. Among the 320 species about 60 are endemic/ rare taxa belonging to different economic crop groups. Based on economic importance in different agricultural and horticultural crops, diversity in wild relatives has been grouped as cereals and millets (51), legumes (31), oilseeds (12), fibre crops (24), fruits (100), vegetables (54), spices and condiments (27) and others (26)[3]. The diversity in wild relatives is distributed in different phytogeographical regions of India, viz. Western Himalayas (125), Eastern Himalayas (82), North-eastern region (132), Upper Gangetic plains (66), Indus plains (North-western plains) (45), Malabar region/western ghats (145) and Deccan region/ Eastern Ghats (91). Among the major food crops, India harbours great diversity in rice and its wild/weedy relatives. The wild and weedy relatives of cultivated rice (*Oryza sativa* L.), extensively distributed in India

are *O. nivara* Sharma et Shastry, *O. rufipogon* Griff., *O. officinalis* Wall. ex Watt, *O. malampuzhaensis* Krishn. et Chandr. and *Porteresia coarctata* (Roxb.) Tateoka.

Diversity in wild edible plants

The ethnic and cultural diversity of the country has contributed to richness of plant genetic diversity. There are over 427 tribal communities which is 9.74% of the total population, comprising 227 ethnic groups, spread over to 5,000 forest villages. These tribal communities and ethnic tribes use wild edible plant species, including roots and tubers, leafy green vegetables, bulbs and flowers, fruits and seeds and nut[11].

Nearly 5,000 species have been found useful and these include both wild and cultivated plants[12]. Under the All India Coordinated Research Project on Ethnobiology about 8,900 species used by tribal communities have been recorded of which 3,900 are used for food. The wild edible plants of India, include over 1,000 species of which various plant parts used are given below: Roots and tubers (145 species of which 33 are cultivated and/ or maintained by native communities in home gardens/ backyards); leafy vegetables (521 species of which 72 are domesticated/ semi-domesticated); flowers and buds (101 species of which 15 are cultivated, and/ or occur as backyard cultigen); fruits (647 species of which 107 are cultivated and some are only grown as homestead cultigens) and; seeds and nuts (118 species of which 25 are cultivated and/ or occur in backyards). Total diversity in this group includes about 120 domesticated/ semi-domesticated species spread over to different phytogeographical regions of the country.

Diversity in medicinal and aromatic plants

There are about 8,000 species of medicinal and aromatic plants mainly distributed in humid tropical and temperate forests of the Indian subcontinent. These are still largely used in traditional indigenous systems of medicine and are gathered from the wild. The important ones, for example, are *Rauvolfia serpentina*, *Ocimum*, *Cymbopogon*, *Emblica officinalis*, *Swertia chirayita*, *Podophyllum hexandrum*, *Nardostachys jatamansi*, etc. Several species are presently collected from wild or are under cultivation in selected pockets of the country. A collaborative work plan involving scientists, government institutions etc. is suggested to help preservation the traditional knowledge system and practices and conservation of medicinal plants and upliftment of rural economy[13].

DOCUMENTATION

Systematic documentation and updating of database on PGRFA has been done at national level. Inventorying and monitoring of PGRFA has been one of the priority areas pursued by different

crop based organizations/ institutes. Inventories and survey reports of crops and wild economic plants have been published from time to time. Besides organizations such as Botanical Survey of India, Council for Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT), Department of Environment, Forests and Wild Life along with bioinformatics cells/ departments with scientific organization are playing a pivotal role in developing value based data/ information for diverse users.

RELATIVE IMPORTANCE (FOOD SECURITY, ECONOMIC, SOCIAL) OF DIFFERENT CROPS AND THEIR PRODUCTS

The relative importance of various crops is changing significantly over the past 10 years. Crops like soybean, sunflower, groundnut and cotton have gained more acreage during these years leading to decrease in cultivation of other crops of local importance and the economic and policy changes. The major reasons are: changes in socio-economic status/ life style, crop diversification for increased profitability, market scenario, etc. Cultivation of industry based crops [*Hordeum vulgare* (barley) for malt industry, low erucic acid *Brassica* lines; cultivars having good marketability and returns (potato, soybean, french beans, onion, etc.] and species having buy back policy (medicinal plants) has resulted in gradual replacement of native/ landraces. Good transportation and food storage facilities have significantly contributed to better management of vegetables/ perishable types.

FUTURE NEEDS AND PRIORITIES

Agricultural ecosystems that harbour diversity of PGRFA are more in a state of flux, as compared to other natural ecosystems, since cropping patterns are changing every season. Modern agricultural practices strongly favour reduction of crop diversity by providing the subsidies for cultivating high yielding varieties and reducing weeds/wild plants diversity by using crop protection measures. By providing positive incentives to local communities, this diversity may be maintained[14]. Thus there is a great need to assess the state of PGRFA diversity at regular intervals to record changes in species population as well as monitoring genetic erosion, if any. Keeping in view the value of PGRFA, the following thrust areas have been identified:

- Identification of gaps in management of PGRFA;
- Assesment of loss of diversity in farming systems using continued analysis of land use patterns; in crop diversity within a crop species through genetic diversity analysis; and in wild and weedy relatives at *in situ* level;
- Collection of genetic diversity in crops and their wild relatives ;

Table 1.3: Quantity and value of export of principal agricultural commodities (Quantity in 000' and value in million Rs.)

Items	1997-98		1998-99		1999-00		2000-01		2001-02		2002-03		2003-04*	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Pulses	168.05	3608.86	104.09	2230.26	194.18	4195.60	244.08	5370.80	161.64	3691.30	148.08	3450.20	150.99	3225.70
Rice basmati	593.32	16856.20	597.79	18769.10	638.38	17803.40	849.02	21549.40	667.07	18427.70	708.79	20584.70	770.76	19909.20
Rice (others)	1795.74	16853.80	4365.89	44038.50	1257.79	13455.80	682.27	7772.60	1541.49	13313.70	4259.08	37727.70	2601.47	21421.60
Wheat	1.52	4.00	1.76	13.60	-	-	813.49	4150.90	2649.38	13302.10	3671.25	17598.70	4022.71	23493.70
Other cereals	15.35	125.90	9.53	86.80	6.05	99.10	45.09	387.50	144.73	1159.20	106.08	910.60	570.30	3759.10
Tobacco unmfg.	134.07	9174.80	75.04	5722.90	118.84	8120.40	97.34	6612.60	84.48	5820.50	100.47	7335.20	121.71	8015.00
Tobacco mfg.	10.63	1527.60	13.93	1895.00	12.79	1968.80	10.01	2059.50	13.46	2256.60	-	2893.70	-	2893.10
Spices	230.53	14096.60	209.83	16325.20	234.99	17674.30	244.68	16177.40	239.29	14969.70	277.02	16554.90	246.98	15256.0
Cashew	76.90	13999.10	77.28	16274.70	92.32	24556.10	89.16	20495.80	98.20	17886.80	129.43	20529.40	100.30	16969.90
Sesamum and niger seeds	129.32	3025.80	105.25	3235.10	111.27	3737.30	211.76	5953.10	241.19	6100.80	154.44	4508.80	208.33	9432.20
Groundnut	245.40	5663.00	58.33	1396.60	158.13	3717.60	201.37	3164.00	112.81	2509.40	67.89	1783.00	176.93	5440.90
Oil meals	4497.91	34352.30	3487.81	19416.90	2594.25	16378.60	2417.24	20446.90	2781.72	22629.30	1776.13	14873.60	3172.31	32716.30
Castor oil	204.42	5761.30	203.91	6721.10	269.11	10674.00	259.64	9527.60	213.68	6259.40	177.69	6098.10	157.75	6355.60
Sugar and molasses	246.79	2549.30	22.61	244.40	142.70	402.70	767.13	5050.90	1677.57	17818.50	1662.37	18145.40	1282.90	12205.50
Floriculture products	-	867.50	-	1059.60	-	1167.20	-	1179.60	-	1274.30	-	1807.70	-	2208.00
Fruits & vegetables seeds	4.65	534.80	4.95	645.80	5.40	795.00	9.28	625.90	4.93	621.90	8.92	979.60	5.33	523.00
Misc. Processed items	-	255.80	-	2550.80	-	2953.60	-	5326.20	-	7241.80	-	9100.80	-	10834.00
Cotton raw and waste	157.53	8218.90	41.96	2069.20	15.91	770.70	29.70	2210.70	8.23	426.90	11.75	502.80	167.05	8114.70
Coffee	160.27	16961.40	193.61	17279.20	190.11	14348.50	184.90	11848.70	176.26	10949.20	184.87	9939.80	180.44	10822.20
Tea	193.70	18762.90	210.40	22648.90	179.31	17846.70	187.43	17887.10	180.10	17192.20	182.86	16520.70	184.30	15945.60
Total (Agri.)	-	248374.50	-	255106.40	-	253136.60	-	286573.70	-	297286.10	-	346539.40	-	368939.0
Total export	-	1301006.40	-	1397517.70	-	1590952.00	-	2013564.50	-	2090179.70		2551372.80		2915819.30
% Share of agricultural exports	-	19.09	-	18.25	-	15.91	-	14.23	-	14.22		13.58		12.65

Source: Agricultural Statistics at a Glance. 2004. Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.

- Characterization, evaluation, multiplication and conservation of trait specific material;
- Documentation of information on diversity in PGRFA ;
- Linkages with organisations involved in management of PGRFA; and
- Awareness generation.

The data provided by stakeholders indicated that regular survey and updation is required to assess status of PGRFA with reference to number of crops cultivated in an area and number of varieties of each crop being cultivated in that area. Similar situation is seen in relation to diversity available. There is a need to further investigate in this area and update information on assessment of diversity distribution of PGRFA and genetic erosion. Despite the fact that a lot of survey and inventorization has been done over the years under various programmes at NBPGR, its Regional Stations and National Agricultural Technology Project (NATP) on plant biodiversity there is a need to collect more information from unexplored areas as well as areas explored more than 20 years back. Measurement of genetic erosion and assessment of concentration of diversity should be monitored through ground surveys and modern tools (GIS) for mapping of PGRFA.

To better understand the roles and values of the diversity of PGRFA, emphasis should be given on the food and cultural habits of the tribal communities of the country which are highly dependent on local diversity for their survival. For monitoring of genetic erosion and quick response to observed erosion, a combined effort needs to be globally monitored through networking systems based on regular sampling of varieties and their data analysis against a time line using statistical and molecular tools.

International linkages, project formulation and sufficient funding for such activities need to be explored. Training on the study of genetic erosion needs to be given to at least one plant breeder from each crop based agricultural university and is also required in developing and using early warning systems for controlling genetic erosion. An awareness campaign need to be launched at grass root level among actual stakeholders to make them realize the importance and value of PGR diversity in sustainable development of agriculture.

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THE STATE OF *IN SITU* MANAGEMENT 2

In situ conservation of Plant Genetic Resources (PGR) forms an integral part of the biodiversity conservation programmes in India. The programme of biosphere reserves was initiated under the Man and Biosphere' (MAB) Programme by UNESCO in 1971. The purpose of formation of biosphere reserves was to conserve *in situ* all forms of life, alongwith its support system so that it could serve as a system for monitoring and evaluating changes in natural ecosystems. Establishment of forest area reserves, national parks and protected areas is being promoted to facilitate *in situ* conservation. The Biosphere Reserves programme was launched by the Ministry of Environment and Forests (MoEF), with the objective of identifying representative ecosystem which are still in pristine condition and strengthen the conservation efforts keeping in view the livelihood needs of the people. Consequently, 14 Biosphere Reserves have been designated (Table 2.1) of which four namely, Nilgiris, Nanda Devi, Sunderbans and Gulf of Mannar are included in the World Network of Biosphere Reserves[1]. Another 11 more biosphere reserves are on the anvil. Under the UN World Heritage Convention, five protected areas have been designated World Heritage Sites; and consequent to the country becoming a party to the Ramsar Convention, six wetlands (Chilka Lake, Keoladeo Ghana National Park, Wular Lake, Harike Lake, Sambhar Lake, Loktak Lake) have been designated as Ramsar sites for conserving the ecological characteristics. In addition, there are 92 National Parks and 500 wildlife sanctuaries in the country covering an area of 15.67 m ha. Further, adopting a participatory approach Joint Forest Management programmes, integrating the ecological and socio-economic parameters for sustainable conservation of ecosystems have been undertaken. Under the programme, the local communities and the state governments have defined roles and responsibilities with regard to forest protection and development. While ensuring forest conservation, the local communities are provided with alternative sources of livelihood and assured access to forest and related produce. Twenty eight states have adopted this programme which involves 8.4 million families that manage around 17.33 m ha forest land. The establishment of sanctuaries in Tura range in Garo Hills of Meghalaya for conservation of rich native diversity of wild *Citrus* and *Musa* species, and for *Rhododendron* and orchids in Sikkim are the examples of *in situ* conservation of economically important species.

