South Asia Network on plant genetic resources (SANPGR)

Proceedings of Fourth Meeting, Kathmandu, Nepal
1-3 September, 1998

Bhag Mal, P.N. Mathur and V. Ramanatha Rao, editors
The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization operating under the aegis of the Consultative Group on International Agricultural Research (CGIAR). IPGRI’s mandate is to advance the conservation and use of plant genetic diversity for the well-being of present and future generations. IPGRI’s headquarters is based in Rome, Italy, with offices in another 14 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

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Contents

Foreword v
Preface vi
Inaugural Address vii
Recommendations ix

Session I : Review of Follow-up Actions on the Recommendations of the Third SAC Meeting 1

Session II : Status of National PGR Programmes (Country Reports)
Status of plant genetic resources in Bangladesh
M.O. Islam 4
Agro-biodiversity perspectives and plans in Bhutan
P. Pradhan 11
Status of national plant genetic resources programme in India
P.L. Gautam 18
Plant genetic resources activities in Nepal
K.K. Sherchand 44
Conservation and sustainable use of plant genetic resources in Sri Lanka
A.H.M. Jayasurya and S.C.J. Dissanayake 51

Session III : IPGRI Activities in the APO Region
Plant genetic resources activities in South Asia
Bhag Mal and P.N. Mathur 66
IPGRI-APO activities on plant genetic resources in the region - An overview
V. Ramanatha Rao, K.W. Riley, P. Quek, Bhag Mal and M. Zhou 74

Session IV : National Policies on PGRFA and their Implementation
CBD, GPA, IPR and related policy issues and their implementation in India
S.P. Tiwari 91
National goals, policies, programmes and legislation in Sri Lanka
A.H.M. Jayasurya and S.C.J. Dissanayake 108
National policies on PGRFA and their implementation in Nepal
R.P. Sapkota 112
Policy issues related to CBD, GPA, TRIPS and their implementation status in Bangladesh
M.G. Hussain 117
National biodiversity assessment in Bhutan - Policies and strategies
P. Choephyel 123

Session V : Strengthening PGR Collaboration
Crop networks
P.L. Gautam 132
Information network for promoting the use of plant genetic resources in South Asia
P.N. Mathur and P. Quek 134
Session VI: Promoting PGR Conservation and Use
Complementary conservation strategies
V. Ramanatha Rao 139
On-farm conservation of crop genetic resources through use
B.R. Sthapit and D. Jarvis 151

Session VII: Identifying Research and Training Needs
Training needs for plant genetic resources in South Asia
M.G. Hossain 167

Technical Programme 171
List of Participants 174
Acronyms 176
Foreword

Regional plant genetic resources (PGR) networks can be very effective mechanisms for strengthening National Programmes, promoting exchange of germplasm, helping to set common agenda and priorities on conservation and use of PGR, formulating consistent policies, and in conveying regional views. Moreover, strengthening of regional networks is a priority activity, agreed to in the Global Plan of Action (GPA) for the conservation and use of Plant Genetic Resources for Food and Agriculture (PGRFA). For IPGRI, supporting such networks is an important part of our work in the Asia, Pacific and the Oceania region.

In South Asia, such regional collaboration takes place through the South Asia Network on Plant Genetic Resources (SANPGR). This network brings together the national PGR coordinators nominated by member countries, namely, Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka with the purpose of sharing information, needs and opportunities regarding PGR in the region. IPGRI office for South Asia, located in New Delhi, provides a Secretariat for this network. SANPGR meetings are held every 2 years hosted by one of the member countries. This reporting on the Proceedings of Fourth Network Meeting, which was held in Kathmandu, Nepal from 1-3 September 1998. Previous meetings were held in New Delhi, India in 1990, Peradeniya, Sri Lanka in 1992 and Dhaka, Bangladesh in 1995.

The objectives of the Nepal SANPGR meeting were to take stock of activities carried out under the Convention on Biological Diversity and Global Plan of Action; to understand recent policy changes taking place at national and global levels, and to formulate action plans for regional collaboration. Finally, this meeting was to establish better linkages for PGR activities among the member countries.

Reports indicate that the meeting was very successful in achieving many of the above objectives specifically:

- Proposals were made for joint characterization and evaluation of existing collections, as well as for collecting new germplasm
- Joint development of documentation and information activities on PGR was agreed
- Agreement to try to develop a consensus on access and benefit sharing and to explore a possible South Asia approach to these issues
- Sharing expertise on conservation and management of ex situ collections
- India’s offer to neighbouring countries to serve as a back-up or duplicate storage for their collections was noted. This offer merits further examination and response by the other SANPGR members

There was increased awareness and understanding about the importance and role of in situ and on-farm conservation among national coordinators as a result of this meeting. In addition, I am happy to note that the information in the country reports, in these proceedings has been subsequently incorporated into reports made to the Global Plan of Action implementation meeting for Asia/Pacific, which took place in the Philippines in December 1998.

I trust the publication of the recommendations and reports from SANPGR meeting, which are contained in this volume will serve to foster continued close collaboration, and help insure that the recommendations are implemented.

Finally, I would like to thank Drs Bhag Mal, P.N. Mathur and V. Ramanatha Rao for their role in organizing the meeting and editing this volume.

(Kenneth W. Riley)
Regional Director
IPGRI-APO
Preface

The South Asia Network on Plant Genetic Resources (SANPGR), earlier known as South Asia Coordinators (SAC), aims to improve the conservation and use of plant genetic resources in South Asia through collaborative efforts amongst the member countries. Six countries of South Asia region, namely, Bangladesh, Bhutan, India, Nepal, Maldives and Sri Lanka collaborate in this network. The objectives of the network are to enhance scientific interaction, promote exchange of germplasm and sharing of information and technologies, identify common priorities for research and training, foster collaboration for joint research and development, derive greater benefits for human resource development from the strengths of partners and to provide a platform for developing common policies and harmonizing regional views on plant genetic resources issues and related policy matters in the region. The national PGR coordinators and other specialists from member countries meet every two years in different countries on a rotational basis to review the progress and to formulate future plans on activities of common interest. Three meetings had earlier been organized at the National Bureau of Plant Genetic Resources, New Delhi, India (1990), Plant Genetic Resources Centre, Peradeniya, Sri Lanka (1992) and Bangladesh Agricultural Research Council, Dhaka, Bangladesh (1995). The follow-up of the recommendations of the previous meetings resulted in a significant progress relating to national programme strengthening including setting-up of PGR coordination committees, information management and human resources development.

This publication reports the proceedings of the fourth meeting of SANPGR organized at Nepal Agricultural Research Council, Kathmandu, Nepal from 1-3 September 1998. This meeting took place at a time when significant developments were taking place in the field of plant genetic resources including policy issues at the national/regional and international level. The discussions during the meeting, besides presentations of country status reports, focused on programmes for implementing Global Plan of Action (GPA), National PGR Coordination Committees, strengthening databases, establishing new crop networks and exchange of germplasm through Material Transfer Agreements (MTA). The deliberations of the meeting were very interesting and resulted in several useful recommendations which will go a long way in promoting collaboration amongst the countries in the South Asia region.

We are confident that this publication will be immensely useful to the students, researchers, policy makers and others concerned with conservation and use of plant genetic resources. We are highly thankful to the Nepal Agricultural Research Council for providing the venue and other required support in organizing this important meeting.

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Inaugural Address

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Mr Chairman, Dr Ramanatha Rao, Dr Bhag Mal, distinguished participants and guests, ladies and gentleman,

I am pleased to be here this morning at the opening ceremony of the 4th Meeting of the South Asia Network for Plant Genetic Resources (SANPGR) organized by the International Plant Genetic Resources Institute (IPGRI) and the Nepal Agricultural Research Council (NARC). I extend my sincere thanks and appreciation to the workshop organizers for selecting Nepal as the venue for this important meeting.

I consider it as a good opportunity to share with you some of my thoughts relating to plant genetic resources, a subject of global concern, and their conservation and use for continued agricultural development of our countries.

Despite the fact that the science of plant genetic resources has only received attention relatively recently, it has gained significant importance in a short period of time. I am told that several national and international meetings, workshops, seminars have been organized to ensure the conservation of the plant genetic resources in South Asian countries. The need to develop activities for the conservation and utilization of the biological diversity has been emphasized in the United Nations Convention on Biological Diversity (CBD) in 1992. This emphasis reflects the global concerns with the loss of biological diversity particularly the crop diversity which is needed for continued agricultural development for increased food production. I hope, the presentations, deliberations and recommendations of this meeting will be in full conformity with CBD objectives.

The human population of South Asia Association for Regional Cooperation (SAARC) countries at present is estimated to be around 1244.06 million. This is also the region where the population growth remains one of the highest in the world and is likely to double in the next 30-40 years. Naturally, this demands an accelerated growth of food production.

The South Asian region is believed to be one of the cradles of world agriculture. It has diverse agro-ecology and rich genetic diversity of different agri-horticultural crops and their wild relatives, medicinal herbs and other locally important economic plant species. The International Plant Genetic Resources Institute periodically organizes regional meetings, workshops, seminars and trainings to promote and strengthen the need-based plant genetic resources conservation and utilization activities in the region.

Nepal, one of the smaller countries of the South Asian Region, is undoubtedly endowed with rich genetic diversity in crops like rice, wheat, barley, maize, beans and millets. It has become a hunting ground for many bio-scientists, naturalists, and explorers as it has wide variation in climate, soil and agro-ecology. These have contributed to plant genetic variability and eventually to the existing crop diversity. Nepal is the country where rice and finger millet are grown probably at the highest elevation in the world. However, unfortunately these weld-adopted crop genetic resources are increasingly disappearing due to the replacement by modern high yielding varieties. It is urgent to conserve and use these traditional natural resources for sustainability in agriculture and to combat epidemics of pests and diseases. Several plants are endemic to this region.

It is very much satisfying to note that in a number of cases, the scientists of Nepal have used the local landraces of different crop species in developing the high yielding varieties in rice, wheat and maize which are widely popular in Nepal. I think, therefore, it is of utmost importance to maintain genetic diversity within crop gene-pools for use by the plant breeders.
Ladies and gentlemen, I have expressed my observations and some of my feelings on this subject. I suggest that we must adopt the policy to ensure the security and availability of this varied gene pool as and when needed. South Asian countries still lack national policies and appropriate legislations for biodiversity action plans as stipulated by the CBD. There should be a common thinking to bring about such legislations in each country in the region.

Now I leave the important task to you scientists, plant genetic resources coordinators and experts, to come up with the fruitful action plan for future programmes in South Asian countries.

Finally, I wish that your stay in Nepal would be enjoyable and participation in this meeting fruitful. With this, I take the pleasure in declaring this workshop open.

Thank you.
South Asia Network on Plant Genetic Resources (SANPGR) Meeting Organized at NARC, Kathmandu, Nepal

[1-3 September 1998 ]

Recommendations
The Fourth SAC (Now SANPGR - South Asia Network on Plant Genetic Resources) meeting was organized by IPGRI at the Nepal Agricultural Research Council (NARC), Kathmandu, Nepal from 1-3 September, 1998. The deliberations of the meeting were structured into eight technical sessions. The meeting was attended by 18 participants from Bangladesh, Bhutan, India, Nepal, Sri Lanka and IPGRI.

The major recommendations that emerged out of critical discussions are given below:

General recommendations
1. The participants felt that the present nomenclature ‘SAC’ (South Asia Coordinators) does not emphasize PGR coordination activities envisaged under the Network. Several alternatives were considered and it was resolved that the name should be South Asia Network on Plant Genetic Resources. The acronym SANPGR was agreed to. It was also clarified that this was appropriate in view of the fact that participation is not restricted to Country Coordinators and other experts may also participate as per the need of specified agenda of the meetings.
2. The review of the follow-up actions indicated several achievements based on the actions taken on the recommendations of the previous meeting. There were only a few actions that could not be followed up due to some reasons. The group suggested that the respective National Programmes (NPs) should ensure the follow-up and complete the activities as planned.
3. In view of the diversity and organizational structure of the various government systems in different countries in the region, the Group agreed to have one focal point (Country Coordinator) for PGR activities and one or two contact points for forestry and horticulture, as needed. The participants agreed to accord enhanced emphasis on forestry genetic resources and horticulture and hence the need to identify contact points for horticulture and forestry. The National Programmes should ensure identification of these contact points. It was also agreed that the proposals regarding forest genetic resources conservation and use should be addressed to IPGRI-APO Regional Office at Serdang, Malaysia with a copy to IPGRI South Asia Office, New Delhi.
4. A strong desire was expressed that IPGRI should participate, when requested by the national programmes and when possible, in national PGR meetings such as annual review and planning meetings and provide appropriate guidance and advice. Such participation will be based on the request by member countries and availability of funds.
5. Importance of documenting Indigenous Knowledge and its use in both conservation and utilization was recognized. National Programmes may take up such work and technical support may be provided by IPGRI.
6. The modalities of working with NGOs need to be developed by IPGRI. The National PGR Coordinators should be informed by IPGRI about the programmes going on with NGOs in respective countries.
7. The organization of National PGR Workshops was considered to be very useful in creating awareness about PGR conservation and use and it was strongly felt that the
National PGR Workshop should also be organized in Sri Lanka and Bhutan, where the PGR activities have already gained momentum.

8. The proceedings of the 4th South Asia Coordinators' meeting held at NARC, Kathmandu should be published and distributed by IPGRI.

9. It was agreed that the next meeting of SANPGR should be organized in India during the year 2000.

GPA follow-up

10. The Group recommended that the countries of the South Asia region may facilitate to put in place the necessary regulatory/legislative mechanism as required under the provisions of CBD, WTO, TRIPS, etc. as per their national needs and requirements.

11. The follow-up of Global Plan of Action (GPA) was considered to be extremely important. The participants agreed to take stock of actions that have been taken/initiated on the 20 priority areas of the Global Plan of Action. If some areas are still left unattended, the same may be addressed expeditiously so that the region is fully prepared eventually for the meeting of Conference of Parties (CoP) as well as the GPA Implementation Meeting in December 1998. Formulation of National Coordination Committees and Crop Germplasm Advisory Committees wherever necessary should also be completed.

PGR management

12. The proposal for depositing duplicate sets of collections for long-term conservation in one of the national genebanks in the region was considered and the countries agreed to think seriously about it for future use. For example, NBPGR India has well developed infrastructural facilities and expertise on PGR conservation, especially ex situ, and the countries in the region could benefit from it. The Group suggested that the modalities for bilateral agreements may be worked out by interested NPs and IPGRI may facilitate this on receipt of specific requests from the respective Country Coordinators.

13. The need for complementary conservation strategies to capitalize on synergies of different ex situ and in situ methods was recognized by the Group. The participants realized the importance of in situ conservation in the area of conservation of landraces as well as wild relatives and need for development of sound scientific principles for in situ conservation was recognized. It was agreed that, in order to ensure sustainability of in situ conservation, participatory plant breeding efforts, the award of incentives needs to be evolved and simultaneously efforts on value addition and development of niche markets have to be made.

Increased regional collaboration

14. Strengthening PGR databases in the countries in South Asia was identified as a priority. The following needs were identified: Bangladesh (backstopping and follow-up on the training conducted in the past); Bhutan (database development and management); India (electronic cataloguing, linking software with GIS, in-country PGR database linkages, awareness); Nepal (home page and GMS database); Sri Lanka (linkage with other databases and GIS technology). Therefore, a need for developing a regional database containing information on NP organization, structure, policies as well as germplasm was agreed to ensure transparency and efficiency in the use of plant genetic resources, including equitable sharing of benefits. It was agreed that all the National Programmes in the region will provide information for development of Information Network to IPGRI South Asia Office, New Delhi. This information will then be placed on CD-ROM drive and also on the Internet. It was also agreed to develop a Home-Page for SANPGR and to link it with National Programmes in the region.
15. The participants recognized the need for focusing more on regional issues rather than country-specific issues as the major focus of SANPGR. It was agreed to enhance collaborative efforts on various plant genetic resources activities in the region, including the ones on policy issues. Some of the activities that can be developed for joint action are: joint exploration and collecting; joint characterization and evaluation; development of information network; jointly addressing the issues related to access to germplasm; sharing of expertise for PGR conservation management and joint publication of a text book on PGR for postgraduate students. National programmes need to be proactive in developing the proposals and then IPGRI could play a facilitating role.

16. Satisfaction was expressed with current mode of operation of crop networks in the region and it was agreed that these should be continued. The Group also suggested that the existing informal crop networks on underutilized crops, viz., sesame, Lathyrus, buckwheat, safflower, etc. should be developed into formal networks. Based on criteria namely, i) regional importance, ii) potential to contribute to food and nutritional security and iii) not addressed by any of the CG Centres, the following four new crops/crop groups were identified as priority crops to establish crop networks in South Asia region:
   i) Minor millets (Finger millet, kodo millet, foxtail millet, little millet)
   ii) Minor legumes (Black gram, rice bean, lablab bean, horsegram)
   iii) Amaranth
   iv) Cucumber

The NPs and IPGRI should initiate appropriate action to establish these networks. The NPs should provide all the relevant information (diversity, distribution, collections maintained and the ongoing activities on these crops etc., to IPGRI South Asia Office, New Delhi.

Plant quarantine

17. Plant quarantine was considered an important area in view of safe movement of germplasm into the region. An urgent need was felt for regulating the exchange of in vitro materials with appropriate quarantine measures and biosafety regulations was recognized. Establishment of a Regional Plant Quarantine Network for South Asia region was suggested. It was recommended that a special session be organized in the next SANPGR meeting for in-depth discussion on plant quarantine issues.

18. It was emphasized that for the success of the SANPGR, there is an urgent need to exchange germplasm between the countries of the region. Such exchange should be for research purposes, especially the released and notified varieties under a simple material transfer agreement (MTA). IPGRI’s assistance was requested in developing the MTAs and NBPGR, India will take the initiative in this direction in collaboration with IPGRI. To increase the efficiency, it was agreed that the germplasm exchange should take place through a single window system and to begin with, the released varieties can be exchanged. Other materials will be considered on a case by case basis.

Research and human resource development

19. The following infrastructural development/research needs were identified: DNA storage (India); establishment of in vitro facility (Bangladesh); Isozymes and molecular characterization (Nepal); refinement of ex situ conservation techniques, especially in vitro, in more developed institutions like NBPGR, India, with work being carried out in network mode, other institutions in the region sharing some of the tasks; determination of the extent and distribution of genetic diversity in certain economically important plants in the region.
20. The need for increased efforts by both NPs and IPGRI in the area of human resource development to provide skilled staff to better conserve and sustainably use PGR was strongly felt. It was suggested that assessment of impact of training in the region should be undertaken through a questionnaire survey. The participants also agreed to that more efforts should be made to retain the trained staff, especially those that were sent on specialized training, in PGR related work/institutions. The following training needs were identified in the region:

- M.Sc. and Ph.D. training at IARI/NBPGR, India and elsewhere
- Characterization, evaluation and documentation (including evaluation for specific traits, molecular characterization, genetic diversity analysis)
- Wide hybridization, including embryo rescue techniques to increase the scope of use of germplasm
- Data management and software integration and bioinformatics network
- Molecular characterization; study tour for better understanding of in situ conservation, especially the work that is being done by IPGRI in Nepal;
- Training in in vitro conservation, cryopreservation and DNA storage.
Review of follow-up actions on the recommendations of the third SAC meeting

In order to take stock of the follow-up actions taken on the recommendations of the third South Asia Coordinators (SAC) meeting held at Bangladesh Agricultural Research Council (BARC), Dhaka, Bangladesh from 10-12 January 1995, a separate session was organized. The Country Coordinators presented the reports and highlighted the actions taken in respect of general recommendations as well as specific country recommendations.

Dr P.L. Gautam presented the follow-up action report for India and highlighted the progress as follows: i) Genebank facility with capacity of 1.0 million seed samples has been operationalized at National Bureau of Plant Genetic Resources (NBPGR), New Delhi. A quantum jump from 144,109 to 168,293 seed samples was achieved by June 1998. Conservation protocols have been standardized and materials have been conserved in cryobanks and in vitro banks. Studies have been initiated on on-farm/in situ conservation in paddy and tribal-area crops. Medium-term conservation facilities have been extended to many National Active Germplasm Sites (NAGS), ii) A Research Advisory Committee has been constituted to deal with PGR activities including policies, iii) IPGRI supported training programmes were undertaken on Seed Genebank Management in 1996 and Tropical Fruit Species Conservation and Use in 1997 and several in-country training programmes were organized by NBPGR for enhancing the skills of more than 200 participants, iv) M.Sc. PGR course has been started in collaboration with Indian Agricultural Research Institute (IARI), New Delhi, v) For creating public awareness and promoting concern for agro-biodiversity, a national workshop was organized in 1997 by NBPGR in collaboration with National Academy of Agricultural Sciences (NAAS), vi) NBPGR is willing to collaborate in joint activities relating to germplasm collecting, sharing of information, germplasm exchange based on Material Transfer Agreement (MTA) and providing a slot for Sri Lanka for M.Sc. PGR course.

Mr P. Pradhan presented the details of follow-up actions taken in Bhutan for different Plant Genetic Resources (PGR) activities. He mentioned that there is now a greater awareness about the need for efficient conservation and effective use of plant genetic resources and a National Biodiversity Programme (NBP) is planned to be established with financial support from the Government of Netherlands. Activities have also been initiated for documentation and database development and the concerned staff have been provided the requisite training. A training programme on ‘Field Collection of Rice Germplasm’ was organized with support from the International Rice Research Institute (IRRI) in 1996. Germplasm exchange has been considered of vital importance and modalities for exchange between the countries within South Asia region need to be developed.

Dr M. Obaidul Islam informed that Bangladesh Government provides steady support to plant genetic resources activities. Several recommendations have been implemented in Bangladesh which included formation of a National Committee on Plant Genetic Resources (NCPGR) in 1996, organizing National PGR workshop in 1997 with International Plant Genetic Resources Institute (IPGRI)/BARC support, initiating the process of establishment of National Plant Genetic Resources Institute, conducting national training on PGR documentation and hyacinth bean germplasm collection by Plant Genetic Resources Centre (PGRC). The Ministry of Agriculture, Forestry and Environment identified a programme for biodiversity conservation. He further mentioned that the activities on in situ conservation of wild rice and coconut germplasm collecting from coastal ecosystem could not be taken up due to financial constraints.

Dr M.P. Upadhyay presented the information on follow-up actions taken in Nepal and apprised that training programmes supported by IPGRI, Japan International Collaboration Agency (JICA) and International Rice Research Institute (IRRI) were organized and 40 persons...
of Nepal Agricultural Research Council (NARC), Department of Agriculture, Department of Plant Resources, Institute of Agriculture and Animal Sciences and Non-Governmental Organizations (NGOs) were trained in different fields of PGR. The scientists and technicians have also been trained to establish database to promote linkage. Efforts have been initiated to constitute a National PGR Coordination Committee which will coordinate various PGR activities undertaken by different agencies and will guide in formulating national policies and related issues. He further mentioned that IPGRI’s support for providing technical expertise for developing project proposals for: i) Characterization of finger millet, barley, buckwheat and amaranth, ii) Establishment of PGR conservation and utilization centre, iii) Strengthening scientific basis of in situ conservation and feasibility studies in buckwheat. Two workshops organized to review PGR activities and exchange of scientific information created awareness on PGR at the national level. An expert help was provided by IPGRI in the preparation of country report required by the International Conference and Programme on Plant Genetic Resources (ICPPGR).

Dr A.H.M. Jayasuriya presented the information on the status of follow-up actions taken in Sri Lanka. He mentioned that the Government of Sri Lanka maintains steady support to PGR activities and, in addition, the Plant Genetic Resources Centre (PGRC) received financial support from JICA. The formation of a National Coordination Committee is presently being discussed and the approval from the Ministry of Agriculture and Lands will be requested. An action plan for conservation of biodiversity in Sri Lanka was prepared by the Ministry of Forestry and Environment in 1997. Biodiversity Action Plan (BAP) has identified the objectives and the recommended actions relating to legal measures, and PGR information management has been initiated. Various training programmes have also been organized for enhancing the knowledge of scientists and technicians in the field of PGR. For public awareness, special programmes for schools and universities were conducted at PGRC, while general awareness programmes were taken up for farmer organizations, farmer groups, NGOs and the general public. An International Seminar on ‘Present Status and Future Prospects of PGR Conservation and Utilization’ was organized in 1996 in collaboration with JICA in which six Asian countries, namely, Bangladesh, Indonesia, Japan, Pakistan, Philippines and Sri Lanka participated.

Dr Bhag Mal, in his presentation, highlighted the follow-up actions taken by IPGRI on various recommendations. He mentioned that IPGRI provided technical and financial support to National Programmes (NPs) by way of support to PGR activities on okra, buckwheat, safflower, sesame, *Lathyrus*, coconut and tropical fruits, infrastructure support and human resources development. The National Coordinators were requested to take appropriate steps for constituting National PGR Coordination Committees. The germplasm exchange and quarantine guidelines developed by NBPGR were made available to other countries in the region. IPGRI provided support for organizing training programmes on Seed Genebank Management and Tropical Fruit Species Conservation and Use, *Lathyrus* Genetic Resources Network Meeting and developing curriculum for M.Sc. PGR course in India, training on GMS software in Bangladesh and PGR Documentation training in Nepal.

Public awareness has been created by organizing National PGR Workshop in Bangladesh and publishing 3 issues of IPGRI-APO Newsletter in a year and distributing these to NPs for which the current mailing list is 2500. The proceedings of 3rd SAC meeting held in Bangladesh in January 1995 has been published and widely distributed.

Other activities undertaken by IPGRI include: supporting research activities on phenology of bamboos, genetic diversity and conservation of bamboo and rattan species in India and ecogeographic survey and phenology of rattans in Nepal; development of database for eggplant and wild *Abelmoschus* spp., at NBPG and small millets at the University of Agricultural Sciences, Bangalore, India; technical support for preparing PGR status reports for Bangladesh, Nepal and Sri Lanka for FAO Conference at Leipzig; organizing Asia-
Pacific Regional Consultation on PGR in India in 1996 and national PGR workshop in Bangladesh in 1997; preparation of status reports on genetic resources of tropical fruits and support by way of advice, interaction, visits and dissemination of relevant PGR literature.