Table 2.1: Biosphere Reserves set up in India

Name of the biosphere Reserve & total geographical area (km^2)	Date of Notification	Location (State)
1. *Nilgiri (5520)	01.08.1986	Part of Wynad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills (Tamil Nadu, Kerala and Karnataka)
2. *Nanda Devi (2236.74)	18.01.1988	Part of Chamoli, Pithoragarh & Almora Districts (Uttarakhand)
3. Nokrek (820)	01.09.1988	Part of Garo Hills (Meghalaya)
4. Manas (2837)	14.03.1989	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang Districts (Assam)
5. *Sunderbans (9630)	29.03.1989	Part of delta of Ganges & Brahamaputra river system (West Bengal)
6. *Gulf of Mannar (10500)	18.02.1989	Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
7. Great Nicobar (885)	06.01.1989	Southern most islands of Andaman and Nicobar (A&N Islands)
8. Similipal (4374)	21.06.1994	Part of Mayurbhanj district (Orissa)
9. Dibru-Saikhowa (765)	28.07.1997	Part of Dibrugarh and Tinsukia districts (Assam)
10. Dehang Debang (5111.5)	02.09.1998	Part of Siang and Debang valley (Arunachal Pradesh)
11. Kanchanjunga (2619.92)	07.02.2000	Parts of North and West Sikkim
12. Pachmari (4926.28) (Madhya Pradesh)	03.03.1999	Parts of Betur, Hoshangabad and Chindwara

13. Agasthyamalai (1701)	12.11.2001	Parts of Thirunelveli and Kanyakumari (Tamil Nadu) andThiruvananthapuram, Kollam and Pathanmthitta (Kerala)
14. Achanakmar-Amarkantak (3835.51)	30.03.2005	Parts of Anupur and Dindori (Madhya Pradesh) and parts of Bilaspur (Chhattisgarh)

Site with * have been recognized by UNESCO on World Network of Biosphere Reserves

The MoEF has also launched a Mangrove Conservation Programme in 1987. The Ministry has so far identified 38 mangrove areas for intensive conservation and management in the country (Table 2.2). These areas are identified on the recommendation of National Committee on Mangroves & Coral Reefs on the basis of their unique ecosystems, biodiversity etc. Initiative is Management Action Plans (MAPs) for undertaking activities like raising mangrove plantations, protection, catchments area treatment, siltation control, pollution abatement, biodiversity conservation, sustainable resource utilization, survey & demarcation, education & awareness etc. are supported by Central Government. This is further supplemented by research and developmental activities which can give scientific inputs for smooth execution of Management Action Plans.

Table 2.2: State-wise list of Mangroves areas identified by the Ministry

State / Union Territory	Mangrove Area
West Bengal	1. Sunderbans
Orissa	2. Bhaitarkanika, 3. Mahanadi, 4. Subernarekha, 5. Devi, 6. Dhamra, 7. MGRC, 8. Chilka
Andhra Pradesh	9. Coringa, 10. East Godavari, 11. Krishna
Tamil Nadu	12. Pichavram, 13. Muthupet, 14. Ramnad, 15. Pulicat, 16. Kazhuveli
Andaman & Nicobar	17. North Andamans, 18. Nicobar
Kerala	19. Vembanad, 20. Kannur
Karnataka	21. Coondapur, 22. Dakshin Kannada / Honnavar, 23. Mangalore Forest Divisions, 24. Karwar
Goa	25. Goa

Maharashtra	26. Achra-Ratnagiri, 27. Devgarh-Vijay Dur, 28. Veldur, 29. Kundalika- Ravdana, 30. Mumbra-Diva, 31.Vikroli, 32. Shreevardhan, 33. Vaitarna, 34. Vasasi-Manori, 35. Malvan
Gujarat	36. Gulf of Kutchh, 37. Gulf of Khambat, 38.Dumas-Ubhrat

A National Management Genetic Resources centre has been established by the Ministry in Orissa, Sunderbans (West Bengal) has been included in the World list of Biosphere Reserves by UNESCO. Two mangrove species *Rhizosphora annamalyana* occurring in Pichaveram (Tamil Nadu) and *Heritiera kanikansis* of Bhitarkanika (Orissa) are endemic to India.

INVENTORIES AND SURVEYS — ASSESSMENTS AND PRIORITIES

During the last 10 years, areas surveyed for *in situ* conservation of PGRFA are given in Table 2.3.

Table 2.3: List of important areas surveyed for the *in situ* conservation

Name of the area	State
Achankovil valley	Tamilnadu
Andaman and Nicobar Islands	Andaman and Nicobar Islands
Chendruny Wildlife Sanctuary	Kerala
Hill District of Darjeeling	Assam
Kashmir valley (Anantnag, Baramulla, Doda, Kupwara, Laddakh)	Jammu and Kashmir
Malwa	Madhya Pradesh
Neyyar Wildlife Sanctuary	Kerala
Peppara Wildlife Sanctuary	Kerala
Punalur- Thenmala- Aryankavu	Kerala
Ryalseema	Andhra Pradesh
Saurashtra	Gujarat
Spiti valley, Changer area of Hamirpur,	Himachal Pradesh

Kangra, Bilaspur and Mandi, Outer saraj and Greater Himalayn National Park of Kullu, Chopal, Dodra Kuar of Shimla, Trasgiri track of Sirmour	
Silent Valley National Park	Kerala
Siruvani- Iruttupalam	Kerala
Tehri Garhwal region	Uttarakhand
Telangana	Andhra Pradesh

Twenty nine threatened species (Table 2.4) have been reported by different stakeholders. However, as per the BSI[2] list none of these species have been reported as threatened; *Piper hapnium* has been reported as intermediate and *Vanilla aphylla* as vulnerable. Besides, there are many landraces and folk vareities particularly of wheat, rice and maize which have disappeared[3]. Few to mention are *Dharmouri*, *Shruin, Rundan* of wheat *Madholu Matalu, Bowru Tapta, Kodri, Sukul* of rice, Chitkanu of maize, *Tilgoglu, Taruz* or *Sarshaf* and *Sandiji of* mustard.

Table 2.4: List of threatened species reported by different stakeholders

1. *Abelmoschus cailli*	20 *Habenaria intermedia*
2. *Abelmoschus ficulneus*	21. *Hordeum spontaneum*
3. *Aconitum heterophyllum*	22. *Lilium polyphyllum*
4. *Allium carolinianum*	23. *Macrotomia benthamii*
5. *Arnebia benthamii*	24. *Malus baccata*
6. *Atropa belladonna*	25. *Nardostychus jatamansi*
7. *Bunium persicum*	26 *Ophioglossum sp.*
8. *Carthamus lanatus*	27. *Picrorhiza kurroa*
9. *Cicer microphyllum*	28. *Piper barberi*
10. *Citrus rugulosa*	29. *Piper hapnium*
11. *Citrus assamensis*	30. *Podophyllum hexandrum*
12. *Citrus indica*	31. *Polygonatum cirrihifolium*

13. *Citrus latipes*	32. *Prunus rufa*
14. *Citrus limettioides*	33. *Rheum emodi*
15 *Citrus limmetta*	34. *Saussurea obvallata*
16. *Citrus macroptera*	35. *Solanum gillo*
17. *Citrus megaloxycarpa*	36. *Swertia chirayita*
18. *Colchicum luteum*	37. *Taxus baccata*
19. *Dioscorea deltoidea*	38. *Vanilla aphylla*

Some of the areas in N.E. States of India have been identified for survey of crops and their wild species of local importance for immediate conservation efforts (Table 2.5).

Table 2.5: Areas and species requiring immediate surveys and inventorization in North Eastern States of India

State	Species	Localities/habitats
1. Arunachal Pradesh	*Citrus jambhiri*	Around Shimmong, Pugging, Ramshing and Gossag villages of Yingkiong, Arunachal Pradesh, along the course of Siang river.
2. Assam	14 different species of bamboos	In between Lumding and Halflong of NC Hills district.
3. Meghalaya	*Phyllanthus emblica*	Nongkhyllum, Khonjoy, Nongjri and Rajaju of West Khasi Hills district.
4. Manipur	i) *Lilium mackliniae*	Siroy Hills, Ukhrul district of Manipur.
	ii) *Zizania latifolia*	Loktak Lake area.
5. Tripura	*Psidium guianensis* Various species of *Ziziphus.*	
6. Mizoram	Members of Musaceae and Zingiberaceae.	

Several new/difficult areas were explored for the first time under the World Bank funded Mission Mode Project on Plant Biodiversity (National Agricultural Technology Project). Sixteen special missions were also executed in different areas that are likely to loose the diversity due to natural or human disturbances. New records were collected and identified in *Musa acuminata* x *M. balbisiana* (Bhat Manohar, a *Musa species* – first known natural tetraploid of banana), *Corchorus pseudo-olitorius* (new species). Besides, rare/endemic/endangered species, viz. *Citrus rugulosa* (Western Ghats), *Cucumis prophetarum* (Rajasthan), *Garcinia imberti* (Kerala), *Meconopsis aculeata* and *Podophyllum hexandrum* (Western Himalaya), *Luffa hermaphrodita* (Rajasthan), *Cycas beddomei*, *Rauvolfia serpentina*, *Aegilops tauschii* (Lahaul-Spiti, Kinnaur, Pangi in Himachal Pradesh), *Fagopyrum emarginatum* (Kargil, Jammu & Kashmir and Kinnaur in Himachal Pradesh), *Citrus indica* (Arunachal Pradesh) and *Vanilla andamanica* (South Andaman, A&N Islands) have been collected.

The important threats listed by stakeholders include - introduction of new high yielding and improved cultivars, urbanization, deforestation, shifting cultivation, over-exploitation and lack of regeneration, genetic erosion, human interference, faulty and unscrupulous collection, modernization of agriculture, biotic and abiotic stresses, natural disasters, lack of availability of seeds of local varieties, changing cropping patterns due to commercialisation of agriculture, unpredicted weather, changes in food habits, lack of awareness at grassroot level, less R&D thrust, including value addition on traditional and crops of minor importance.

Although, the survey and inventorization activities have been included in the draft national biodiversity action plan, there is a need for training scientists in survey and inventorization of PGRFA in the country. The adequacy of Indian efforts to survey and inventorize PGRFA in the country is reflected in the on-going plans for the PGRFA in all priority activity areas of the country.

The main constraints indicated in survey and inventorization of PGRFA in the country are lack of focused and co-ordinated approach by the concerned organizations, insufficient financial support and need for strengthening skills of technical staff. The organizations which have reported *in situ* conservation activities are doing these in isolation. In fact, unlike *ex situ* conservation, *in situ* on farm conservation activity especially on PGRFA has not been given as major responsibility to any of the organization.

For promotion of conservation of crop wild relatives and wild plants relevant to food production, programmes have been developed and reasonable progress has been made. Efforts have also been initiated to update and revise status of wild relatives of crop plants in India. A document in

this regard is likely to come by the end of 2007. Despite a strong national policy support for the conservation of crop wild relatives, they are not usually considered in Environmental Impact Assessments (EIAs).

The plant species that require immediate attention for *in situ* on farm conservation have been prioritized and suitable sites based on the quantum and nature of genetic diversity have also been identified. However, a comprehensive strategy is required to be framed and put into action at national level. For development of effective conservation strategies, there is a need for prioritizing collection of threatened landraces and species. In fact, true landraces and farmer's varieties are required to be identified along with their pedigree records and other related information. In many cases, the same landrace is known by various names. Critical evaluation of true landraces, including biochemical and molecular characterization is the need of the hour. Rice can be taken up as priority crop for this purpose. Nevertheless, efforts are underway and some information in rice has been synthesized at NBPGR.

ON FARM MANAGEMENT AND IMPROVEMENT OF PGRFA

The NBPGR-NATP Mission Mode Project (2000-05) on household food and nutritional security focused on tribal areas and local communities in 10 states of India. The project emphasized on identification of life support crop species, horticultural species and vegetable gardening, domestic animal species and fisheries in these areas. The thrust was on value addition of the local germplasm and also impact assessment after completion of the first phase of activities. The project was in operation at 53 centres covering 509 villages with the partnership of over 15,000 farm families in 23 states of the country. An overall increase in household income, availability of food and nutrition was assessed in all the areas adopted under the project.