IPGRI has now focussed greater attention on developing a regional database for PGR activities, which will be made available to the countries in the region for further use. In this context, Ms M.I. Mai, IPGRI Consultant, made a brief presentation on ‘Development of Regional Database’. She highlighted that the coordination of Plant Genetic Resources for Food and Agriculture (PGRFA) is becoming increasingly complex and strategic planning is necessary for each country to monitor and ensure that national policies are implemented properly. Under the Global Plan of Action (GPA) agreed by 155 countries, priority activities on plant genetic resources have been identified. For this, there is a need to assess the status of PGR activities in each country in order to identify the gaps in the national programmes.

IPGRI has developed a method to evaluate the national programmes by using key information indicators. The information collated will be based on a set of national programme components and will be very valuable in assessing, planning and implementing actions. For example, this database will comprise information on the genetic diversity and erosion, current policies and legislation relating to PGRFA, the status of each country as a member of regional or crop networks, the various functions, activities and achievements of each institution involved, and the status of germplasm conserved. All this will be incorporated into a database and made accessible via the internet, and with appropriate funding, on a CD-ROM format, in order that it can effectively be shared among member countries and other users.

Such a database will be extremely beneficial to national programmes as it will contain valuable information in one place that will help in identifying gaps in PGR related activities. The descriptors used will be formatted in such a way as to allow policy-makers and decision-makers to convey complex information in a simplified form and provide yardsticks against which the impact of public policy and planning relating to PGRFA can be measured. The impact of the information contained in such database will extend further as it can be a very useful tool for donor agencies to assess the status and usage of PGRFA in a country for purposes of future funding.
Status of plant genetic resources in Bangladesh

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Introduction

Plant genetic resources are an important component of ecological complexes and play a central role in the functioning of the biosphere and constitute the genepool which breeders use continuously to develop useful cultivars in accordance with specific criteria to serve human interest. Yet, many of these resources are often unused and are depleting rapidly. Broadening of genetic base is a key element in achieving sustainable agricultural production for the benefit of present and future generations which may require new sources of genes while facing unexpected challenges due to hostile environmental factors including biotic and abiotic stresses.

Bangladesh is situated in the transition zone of Southeast and Southwest Asia, which is enriched with common biodiversity and cultural heritage of this region. As a part of the Indian sub-continent, the country has gradually been enriched by plant wealth distributed to surrounding gene centres. Natural inflow, perpetuation and socio-cultural heritage of similar agro-ecological diversity have been instrumental in developing diverse gene pools of different crop species. Subsequent natural and human selection for specific needs and introduction of new species led to agro-ecological diversification. The germplasm was also introduced from different parts of the world through travelers, invaders, traders, missionaries and sailors, especially by sea port linkage. Enormous genetic variability exists within landraces of traditional crops, viz., rice, millets, mungbean, cucurbits, sesame, eggplant, hyacinth bean, amaranth, chilli, jute and allied fibres, tree cotton, spices and condiments, mango, jackfruit, banana, jujube, guava, citrus, tropical minor fruits, yam, taro, elephant foot yam, sweet potato, yam bean, forest species and medicinal and aromatic plants.

The present breeding approach has successfully contributed towards bringing the green revolution. Rapid genetic erosion is taking place due to intensive cultivation of modern varieties forced by food demands, various development activities and natural disasters. Despite an alarming rate of loss, the country’s biodiversity continues to be impressive. The wide genetic diversity of native agri-horticultural crops, wild and weedy species, is mainly found in Shylet, Mymensing, Dinajpur and Chittagang districts where the inhabitants are the tribal people of different ethnic groups. These tribal groups with their own culture, religious beliefs and food habits have a rich knowledge of plant genetic resources available in their surroundings. These resources contain potential genes that are of immense genetic value in crop improvement programmes, allowing for their use either through conventional breeding or application of biotechnology.

Current status of plant genetic resources activities

The concept of plant genetic resources conservation and utilization in Bangladesh is being rapidly implemented after the Convention on Biological Diversity (CBD) came into existence and a proposal has been made by the National Committee on Plant Genetic Resources to establish a Plant Genetic Resources Institute under the National Agricultural Research System. Presently, respective institutional genebanks: Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI) and Bangladesh Jute Research Institute (BJRI) are engaged in conducting genetic resources activities for their respective mandate crops.
Exploration and collection
BARI initiated germplasm collection of almost all agri-horticultural crops (except rice, jute, sugarcane and tea) in the late 70s. A more systematic approach to collection, conservation, evaluation and documentation of plant genetic resources started in 1987 with installation of long and medium-term conservation facilities at the genebank under Plant Breeding Division. BARI laid special emphasis on germplasm conservation, evaluation, utilization, documentation and exchange after CBD. The genebank activities were separated out from Plant Breeding Division in 1996 and were placed under a newly created Plant Genetic Resources Centre (PGRC).

In the mid 60s, Food and Agriculture Organization of the United Nations (FAO) initiated collecting of rice genetic resources. This was followed by the Consultative Group on International Agricultural Research (CGIAR) supported International Rice Research Institute (IRRI) for rice germplasm collecting all over the rice growing countries (Zaman 1997). BRRI alone, and also jointly with IRRI made a number of expeditions during the early 70s (Bashar and Sarkar 1997), and considerable rice germplasm was collected from all over the country.

BJRI has started national and almost global collection of jute and allied fibres systematically after establishment of a genebank in 1982. Indigenous jute, kenaf and mesta germplasm were collected during 1986-89 with financial assistance from Bangladesh Agricultural Research Council (BARC). Exotic germplasm of jute and allied fibres were collected under the auspices of the International Jute Organization (IJO) and IPGRI (Sobhan et al., 1997). BJRI genebank has been functioning as the Central Germplasm Repository (CGR) of the IJO. Details of the germplasm collected and conserved at different institutes are given in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Germplasm collecting, conservation and characterization at different institutes in Bangladesh</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Species</strong></td>
</tr>
<tr>
<td><strong>BARI</strong></td>
</tr>
<tr>
<td>Cereals</td>
</tr>
<tr>
<td>Pulses</td>
</tr>
<tr>
<td>Oilseeds</td>
</tr>
<tr>
<td>Vegetables</td>
</tr>
<tr>
<td>Spices</td>
</tr>
<tr>
<td>Root and tuber crops</td>
</tr>
<tr>
<td>Fruit crops</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>BRRI</strong></td>
</tr>
<tr>
<td><em>Oryza sativa</em></td>
</tr>
<tr>
<td><em>O. rufipogon</em></td>
</tr>
<tr>
<td><em>O. officinalis</em></td>
</tr>
<tr>
<td><em>O. glaberrima</em></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>BJRI</strong></td>
</tr>
<tr>
<td><em>Corchorus</em> spp.</td>
</tr>
<tr>
<td><em>Hibiscus</em> spp.</td>
</tr>
<tr>
<td>Allied genera</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
Bangladesh Sugarcane Research Institute (BSRI) started germplasm collecting in 1954 and has so far collected 912 accessions which include 787 of *S. officinarum* and 26 of *S. spontaneum*. All these accessions are conserved in the field and 150 flowering varieties are maintained in a separate breeding garden (Awal 1997). All these accessions have been characterized/evaluated. Bangladesh Forest Research Institute (BFRI) followed two general approaches for conservation, viz., *in situ* conservation which includes national parks, managed nature reserves, multiple-use management and *ex situ* conservation includes preservation plots, clonal banks, arboretum. Bangladesh Tea Research Institute (BTRI) is maintaining 320 clonal and seed stocks of tea (*Camellia sinensis* L). The recognized varieties are var. *sinensis*, var. *assamica* and a sub-species *lasiotalyx*. BTRI is also maintaining three coffee species, viz., *Coffee arabica*, *Canephora* and *C. libera* in its working collection in the field genebank.

**Germplasm documentation, utilization and exchange**

Initial documentation of passport data is carried out by PGR scientists, but in most of the cases, evaluation is done by respective crop breeders for desired traits. Characterization work is generally done during regeneration of germplasm. The limited manpower, field and laboratory facilities have restricted the evaluation work. However, BFRI has published a catalogue on jute, whereas, BARI has published catalogues on mungbean, *Lathyrus*, chilli, yam, amaranth, cucurbits and has introduced Genebank Management System (GMS) software developed by IPGRI for documentation of germplasm. The details of germplasm utilization and exchange are given in Table 2.

**Table 2. Germplasm utilization and exchange by different institutes**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sources of germplasm</th>
<th>Accessions exchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cereals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>Landraces</td>
<td>Exotic</td>
</tr>
<tr>
<td></td>
<td>BR-5, BR-22, BR-23,</td>
<td>IR-5, IR-8, IR-20,</td>
</tr>
<tr>
<td></td>
<td>BR-34</td>
<td>BR-2, BR-5, BR-6,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BR-7, BR-16, BR-17,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BR-18, BR-19, BR-26,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BR-32, BR-33, BR-35,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BR-36</td>
</tr>
<tr>
<td>Wheat</td>
<td>Kheri</td>
<td>Bolaka-71, Doel,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pavon, BAW-18, BAW-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39, BAW-43, BAW-28,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BAW-38, BAW-171,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and BAW-452</td>
</tr>
<tr>
<td>Maize</td>
<td>–</td>
<td>Suvra, Bornali,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Khoivutta, Mohaor</td>
</tr>
<tr>
<td>Barley</td>
<td>–</td>
<td>BARI barley-1 &amp;-2</td>
</tr>
<tr>
<td>Foxtail millet</td>
<td>Tusar</td>
<td>–</td>
</tr>
<tr>
<td>Pulses</td>
<td>BARI chola-5</td>
<td>Nabin, BARI chola-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BARI chola-3,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BARI chola-4,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BARI chola-6</td>
</tr>
</tbody>
</table>

Contd...
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lathyrus</strong></td>
<td>–</td>
<td>–</td>
<td>BARI khesari-1 &amp; -2</td>
<td>–</td>
</tr>
<tr>
<td><strong>Lentil</strong></td>
<td>Utfoal</td>
<td>BARI masur-4</td>
<td>BARI masur-2 &amp; -3</td>
<td>–</td>
</tr>
<tr>
<td><strong>Blackgram</strong></td>
<td>–</td>
<td>BARI mash-1</td>
<td>BARI mash-2, BARI mash-3,</td>
<td>–</td>
</tr>
<tr>
<td><strong>Mungbean</strong></td>
<td>BARI mung-3, BARI mung-4,</td>
<td>Kanti, BARI mung-5</td>
<td>–</td>
<td>350</td>
</tr>
<tr>
<td><strong>Cowpea</strong></td>
<td>BARI falon-1</td>
<td>BARI falon-2</td>
<td>–</td>
<td>60</td>
</tr>
<tr>
<td><strong>Oilseeds</strong></td>
<td>Tori-7, Rai-5, Kalyania, Dhali, Sonali</td>
<td>Pt-303, M-27</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Groundnut</strong></td>
<td>DA-1, M-5</td>
<td>DM-1, DG-2, Acc.12, ICGE-55</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td><strong>Sesame</strong></td>
<td>T-6, 11, Jamalpur</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Safflower</strong></td>
<td>Saff-1</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Linseed</strong></td>
<td>Lin-1,</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Niger</strong></td>
<td>Sova</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Sunflower</strong></td>
<td>–</td>
<td>Keroni</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Soybean</strong></td>
<td>–</td>
<td>Brag, Devis, Sohag, BARI soybean-4</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Vegetables</strong></td>
<td>Uttara, Tarapuri, Suktara</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Brinjal</strong></td>
<td>Provati</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Cabbage</strong></td>
<td>BARI Deros-1</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Okra</strong></td>
<td>BARI law-1</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Bottle gourd</strong></td>
<td>BARI matorsuti-1, BARI matorsuti-2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Garden pea</strong></td>
<td>Tasakisan,</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Radish</strong></td>
<td>BARI mula-2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Tomato</strong></td>
<td>Raton, Manik, BARI tomato-3, -4, -5</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Hyacinth bean</strong></td>
<td>BARI shim-1, BARI shim-2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Root &amp; tuber crops</strong></td>
<td>12 variety</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Potato</strong></td>
<td>Doulatpuri, Tripti, Kamla Sunduri</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Sweet potato</strong></td>
<td>Bilashi, Latiraj</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Taro</strong></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Spices</strong></td>
<td>Sinduri, Dimla</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Tamarind</strong></td>
<td>BARI paeaj-1</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Onion</strong></td>
<td>Jointipur</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Black pepper</strong></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td>BARI am-1, -3</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Mango</strong></td>
<td>BARI lichi-1, -2, -3</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Lichi</strong></td>
<td>BARI peara-2</td>
<td>BARI jamrul-1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Guava</strong></td>
<td>Shahi</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Papaya</strong></td>
<td>BARI lebu-1, -2, -3</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Citrus</strong></td>
<td>BARI jamrul-1</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Waxjambu</strong></td>
<td>BARI coconut-1, -2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Coconut</strong></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
Human resource development

PGR scientists, horticulturists and breeders of different institutes have received training on PGR collecting, genebank management, germplasm conservation, documentation and utilization. More training is needed on PGR as it is a continuous process to enhance professional skills of scientists. BARI and BRRI conducted two separate training programmes in 1996 on PGR with the help of IPGRI and IRRI, respectively. Details of training programmes conducted during 1989-1998 are given in Table 3.

Table 3. Training programmes conducted during 1989-1998

<table>
<thead>
<tr>
<th>Institutes</th>
<th>Year</th>
<th>Participants</th>
<th>Training course</th>
<th>Organized by</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARI</td>
<td>1989</td>
<td>1</td>
<td>Germplasm characterization and conservation</td>
<td>JICA</td>
</tr>
<tr>
<td>BARI</td>
<td>1992</td>
<td>1</td>
<td>Germplasm characterization</td>
<td>IPGRI</td>
</tr>
<tr>
<td>BARI</td>
<td>1992-93</td>
<td>1</td>
<td>Development of techniques for cryopreservation</td>
<td>JICA</td>
</tr>
<tr>
<td>BARI</td>
<td>1993</td>
<td>2</td>
<td>Training workshop on PGR</td>
<td>IPGRI/ICRISAT</td>
</tr>
<tr>
<td>BARI, BRRI</td>
<td>1994</td>
<td>2</td>
<td>Genebank management and documentation</td>
<td>IPGRI &amp; MARDI</td>
</tr>
<tr>
<td>BARI</td>
<td>1995</td>
<td>1</td>
<td>Conservation and utilization of PGR</td>
<td>DSE, Germany</td>
</tr>
<tr>
<td>BARI</td>
<td>1995</td>
<td>1</td>
<td>PGR conservation and utilization</td>
<td>USC, Canada</td>
</tr>
<tr>
<td>BARI, BRRI, BJRI</td>
<td>1996</td>
<td>12</td>
<td>Genebank Management System (GMS) Software</td>
<td>BARI/IPGRI</td>
</tr>
<tr>
<td>BARI, BRRI, BJRI</td>
<td>1996</td>
<td>12</td>
<td>Germplasm characterization</td>
<td>BRRI/IRRI</td>
</tr>
<tr>
<td>BARI, BJRI</td>
<td>1996</td>
<td>2</td>
<td>Seed genebank management</td>
<td>IPGRI/NBPGR</td>
</tr>
<tr>
<td>BARI</td>
<td>1997</td>
<td>1</td>
<td>Conservation and utilization of PGR</td>
<td>DSE, Germany</td>
</tr>
<tr>
<td>BARI</td>
<td>1997</td>
<td>1</td>
<td>Germplasm conservation</td>
<td>DSE, Germany</td>
</tr>
<tr>
<td>BARI</td>
<td>1998</td>
<td>1</td>
<td>Germplasm conservation</td>
<td>DSE, Germany</td>
</tr>
<tr>
<td>BARI</td>
<td>1998</td>
<td>2</td>
<td>Follow-up training on conservation and utilization</td>
<td>DSE, Germany</td>
</tr>
<tr>
<td>BARI</td>
<td>1998</td>
<td>1</td>
<td>PGR documentation</td>
<td>SEARCA/IPGRI</td>
</tr>
</tbody>
</table>

Future training needs

The skills of national programme staff need to be enhanced in the following areas:

- Germplasm regeneration and management techniques in open pollinated crops
- In vitro and cryopreservation techniques for PGR conservation
- Taxonomical classification and identification of crop species
- Germplasm characterization through molecular marker techniques
- Seed technology and seed physiology
- Seed health and plant quarantine

Regional collaboration and linkage

Some collaborative crop research programmes already exist in the country with International Center for Agricultural Research in the Dry Areas (ICARDA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), Asian Vegetable Research and Development Centre (AVRDC), IRRI and IPGRI where germplasm collecting, evaluation and utilization are being undertaken by respective breeders. Further regional linkage would be helpful in crop improvement programmes in similar agro-ecological conditions in South Asia.
Existing regional linkage and collaboration
- Conservation of rice biodiversity with IRRI/SDC
- Collecting, characterization, conservation and exchange of improved varieties of jute with jute growing countries

Future collaboration needs with South Asian Association for Regional Cooperation (SAARC) countries
- Joint collecting, evaluation, documentation, sharing and exchange of germplasm
- Domestication and introduction of new crop species from SAARC countries
- Documentation and promotional activities in underutilized crops
- Regional germplasm repository for duplicate conservation

National policies on Plant Genetic Resources for Food and Agriculture (PGRFA)
Plant genetic resources should be used judiciously for the welfare of humankind. Cultivation of modern varieties, introduction of new crop species as well as protection of landraces are the country priorities for future food security. Diversification of food habits and inclusion of several underutilized crops under food commodities would help to protect plant genetic resources and create less pressure on intensive cereal production. In this regard, regional and global collaboration would be effective.

Convention on Biological Diversity (CBD) which created the international condition for countries allowing access to and exchange of genetic resources, set another challenge to the National Committee on PGR which was formed in 1996 to implement the provisions of CBD which was ratified in 1994. This Committee is responsible for giving direction and formulating national policies to protect and conserve the country’s plant biodiversity, promote sustainable use of these resources, ensure equity in benefits arising from the use of these resources, as well as the rights of indigenous people and farmer communities.

Follow-up of CBD and GPA activities
The follow-up actions taken for implementing CBD and GPA activities are briefly given below:
- The National Committee on Plant Genetic Resources (NCPGR) has prepared a draft legislation on Plant Variety Protection Act
- A national workshop on plant genetic resources was organized by BARC/IPGRI/NCPGR in Dhaka in 1997
- A national training programme on germplasm documentation using GMS was organized by IPGRI/BARI in 1996
- A five-year science and technology project has been undertaken by National Herbarium and Dhaka University on comprehensive survey for diversity of all groups of plants: documentation, distribution and utility of germplasm
- A three-year project on survey of threatened species with a view to writeup a red data book on Bangladesh Plants
- Germplasm collection and conservation of indigenous crops
- Create awareness among people on the importance of indigenous PGR for food, medicine or economic prospect for income generation and environmental protection

References
Arora and P.N. Mathur, eds.), Bangladesh Agricultural Research Council, Dhaka, Bangladesh.


Agro-biodiversity perspectives and plans in Bhutan

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Introduction
The Kingdom of Bhutan covers an area of 46,500 square kilometres and the population is estimated at 600,000. The terrain of the country is characterized by hills and mountains with deep valleys. Valleys in the inner mountains receive less than 900 mm of annual rainfall, while it is as high as 5000 mm in the foothills. Varying altitudes, rainfall and aspects of the mountains combine to give each valley a unique set of conditions. The huge diversity of the country’s climate ranges from wet sub-tropical to alpine condition. Development in Bhutan is guided by two basic principles: (i) it is essential to preserve the rich natural and cultural heritage of the country and (ii) development from subsistence to modern economy must proceed in a sustainable manner.

Bhutan is the least densely populated country in South Asia and about 85% of its population live in rural areas. The settlement patterns are determined by the local topography and it is concentrated in the valleys of inner Himalayas and foot hills in the South. The population is growing rapidly at an estimated rate of 3.1% per annum. The Renewable Natural Resources (RNR) sector of the Royal Government of Bhutan (RGOB) covers agriculture, livestock and forest including nature conservation. Although the economy has been diversified, the RNR sector remains the single most important sector accounting more than 40% of the GDP. Increasing population pressure on traditional production system is leading to more extensive use of natural resources. Since there is little scope for expanding agricultural land, intensification of the production system and introduction of improved technologies are the main options to meet the increasing demand for food and to provide opportunities for income generation. These options may pose threats to the environment and biodiversity when short-term benefits are exploited at the cost of long-term requirements.

Updated estimates of land cover show that forest accounts for 72% of land area while cultivated area accounts for 7.8%. In the arable areas, virtually all accessible and moderately sloped lands are utilized. The cultivated area is distributed among cultivated wetland, dryland, tseri land (long fallow rotation), mixed cultivated land, and others. The cultivated wetland is only 12.3% of the area under agriculture but it is by far the most important land use system and contributes 40% of the country’s food production. The cultivated area under horticultural commodities accounts 10% and provides major horticultural export commodities.

Bhutanese farmers have a long cultural tradition of living in harmony with the natural environment. This positive attitude is being continued largely by socio-cultural values placed on genetic resources. For arable agriculture, sustainable development means continued increase in food production to meet the demand of increasing population and the conservation of natural resources on which the production depends. Inadequate infrastructure, lack of experience in problem identification and management, lack of strategic orientation and poor access to information are some of the constraints in achieving the goal of sustainable development.

There are a number of critical issues facing Bhutanese agriculture in the years ahead. The drive to attain food self-sufficiency using modern crop varieties is bound to replace indigenous varieties. Replacement of landraces and folk varieties with elite cultivars could lead to severe genetic erosion. Increasing livestock population in highlands could lead to a dramatic degradation of range lands causing loss of much of potentially useful plant genetic resources (PGR).
Biodiversity

Bhutan straddles two bio-geographical realms: (i) the Palearctic realm of the temperate Euro-Asia and (ii) the Indo-Malayan realm of the Indian sub-continent. The biomes in Bhutan stretch from sub-tropical in the South through temperate in the central interior, to the alpine zone in the North. Within Bhutan’s borders, one can find over 60% of the endemic species of the eastern Himalayan region. Bhutan has been rightly declared as one of the ten global "hot-spots" of biological diversity. Many ecologists believe that Bhutan is the best place for conserving eastern Himalayan biodiversity.

In Bhutan’s context, it is extremely difficult to draw a line between agro-biodiversity and biodiversity in general. Fig. 1 provides a schematic overview of the position of agro-biodiversity within the general concept of biodiversity and illustrates the relationship between agro-biodiversity and biodiversity in general. Agro-biodiversity at one end of the magnitude of biodiversity include PGR for food and fodder, wild relatives of domesticated species, plants that produce medicines and the plants of socio-economic and cultural importance. It is from this perspective that Bhutan has placed importance on agro-biodiversity and the diversity of plants of socio-cultural importance. Fig. 1 also highlights the different conservation and management strategies that are adopted in the 8th Five Year Plan (FYP).

Fig. 1. Position of agro-biodiversity within the general concept of biodiversity
Recognizing the magnitude of the biodiversity, the forestry and agriculture sectors of the Ministry of Agriculture are working from the two ends of the spectrum. Efforts made from the two ends are coordinated at the Ministry level. Cautious steps are being taken in conserving and sustainably using the biodiversity in the country.

The Bhutanese agriculture reflects the ethnic background of the people and the inherent environment. It has strong influence on crop choice, cultivation practices and eating habits. Through, a long process of natural and human selection, a wide array of crops and their varieties within crop species exists, sometimes hidden in remote areas. Many of the native crops as well as those introduced into Bhutan long ago possess significant genetic diversity and are ecologically well adapted to the specific local environments. Besides locally adapted landraces, related wild species can be found in their natural habitat.

The objectives of agro-biodiversity conservation and agricultural development using modern varieties do contradict at times, but both have common grounds of mutual benefits. Agricultural productivity and food security can only be increased and sustained with the rational utilization of local genetic resources for developing modern varieties. The modern varieties have to be developed and modified on a regular basis using genes from local plant resources to counter the production problems often caused by the parallel evolution of pests and pathogens.

**Agro-biodiversity in use**

Utilization and conservation of agro-biodiversity goes hand in hand. The rationale for conservation of agro-biodiversity is to maintain the materials for use by future generations. The utilization and conservation of agro-biodiversity is expected to contribute to three primary areas, viz., (i) sustainable development, (ii) food security and (iii) financial benefits. The primary goals that have been set for utilization of agro-biodiversity are (i) direct utilization by farmers, (ii) utilization by breeders as resource materials for crop improvement and (iii) restoration in the case of natural calamities.

There is neither synthesized nor complete information on agro-biodiversity available in the country. The major cereals and pseudo-cereals traditionally cultivated in the country are maize, rice, wheat, barley, millets and buckwheat. Among vegetables, chillies tops the list followed by radish, eggplant and turnip. Soybean, cowpea, ricebean, mungbean, pea and pigeonpea are some of the legumes cultivated in the country. Rapeseed mustards and niger are the major oilseeds. Potato, apple, cardamom and mandarin orange are the major export crops. The list of minor agricultural crops adds up to 20 out of which 12 are widespread across the country and the list of traditionally cultivated vegetables adds up to 27 (Roder and Gurung 1990). From about one third of the country’s rice growing area, 188 rice varieties have been collected and the country’s wide diversity on other crop species is yet to be recorded.

No systematic attempt has so far been made for assessing the indigenous forage genetic resources. Only recently, the RNR research programme has initiated the process of compiling the list of most common forage genetic resources of the country.