The MS Swaminathan Research Foundation, Chennai a NGO, has successfully applied bottom-up efforts to conserve local agro-biodiversity by linking the livelihood security of villagers with the wider ecological security of the region. It has established effective community agro-biodiversity conservation and management programmes aimed at integrated village development in tribal groups particularly in the Jeypore tract of Orissa. The tribal communities of Tola, Baliguda, Patraput, Kashiguda, Nuaguda and Mohuli villages are involved in participatory plant breeding and the compilation of community biodiversity registers, which have been combined with the development of community seed and grain banks. The initiative has resulted in the revitalization of on farm conservation traditions and livelihood systems[4].

On farm conservation and promotion of pseudo cereals (amaranth and buckwheat) and minor millets (finger millet, proso millet, foxtail millet and barnyard millet) in participatory mode in Himachal Pradesh was started by NBPGR in 2004[5]. The major objective of the programme was to undertake (i) participatory conservation and management of mountain crops biodiversity at selected sites and (ii) skill development and capacity building of farmers for agricultural diversity based livelihoods. So far, initiatives such as preliminary survey work to document the nature and extent of genetic diversity have been undertaken the sites have been selected. Some of them are Shilai, Naya, Andheri, Sangrah in Sirmour; Thalog, Kupvi, Kothi in Shimla; Nichar and Neshang in Kinnaur; outer Saraj and Nirmond in Kullu, Bharmour and Holi in Chamba, Cahcyot, Zanzali in Mandi, and Barot and Chhota Banghal on Kangra and Changer (highly rain fed) area of Hamirpur and Bilaspur, so as to create awareness amongst farmers. Three brainstorming session involving farmers and officials of agriculture department at the sites and at NBPGR, on food and medicinal value, and importance of conservation of traditional crops and landraces were organized. After organizing the awareness programmes, there was significant increase in the demand of seed of traditional crops and their landraces. In some areas such as Changer area of Hamirpur and Kangra, finger millet has been brought back into cultivation. The need of taking out the seed of some famous rice landraces from the gene bank was also felt for multiplication and subsequent restoration in their original growing areas.

In situ on farm conservation of paddy in Bastar area of Chattisgarh by NBPGR, Indira Gandhi Agricultural University, Raipur, and International Rice Research Institute (IRRI) Philippines, is another interesting activity. Over 60 landraces of rice have been genetically identified of which over 300 have been collected from Orissa. Molecular diversity studies in some minor millets collected from the tribal tract of Orissa is also being undertaken. Preliminary studies have been undertaken for management of plant diversity in traditional ecosystems of western Himalayas in Uttaranchal state[3]. Existing crop genetic diversity at inter and intra species level was assessed mainly in rice, french bean, amaranth, buckwheat and barnyard millet and factors for change in crop composition and farming systems during the recent past studied. Farms management of rice landraces was studied in detail. Various benefits enhancing options for farmers from local crop diversity were scrutinized based on farmers perceptions and priorities for efficient management of local crop diversity on farm and its sustainable utilization for agricultural production.

Maintenance and continuous cultivation of various crop landraces in farmers' field is another examples of *in-situ* on farm conservation of crop diversities. Pockets of 'Apatani plateau' (Lower Subansiri) and 'Khamti Valley' (Lohit) of Arunachal Pradesh is an ideal example of *in-situ* conservation

practice for rice landraces. Many endemic plant species, their occurrence, population frequencies and size has become a matter of concern by the State Forest Department. Appropriate measure and restrictions have been imposed in favour of their natural regeneration sites. Some of the examples are given in Table 2.6.

Table 2.6: Crop species and their natural regeneration sites in North-eastern India

	Species	Sites
1.	*Nepenthes khasiana*	Jaintia Hills, Meghalaya
2.	*Lilium maclineae*	Manipur
3.	*Coptis teeta*	Dibang valley, Arunachal Pradesh
4.	*Citrus indica*	Nokrek range, West Garo Hills, Meghalaya
5.	*Citrus megaloxycarpa*	Jampui Hills (Mizoram – Tripura border)
6.	*Digitaria cruciata* var. *esculenta*	West Khasi Hills
7.	*Moghania vestita*	Khasi Hills District
8.	*Wallichia triandra*	Upper Subansiri District, Arunachal Pradesh

Surveys made over past decades on crop germplasm resources, results revealed some interesting information which needs further extensive studies in order to substantiate for adoption their *in situ* conservation measures and subsequent management.

On farm management of PGRFA

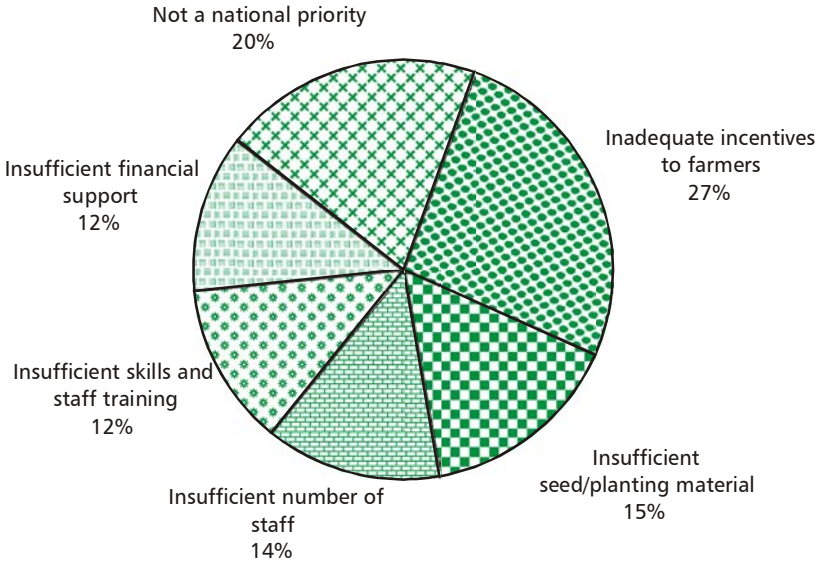
The level of integration of on farm conservation efforts into national programme(s) has been reported to be low and the level of priority of on farm management on PGRFA within national programmes is reported to be medium. The incentives used to promote on farm management of PGRFA in the country is only in the form of supportive research. The major limitation for on farm management and improvement of PGRFA in the country are inadequate incentives to the farmers, insufficient seed/ planting material, insufficient number of staff, unskilled staff and insufficient financial support (Figure 1).

The frequency of activities carried out in the country to promote on farm management and improvement of PGRFA in the following areas is considered to be occasional. The areas addressed are participatory plant breeding, participatory cultivar selection, community-based research, market development, processing and packaging, strengthening local seed supply, diversity fairs and seed exchange and increasing public awareness. Four programmes were developed for conservation of

crop wild relatives and wild plants for food and agriculture and significant progress has been made in 22 crop species[6]. Another four programmes are in place to support community-based management of crop wild relatives and wild plants[6] in non-protected areas. Different Governmental, Non-Governmental departments are involved for undertaking these activities.

An Act to promote conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto, has been recently passed by Indian Government (The Biological Diversity Act 2002 and Rules 2004).

Fig 1. Major Limitations to On-farm Management and Improvement of PGRFA in the Country

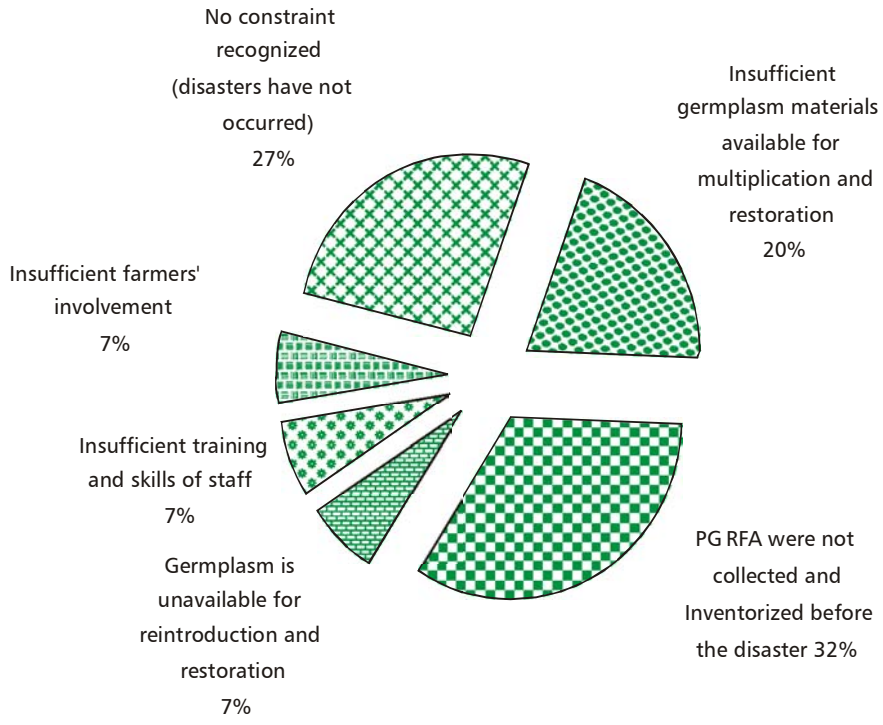


RESTORATION OF AGRICULTURAL SYSTEMS FOLLOWING DISASTERS

The greatest constraint recognized for restoration of disaster-struck agriculture systems is the absence of collecting, inventorying, and conservation activities in these areas, prior to the event of disaster (Figure 2).

There is a mechanism within the country to facilitate rapid acquisition, multiplication, distribution and cultivation of germplasm, following natural disasters. This includes the assessment of the farmers needs. The information on the local seed supply system is adequate to identify and facilitate germplasm re-introduction. However, there is a great need for strengthening adequate linkage with information systems (including indigenous knowledge) for appropriate tracking of germplasm required for restoration.

Fig 2. Constraints in Restoration of Locally Adapted Germplasm following Disasters



IN SITU CONSERVATION OF WILD CROP RELATIVES AND WILD PLANTS FOR FOOD PRODUCTION

Efforts have been made for documentation and protection of indigenous technical knowledge and also the germplasm of the local landraces/ farmers' varieties, particularly in the states of Gujarat and Rajasthan, by the Society for Research Initiatives for Sustainable Technologies and Institutions, Ahmedabad and also National Innovation Foundation, Ahmedabad. Programmes for biodiversity conservation associated with livelihood approach have also been undertaken by Ashoka Trust for Research in Ecology and the Environment, particularly in Western Ghats.

Several civil society organizations in association with national and international agencies are engaged in *In situ* conservation of targetted species. For example, Foundation for Revitalisation of Local Health Traditions in collaboration with the state forest departments of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra, with the support of DANIDA and UNDP have established 54 forest gene bank sites called Medicinal Plant Conservation Areas (MPCA). The network of 54 MPCAs, measuring 200 ha to 500 ha each, has been established gradually since 1993 and represents all forest types with large bio-climatic and soil regime variation. These gene banks harbour 45% of

recorded populations of flowering and medicinal plants of Peninsular India, including 70% of those listed in red-data book. The intra-specific diversity that is conserved in the MPCA network can be used to provide authenticated quality planting material for commercial cultivation to meet rising demands of the herbal industry. MPCAs also constitute 'study sites' for threatened species recovery research. MPCAs have proved crucial in capacity building of forestry staff, local communities and researchers in the conservation of medicinal plants for sustainable use and equitable benefit sharing.

In addition, some other projects and the organizations addressing issues of conservation of medicinal plants, traditional medicine and health care, commercialization and their contribution to sustainable livelihoods are-

- Documentation of Traditional Health Practices in Mayurbhanj District, Orissa, International Herbal Cross Society, Bhubaneshwar (IHCS)
- Conservation & Cultivation of Medicinal Plants in Mountain Areas of Garhwal Region, The Society for Himalayan Environmental Research (SHER)
- Community Based Sustainable Management of Medicinal Plants in Betul District, Madhya Pradesh, Indian Institute of Forest Management (IIFM)
- Strengthening the Traditional Health Practices and Training in Cultivation of Medicinal Plants to the Women and Herbal Healers of District Chittoor in Andhra Pradesh, Peoples Clinic Trust, Chittoor (PCT)
- Development of Strategies for Production and Improvement of MAPs growing in the Tribal Belts of Southern Rajasthan, Indian Environment Society (IES)
- Development of Production to Consumption and Marketing Systems-based Strategies for the Sustainable use of Medicinal Plants in the Western Ghats, Kerala, Arya Vaidya Sala, Kottakal, Kerala
- Exploring the Potentials of Medicinal and Aromatic Plants in Bundelkhand Region of Uttar Pradesh, UTTHAN for Sustainable Development, Allahabad, Uttar Pradesh.
- Development of Strategies and Methods to Support Traditional Tibetan System of Medicine for the Improvement of Primary health care in Ladakh Region, Jammu & Kashmir, India, Ladakh Heart Foundation and Yathong Foundation, Leh, Ladakh.
- Promotion of on farm cultivation of traditional hill crops and farmer's varieties. The Society for

Agriculture Research Training and Health Education (SARTHE) in Sirmour region of Himachal Pradesh.