**Threats to agro-biodiversity**

The people of Bhutan depend on a variety of plant genetic resources for food, fibre, natural dye, medicine, income generation and other needs of ethno-botanical importance. To meet the steadily increasing demand for food and other agricultural products, Bhutan continues to introduce exotic crop varieties and improve local varieties through breeding and selection. There is a chance that this may lead to an irreversible loss of traditional plant genetic resources which through centuries of cultivation have developed gene complexes for adaptation to local growing conditions. The threats to agro-biodiversity that can be
identified in Bhutan are:

- Over-exploitation and depletion of agro-biodiversity
- Emerging threats from the rapid growth of human population
- Introduction of exotic species
- Lack of ownership to the community based natural resources
- Inadequate documentation of indigenous knowledge and inefficient use of information, and
- Inadequate legal and institutional mechanisms to promote sustainable use of biodiversity

National needs for agro-biodiversity

The need for a national programme on agro-biodiversity has been consistently emphasized and it is expected to be in place by 2002 (MoA 1996b). The programme will take into account a wide range of native and exotic food, horticulture, fodder and other species of socio-economic and cultural importance. It will ensure the national obligation and the benefit thereof enshrined in the "Convention on Biological Diversity" (CBD). To date, very little systematic work on collecting and conservation of plant genetic resources for food and agriculture (PGRFA) have been carried out. This is firstly because the research programme as well as the scientific and technical capability is weak and secondly, there is still little awareness on the importance of agro-biodiversity.

The legal mechanism to safeguard the utilization of indigenous agro-biodiversity for the benefit of the people of Bhutan is yet to be developed. The abstract descriptions of Bhutan's biogeographic regions and major ecosystems have to be more scientifically and accurately defined and described. This as a priority area which could be addressed through long-term fellowship training of Bhutanese scientists engaged in research on biodiversity within the country.

Taking into account the national needs and global obligations, Bhutan is in the process of developing a consolidated strategic, multi-sectoral framework for the conservation of Bhutan's full complement of biodiversity.

Agro-biodiversity policy

National agro-biodiversity programme

A national agro-biodiversity programme (ABP) will be in place during 8th Five Year Plan 1997-2002 (MoA 1996b). The ABP will take into account agro-biodiversity, both wild and cultivated, used for food, fodder, fruits and vegetables, fibre, medicines, dyes and others of socioeconomic and cultural importance. At the national level, it will create the repository of information and will also provide information on the country's agro-biodiversity.

Access and exchange policy

The access to and exchange of genetic resources is an important issue in the international context. The Ministry of Agriculture (MoA), the RNR sector of the RGOB believes that while exercising sovereign rights over the national genetic resources, the exchange of PGR should not be hampered. While exercising the national sovereign rights of the country over its plant genetic resources, the legal framework of Bhutan manifests the bindings under international agreements.

Once the ABP is in place, it will be the formal channel for exchange of PGRFA meant for research and development. Further, it will ensure the elaboration and implementation of the various elements of agro-biodiversity policy. These include: (i) access and exchange of PGRFA, (ii) Farmers' Rights (FR), (iii) Material Transfer Agreement (MTA), (iv) germplasm collection, (v) safe duplication, (vi) national seed policy, and (vii) plant quarantine.
Cooperation and commitment on agro-biodiversity

The agro-biodiversity policy of Bhutan is in line with the FAO International Commission on Plant Genetic Resources (ICPGR) and the FAO International Undertaking. To date, Bhutan chose not to participate in the FAO Commission’s meetings, but will continue to participate in the regional and global fora and activities thereof. This is, however, expected to be reviewed once ABP is in place.

During the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Bhutan signed the Convention on Biological Diversity which was ratified by the 73rd Session of the National Assembly. This confirms the commitment of the RGOB to conserve its biodiversity. Therefore, at the international level, Bhutan supports the following objectives of the Convention on Biological Diversity:

- Conservation of biological diversity
- Sustainable use of biodiversity components
- Fair and equitable sharing of the benefits arising out of the utilization of PGR
- Appropriate access to genetic resources
- Appropriate transfer of relevant technologies

Intellectual property rights

The Intellectual Property Rights (IPR) issue is important in the context of international cooperation. Among others, it has a direct bearing on the Farmers’ Rights which is imperative to recognize their contribution in developing and maintaining traditional folk varieties for generations. The ABP will address and elaborate on this issue. Other important issues in the area of IPR are Material Transfer Agreements (MTAs) leading to royalty sharing mechanisms, patenting and Plant Breeders Rights (PBR).

Priority setting

At the national level, Bhutan has set aside over 26% area of the country as national parks and protected areas for in situ conservation of biodiversity. The complexity of the actions required for conserving the whole spectrum of biodiversity, combined with financial and institutional constraints, means that the first element must be to set priority.

Conserving all the genetic variability present within different systems is neither possible nor necessary. Thus, it is necessary to determine priorities considering the socioeconomic and cultural values of the crops, the requirements of plant breeders, the level of genetic erosion taking place, and the current status of conservation in ex situ, in situ and on-farm. The options and approaches being outlined take into account the available resources in hand and resources committed for agro-biodiversity activities. Within the framework of the policy objectives, the priorities for conservation of agro-biodiversity are:

- Strengthening institutional capability of organizations that work in the field of agro-biodiversity
- Education and training on legal issues on biodiversity to ensure the legal aspects of biodiversity such as sovereign rights, IPR, MTA and FR
- Stock taking and assessment, including pattern of diversity
- Participatory plant breeding, and realization of the concept of Common Property Resources Management (CPRM) for sustainable use
- Ensuring financing mechanisms for agro-biodiversity programme and
- Creating conditions and incentives for local biodiversity conservation

Research on biodiversity

Some of the priority activities that fall under the domain of research are:

- Description of biogeographic regions and major ecosystems
- Comprehensive national listing/biodiversity accounting, indicating their location,
distribution, and description giving priority to ecologically important locations

- Indigenous knowledge/ethnobotany/socio-cultural aspects of biodiversity, and
- Socioeconomic valuation of commercially valuable genetic resources

The research is oriented towards direct application for the conservation and sustainable utilization of biological diversity. Multidisciplinary team approach is given priority that emphasizes relationship between socioeconomic and cultural factors. People/farmers’ participation in research is emphasized.

Information on the current state of PGR and the key ecological, geographic, socioeconomic and cultural determinants of the genetic diversity and the pattern of distribution is an essential input in building a comprehensive inventory of agro-biodiversity. Such background information will establish the basis for a feasible, target-oriented approach. Pilot studies are being conducted on the following aspects:

- Magnitude of diversity in crop genetic resources, and
- Indigenous knowledge on agro-biodiversity traditionally known to the farming communities

**Agro-biodiversity conservation strategy**

Three different strategies for the conservation of agro-biodiversity have been adopted:

- **In situ** conservation for crops and related wild species
- **Ex situ** conservation, and
- On-farm management

**In situ conservation**

Besides environmental concerns, the objectives of the national parks and protected areas, nature reserves and multi-purpose use forests is the *in situ* conservation of flora and fauna, including the wild relatives of domesticated species.

The *in situ* conservation of domesticated plants is contributed by the less developed, largely subsistence based mountain agriculture system. Bhutan maintains its sovereign right over genetic resources on its territory and Forest and Nature Conservation Act 1995 prohibits illegal exploitation.

The Nature Conservation Section (NCS) of the Forestry Services Division (FSD) of the Ministry of Agriculture (MoA) is a para-statal entity complementary to the ABP responsible for *in situ* conservation of biodiversity. The protected areas consisting of parks and nature reserves, are managed by the NCS to conserve the wild living resources and their natural habitats at the ecosystems level. These protected areas hold important genetic resources of agricultural significance. The ABP in collaboration NCS will monitor the changes in the genes and genotype frequencies, and the process of dynamism in the ecological habitats.

**Ex situ conservation**

In the absence of national capacity, the *ex situ* conservation activities such as collecting, documentation, characterization, evaluation and their effective utilisation in crop improvement have been minimal. This does not mean that their importance is undermined. It is committed that ABP will be in place by 2002. It will then begin to take care of the national concern on agro-biodiversity. The programme will have the following national mandate (NEC 1996) to:

- Ensure the conservation of agro-biodiversity as basis for food security
- Promote sustainable use and conservation of agro-biodiversity through participation of user groups
- Ensure fair and equitable sharing of benefits arising from the utilization of agro-biodiversity, through appropriate policy and legislative measures, confirming the farmers' rights, and
Create awareness on the importance to conserve and sustainably use the agro-biodiversity

**On-farm management**
A genebank provides an alternative to conserve germplasm of crops but it must be realized that, in agriculture, almost a natural process of continued evolution takes place. Also, it is strongly believed that diversity at farm level provides the basis for stability and household food security. Based on this understanding, the on-farm management strategy has been outlined for sustainable utilization of agricultural biodiversity. The four regional RNR research centres operating under the Research, Extension and Irrigation Division (REID) of MoA have adopted the process of participatory plant breeding to broaden the base of genetic diversity at farm level. The problem with on-farm management of agro-biodiversity is that it lacks long-term security, as the farmers' main concern is not so much with conservation as it is with economic survival.

**Organizations responsible for biodiversity conservation**
The National Environment Commission (NEC) of Bhutan is responsible to ensure that there are adequate policies, strategies and programmes on biodiversity to meet the obligations of the CBD. It is the lead agency responsible for entering into international dialogues.

At the implementation level, the MoA, with its two functional divisions FSD and REID, is responsible for conservation and sustainable utilization of biodiversity. The NCS of FSD is responsible for managing national parks, protected areas and nature reserves, while Forestry Resources Development Section (FRDS) of FSD ensures sustainable management of multipurpose use forest for conserving the ecosystems and species diversity *in situ*. For agro-biodiversity, the REID of MoA has initiated multi-prong steps to conserve and sustainably use the country’s agro-biodiversity in the long run.

With the initiation of ABP, there will be two complementary programmes within the MoA, viz., the Nature Conservation Programme (NCP) and Agro-biodiversity Programme (ABP). The two programmes organized at the two ends of the spectrum of biodiversity will jointly ensure conservation and sustainable use of biodiversity at all levels (NEC 1996).

The main concern of the NCP is the conservation of ecosystems and species while that of ABP will be the conservation and sustainable utilization of the genetic diversity within crops and related wild species.

**References**
Status of national plant genetic resources programme in India

P.L. Gautam
Director, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi, India

The national plant genetic resources activities in India are spearheaded by the National Bureau of Plant Genetic Resources (NBPGR), as the nodal agency of the Indian National Plant Genetic Resources System (IN-PGRS), under the umbrella of the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India and the Indian Council of Agricultural Research (ICAR) (Fig. 1).

**Fig. 1.** The Indian National Plant Genetic Resources System (IN-PGRS)

### Activities/ component areas

The national PGR programme essentially includes the following activities/components:

- Germplasm exploration, collecting, accessioning and documentation
- Germplasm introduction, exchange, accessioning and inventorization
- Plant quarantine and phytosanitary examination
- Germplasm characterization, evaluation, documentation and supply on request for promoting use
- PGR conservation:
  a) National *ex situ* base collection
     - Long-term seed bank (-20°C)
     - Cryo bank (-150°C/ -196°C)
     - *In vitro* bank
     - Field repositories
     - National Herbarium of Cultivated Plants (NHCP)
  b) Medium-term conservation of active/working collections
  c) *In situ* conservation - citrus gene sanctuary in Nokrek, Meghalaya
  d) On-farm conservation studies on rice-wheat system and tribal area crops
  e) Back-up research on conservation regimes and protocols
• Registration of plant germplasm
• Promotion for germplasm use - proactive role
• New areas related to PGR
  a) Regulation of exchange of Genetically Modified Organisms (GMOs)
  b) Containment facility for post entry quarantine of transgenics
  c) Other areas (terminator technology; patenting of Indian landraces/varieties outside the country, etc.)
• Biochemical and molecular characterization of PGR
• Thrust on underutilized crops
• Human Resource Development (HRD) in PGR management
  a) training,
  b) postgraduate degree on PGR,
  c) HRD of the IN-PGRS staff.
• Outreach, collaboration and linkages
• PGR policy issues
• New thrust - National Agricultural Technology Project (NATP) on PGR

The NBPGR, with its network of 11 regional stations located in diverse agro-climatic zones of the country (Fig. 2), the 30 National Active Germplasm Sites (NAGS) situated at different crop based ICAR Institutes and State Agricultural Universities (SAUs) and other locations, discharges these functions/activities in a balanced and partnership mode.

![The NBPGR network of regional stations](image)

Fig. 2. The NBPGR network of regional stations
Achievements

Germplasm exploration and collecting

Looking into the national needs and in consonance with the global obligations as provided by the FAO International Undertaking on Plant Genetic Resources (IUPGR), Global Plan of Action (GPA) and the Convention on Biological Diversity (CBD), the NBPGR has been planning, organizing and conducting systematic collecting expeditions in the country. This systematic effort has been made through NBPGR’s own initiatives and collaborative missions on request from partners, and 611 explorations were undertaken between August 1976 and August 1998, which resulted in collecting of 111,380 accessions of different crops and their wild forms/relatives from diverse agro-ecological niches. This bounty is not only sizable but significant in view of the increased priority for conservation and sustainable use of PGR in the GPA.

During the period 1995-96 to June 1998, NBPGR has undertaken 97 explorations, and a total of 8743 accessions were collected (Table 1) in collaboration with various national/international agencies. Several explorations were conducted exclusively by the NBPGR and its regional stations/base centres.