- Cultivation of organic medicinal rice (s) of Kerala. The Navara Eco Farm.
- GREEN Foundation is a community based organisation working towards the conservation of agro biodiversity and the promotion of sustainable agriculture in the semi-arid regions of South India.

FUTURE NEEDS AND PRIORITIES

For promotion of *in situ* conservation of crop wild relatives and wild food plants, there is a need to validate information about the usage of wild species for food or other purposes. This can be achieved through participation of communities and promotion of village level gardens of local diversity.

Considering the size of the country, the number of crops cultivated and the amount of genetic diversity available in different crops, the on farm conservation efforts have been very limited. Therefore, for promotion of on farm management and improvement of PGRFA, there is a need for policy support at national level.

As this strategy of conservation is resource demanding and would involve a number of stakeholders, it would need development of appropriate methodologies and modalities for sustainable adoption. It can be achieved through a networking of existing infrastructure by involving farmers, local bodies, government and non-government agencies including those involved in value addition and market research. This strategy can only work if corresponding benefits are ensured to the farmers/ communities of the country.

The changing agriculture scenario calls for an emphasis to be laid on *in situ* on farm conservation of PGRFA to keep the process of evolution of genetic diversity responding to changing environment. In this regard, the scope of home gardens needs to be extended to medicinal food and nutritional supplements at village level to ensure nutritional security, health and improved income to the farmers.

In order to maintain farm and crop diversity, critical and detailed evaluation of landraces is required. There have been examples where landraces have out yielded the released varieties. The yield of rice landraces from Uttaranchal viz. *Thapachini, Jhumkya, Kushboo, Agriya, Lathmar, Kali, Makhri, Basmati Nagani, Lalmati* was compared to modern varieties and it was found that yield of landraces ranged from 4.3 to 5t/ha. *Thapachini* being the highest yielder, whereas the average yield of modern varieties was 2.8t/ha despite the fact that latter were provided with all recommended

inputs[7, 8]. Similarly, traditional crops or crops of regional importance need value addition so that their cultivation is encouraged. These can be linked with tourism industry also. It will also take care of changing food habits.

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THE STATE OF *EX SITU* MANAGEMENT 3

The *ex situ* conservation approach requires systematic long-term conservation of viable propagules of collections outside the natural habitat of species. Realizing the importance of collecting and conserving PGRFA, India has taken strategic steps for their *ex situ* conservationusing appropriate approaches, especially in the last three decades. Majority of this work is carried out under Indian Council of Agricultural Research (ICAR) by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, which is the nodal organisation for *ex situ* management of PGRFA. Additionally, several economically important plant species are also conserved in botanic gardens of various plant science based institute, most of which come under the jurisdiction of the Botanical Survey of India (BSI), Ministry of Environment and Forests (MoEF). The various types of components that constitute the *ex situ* conservation of PGRFA in India are listed in Table 3.1.

Table 3.1: Details of various *ex situ* conservation sites for PGRFA in India

Type of conservation	Nodal Ministry/ Department	Number of facilities
Seed genebank (long-term collections, -18°C)	Ministry of Agriculture, ICAR	1
Seed genebank (medium-term collections, 4°C)	Ministry of Agriculture, ICAR	28
Seed genebank (short-term collections at around 10°C)	Ministry of Agriculture, ICAR	13
Botanical gardens	Ministry of Environment, BSI	150*
In vitro conservation (4°C to 25°C)	Ministry of Agriculture, ICAR	5
Field genebank	Ministry of Agriculture, ICAR, SAU	25
Cryopreservation [using liquid nitrogen in vapour phase (-170°C) or liquid phase (-196°C)]	Ministry of Agriculture, ICAR	2

* Source: National Report of MoEF for CBD (2005).

The NBPGR has been entrusted with the responsibility to plan, conduct, promote, co-ordinate and take lead in activities concerning collection, characterization, evaluation, conservation, exchange, documentation, and sustainable management of diverse germplasm of crop plants and their wild relatives with a view to ensure their availability for use over time to breeders and other researchers. The NBPGR with its 10 regional stations/base centres/quarantine centres over different phyto-geographic zones of the country, active collaboration and linkages with over 40 National Active Germplasm Sites (NAGS) situated at different crop-based ICAR institutions and state agricultural universities (SAU) and various other crop improvement programmes and has been spearheading the national activities on PGRFA management. The base collection of germplasm is kept in long-term storage by NBPGR in its National Genebank, which is linked to numerous crop-specific active collections that are maintained at appropriate locations. The National Genebank of NBPGR has three types of storage facilities - seed genebank, cryogenebank and *in vitro* genebank. The seed genebank was first established in 1986 and expanded in 1996 and presently has 12 long-term storage modules that are kept at –18^{0}C. Also, there are six medium term modules maintained at 4-10^{0}C. In addition to seed conservation, other *ex situ* conservation methods, such as *in vitro* conservation and cryopreservation have been employed to conserve species, predominantly having non-orthodox seeds (seeds which loose their viability when dried below a critical moisture content and are sensitive to low temperature storage) and vegetatively propagated species. The cryobank comprises six extra-large capacity (180 liter) cryo-tanks that store samples in the vapour phase of liquid nitrogen (-160 to -180^{0}C), and three smaller cryotanks (30-60 litre) where samples are held in the liquid phase (-196^{0}C). The *in vitro* genebank has four culture rooms at 25^{0}C for maintenance of slow-growing cultures. The National Genebank of NBPGR currently has 3,49,020 accessions of germplasm belonging to nearly 1,187 species (Table 3.2).

Table 3.2: Germplasm accessions conserved in the National Genebank of NBPGR (as on December 31, 2006)

Crop Group	Accessions (no.)		
	Seed Genebank	Cryogenebank	*In Vitro* Genebank
Cereals	134,421	239	
Millets and forages	48,657	287	
Pseudocereals	5,492	76	

Grain legumes	52,844	632	
Oilseeds	47,515	470	
Fibre crops	9,546	64	
Vegetables	21,201	432	531
Fruits and nuts	265	2,123	650
Medicinal, aromatic and narcotics plants	5,333	805	357
Spices and condiments	1,632	115	346
Agroforestry and forestry	2,053	1,636	
Plantation and industrial crops		789	20
Duplicate safety samples	10,235		
Pollen grains		254	
Total	**339,194**	**7,922**	**1,904**
Grand Total			**349,020**

Active germplasm collections are maintained at NBPGR regional stations and the NAGS situated at different crop-based ICAR institutions and SAU, which are held in modules maintained at 4-10^{0}C. A total of 18 medium-term storage modules (7 at NBPGR centres and 11 at NAGS) are used for storage of active collection of seed propagated crops. These centres also manage the field genebanks of clonally propagated crops. The directory of various NAGS together with the germplasm accessions maintained is presented in Table 3.3. More than 1,76,000 accessions are held in the NAGS and used for research and crop improvement programmes in the country. In addition, there are ten more medium-term storage facilities maintained by other institutions belonging to different public and private organisations.

Table 3.3: National Active Germplasm Sites for active collections of PGFRA in India (as on 31 December, 2006)

	Crop(s)	Institute	Accessions (no.)
Field Crops			
1.	Cotton	Central Institute of Cotton Research, Nagpur[4]	8,768
2.	Crops of North-east Region	ICAR Research Complex, Northeast Hill Region, Shillong[4]	867
3.	Fodder crops	Indian Grassland and Fodder Research Institute, Jhansi[4]	6,267
4.	Groundnut	NRC[2] on Groundnut, Junagarh[4]	6,432
5.	Jute and allied fibres	Central Research Institute for Jute and Allied Fibres, Barrackpore	4,653
6.	Maize	Project Directorate on Maize, IARI, New Delhi	2,500
7.	Oilseeds	Directorate of Oilseeds Research, Hyderabad[4]	9,070
8.	Pearl millet	AICRP[3] on Pearl Millet, Jodhpur	3,100
9.	Pulses	Indian Institute of Pulses Research, Kanpur[4]	5,021
10.	Rapeseed and mustard	NRC on Rapeseed and Mustard, Bharatpur	8,082
11.	Rice	Central Rice Research Institute, Cuttack[4]	24,000
12.	Rice and *Lathyrus*	Indira Gandhi Krishi Vishwa Vidhyalaya, Raipur[4]	15,000
13.	Small millets	AICRP on Small millets, Banglore[4]	13,290
14.	Sorghum	NRC on Sorghum, Hyderabad	7,366
15.	Soybean	NRC on Soybean, Indore	2,500
16.	Sugarcane	Sugarcane Breeding Institute, Coimbatore	5,861
17.	Tobacco	Central Tobacco Research Institute, Rajhamundry	2,359

18.	Under-utilized crops	NBPGR, New Delhi[4]	199
19.	Wheat and barley	Directorate of Wheat Research, Karnal[4]	7,000
Horticultural/Agroforestry crops			
20.	Agroforestry spp.	NRC on Agroforestry, Jhansi	40
21.	Arid fruits	Central Institute on Arid Horticulture, Bikaner	1,923
22.	Banana	NRC on Banana, Tiruchirapalli	113
23.	Cashew	NRC on Cashew, Puttur	500
24.	Citrus	NRC on Citrus, Nagpur	51
25.	Grape	NRC on Grapes, Pune	600
26.	Litchi, bael, aonla, jackfruit and other horticultural crops[3]	NRC on Litchi, Muzzaffarpur Indian Institute of Horticultural Research, Bangalore	2,426
27.	Medicinal and aromatic plants	NRC on Medicinal and Aromatic Plants, Anand	190
28.	Mango[1]	Central Institute for Sub-Tropical Horticultural, Lucknow	-
29.	Mulberry[1]	Central Silk and Mulberry Genetic Resources Centre, Hosur	-
30.	Oil Palm	NRC on Oil Palm, Eluru	103
31.	Onion and garlic	NRC for Onion and Garlic, Nasik	1,066
32.	Orchids	NRC for Orchids, Gangtok	225
33.	Endemic, rare, endangered, ornamental and economic plant species	National Botanical Research Institute, Lucknow	1,870

34.	Plantation crops	Central Plantation Crops Research Institute, Kasargod	522
35.	Potato	Central Potato Research Institute, Shimla	2,840
36.	Spices	Indian Institute of Spices Research, Calicut	6,055
37.	Temperate horticultural crops[3]	Central Institute of Temperate Horticulture, Srinagar[4]	780
38.	Tropical fruits, vegetables, ornamentals and medicinal plants	Indian Institute of Horticulture Research, Bangalore	3,737
39.	Tuber crops	Central Tuber Crops Research Institute, Thiruvananthapuram	3,871
40.	Vegetables	Indian Institute of Vegetables Research, Varanasi[4]	16,139

[1]Figures not available; [2]NRC: National Research Centre; [3]AICRP: All India Coordinated Research Project; [4]with medium-term storage facility

Numerous botanic gardens managed by the BSI and several other organisations help in *ex situ* conservation of economically important as well as endangered, threatened and rare plant species. The tradition of setting up of Botanic Gardens in India dates back to over 200 years when large spaces within major cities in India were set-aside for the purpose. The Indian Botanic Garden at Calcutta was established in 1787. It now spreads over an area of 110 hectares and has around 15,000 plants belonging to 2,500 species. Presently there are 150 organized botanic gardens or large parks in India, of which 33 gardens are managed by the Government, 40 by Universities and the rest are in public domain. The Government of India has also recently initiated establishment of National Botanical Garden in NOIDA in Uttar Pradesh. In all, about 150,000 live plants belonging to nearly 4,000 species (including 250 endemic species) are conserved in these botanic gardens.

SUSTAINING AND EXPANDING *EX SITU* COLLECTIONS

Amongst the total accessions of PGRFA conserved in India, about 64.2% is conserved in long-term seed genebank and 33.3% is held either in medium- or short-term storage or in field genebanks. The rest are conserved in cryobanks or *in vitro* genebanks. Stock inventorization and monitoring of viability is performed regularly in most of the accessions, while the genetic integrity is checked occasionally.

The data related to *ex situ* collections is predominantly published in the form of printed copy and most of the publications include passport data, characterization and evaluation data. About 60% publications contain analyzed data, whereas 34% publications have raw data.

The greatest constraints to sustain *ex situ* collections are lack of funding and limited number of trained staff to cover all activities related with management of PGRFA following all possible approaches. Lack of adequate facilities is also a constraint in some organizations. For better management practices to reduce genetic changes or loss of genetic integrity, attention is paid to select suitable regeneration environment, adequate population size and proper handling of regenerated material in close collaboration of crop-based institutes.