Table 1. Plant germplasm collected during the period 1995-96 to 1997-98

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of explorations</th>
<th>Number of accessions collected</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>97</td>
<td>8743</td>
<td></td>
</tr>
</tbody>
</table>

Extent of diversity collected

Among 130 accessions in pointed gourd (*Trichosanthes dioica*) from parts of eastern Uttar Pradesh, Bihar and West Bengal, presently being maintained at the Project Directorate of Vegetable Research (PDVR), Varanasi, cultivars "Santokhawa" (drum shaped), "Kelwa" (prolific yielder), "deshi" (fruits in cluster) and a landrace from Gopalganj merit specific mention. Eighteen accessions of *Cucumis hardwickii* (wild progenitor of cultivated cucumber) were made from Kulhal range in Dehradun Himalayas, which are resistant to powdery/downy mildew and green mottle mosaic virus. Diversity in medicinal and aromatic plants collected from lower and higher elevations, including tribal areas of Kanger (Bastar District), covered *Acorus*, *Aloe*, *Asparagus*, *Catharanthus*, *Coleus forskohlii*, *Mucuna*, *Calastus paniculata*, *Tinospora cordifolia*, *Viola*, *Vitex*, *Bauhinia*, *Chlorophytum*, *Polygonum*, *Barleria* etc. Pigeon pea collections exhibited variability in plant type/spread and crop maturity.

The khesari (*Lathyrus*) collections represented largely drought tolerant types, varying in seed size and colour. Important landraces included *Lathri* and *Lakhri* and bold seeded *Lakh*. Phalsa (*Grewia subinaequalis*) collections from Telangana region exhibited variation for plant
habit, leaf size and shape, size of fruits and pulp colour (green/pink), taste of fruits (sweet/sour), etc. Banana (both cultivated and wild) from Mizoram included important types such as Cavendish, Ballehuria and Banpaul. *Citrus* collections represented diversity in *C. reticulata*, *C. sinensis*, *C. macroptera*, *C. jambhiri*, *C. limetta*, *C. limon*, *C. medica*, *C. aurantifolia* and *C. megalaxycarpa* from north Tripura and Mizoram. In walnut, collections from Uttar Pradesh Hills were best for kernel/nut ratio as well as size and appearance of fruits. Less known economic plants, namely, *Coix lacryma-jobi*, *Allium wallichii*, *Amaranthus caudatus*, *Moghania vestita*, *Rubus nutan* and, *Berberis chitria* were also added to the existing collections.

Further, following the allocation of joint collectors' numbers on NBPGR passport data sheets, the germplasm collections are allocated the national identifier numbers by the NBPGR. Such numbers are characterized with prefixes "IC", i.e. "Indigenous collections" and it aims to provide systematic lineage of accessions under sustainable use and a traceable record for equitable sharing of benefits through a regulated access for use on prior informed consent and on mutually agreed terms as per CBD requirements.

**Regional imperative**
A total of 126 accessions made in *Artocarpus* species, an identified priority underutilized fruit plant species of the sub-region, comprised *A. heterophyllus* (116), *A. lakoocha* (10) from Chotanagpur region in Bihar and Sundergarh and Keonjhar districts in Orissa. Variability was observed/collected with respect to maturity, fruit bearing capacity, seed shape, size and colour. Looking into the priority for the joint exploration in the region, the NBPGR has expressed its willingness to the IPGRI to participate for collecting jackfruit, chow-chow (squash) and perilla in Bangladesh and Nepal.

**Germplasm introduction and exchange**
In order to meet the requirements of scientists working in ICAR Research Institutes, State Agricultural Universities, other institutions, including the non-governmental organizations and also the private sector seed companies, introduction of seed/plant propagules for research purposes has been done by the Bureau through issuance of import permits and the regulated single window entry. The introduction/exchange involved three categories, namely, (a) materials introduced at the initiative of the Bureau (b) material obtained on requests from the scientists/institutions/organizations/other stakeholders/collaborators, and (c) entries for international trials/nurseries.

**PGR import**
A total of 196 543 samples (germplasm = 30 615; trials = 165 938) were procured during 1995-98 in 315 consignments from 58 countries. New nursery import cases registered were 585. The germplasm imported included cereals and millets (144 777), oilseeds (1 937), pulses (13 885), fruits (2 114), vegetables (3 468), fibre crops (76), forage crops (1 956), sugar yielding crops (108), ornamentals (41), medicinal and aromatic plants (497), underutilized and underexploited plants (495), tuber crops (140), spices and condiments (159), narcotics and beverage plants (177). The seed and planting materials were exchanged on the basis of requests received from the scientists working in ICAR institutes/state agricultural universities in India, under various protocols/work plans/MoUs with different countries/CGIAR institutions.

**Promising introductions**
Some promising introductions made during the period included, *Glycine max* (EC 389390-400) - rust resistant lines from Taiwan, *Brassica napus* (EC 394357) - low in glucosinolate content, zero erucic acid content from Australia and other resistant lines in various agri-horticultural crops. The details regarding the promising germplasm introduced in the recent past are given in Table 2.
Table 2. Promising introductions during 1995-98

<table>
<thead>
<tr>
<th>Crops</th>
<th>Accession ID</th>
<th>Country</th>
<th>Type of material</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Anacardium occidentale</em></td>
<td>EC 401540-44</td>
<td>Brazil</td>
<td>High yielding varieties</td>
</tr>
<tr>
<td><em>Brassica juncea</em></td>
<td>EC 410682-685</td>
<td>Belgium</td>
<td>Transgenic lines</td>
</tr>
<tr>
<td><em>B. oleracea</em></td>
<td>EC 410686-705</td>
<td>Belgium</td>
<td>Transgenic lines</td>
</tr>
<tr>
<td><em>Beta vulgaris</em></td>
<td>EC 400779-89</td>
<td>USA</td>
<td>Varieties with resistance to <em>Fusarium</em> stalk blight, multigerm and monogerm types and male sterile lines</td>
</tr>
<tr>
<td><em>Cucumis melo</em> and CMV</td>
<td>EC 399866-212</td>
<td>UK</td>
<td>Resistant to downy mildew, powdery mildew</td>
</tr>
<tr>
<td><em>Cuphea sp.</em></td>
<td>EC 408528-408872</td>
<td>USA</td>
<td>Wild relatives</td>
</tr>
<tr>
<td>Forage legumes</td>
<td>EC 400930-1436</td>
<td>Ethiopia</td>
<td>Different species of <em>Medicago, Trifolium, Stylosanthes, Desmodium, Centrocema, Clitoria, Macroptilium</em> etc.</td>
</tr>
<tr>
<td><em>Fragaria sp.</em></td>
<td>EC 405724</td>
<td>Canada</td>
<td>Cultivar adapted to adverse conditions</td>
</tr>
<tr>
<td><em>Helianthus sp.</em></td>
<td>EC 405027-405071</td>
<td>USA</td>
<td>Wild germplasm</td>
</tr>
<tr>
<td><em>Lycopersicon esculentum</em></td>
<td>EC 401908-098</td>
<td>Canada</td>
<td>Disease resistant varieties</td>
</tr>
<tr>
<td>Medicinal and aromatic plants</td>
<td>EC 402989-403038</td>
<td>Denmark</td>
<td>Species of <em>Hyoscyamus, Mentha piperata, Pelargonium sp., Plantago sp., Papaver sominiferum</em> etc.</td>
</tr>
<tr>
<td><em>Opuntia sp.</em></td>
<td>EC 400675-725</td>
<td>USA</td>
<td>Edible fruit varieties</td>
</tr>
<tr>
<td><em>Oryza sativa</em></td>
<td>EC 408491-524</td>
<td>Philippines</td>
<td>Transgenic lines</td>
</tr>
<tr>
<td><em>Oryza sp.</em></td>
<td>EC 407431-460</td>
<td>Philippines</td>
<td>Wild germplasm</td>
</tr>
<tr>
<td><em>Phaseolus vulgaris</em></td>
<td>EC 402962-85</td>
<td>Columbia</td>
<td>Donor with traits like red seeded, bold seeded, determinate plant type with resistant to bean common mosaic virus, <em>Sclerotinia</em> and <em>Anthracnose</em></td>
</tr>
<tr>
<td><em>Phoenix sp.</em></td>
<td>EC 406066-070</td>
<td>Columbia</td>
<td>Pathogen tested cultivars</td>
</tr>
<tr>
<td><em>Pyrus communis</em> varieties</td>
<td>EC 402391</td>
<td>Iraq</td>
<td>High yielding, early maturing type</td>
</tr>
<tr>
<td><em>Solanum tuberosum</em></td>
<td>EC 401445-52</td>
<td>Netherlands</td>
<td>Potato hybrids</td>
</tr>
</tbody>
</table>

**Germplasm export**

Total number of consignments exported during 1995-98 were 222 and total number of samples exported were 3579. PGR export from IN-PGRS during 1995-98 included cereals and millets (2 221), oilseeds (523), pulse crops (263), vegetable crops (253), fruit plants (29), forage plants (25), underutilized and underexploited plants (30), fibre crops (32), narcotic plants (52), tuber crops (113), medicinal and aromatic plants (10), spices and condiments (12), sugar yielding plants (14), and miscellaneous (2).

**In-country supply/exchange**

PGR services for sustainable use of germplasm were maintained through the in-country supply/exchange. Based on specific requests, a total of 44 493 samples of different crops,
vix., cereals and millets (38,016), oilseeds (184), legumes (2,569), vegetables (1,883), fruit plants (213), underutilized and underexploited plants (57), narcotics (8), fibre crops (1,263), medicinal and aromatic plants (229), and spices and condiments (71) were supplied by the Bureau to various ICAR Institutes/Coordinated projects, state agricultural universities, farmers and private seed agencies in different states and union territories in the country. This includes the supply of active collections (27,381 accessions) made from Bureau's network to 499 indentors.

**In vitro multiplication and exchange**

Such services have been added to the PGR programme to promote germplasm use of difficult species. The services were rendered to several organizations and research workers on request. In banana, 19 accessions were supplied to National Research Centre on banana, Trichy, University of Agricultural Sciences, Dharwad, Karnataka and a private company in Ellur, Andhra Pradesh. Twenty two in vitro accessions of sweet potato introduced from CIP, Lima, Peru and two from existing collection, were multiplied and supplied to CIP Regional Centre, New Delhi. Ten accessions of ginger were supplied to Nematology Division, Indian Institute of Agricultural Research (IARI), New Delhi. One accession of *Tylophora* was also supplied on request for research purpose.

**Priorities and future projection**

The NBPGR has been issuing import permits to all interested individuals/institutions for research purpose with a minimal undertaking, ascertaining free exchange for germplasm use. However, under the present CBD regime, need has been felt to ensure prior informed consent and mutually agreed terms for exchange of/access to germplasm through the single window system. Accordingly, a Material Transfer Agreement (MTA) has been drafted and widely circulated in the country for comments. The responses are being analyzed and presented to a high level National Committee on PGR Management for further action/implementation.

**Plant quarantine**

The different activities undertaken and the salient accomplishments made under each are given below:

**Quarantine processing**

During the past three years, 224,168 samples (Import = 219,927 and export = 4,241) comprising seeds/vegetative propagules as tubers, suckers, rhizomes, cuttings and rooted plants of germplasm of various agri-horticultural crops and their wild relatives introduced/exchanged were processed/examined for quarantine clearance/phytosanitary certification (Table 3).

Systematic pest detection resulted in the interception of several exotic pests including insects, mites, nematodes, fungi, viruses, bacteria, etc. All efforts were made to salvage the infected/infested/contaminated germplasm and the pest free valuable germplasm material was released to the user scientists. During past three years, of the 2,168 infected/infested/contaminated samples, almost all samples (except 22) were made pest free, at an average rate of success of about 99 per cent using various physico-chemical treatments. Equal care was taken for quarantine processing and clearance of pest free germplasm material meant for export before issuing phytosanitary certification (Table 3).
Table 3. Quarantine processing of germplasm under exchange (1995-98)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample processed</th>
<th>X-ray screening</th>
<th>No. of samples</th>
<th>Samples treated</th>
<th>Rejected</th>
<th>Salvaged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Import</td>
<td>Export</td>
<td>Infested</td>
<td>Contaminated with Nematodes</td>
<td>Infected</td>
<td>Contaminated with weeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nematodes</td>
<td></td>
<td>weeds</td>
</tr>
<tr>
<td>1995-96</td>
<td>71121</td>
<td>1869</td>
<td>555</td>
<td>425</td>
<td>17</td>
<td>64</td>
</tr>
<tr>
<td>1996-97</td>
<td>73743</td>
<td>1689</td>
<td>894</td>
<td>420</td>
<td>101</td>
<td>351</td>
</tr>
<tr>
<td>1997-98</td>
<td>75063</td>
<td>683</td>
<td>1850</td>
<td>430</td>
<td>230</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>219927</td>
<td>4241</td>
<td>3299</td>
<td>1275</td>
<td>348</td>
<td>447</td>
</tr>
</tbody>
</table>

Interceptions
Insect pests, nematodes and pathogens of economic significance were intercepted in the introduced germplasm, especially those which are not yet reported from India or those which have a wide host range or have different virulent races/strains/biotypes (Table 4).