Priorities for expanding *ex situ* conservation activities would be wild and weedy relatives of crop plants and trait and agro-ecological specific germplasm. Funding may be required in crops of regional/ global importance. Priority setting for *ex situ* conservation are clear in India because of its commendable strength in this area. However, this may need facilitation for targeted collections based on specific trait(s) or regional/ global importance.

There is a built-in duplicity of accessions in the system, wherein the accessions conserved at NAGS and the crop-based institutes as active collection are conserved as base collection in the National Genebank. The active collections are used in research and crop improvement and the National Genebank helps in restoration of lost accessions to the active sites. This also serves as safety mechanism.

There exists medium to high capability for research and use of improved methodologies for *ex situ* conservation. Nevertheless, strengthening of technical and infrastructure capabilities is required in some cases. The capacity building in genebank management and information systems has been carried out satisfactorily, though there is a need for extension of medium-term facilities to more crop-based institutes to cover larger number of crops. In last ten years 1,96,745 accessions were collected under 166 projects involving 599 professional and of these 1,04,084 accessions have been conserved. The maximum number of accessions conserved in *ex situ* are in the category of traditional cultivars and landraces. A significant number of collections belonging to wild and weedy relatives and advanced and improved cultivars developed using various genetic resources are also being conserved. The details of the total accessions and safety duplicates conserved as active collections under *ex situ* are presented in Table 3.4.

Table 3.4: Total accessions conserved *ex situ* and number of safety duplicates for various categories of crop species (1996 – 2005)

Status	No. of crop sp.	No. of accessions	Safety-duplicates as active collections	Safety-duplicates (%)
1. Traditional cultivar/ Landrace	280	121274	84931	70
2. Wild	314	15881	4745	30
3. Weedy	70	267	11	4
4. Breeders' Line	37	14661	2272	15
5. Mutant/ Genetic Stock	26	7898	4880	62
6. Advanced/ Improved cultivar	59	9080	4867	54
7. Others	73	27662	2378	9

REGENERATING THREATENED *EX SITU* ACCESSIONS

Amongst the *ex situ* conserved accessions which are threatened (low seed number, loss in viability during storage) 38,031 have been already regenerated according to established standards, while 42,148 still require regeneration. In the latter case, where priorities for regeneration have been set and the activities are underway, a maximum of 10 years may be required. Most of the stakeholders (65%) have reported good regeneration capabilities of *ex situ* accessions in restricting the loss of genetic diversity. Only 15% have reported undertaking of regeneration of existing backlogs.

PLANNED AND TARGETED COLLECTION

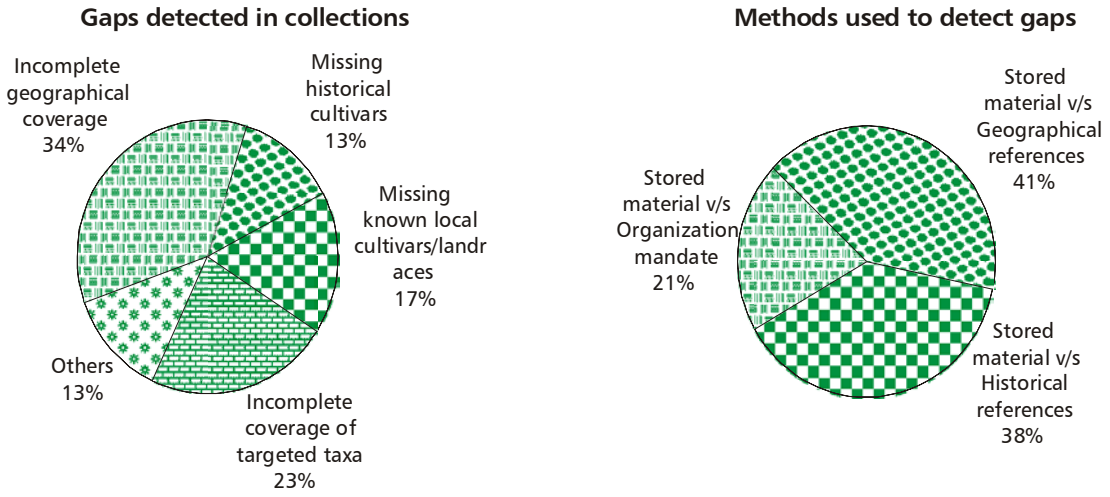
Planned and targeted collection of PGRFA has been systematically undertaken in India, especially during 2000-2005 under the World Bank funded National Agricultural Technology Project (NATP). The number of accessions collected, districts explored and accessions stored in the long-term storage (LTS) are indicated in the Table 3.5.

Table 3.5: Details of collection missions undertaken for targeted collection of PGRFA (1996-2005).

Item	Number
Collection missions	78
Crop species collected	671
Accessions collected	86,605
Accessions in long-term storage	55,595
Total districts covered for the exploration	402

Major gaps in collection are under-explored/unexplored areas and incomplete coverage of gene pools of the targeted taxa (Figure 3). Priorities, needs and constraints in supporting planned and targeted collection of PGRFA, have been taken into consideration for further action at national or sub-regional level. Support may be needed from regional and/or international organizations on trait-specific and area-specific collections in certain crops.

Fig 3. Gaps detected and methods used in supporting planned and targeted collection of PGRFA



FUTURE NEEDS AND PRIORITIES

Though large germplasm has been amassed under *ex situ* conservation, a good number of accessions collected earlier lack passport, characterization and/or evaluation data, which in many cases has to be extracted from archive records. The present emphasis is to collect and assemble trait-specific accessions from different agro-ecological zones/ sources to facilitate their use in crop improvement.

There is a national mechanism for registration of the potentially valuable germplasm with unique traits to facilitate their documentation and use in basic research and crop improvement. This area needs further strengthening with increased evaluation of genetic resources against important biotic and abiotic stresses and for other desirable traits. The stakeholders having MTS facility have reported the existing storage space as one of the constraints while the stakeholders without MTS facility have demanded for creation of such facility for efficient conservation of germplasm. There is an urgent need to identify duplicates of accessions that exist within and among genebanks and to rationalise the collections for optimising the costs of conservation.

Recognizing the mandate for conservation of a wide spectrum of crops with different breeding systems, for sustainability of the present *ex situ* conservation, it is required to develop appropriate regeneration protocols with suitable plant populations in a large number on un-investigated or less investigated crops. In addition, funding for specific programmes may be required for regenerating threatened *ex situ* accessions. The wild relatives are poorly represented in most of the *ex situ* collections and priority in the major food crops should be to collect mainly the wild and weedy relatives, filling the gaps in collections during trait-specific and area-specific explorations. Also, the under-utilized crops and a number of native species that occur in the wild, which are utilized for medicinal purposes in the traditional health care systems require greater attention.

A national effort by multi-disciplinary teams of scientists for the characterization (including molecular characterization), evaluation and pre-breeding programmes, using biotechnological tools, wherever required, would provide the necessary thrust for utilization of conserved PGR. The PGR conservation is a long-term, resource intensive commitment, though imperative for sustainable development and posterity.

THE STATE OF USE 4

Plant Genetic Resources for Food and Agriculture (PGRFA) are vital to the development and welfare of human society. They contribute enormously towards achieving the global objectives of food security and poverty allevation, environment protection and sustainable development. The local communities and farmers in India have sustained and enriched the diversity of these resources which they domesticated, used, conserved and made available to meet the ever increasing needs of the present and future generations. Characterization and evaluation of germplasm is required to know its worth or usefulness and availability of information on characterization and evaluation of conserved genetic resources is the key to utilization.

Plant breeding provides many examples of the use of genetic resouces for the improvement of the varieties of crop plants. There are examples that range from highly specific improvement to one major factor such as susceptibility to a pest or disease to all round improvement in yield, agronomical traits, disease resistance and to changes in the form and structure of the plant type. The use of germplasm in major food crops in India has been presented:

FOOD CROPS

India has been considered the primary centre of origin of rice and a largest number of accessions were conserved in National Gene Bank (NGB) of National Bureau of Plant Gentic Resources (NBPGR), India and Indian material is also conserved at International Rice Ressearch Institute (IRRI) Philippines. The working collections are being maintined at Central Rice Research Institute, Directorate of Rice Research and various other institutes. A wide range of variability identified in the Indian germplasm (cultivated and wild *Oryza* species) has led to identification of several donors. Over 30 donors have been registered at NBPGR for useful traits. Effective utilization of diverse donor sources has led to evolution of over 700 varieties suited to diverse environments with resistance to biotic and abiotic stresses and high yield potential. This include varieties suitable to irrigated ecology (314), raindfed uplands (84), rainfed lowlnds (44), deep water (33), high attitudes (33), saline and alkaline soils (15), aromaic rice (19), etc. Many Indian bred elite lines (33) have been released as varieties (46) around the world. Use of wild relatives needs special mention with the identification and incorporation of *Oryza nivara* gene for resistance to grassy stunt virus, *O. officinalis*

for resistance against brown plant hopper, *O. glaberrima* and *O. eichengeri* for resistance to gall midge (Biotype II) and *O. longistaminata* for bacterial leaf blight in India [1].

Wheat is another important crop of India. A large number of accessions were conseved in NGB and working collections are being maintained at various institutes and State Agricultural Universities (SAUs). Evaluation and characterization of germplasm has resulted in identification of various donors for resistance/ tolerance to biotic and abiotic stresses with high yield potential. Many local bread wheats are being utilized nationally and internationally are Hard red Calcutta, Etawah and Indian G, Jaipur Local, Kharchia local, Mondhya 417, Muzaffar Nagar White, NP 6, NP 22, C 13, C46, BR 319, AO 13 and AO 90, etc. Over 70 genetic stocks have been registered in wheat and triticale. Several molecular markers were also identified in wheat mainly focused on genes for disease or insect-pest resistance[2]. Direct selection from germplasm and their use in hydridization programme have led to release of about 280 varieties[3].

Maize, being a cross pollinated crop, has populations comprising freely interbreeding individuals which are heterogenous. The utilization of introduced materials in hybridization programmes has greatly contributed in sorghum and pearl millet improvement in India. *HC-308, Pant Chari-5, CSH-13, PCH-106* and *safed moti* are some the released forage varieties and hybrids of sorghum using the germplasm during 1996-2006. Traditional uses of millets are classified into nine major food categories in India *viz*., thick porridges, thin porridges, steam-cooked products, fermented breads, unfermented breads, boiled rice like products, alcoholic beverages, non-alcoholic beverages and snacks[4]. A large number of indigenous and exotic germplasm and inbred lines were characterized and evaluated at NBPGR and Maize Directorate, New Delhi and its collaborators. This has led to release of about 48 hybrids and 98 composites. The hybrids that played an important role in increasing the maize productivity in the country include Ganga Safed 2, Hi-starch, Ganga 5, Sartaj, Ganga 11, Deccan 103, Decan 105, Paras and Parkash. Traditionally ,maize is grown in Inda in monsoon. However, intensive study on the development of cold tolerant germplasm has opened an era for production of winter maize in India with the release of Partap and Partap1[5]. Recently, the work on QPM (Quality Protein Maize) has been strengthened and promising hybrids (Shaktiman 1 and Shaktiman 2) have been released. The released popcorn composites are Amber Popcorn, VL Amber Popcorn, Pearl popcorn; and sweet corn composites are Madhuri and Priya. Though, no cultivar has been released specially as baby corn, early maturing hybrids namely Parkash, Vivek 5, Pusa 1 and Pusa 2 are recommended for cultivation as baby corn[6].

Barley, sorghum and pearl millet are also important food crops and occupies fairly large area in

India. A large number of accessions in each crop were evaluated and some of the promising lines were identified. Utilization of promising lines resulted in release of about 95 varieties in barley, 19 hybrids and 120 varieties in sorghum and 25 open pollinated varieties in pearl millet for all India cultivation.

OILSEEDS AND PULSES

The systematic evaluation for various morpho-agronomic and quality traits, reaction to biotic and abiotic stresses resulted in the identification of donors for use in the varietal improvement. Some of the genetic stocks registered at NBPGR are of *Brassica juncea* (16), *B.* napus (8), *B. carinata* (1), *B. rapa* ssp. *brown sarson* (1) for desirable traits . Effective utilization of germplasm has led to release over of 150 varieties of rapeseed mustard covering Indian Mustard (*B. juncea*), Karan Rai (*B. carinata*), Toria (*B. rapa* ssp. *toria)*, yellow sarson (*B. rapa* ssp. *yellow sarson*), brown sarson (*B. rapa* ssp. *brown sarson*), gobhi sarson (*B. napus*) and taramira (*Eruca sativa*)[7].