Table 4. Important interceptions made from the germplasm under exchange

<table>
<thead>
<tr>
<th>Interception</th>
<th>Host(s)</th>
<th>Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insects/Mites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthoscelides obtectus</td>
<td>Phaseolus vulgaris</td>
<td>Republic of Colombia</td>
</tr>
<tr>
<td>Bruchophagus roddi</td>
<td>Medicago sativa</td>
<td>USA</td>
</tr>
<tr>
<td>Gymnettorn sp.</td>
<td>Plantago</td>
<td>Italy</td>
</tr>
<tr>
<td>Sitophilus granarius</td>
<td>Wheat</td>
<td>Syria</td>
</tr>
<tr>
<td>Sitophilus zeamais</td>
<td>Zea mays</td>
<td>Philippines, USA</td>
</tr>
<tr>
<td>Systole sp.</td>
<td>Coriandrum sativum</td>
<td>Mauritius</td>
</tr>
<tr>
<td></td>
<td>Pimpinella saxifraga</td>
<td>Italy</td>
</tr>
<tr>
<td>Eriophyid mites</td>
<td>Malus rooted plants</td>
<td>USA</td>
</tr>
<tr>
<td>Nematodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aphelenchoides besseyi</td>
<td>Paddy</td>
<td>Thailand, Philippines, Netherlands</td>
</tr>
<tr>
<td>Aphelenchoides sp.</td>
<td>Zingiber officinale</td>
<td>Malaysia</td>
</tr>
<tr>
<td></td>
<td>Avena sp., potato tubers</td>
<td>Netherlands, UK, Philippines</td>
</tr>
<tr>
<td></td>
<td>yam (corms)</td>
<td>Taiwan</td>
</tr>
<tr>
<td>Aphelenchus sp.</td>
<td>Malus rooted Callus</td>
<td>Holland</td>
</tr>
<tr>
<td>Ditylenchus sp.</td>
<td>Allium sp.</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td>Malus rooted cuttings</td>
<td>USA</td>
</tr>
<tr>
<td>Helicotylenchus sp.</td>
<td>Fragaria sp.</td>
<td>USA</td>
</tr>
<tr>
<td>Pratylenchus penetrans</td>
<td>Apple (rootstocks)</td>
<td>UK</td>
</tr>
<tr>
<td>Pratylenchus sp.</td>
<td>Apple (rootstocks)</td>
<td>Netherlands</td>
</tr>
<tr>
<td></td>
<td>Potato tubers</td>
<td></td>
</tr>
<tr>
<td>Tylenchorhynchus sp.</td>
<td>Potato tubers</td>
<td>Netherlands</td>
</tr>
<tr>
<td>Tylenchorynchus brevilineatus</td>
<td>Napier grass roots</td>
<td>India</td>
</tr>
<tr>
<td>Pathogens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternaria brassicola</td>
<td>Brassica sp.</td>
<td>Canada, Belgium, USA, Japan, UK,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taiwan, Sweden</td>
</tr>
<tr>
<td>Alternaria brassicae</td>
<td>Brassica sp.</td>
<td>UK, Sweden, USA</td>
</tr>
<tr>
<td>Alternaria sesami</td>
<td>Sesamum</td>
<td>Israel</td>
</tr>
<tr>
<td>Dreschlera sorokiniana</td>
<td>Wheat</td>
<td>Mongolia, Mexico</td>
</tr>
<tr>
<td></td>
<td>Hordeum vulgare</td>
<td>Mexico</td>
</tr>
</tbody>
</table>

contd..
Table 4. contd..

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Host</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. oryzae</td>
<td>Oryza sativa</td>
<td>Philippines</td>
</tr>
<tr>
<td>P. maydis</td>
<td>Zea mays</td>
<td>Thailand</td>
</tr>
<tr>
<td>Peronospora manshurica</td>
<td>Soybean</td>
<td>Taiwan, Russia, USA</td>
</tr>
<tr>
<td>Phoma betae</td>
<td>Sugarbeet</td>
<td>USA</td>
</tr>
<tr>
<td>Puccinia carthami</td>
<td>Safflower</td>
<td>China, USA</td>
</tr>
<tr>
<td>Uromyces betae</td>
<td>Sugarbeet</td>
<td>USA, Germany</td>
</tr>
</tbody>
</table>

Post-entry Quarantine Nursery (PEQN)

Germplasm material heavily treated with pesticides or suspected to carry seed borne viruses are grown in PEQN field and insect-proof screen houses and are being regularly examined. The material grown in PEQN during 1995-1998 and the interceptions thereof are presented in Table 5.

Table 5. Germplasm material grown in PEQN and interceptions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2619</td>
<td>1958</td>
<td>1719</td>
<td>Aphids</td>
</tr>
<tr>
<td>Barley</td>
<td>483</td>
<td>587</td>
<td>529</td>
<td>Aphids, Covered smut</td>
</tr>
<tr>
<td>Triticale</td>
<td>246</td>
<td>228</td>
<td>397</td>
<td>–</td>
</tr>
<tr>
<td>Vigna sp.</td>
<td>19</td>
<td>–</td>
<td>70</td>
<td>White flies, Mites</td>
</tr>
<tr>
<td>Soybean</td>
<td>99</td>
<td>495</td>
<td>220</td>
<td>Pea leaf miner, Pea seed borne mosaic</td>
</tr>
<tr>
<td>Pea</td>
<td>45</td>
<td>118</td>
<td>24</td>
<td>–</td>
</tr>
<tr>
<td>Lathyrus sp.</td>
<td>1</td>
<td>58</td>
<td>34</td>
<td>–</td>
</tr>
<tr>
<td>Vicia sp.</td>
<td>60</td>
<td>80</td>
<td>8</td>
<td>–</td>
</tr>
<tr>
<td>Phaseolus sp.</td>
<td>82</td>
<td>203</td>
<td>78</td>
<td>Poty virus</td>
</tr>
<tr>
<td>Sunflower</td>
<td>73</td>
<td>125</td>
<td>272</td>
<td>–</td>
</tr>
</tbody>
</table>

Development of new techniques for salvaging the seed germplasm under exchange

The following new techniques were standardized/developed to salvage the seed samples:

**Entomology**

i) Methyl bromide fumigation schedule for chalcidoids and bruchids infesting different seeds

ii) Treatment with hydrogen cyanide gas for eradication of seed chalcidoids and bruchids

iii) Vacuum fumigation schedule for seed inhabiting chalcidoids and bruchids

iv) Standardization of X-ray radiography technique for excluding mango stone weevil, *Sternochaetus mangiferae*

**Nematology**

i) Elimination of white tip nematode, *Aphelenchoides besseyi* from paddy seeds

ii) Eradication of *Heterodera zea* from *Vetiveria zizanioides* roots by HWT

iii) Elimination of root knot nematode (*Meloidogyne incognita*) from *Mentha spicata* plants with HWT

iv) Elimination of *Pratylenchus penetrans* from peach plants by HWT

v) Salvaging of rose plants infected with lesion nematode (*Pratylenchus zeae*) by HWT

vi) Elimination of root knot nematodes from chinese potato tubers by HWT

vii) Eradication of *Meloidogyne incognita* from grapevine root stock by HWT

viii) Salvaging of apple root stock infected with lesion nematode (*Pratylenchus vulnus*) by HWT

ix) Elimination of *Aphelenchoides besseyi* from seeds of proso millet and foxtail millet by pre-soaking the seeds in 1 per cent hydrogen peroxide
Pathology
i) Salvaging of safflower seeds infected with rust (Puccinia carthami)
ii) Salvaging of sugarbeet seeds infected with rust (Uromyces betae)

Nematode survey
Nematode survey was undertaken with a view to know the plant parasitic nematodes present in the experimental farms of NBPGR regional stations at Thrissur, Shillong, Akola and Jodhpur and to avoid the damage to the crops by adopting suitable control measures. Survey of the farm area at Akola revealed the presence of Heterodera zeae in the soil samples from rhizosphere of maize. While H. cajani cysts were found in pigeonpea plots, soil collected from jowar, minor millets and sesame had predominant population of Tylenchorhynchus sp. Appropriate control measures were suggested to prevent the introduction of nematodes with the planting material from outside and to prevent further increase in the existing population of nematodes.

Preparation of check lists on different crops for risk analysis prior to import
Pest risk in the import of coconut: World literature on coconut insect pests and mites was collected with reference to their geographical distribution, host range, biology, habitat, mode of transmission, detection methods and control measures. It revealed that nearly 46 insects and mites belonging to different insect groups are of quarantine significance and care has to be taken to prevent their entry along with the import of coconut germplasm. The important ones include Acutaspis tingi, Araecerus vieillardi, Aonidiella comperei, A. eremicotis, Aspidiotus destructor-rigidis, Alurnus humeralis, Brevicolaspsis villosa, Cerataphis variabilis, Coelaenomenomenoderer perrieri, Coptoter mes grandiceps, C. pamuae, C. domesticus, Diocalandra frumenti, Hemiberlesia palmne, Kaloter mes samoanus, Microtermes biroi, Nasutitermes novarum-hebridarum, Orthocraspeda catenatus, O. citrinus, Oryzaephilus gibbosus, Plesispa reicheri, Rhynchophorus schach, Strategus quadrifoveatus.

Pest risk in import of oil palm: Out of 216 pests known to infest oil palms, 62 are sap feeders, 85 leaf feeders and 17 are reported to feed on stem, 9 on root, 12 on inflorescence and 31 on fruits and nuts. Insects of quarantine significance include: Cocotyphes congonus, Xyleborus pygmaeus, Himatidium neivae, Pyrodereces centropeta, Trachycentra eleactropha, Aspidiotus sp. Chrysophal us rossi, Diaspis lutea, Brontispa longissima, Amitermes globosus and Rhinotermes longirostrus. Pseudococcus cocomi may accompany the fruits and nuts during exchange of germplasm material. Pests, which may accompany seedlings, include weevil, Leutorstenus elaedis; hespines, Bontispa longtime(frigate); termite, Amitermes globossus, Nasutitermes zeteki, Rhinotermes lingirostrus and gryllid, Brachytrypes membranaceus.

Pest risk in import of Jatropha: About 14 species of insects of quarantine significance belonging mainly to orders Hemiptera, Orthoptera and Coleoptera have been known to infest almost all the plant parts. These are: Helopeltis alluradi, Astertolecanium cristatum, Homocerus sp., Hemilecanium maxima, Pachycoris torridus, Calidea dregii, Nephopteryx semisubcella, Bemisia tabaci, Tetranychus sp., etc.

Virus diseases of Papaya (Carica papaya): World literature on virus/virus-like diseases of papaya revealed that the diseases of worldwide distribution include: papaya mosaic, papaya ringspot, tomato ringspot, tomato spotted wilt, cucumber mosaic, apical necrosis, leaf curl and bunchy top. Virus diseases reported from India include: papaya mosaic (seed borne), papaya ringspot, papaya distortion ringspot, papaya mild mosaic, papaya leaf distortion, papaya leaf reduction, papaya leaf crinkle and papaya leaf curl.
**Virus diseases of temperate shell fruits**: Literature survey and compilation of information on viral diseases of walnut, chestnut, hazelnut and banana is in progress.

**Sunflower diseases**: The information on sunflower diseases with reference to their geographical distribution, causal organisms, biological races, mode of transmission is being compiled. Some of the important seed borne pathogens include *Alternaria helianthi*, *Plasmopara halstedii*, *Pseudomonas syringae pv tagetis* and sunflower rugose mosaic virus. *Pseudomonas syringae pv tagetis* is not yet reported from India.

**Germplasm evaluation, maintenance, documentation and information management**

The role of germplasm in the improvement of cultivated plants has been well recognized. However, the use of germplasm collections is still limited. Until the germplasm has been properly evaluated and its useful attributes are defined, it has little practical value. The germplasm evaluation at NBPGR/IN-PGRS covered whole range of activities starting from the receipt of new samples by the curator to growing these for seed increase, characterization and preliminary evaluation, maintenance, rejuvenation, multiplication, identification of promising types, documentation and cataloguing and finally conservation/distribution to users. Multi-locational evaluation of germplasm at the NBPGR regional stations, ICAR institutes, agricultural universities and other centres including international centres has also been coordinated under this programme.

**Evaluation and maintenance**

Over 30,000 accessions of various agri-horticultural crops were grown and evaluated at the NBPGR Experimental Farm at Issapur during 1995-96 to 1997-98, using augmented block design. The major groups of crops evaluated were cereals (12,312), fodder and forage (12,70), pulses and legumes (3,911), oilseeds (1,186), vegetables (9,021), fruits (206), medicinal and aromatic plants (607), fibre crops (37) and other economic/underutilized crops (528). Further, a sizable number has been evaluated at the NBPGR regional stations as per specific crop responsibilities assigned to each centre based on their agro-ecological condition and crop seasons. These include temperate zone crops at Shimla and Bhowali, arid zone crops at Jodhpur, warm humid tropical to equatorial zone crops at Thrissur, tropical zone crops at Akola, Amravati and Hyderabad, perhumid subtropical zone crops at Ranchi and humid subtropical zone crops at Shillong centre. NBPGR envisages to support/collaborate for need based evaluation at some other locations, including university centres.