Groundnut is relatively recent introduction in India. A considerable amount of variability has been recorded both in cultivated and wild *Arachis* species at ICRISAT, NRC Groundnut and other centres. Sources of resistance to some major diseases and insect pests and tolerance to abiotic stresses were also identified . Only 5 accessions of groundnut were registered for useful traits. Most important parents used frequently for development of varieties through hybridation are Robt 33-1, M 13, J11, GAUG 10, TMV 10. Over 140 cultivars have been released[8].

Large number of accessions of other oilseed crops namely, sesame, soyabean, sunflower and, niger were also evaluated for desirable traits. Use of promising germplasm resulted in release of varieties/ hybrids of sesame (62), soybean (20), sunflower (23) and niger (19). Some of the varieties of sunflower (Sunflower 1) and linseed (Parvati and Shekhar) were released recently using local germplasm.

Major pulse crops of India are pigeonpea, chickpea, mungben, urdbean, lentil, pea, *Lathyrus* and rajmah. Over 50,000 accessions of 26 pulse crops have been conserved in NGB. A large number of germplasm accessions were evaluated for agro-morphological traits, resistance to biotic and abiotic traits and quality parameters and donors were identified. About 40 genetic stocks were registered at NBPGR (pigeonpea:16, chickpea: 9, pea: 5, mungbean: 2, khesari: 2, cowpea: 2, lentil: 2, urdbean: 1 and mothbean: 1). Evaluation of germplasm has led to release of more than 60% of total pulse varieties as direct selection from germplasm in India. Over 230 vareties were developed through hybridization. Pedigree analysis of these varieties revealed narrow genetic base in most of pulse crops because of the frequent use of the same parents and their derivatives in breeding programme. Therefore, immediate corrective measures should be taken up by involving unadapted germplasm accessions and wild relatives in hybridization

progrmmes of pulses[9].

HORTICULTURAL CROPS

In India, rich diversity occurs in horticultural crops (fruits: 100 species, vegetables: 54 species and spices and condiments: 27 species). Many fruit crops, such as mango, citrus and banana have special significance as they have their centre of diversity in tropical India / South-East Asia. Several mango varieties have been evaluated for resistance to insect-pests and for their processing qualities and donors for various characters were identified. Most of the Indian mango cultivars exhibit specific eco-geogrphical requirements for optimum growth and fruiting and varieties for different zones were maintained. India possesses rich diversity in wild *Musa* species in the North-eastern region and southern region. A large number of *Citrus* species and botanical varieties (30) are indigenous to India and have been grown in India for a long time.

The vegetable crops/crop groups having diversity in Indian gene centre include brinjal, okra, cucurbits, taros and yams. A large number of accessions were evaluated for yield, fruit setting, quality and other traits and promising donors were identified for these crops. In solanaceous crops, concerted efforts have resulted in release of varieties and hybrids in tomato (varieties: 64, hybrids:13), brinjal (varieties: 74, hybrids:17), chilli (varieties: 40, hybrids:3). In India, tomato is one of the best example of utilization of wild species in crop improvement. Tomato variety H24 tolerant to tobacco leaf curl virus was developed using *L. hirsutum f. glabtrtum* as a donor[10]. Cucurbits constitute an important and large group. In Indian subcontinent, 36 genera and 100 species are found with 38 species of economic importance. Characterzation and evaluation of germplasm resulted in identification of donors and 12 genetic stocks have been registered at NBPGR. Direct selection of germplasm, or recombination and through mutation breeding resulted in release of 95 varieties of cucurbits[11]. Okra is another important crop of India and ten species are known to occur in India. Promising germplasm accessions for high number of fruits, branches with attractive smooth green fruits, resistance to biotic and abiotic stresses were identified and utilization of these donors has resulted in release of large number of varieties[12].

INDUSTRIAL/ CASH CROPS

Cotton is a major fibre crop possessing high commertial value. Evaluation and characterization resulted in identification of elite germplasm in *G. hirsutum* , *G. barbadense*, *G. arboreum* and *G. herbaceum*. Cotton improvement in India has made an efficient use of genetic resources in the development of cultivars including hybrids. In fact, India is the first nation in the world to develop hybrid cotton for commertial cultivation. About 16 varieties were released for cultivation. Interspecific hybridization has also led to release of varieties (8) and hybrids (7). Two long staple varieties of upland cotton namely MCU 2 and MCU

5 have been obtained by the long duration selection of *G. hisutum* x *G. barbadense* cross and variety Arogya (long staple) from *G. arboreum* x G. *anomalum*[13].

Sugarcane is a major cash crop of the tropical and subtropical regions of India. High diversity in *Saccharum* germplasm is available in India. A large number of germplasm accessions of cultivated and wild species were evaluated for sucrose and juice contents, resistance to biotic and abiotic traits. The top ranking 185 clones that contibuted more to the overall diversity were selected to constitute core set. The sources of various desirable traits for use in hybridization were identified. All the improved varieties of sugarcane are products of interspecific hybridization involving cultivated (*Saccharum officinarium*, *S. barberi*, *S. sinense*) and the wild species (*S. spontaneum* and *S. robustum*)[14].

Jute, mesta, sunnhemp, flax, ramie and sisal are other fibre crops. Jute and allied fibres germplasm has been effectively utilized for develoment of improved varieties. The germplasm which has contributed to the development of more than one cultivar are JRC 212, JRC 321, D 154 of white jute (*Corchorus capsularis*); JRO 632, Sudangreen and Tanganayika 1 of tossa jute (*C. olitorius*); and RT 1, RT 2 and AMV 1 in rosselle ((*Hibiscus sabdariffa*). Utilization of germplasam led to release of over 30 varieties of tossa jute (10), white jute (12), roselle (6), kenaf (2), sunnhemp (1), sisal (1) and ramie (1)[15].

There exists a mechanism of 'Single Window System of Germplasm Supply" to the users in the country. NBPGR is the nodal organization supplying genetic resources to different breeding programmes through its network of Regional Stations and National Active Germplasm Sites [Figure 4]. The number of samples distributed during the last 10 years are given in Table 4.1.

Table 4.1: Number of samples of PGR distributed over the last 10 years

Year	No. of samples
1996	20,775
1997	27,022
1998	23,313
1999	11,064
2000	9,714
2001	10,771
2002	12,274

2003	15,487
2004	15,543
2005	9,366
2006	9,537
Total	1,64,866

UTILIZATION AND ENHANCEMENT OF PGR

There have been a number of success stories in crop improvement programmes resulting in development/ genetic improvements of a number of cultivars/ hybrids that have helped in enhancing the national production demonstrating the contribution in increasing the productivity or overcoming various constraints as detailed in the NISM – GPA report of India.

Constraints in germplasm utilization

Some of the constraints realized in optimum utilization of germplasm are lack of detailed evaluation of available germplasm accessions held in genebank. Also, there have been intense genetic erosion of primitive types and landraces. Many wild and wild related species are difficult to maintain due to differences in their adaptability and seed biology/dormancy. Most wild species are not easily crossable with cultivated species. However, use of new biotechnology tools has resulted in development of few intergeneric and interspecific varieties in some of the crops. Moreover, the genes carrying resistance / tolerance to stresses in wild relatives are linked with undesirable genes that slow down the progress in breeding. Further, in many cases, sources for resistance to some of the important pests-diseases are not available.

Although in most of the crops, a large number of accessions have been assembled, their management for effective use has become difficult. Core collections have been developed only in few crops. Therefore, there is a need for strengthening the application of techniques like development of gene pools, core collections, trait specific core sets, etc.

The breeding capability to perform the genetic improvement in most crops is satisfactory (either increasing or stable) except for oilseed crops.

Most of the crop species have been evaluated for morphological and agronomic traits (Table 4.2). Regular Germplasm Field days are organized on different crops to identify and select the desirable germplasm to be utilized in crop improvement programme. Efforts are also being made for the characterization of crop species for biotic, abiotic and biochemical traits.

Fig. 4: Crop based National Active Germplasm Sites

Table 4.2: Percentage of germplasm characterized and evaluated using different traits

Item	Number of species	%age of germplasm
Characterized for morphological traits	133	74
Characterized based on molecular markers	33	21
Evaluated for agronomic traits	106	73
Evaluated for biochemical traits	81	27
Evaluated for abiotic stresses	55	37
Evaluated for biotic stresses	69	55

A total of 86 crops catalogues containing passport, characterization/ evaluation data on various descriptors have been published by the stakeholders.

Germplasm utilization requires use of stable and heritable traits. Therefore, a network programme on multi-locational evaluation leading to utilization in crop improvement programmes of priority crops has been initiated. Evaluation of crops for agronomical, biotic and abiotic stresses in collaboration with crop-based institutes, Project Directorates (PD), Project Coordinators (PC), National Research Centres (NRC) and All India Coordinated Research Projects (AICRP) is being carried out as detailed in Figure 4.

- First Year: Germplasm accessions collected will be multiplied and characterized for qualitative traits at a suitable location (NBPGR or relevant crop based institutes/PD/PC/NRC).
- Second Year: The accessions will be raised and evaluated for quantitative traits/agronomic performance at relevant institutes (crop-based PD/PC/NRC). The seed produced will be divided into three parts (i) for National Genebank, (ii) for collaborative centre for further testing and use and (iii) for national supply (active germplasm) by NBPGR. First priority is to conserve the germplasm in National Genebank.
- Third Year: Promising accessions will be evaluated in National Germplasm Nursery for agronomic traits by AICRP centres. This will be followed by evaluation for resistance / tolerance to biotic and abiotic stresses and quality traits. Germplasm will be screened under controlled environments as well as in sick plots. The testing environments will be decided by the concerned PC/PD.

The programme on multilocation evaluation of germplasm of four major crops viz, rice, wheat, chickpea and pigeonpea was started during 2002. The programme needs to be expanded to other crops

for which additional resources would be required.

A number of crop improvement programmes are focusing on development of improved cultivars resulting in release of more than 500 varieties in about 77 crop species* (Table 4.3).

Table 4.3: Breeding programmes established and expanded

Breeding Programme	Important target traits	Estimated importance of the improvement	Professional involved	No. of varieties developed
52	141	High	209	300
13	32	High, limited	62	23
28	65	High, medium	109	179
8	21	Limited	18	10
13	41	Medium	57	45
2	7	Medium, limited	12	6
116			**467**	**563**

Maximum Farmer's participation is reportedly highest either at the stage of setting priorities or at the implementation stage (Table 4.4).

* *Abelmoschus esculentus, Allium cepa, Allium sativum, Amaranthus tricolor, Anacardium occidentale, Arachis hypogaea, Areca catechu, Beta bengalensis, Brassica carinata, Brassica juncea, Brassica nigra, Brassica oleracea* var. *botrytis, Brassica* sp., *Cajanus cajan, Callistephus chinensis, Capsicum annuum, Carthamus tinctorius, Citrullus fistulosus, Citrullus lanatus, Cocos nucifera, Cucumis melo, Cucumis melo* var. *utilissimus, Cucumis sativus, Cucurbita maxima, Cucurbita moschata, Cucurbita pepo, Curcuma longa, Daucus carota, Dendranthema x morifolium, Echinochloa frumentacea, Elaeis guineensis, Elaeis oleifera, Elettaria cardamomum, Eleusine coracana, Gladiolus grandiflorus, Glycine max, Gossypium* sp., *Helianthus annuus, Lablab purpureus, Lagenaria siceraria, Linum usitatissimum, Luffa acutangula, Lycopersicon esculentum, Mangifera indica, Manihot esculenta, Momordica charantia, Musa acuminata, Nicotiana* sp., *Nicotiana tabacum, Oryza sativa, Panicum miliaceum, Panicum sumatrense, Paspalum scrobiculatum, Pennisetum glaucum, Phaseolus vulgaris, Piper nigrum, Pisum sativum, Polianthes tuberosa, Psidium guajava, Raphanus sativus, Ricinus communis, Rosa hybrid, Saccharum officinarum, Saccharum* sp., *Sesamum indicum, Setaria italica, Solanum melongena, Solanum* sp., *Solanum tuberosum, Sorghum bicolor, Theobroma cacao, Triticum aestivum, Vigna mungo, Vigna radiata, Vigna sesquipedalis, Vigna unguiculata, Zingiber officinale*

Table 4.4: Extent of farmer's participation (according to local needs) in enhancement/ broadening efforts

Number of Programme/ project/ activity	Number of crops	Farmers involvement
10	14	Implementing Programme
38	34	Setting priorities
5	5	Setting priorities; Implementing programme

The genetic enhancement has been mainly performed through introgression of genes for specific traits. Nevertheless, a limited number of parents have been used indicating the narrow genetic base of most of the varieties developed and thereby increasing the genetic vulnerability to biotic and abiotic stresses. Therefore, there is a need to use diverse genetic resources for broadening the genetic base of varieties resulting in more sustainable productivity.

SEED SUPPLY SYSTEMS AND ROLE OF MARKETS

Structure of seed industry

Indian seed programmes includes the participation of Central and State Governments, Indian Council of Agricultural Research (ICAR), State Agricultural University (SAU) system, public sector, co-operative sector and private sector institutions, Seed sector in India consists of two national level corporations, i.e., National Seeds Corporation (NSC) and State Farms Corporation of India (SFCI), 13 State Seed Corporations (SSCs) and about 100 major seed companies. For quality control and certification, there are 22 State Seed Certification Agencies (SSCAs) and 101 State Seed Testing Laboratories (SSTLs). The private sector has started to play a significant role in the production and distribution of seeds. However, the organized seed sector particularly for food crops cereals continue to be dominated by the public sector.

The Directorate of Marketing and Inspection (DMI) extends supports to the Central and State Governments on agricultural marketing policies and programmes and implement various schemes under them.

The DMI undertakes marketing, research, surveys and in-depth studies of marketing system for various agricultural commodities in the country and suggests remedial measures.

The Directorate is implementing a Central Sector Scheme 'Marketing Research and Information Network' to establish a nationwide network for speedy collection and dissemination of market information. Under this scheme, 993 markets have already been provided connectivity out of which, 764 markets were made operational by the end of March 2005. Besides, connectivity to 411 additional agricultural markets are under process. At present, daily prices of more than 300 commodities and about 2000 varieties are being reported.

There are six participatory community-based seed programmes/ projects/ activities. Twenty three programmes/projects/activities are jointly carried out between formal and informal seed sector. Forty three Programmes/ projects/ activities addressing seed storage problems are in operation in India. A regulatory framework to support local seed system is being developed/ adopted. Seed quality standards have been established through nationally defined rules.

A total of 4,618 cultivars have been released in 162 crops. However, following 10 crops contribute towards 50% of the total cultivars released so far (Table 4.5).

Table 4.5: List of major crops sharing half of the total released cultivars

Name of crop		Number of cultivars released	%age
1.	Paddy	763	17
2.	Wheat	279	6
3.	Sorghum	216	5
4.	Maize	177	4
5.	Groundnut	146	3
6.	Pearl millet	137	3
7.	Upland cotton	129	3
8.	Chickpea	126	3
9.	Apple	125	3
10.	Soybean	93	2
	Total	**2191**	**49**

There are about 298 landraces/ farmers varieties with great economic potential for developing new markets identified in 19 species

PROMOTION OF UNDERUTILIZED CROPS AND SPECIES

Crop improvement efforts have been undertaken for most promising under-utilized crops/species under 23 programmes as reported by 21 stakeholders (Table 4.6).

Table 4.6: Crop improvement programmes/projects/activities for most promising under-utilized crops/ species

Number of Stakeholders	Number of programme/ project/activity	Target	Number of taxa	Topics covered
21	23	Underutilized crops or species; Diversity - rich products	45*	Research; Crop improvement; Improving processing; Market development; Public awareness; Policy changes

During the last 10 years, over 10,000 accessions of underutilized crops have been collected of which nearly 8,000 accessions have been evaluated. This resulted in selection of over 25 varieties of different underutilized crops for cultivation by the farmers under All India Co-ordinated Research Projects/ Network on Small millets, Underutilized crops and Arid Legumes. Performance of some of these varieties was verified on farmers' fields in the tribal, backward and hilly areas under NATP mission on Household Food and Nutritional Security Programme wherein over 8,000 farmers were involved. For promotion of these varieties, 740 q seed of suitable location specific varieties was distributed among 9,000 farmers.

** Amaranthus hypochondriacus, Amaranthus* sp., *Andrographis paniculata, Atriplex* sp., *Azadirachta indica, Camellia sinensis, Canavalia ensiformis, Chenopodium* sp., *Citrullus colocynthis, Citrullus lanatus, Coccinia indica, Coix lacryma-jobi, Elaeis oleifera, Erianthus arundinaceus, Fagopyrum esculentum, Garcinia indica, Gymnema sylvestre, Ipomoea muricata, Jatropha curcas, Luffa acutangula, Madhuca latifolia, Momordica dioica, Moringa oleifera, Murraya koenigii, Parthenium argentatum, Perilla frutescens, Phyllanthus amarus, Pongamia pinnata, Prunus armeniaca, Psophocarpus tetragonolobus, Rubus ellipticus, Salvadora persica, Sauropus androgynus, Sesamum indicum, Simarouba glauca, Simmondsia chinensis, Terminalia arjuna, Trachyspermum ammi, Vicia faba, Vigna angularis, Vigna umbellata*

FUTURE NEEDS AND PRIORITIES

There exist a well established mechanism for distribution of the genetic resources, however, the feedback regarding the utilization is insufficient and therefore requires strengthening.

For distribution of information regarding the potential value of the germplasm conserved, it is required that more catalogues should be published. Although databases at institute level have been developed, there is a need for linking of these databases and creating a national database so that the information on passport data, characterization and evaluation can be accessed by all the concerned stakeholders in a user friendly manner.

As most of the agriculture practiced in the country is of subsistence nature, the traditional seed supply system is still in operation in a large part of the country. For rapid seed supply, there is a need for establishment of linkages between the formal seed distribution system and the traditional system. This may require further research and policy support.

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THE STATE OF NATIONAL PROGRAMMES, TRAINING AND LEGISLATION

5

NATIONAL PROGRAMMES

Ministry of Environment and Forests (MoEF), Department of Agricultural Research and Education (DARE), Department of Agricultural Co-operation (DAC), Department of Science & Technology (DST), Department of Biotechnology (DBT), and Department of Scientific and Industrial Research are the principal Departments/Ministries, which support research activities related to biodiversity, including plant genetic resources.

The MoEF is the nodal policy making agency dealing with all biodiversity-related issues and response to international agreements such as the CBD. The MoEF is also the operational nodal point for GEF in India. Sixteen projects dealing with biodiversity are under implementation, out of which three have been completed. The UNDP GEF/CCF small grant programmes have supported ninety projects in India since 1992 to support activities that demonstrate community based approaches. More financial resources have been accessed from India Canada Environment Facility (ICEF), Canada India Institutional Strengthening Project etc. Botanical Survey of India (BSI) an organization under the MoEF deals with survey, inventorisation, and monitoring of plant biodiversity. The BSI, with the Indian Botanic Garden, Howrah, Botanic Garden of Indian Republic, NOIDA and nine experimental botanic gardens attached to its Circle offices across the country, has an ongoing programme of collection, introduction, multiplication, maintenance and scientific study of rare and threatened, medicinal and economically important species of plants.

NETWORKS

The DARE and ICAR deals with all aspects, including policy, research, conservation, sustainable use, education, training and extension related to domesticated and economically important plants. The National Bureau of Plant Genetic Resources (NBPGR) acts as a nodal organization under the Indian Council of Agriculture Research (ICAR) for planning, conducting, coordinating and promoting all activities concerning PGR of agricultural and horticultural crops and their wild relatives. The Bureau

has headquarters at New Delhi and 10 regional/base centres in different agro-climatic zones of the country. The NBPGR also maintains international linkage and cooperation based on joint memoranda of understanding and work plans signed by DARE/ ICAR with agencies of other countries and international centers.

The NBPGR, being the single window for PGR exchange for research purposes, also performs regulatory functions as the authorized agency for Post-entry Plant Quarantine examination, issuance of Phytosanitary Certificates and issuance of Import Permit for introduction of germplasm for research as per the Plant, Fruits and Seeds (PFS) Order that was revised in the light of World Trade Organization Agreements and the Plant Quarantine (Regulation of Import into India) Order 2003 that came into force with effect from April 1, 2004.

The Bureau has developed and operates the Indian Plant Genetic Resources Management System (IPGeRMS) previously known as Indian Plant Genetic Resources System (IN-PGRS) in the form of network encompassing NBPGR and 40 National Active Germplasm Sites (NAGS) located at the various Institutes, Project Directorates, Coordinating Units, National Research Centres of ICAR, State Agricultural Universities (SAUs) and other stakeholders, such as NGOs and professional societies carrying out activities related to PGR management. The major activities of IPGeRMS for effective management of PGR include germplasm acquisition, characterization, evaluation, documentation and conservation in which NBPGR plays the leading role. The strength of IPGeRMS lies in the synergistic approach established for the maintenance of active collections (collections comprising accessions immediately available for multiplication, distribution and use) at the crop based NAGs for use in crop improvement. Sharing of germplasm is done through recently evolved Material Transfer Agreements (MTA) depending on the users viz within National Agriculture System (NARS), outside NARS but other National Research Organisation or out the country to non-Indians as per the definition and provisions of the Biological Diversity Act. Regular workshops and meetings of concerned persons and organizations are being held to review national activities on conservation and use of PGRFA. The number of technical, legal and managerial/policy experts working in the various National Programmes in India are currently stable but on a decreasing trend.

Under the World Bank funded National Agricultural Technology Project on Sustainable Management of Plant Biodiversity, survey and inventorization of germplasm collection were done alongwith documentation of Indigenous Traditional Knowledge (ITK). This was funded partialty by World Bank. Activities related to germplasm evaluation, regeneration and conservation of PGRFA

were greatly enhanced during the project. Need based trainings were obtained for human resources development and an awareness at large generated amongst the scientific community of the country.

EDUCATION AND TRAINING

Realising the increasing importance of activities related to PGR in the changing global scenario, NBPGR in collaboration with Indian Agricultural Research Institute (IARI) started M.Sc. (PGR) degree programme in 1997 and Ph.D. programme in 2004. In addition, training to professionals is imparted under the Team of Excellence in PGR Training, On-job Training Programmes and Awareness Training Programmes organised regularly. In addition, organisations dealing with curricula of schools and colleges, namely, Ministry of Human Resources Development (HRD), University Grant Commission (UGC) and National Council of Education, Research and Training (NCERT) interacts effectively with other with the ministries and organisations concerned with biodiversity issues for introducing and expanding environmental concepts, themes, issue etc. at the university and school levels. Thus, although there is sufficient existence of educational and training programmes incorporating PGR aspects both at regional and national level, training and education opportunities are regularly needed in the country for effective PGRFA conservation and utilization. Special training programmes are required in specialised areas such as on farm conservation, molecular taxonomy, biotechnological approaches for effective conservation, statistical methodologies and Geographical Information System (GIS) application for diversity mapping and remote sensing in PGR management.

NATIONAL LEGISLATION

In India important legislations have been enforced in response to international developments and have a direct bearing on PGR related activities. They are the Biological Diversity Act 2002, Protection of Plant Varieties and Farmers' Right Act 2001 and Geographical Indications of Goods (registration and protection) Act 1999. In addition, amendments have been made in the Patents (Amendment) Act 2005 and the Plant Quarantine Regulation of Import into India Order 2003 which have a bearing on PGR management. The Seeds Act is also under revision.

INFORMATION SYSTEMS

Software for Genebank Information Management System (GBIMS), Plant Genetic Resources Passport Information Management System (PGRPIMS), Electronic catalogues for the recording of the evaluation/ characterization data, database for the inventorization of import and export of the accessions have been developed at NBPGR and the complete information is being documented using the Relational Database

Management System (RDBSM) tools and is being used by the concerned PGR researchers for the management of the genetic resources.

PUBLIC AWARENESS

The level of public awareness on the importance of PGR conservation in the country is satisfactory, however, literacy about various international agreements and national legislations with regard to plant genetic resources needs strengthening. To achieve this, policy papers and concept notes will have to be developed, widely distributed and debated in workshops, seminars and refresher courses to be organized involving all stakeholders. In addition to the scientific organisations, NGOs and individuals are also involved in public awareness activities in the country and aspects related to PGR are being integrated into the pre-secondary and secondary educational curricula. The important role of mass media to generate public awareness has to be fully recognised and appreciated.

THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

6

The major benefits gained by the country through PGRFA networks are transfer of technology, back-up safety duplicates of germplasm, exchange of germplasm, increased research facilities, sharing of responsibilities for network activities, training for national programme scientists, exchange of information and Joint characterization and evaluation of germplasm

The types of support provided by the Government to support network activities are financial support through membership dues, travel costs, publication costs, technical expertise in joint activities, organization and hosting of network meetings, institutional infrastructure to participate in joint activities and information management support

Seventeen stakeholders have reported involvement in 22 projects/programmes/ activities carried out by their organizations in collaboration with a PGRFA network

INTERNATIONAL PROGRAMMES

International programmes for PGR that have been most beneficial for India were the - Indo-USAID and Indo-uk programmes which have helped in strengthening PGR management in the country during the last 15 years. These programmes helped in strengthening the conservation facilities at NBPGR and its regional stations and also provided advanced trainings to Indian scientists in PGR management activities.

INTERNATIONAL AGREEMENTS

Many international agreements (Table 6.1), treaties, conventions, or trade agreements over the past 15 years that are relevant to the sustainable use, development and conservation of PGR have been signed.

Table 6.1: International agreements signed by India

S. No.	Name of Agreement	Agreement type	Signing date	Ratification date
1	Convention of Biological Diversity	International Treaty/ convention	1992/06	1994/02
2	Global Plan of Action	International Treaty/ convention	1996/07	
3	International Plant Protection Convention	International Treaty/ convention		
5	International Treaty on Plant Genetic Resources for Food and Agriculture Global	International Treaty/ convention	2001/11	2002
6	International Protocol on Biosafety	International Treaty/ convention	2002	2003/01

EXCHANGE OF GERMPLASM WITH OTHER COUNTRIES

Over the past fifteen years, several management action plans have been undertaken to maintain or enhance an access to PGR located outside the country by signing workplans under written MoU's and collaborative/bilateral research programmes with different countries namely Algeria, Argentina, BARC Bangladesh, INIBAP Belgium, IOWA State University USA, ARE Egypt, Belarus, Brazil, Bulgaria, Cuba, CAAS China, Cyprus, Eritrea, NARI Guyana, Indonesia, Iran, Iraq, Israel, Kazakh, LAO PDR, Myanmar, Namibia, Nepal , Panama, PDR Yemen, Peru, Philippines, Qatar, RAAS Russia, Sri-Lanka, Sultanate of Oman, Surinam, Tunisia, UK, Ukraine, USA, Uzbekistan and Vietnam. Various crop germplasm were exchanged under the provision of these work plan's namely rice, wheat, maize, barley, sorghum pearlmillet, finger millet, soybean, sunflower, safflower, rapeseed, mustard, olive, french bean, mungbean, pea, cowpea, urdbean, lentil, *Vicia* sp., *Vigna* sp., Luffa sp., dolichos bean, *Lathyrus*, cotton, chillies, brinjal, onion, cauliflower, chinese cabbage, cucumber, tomato, radish, pumpkin, muskmelon, apricot, coconut, date palm, durian, citrus, mango, banana, grapes, guava litchi, peach, pear pecannut, pistachio nut, plum, pomegranate, papaya, ribes, rubus, sorbus, macadamia nut, *Vaccinium* sp., *mangosteen*, gooseberry, rambuttan, jack fruit, hops, *Flacourtia*

sp, sugarbeet, potato, cassava, carambola, crossandra, *Chrysanthemum*, marigold, gladiolus, lily, *Monstera*, *Limonium*, tree tomato, asparagus bean, berseem, ginger, cumin, ajwain, coriander, fennel, fenugreek, cherimoya, *Solanum s*p., turmeric, *Pycnathemum* sp. *Eleocarpus* sp.

For *ex situ* conservation, exploration and promotion of *Jatropha curcas* national treaty/ convention and an agreement for establishment of regional coconut genebank for south Asia in India were also signed.

Germplasm exchange of various crops was also affected under the SAVERNET-Programme SAARC countries and SANPGR network with participating countries viz., India, Pakistan, Bangladesh, Bhutan, Nepal, Sri Lanka and AVRDC, Taiwan. The information exchanged on crops was also compiled for different countries viz., ASEAN Countries, Chile, France, Italy, Morocco, Mozambique, Netherlands, Oman, Zambia, which had than agreed for formulation of work plan.

ACCESS TO PLANT GENETIC RESOURCES AND SHARING OF BENEFITS ARISING OUT OF THEIR USE AND FARMERS' RIGHTS

7

ACCESS TO PLANT GENETIC RESOURCES

India is a party to relevant international agreements on access to PGR and sharing of benefits arising out of their use including Convention of Biological Diversity (1992); International Treaty on Plant Genetic Resources for Food and Agriculture (2001) and the Global Plan of Action (1996)

TRIPS and CBD compliant legislation/ acts/ policies have been enacted in the country during the past 10 years in terms of providing access to PGR within the country and sharing of benefits arising out of their use. These include- Biological Diversity Act 2002; The Protection of Plant Varieties and Farmers' Rights Act, 2001; The Patents (Amendment) Act 2005 and The Geographical Indications of Goods (Registration and Protection) Act 1999.

Enforcement of Convention on Biological Diversity (CBD 1992) and provisions of Trade Related Aspects of Intellectual Property Rights (TRIPS) led to the apprehension that exchange of germplasm would get restricted. India has been and continues to receive large amount of germplasm from International Agricultural Research Centres (IARCs) supported by Consultative Group on International Agricultural Research (CGIAR) Centres. An analysis on introduction of germplasm from CGIAR Centres (CG centres) and other national genebanks (NGB) during pre-CBD period (1988-1992) and post-CBD period of (1997-2001) was done to get the comparative idea on how the exchange (import/export) was effected after CBD came into force. In the post-CBD era, there was an overall decline of 14.5 % in introduction. The trend may however change after the International Treaty on Plant Genetic Resources for Food and Agriculture (IT-PGRFA), a legally binding treaty comes into force (FAO 2002), which envisages a facilitated access to plant genetic resources for food and agriculture held by countries through multilateral system (MS) of exchange. This access under the Treaty would be only for utilization, conservation, research, breeding, training and an access for chemical, pharmaceutical and other non-food and non-feed purposes is not covered by the treaty. As envisaged under the Treaty, the exchange of genetic resources of the Annex 1 crops of the Treaty (35 Food crop genera and 29 Forage Crop Species) would be under the conditions of a standard material transfer agreement

(SMTA) formulated by the Governing Body of the Treaty in June 2006. The treaty signifies wide international commitment that both traditional and modern technologies should serve humanity, in particular to alleviate hunger and promote sustainable development in developing countries.

Over the past 10 years, several management actions have been undertaken to maintain or enhance access to PGR located outside India as indicated under Chapter 6 on the State of Regional and International Collaboration.

FAIR AND EQUITABLE SHARING OF THE BENEFITS

Mechanisms for benefit sharing have been put in place in the form of different legislations listed above. However, actual cases of benefit sharing have not been encountered yet. Some isolated case studies undertaken have demonstrated benefit sharing arrangements for the holders of the traditional knowledge.

The mechanism of benefit sharing as envisaged in the Biological Diversity Act 2002 is as follows. Section 3 of the Biological Diversity Act 2002 provides for mandatory prior approval of the National Biodiversity Authority (NBA) for obtaining any biological resources occurring in India or associated knowledge for commercial or any other use. However, there are exemption from seeking approval of NBA for exchange of genetic resources under collaborative research projects approved by the Government of India, including bilateral/MoU/multilateral agreements. Further, Section 6 of the Act provides that prior approval of NBA is also required before applying for any IPRs in or outside India for any invention based on research or information on a biological resource obtained from India. The NBA grants such approvals subject to terms and conditions so as to secure equitable sharing of benefits arising out of the use of accessed biological resources, and associated knowledge. Similarly, Indian industry is required to provide prior intimation to the concerned State Biodiversity Board (SBB) about the use of biological resource, and the SBB has the power to restrict any such activity which violates the objectives of conservation, sustainable use and equitable sharing of benefits. The NBA as well as the SBBs are required to undertake mandatory consultation of the concerned local level Biodiversity Management Committees (BMCs) for decision making process relating to access and benefit sharing, thereby formalizing the prior informed consent by communities for access and benefit sharing.

IMPLEMENTATION OF FARMERS' RIGHTS

International agreements that are relevant to the implementation of Farmers' Rights, viz. Convention

of Biological Diversity, Global Plan of Action, International Treaty on Plant Genetic Resources for Food and Agriculture have been subscribed.

The Protection of Plant Varieties and Farmers' Rights Act, 2001 has been enacted as a national legislation to achieve or enhance the implementation of Farmers' Rights. The implementation of this legislation involves the setting up of a Protection of Plant Varieties and Farmers' Rights Authority which would take care of the provisions under the Act. Further rules and regulations for awarding rights and recognition to farmers have been notified by the Authority in 2006.

The Salient features of the legislation are:

- The legislation extends to all categories of plants except micro-organisms.
- In order to be eligible for protection, a variety must be new, distinct, uniform and stable.
- Farmers would continue to enjoy their traditional rights to save, use, exchange, share and sell their produce of the protected variety with the only restriction that the farmers would not be able to sell branded seed of the protected variety for commercial purposes.
- Farmers can claim compensation if the variety fails to perform as claimed by the breeder.
- The authority can give a compulsory licence to a third party to produce seed if the licence / breeder fails to produce the required quality / quantity of seed.
- The Rules under the "Protection of Plant Varieties & Farmers' Rights Act, 2001" have been notified in the Gazette, in 2003, and 2006.

8 THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

Crop improvement programmes in India have made tremendous contributions over the second half of the twentieth century providing enormous economic, social and environmental benefits. This has not only helped in attaining food security through path-breaking new technologies but also ensured enough food. The research conducted both independently by the National Agricultural Research Systems (NARS) and in partnership with International Agricultural Research Centres (IARCs) was appropriately supported by effective management of PGR, faster adoption of new crops, modern varieties and hybrids, right policies and the innovative mechanisms for technology transfer.

The major components of management of PGR include activities related to the acquisition of germplasm, their conservation and characterization and evaluation leading to sustainable utilization. The acquisition of germplasm has been through collection of indigenous diversity and through exchange of germplasm from other countries. In India, there is a single window system operated by NBPGR for germplasm exchange - which includes the import and export - and quarantine of small samples, including those of transgenics, meant for research. Earlier though the germplasm was freely accessed and exchanged, the recent global developments have necessitated regulations for access to germplasm subject to various national legislations and policy changes. The conservation of PGR is achieved through the *in situ* and *ex situ* strategies. *In situ* conservation ensures that the genetic diversity available in the genetic resources rich areas is conserved, while allowing the evolutionary process to continue.

The responsibility of maintaining the *ex situ* collection of PGR on long-term basis is entrusted to the National Genebank of the NBPGR. The National Genebank operates in the network mode and has an effective linkage with others engaged in PGR management thus making conserved PGR easily accessible to plant breeders. The germplasm collections are conserved as base collection in the seed genebank, *in vitro* genebank or cryogenebank, at NBPGR, New Delhi or are maintained as field genebanks at the appropriate sites. The active collections are conserved in a network of NBPGR Regional Stations and the various National Active Germplasm Sites (NAGS) located at crop based institutes/ state agriculture universities/crop improvement programmes. In addition, every plant

breeding programme in the country has working collections; and these are also linked with the National Genebank. The centres are also linked with NBPGR for evaluation of germplasm.

The germplasm stored in the National Genebank network is available to various researchers. The request for germplasm is first forwarded to the concerned NAGS/NBPGR Regional Stations for providing the material from the active collection. When any accession is not available in the active collection, the germplasm is obtained from the base collection for multiplication to replenish the active collection as well as for supply to the users.

The effective PGR management has helped in increasing the food production through appropriate acquisition (indigenous and exotic germplasm) and their effective utilization in the crop improvement programme. Classical use of dwarfing genes, such as 'Norin-10' in wheat and 'Dee Geo Woo Gen' in rice, have been instrumental in gaining productivity jumps and thereby providing food security to the increasing population. Wheat and rice breeding materials introduced from IRRI, Philippines and CIMMYT, Mexico during the 1960s laid the foundation of Green Revolution. These were high yielding, dwarf and input responsive germplasm used as parents in recombination breeding which were later utilized by Indian breeders to suit different agro-climatic conditions.

Landraces have been an important source of individual characteristics introduced into new varieties by modern plant breeders. In many cases, the genetic material provided by landraces has also been used to broaden the genetic base of crops through the recurrent selection of landrace material in the environment for which new varieties are required. Though exploitation of genes from wild relatives has been limited due to difficulty in making viable crosses between wild and domesticated species, the resistance genes from wild species in cases such as *Oryza nivara* and *Cucumis hardwickii* have helped in saving rice and cucumber crops respectively from imminent extinction. The recent developments in recombinant DNA technology has raised the prospects of a better understanding of gene expression and transfer of useful traits to cultivated species, which was not possible earlier by the conventional means. This knowledge shall lead to novel and precise screening tools for genetic resources to identify new sources of raw materials and facilitate the use of genetic resources in the development of modern crop varieties and hybrids particularly targeted for different environments including biotic and abiotic stresses.