During characterization and preliminary evaluation using sets of minimal descriptors/descriptor states, a wide variability was observed. Some of the accessions which showed promise for different traits include, early types - maize (IC 130698, IC 130839, IC 130875, IC 130472, IC 130475), urdbean (PLU 189, PLU 496), lentil (NIC 23658, NIC 23653, NIC 23664, NIC 23652, IC 201677, IC 201766, IC 208332, IC 208335), chickpea (NIC 23708), cowpea (EC 267704, EC 367690, EC 367881, NIC 23006, EC 390202, EC 390270, EC 381862, EC 381868, EC 387117, EC 390289, EC 390271), pea (IC 147907, EC 398539, EC 392975), *Brassica* (NIC 404, NIC 396) and high yielding types - maize (IC 130573, IC 130579, IC 130839, IC 130980), urdbean (PLU 203, PLU 204, PLU 250), lentil (NIC 22646, NIC 22647, NIC 9006), chickpea (NIC 18175, NIC 18170) and cowpea (NIC 22789, NIC 22794, NIC 22803). The list is far from complete and further information is available in NBPGR Newsletters, Annual Reports and Research Highlights.

Simple, rapid and standard methods and protocols were developed and used for phytochemical and biochemical evaluation of germplasm of economically important species. About 1850 accessions of economic crops, including medicinal and aromatic plants, namely, *Ocimum*, *Mucuna*, periwinkle, tinospora, vetivar, *Opium poppy*, *Celastrus*, walnut, guar, *Brassica*...
species, sunflower, sesame and chilli were evaluated for phytochemical contents of industrial use.

**Establishment of core collection**

Two core sets were developed, one each in sesame and mungbean, comprising 343 and 152 accessions, respectively. The designated core set of sesame was tested at four NBPGR regional centres, namely, Delhi, Akola, Jodhpur and Thrissur during Kharif, 1997 for validation and verification. Similarly, the core set of mungbean was grown at Amravati station for validation and verification. Genetic diversity and patterns of variation among the core entries were studied using morphometric data by uni-, bi-, and multivariate statistical analyses, which enabled identification of clear groups for use of representative germplasm.

**Documentation and information management**

The objective is to make the information, generated through characterization and evaluation, available to users for a sustainable use of collections. The NBPGR has so far published 71 crop germplasm catalogues, which describe nearly 80,000 accessions and has developed computer data files for several accessions. Seven crop catalogues were published during this period, which covered safflower, horsegram, eggplant, maize, wild okra, mungbean and lentil. These descriptors included description of passport data, diversity, patterns of variation and selected queries for promising accessions.

A local area network (LAN) has recently been established at the Bureau's Headquarters for exchange of information on PGR across different divisions. Internet and Email facilities have also been provided through VSAT. This will ensure updating the knowledge of scientists in PGR by capturing the required literature on various PGR aspects after being hooked-up to different web sites on the Internet. A web page on the internet projecting introduction to the Bureau and depicting its various activities at the headquarters and regional stations has been created. The NBPGR Home Page can be accessed at http://nbpgr.delhi.nic.in

A computer programme "AUGMENT 1" has been developed at the NBPGR, for analysis of Augmented Randomized Complete Block Design. This programme is now being used in different institutes/universities/research centres. Development of a directory for central database is in process, which aims to help in systematic documentation of the various activities of NBPGR. It is envisaged to finalize the 'Data Directory' on centralized database. The database will bring the entire data relating to the germplasm material conserved in the genebank and also Offices/Divisions to a single platform, to ensure smooth information flow. Developing software package for the centralized database and bringing out electronic catalogues on different crops are some of the future priorities of the NBPGR.

**Documentation of genebank holdings**

Data pertaining to all the accessions stored in the National Repository is documented on the computer. These include passport and evaluation data and the genebank data (germination percentage, moisture, storage data, etc.). The information on specific accessions is depicted in the bar-coded label on the container. Three sets of back-ups of all accessions are kept to safeguard the database against natural calamities like system failure, fire, etc.

**PGR conservation**

**National ex situ base collection**

*Long-term seed bank:* The national genebank at NBPGR represents one of the well equipped and one of the best organized facility for ex situ PGR conservation in the world. In terms of its holdings (169,529 accessions as on 31 August, 1998), this genebank is ranked fourth, following the national genebanks of the USA, China and Japan. The growth of ex situ holdings in the National Genebank at NBPGR in the recent past is sizable, which is clear
from the quantum jump of 32 510 accessions since the last South Asia Coordinators (SAC) meeting (Fig. 3).

The category/crop-wise holdings in the NBPGR base collection (-20°C) as on 31 August, 1998 include cereals and pseudocereals (73447), millets and minor millets (16586), fibre crops (6402), oilseeds (24907), pulses (27172), others (forage crops, narcotics, genetic stocks and registered germplasm (881), vegetables and spices (9347), released varieties (949), medicinal and aromatic plants (567), and safety duplicate samples at ICRISAT and ICARDA (9271).

Strengthening of genebank infrastructure: The ex situ conservation of genetic resources in the eighties was carried out with the help of a self-contained, cold storage module having two compartments with a storage capacity of 30 000 accessions; one maintained at -10°C and another at +5°C. As the inflow of germplasm increased over the years, additional storage space was created by acquiring 4 cold storage vaults (2 of 100 m³ and another 2 of 176 m³ volume) with a storage capacity of 250 000 accessions, which were then maintained at -20°C for the long-term. Subsequently, 12 long-term and one medium-term modules were added under a joint INDO-USAID Project. One medium-term module was also added under the G-15 project for the conservation of medicinal and aromatic plant germplasm. The ex situ seed repository, now comprising 14 long-term modules and 5 medium-term modules, has a total storage capacity of more than one million accessions. It is one of the largest and most advanced ex situ conservation facility in the world, which has, besides the cold storage modules, the infrastructure for processing of agri-horticultural plant germplasm as well as for conducting basic research in germplasm conservation, seed physiology and biochemistry.

Processing of germplasm for long-term storage: Maintenance of high germination potential of accessions held in long-term storage is one of the basic requirements of conservation. All accessions before storage in long-term modules are tested for viability and seed moisture content. The standard for acceptance of samples for long-term storage is a minimum of 85% normal germination. The seed is also dried to moisture content of 3-7% before it is hermetically sealed and stored. For drying the seeds to this level, a special seed dryer is used at a temperature of 15°C and 15% RH. Germplasm holdings are monitored for viability after a particular storage duration depending on certain factors, including the inherent storage
characteristics of the species, the initial viability, the storage conditions, etc. Eventually, the conserved accessions have to be subjected to regeneration and replenishment when their viability drops to 80 per cent.

*Studies on weight/volume relationships in agri-horticultural crops:* The weight-volume relationship was studied in 26 crop species, including barley, maize, paddy and wheat among cereals; Italian millet, Japanese millet, finger millet, kodo millet, little millet and proso millet among minor millets; *Brassica*, groundnut, safflower, sesame and sunflower among oilseed crops; mungbean, urdbean, mothbean, rice bean, adzuki bean, French bean, cluster bean and sunhemp among pulses and legumes and buckwheat among pseudocereals. This study showed a strong positive correlation in majority of the crop species, except finger millet and Italian millet.

*Critical evaluation of seed deterioration in different crops:* These studies were undertaken with the objective of working out the optimum storage conditions for some of the important agri-horticultural crops. Freshly harvested seeds of pearl millet cv. BD-23, brinjal cv. Pusa Purple Long and mustard cv. Pusa Bold were used. Seeds of pearl millet and brinjal were conditioned to 10, 7, 5 and 2.5% moisture content (m.c.), whereas those of mustard were conditioned to 15, 10, 7, 5, 2.5 and 1% m.c. The lots were packed in laminated aluminium foil packets and sealed and kept for conservation at ambient, 20±2°C, +4°C, -10°C and -20°C and monitored for their vigour and viability at three-month intervals. The studies showed that the *Brassica* seed stored with 15% m.c. retained 80% viability at +4°C for nearly 15 months, whereas at other temperature regimes their viability was completely lost within one year. Seeds with 10% m.c. retained good viability for nearly a year at ambient conditions and for 18 months at a controlled temperature of 20°C. At other temperatures, the viability loss was gradual. Further reduction in m.c. resulted in maintenance of viability for a long duration (>80% for about 27 months) even at ambient temperatures. A shift in the temperature from fluctuating ambient to constant 20°C further improved the storability of these seeds which could be stored successfully for about 8 years with good viability. At other moisture levels, i.e., 5, 2.5, and 1%, the seeds were found to retain high viability till date, over 9 years after the initiation of the experiment, although the ultra desiccated seeds have been consistently showing lower vigour.

Seeds of pearl millet and brinjal stored with 10% m.c. retained their viability for 36 and 18 months, respectively, at ambient conditions. Those with lower moisture, especially 5 and 2.5%, showed good storability at all temperatures, including the ambient conditions.

*Ultra desiccation as a cost effective conservation technique:* Seed storage is the cheapest and most reliable method of conserving genetic resources of many plant species. Seeds of majority of cultivated plant species show orthodox storage characteristics (can be dried to low m.c. without loss in viability). It has been shown that at a given temperature, there is a logarithmic relationship between longevity of orthodox seeds and storage m.c. In order to study the usefulness of ultra desiccation for safe and cost effective storage of seeds, studies on the effect of ultra desiccation on longevity were carried out on soybean, pearl millet, chickpea, cotton and sesame. Results so far revealed that desiccation of seeds to below 4% m.c. significantly enhanced the storage life of all the crops studied both under accelerated ageing and ambient conditions. Pearl millet seeds with 3.5% m.c. stored under ambient conditions in aluminium foil pouches showed no significant decline in viability even after 72 months. However, for seed lots with 6.0 and 8.1% m.c. the viability dropped from 95 to 88 and 84%, respectively, during the same storage period. In soybean, seeds of variety PB 1 and PK 472 were dried to 3.5, 4.2, 6.0, 8 and 10% moisture. Seeds at 3.5 and 4.2% m.c. did not show any significant decline in viability even after 68 months of storage. Seeds of variety PB 1 with
3.5% m.c. stored under ambient conditions in aluminium foil pouches recorded 84% germination whereas seed kept at 4°C maintained 92% after 68 months. In cotton, at 10% m.c., the viability declined to 10% after 2 years of storage at ambient conditions, whereas seeds at 5% m.c. retained 80% viability under same storage conditions. Chickpea seeds did not show decline in viability one year after storage at ambient conditions and seed m.c. of 8% and below. In sesame, seeds at 9% m.c. lost viability completely within 7 months of storage but those at 4.5% retained over 92% viability at ambient conditions during same period. These results point towards the beneficial effect of ultra drying in significantly enhancing the longevity of orthodox seeds especially at ambient temperatures.

Seed dormancy: The problem of seed dormancy needs considerable attention in genebanks not only because it can seriously interfere with the results of germination tests designed to assess the viability of accessions but it can also reduce the amount of precious seeds at the time of regeneration, multiplication or other purposes. Therefore, when seeds are sent from a genebank, donar institutions should also send information on special technique(s), if any, needed to break the seed dormancy. Various protocols have been worked out for overcoming dormancy in many crop seeds where dormancy was encountered while testing them for initial viability (Table 6).

Table 6. Protocols for overcoming seed dormancy in different crops

<table>
<thead>
<tr>
<th>Species</th>
<th>Substrate</th>
<th>Temperature</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abelmoschus moschatus</td>
<td>TP/BP</td>
<td>25°/30°C</td>
<td>Sand paper scarification</td>
</tr>
<tr>
<td>Abutilon indicum</td>
<td>TP</td>
<td>25°/30°C</td>
<td>Sand paper scarification</td>
</tr>
<tr>
<td>Achillea species: A. asiatica, A. falcata</td>
<td>TP</td>
<td>20°C</td>
<td>Sand paper scarification</td>
</tr>
<tr>
<td>A. borealis, A. nobilis</td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. filipendiulina, A. santolina</td>
<td>agar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. lanulosa and A. bibersteinii</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asparagus racemosus</td>
<td>TP</td>
<td>20°C</td>
<td>Wet chilling (-20°C for 2 days)</td>
</tr>
<tr>
<td>Bunium bulbocastanum</td>
<td>TP</td>
<td>20°C</td>
<td>Wet chilling (-20°C for 2 days)</td>
</tr>
<tr>
<td>Cassia occidentalis</td>
<td>TP/BP</td>
<td>25°C</td>
<td>Sand paper scarification</td>
</tr>
<tr>
<td>Datura metel</td>
<td>TP</td>
<td>25°C</td>
<td>Sand paper scarification</td>
</tr>
<tr>
<td>Glycyrrhiza glabra</td>
<td>TP/BP</td>
<td>25°C</td>
<td>Acid/ sand paper scarification</td>
</tr>
<tr>
<td>Mucuna pruriens</td>
<td>BP</td>
<td>25°C</td>
<td>Cutting</td>
</tr>
<tr>
<td>Ocimum sanctum</td>
<td>TP</td>
<td>25°C</td>
<td>0.2% KNO₃ + light</td>
</tr>
<tr>
<td>Potentilla fulgens</td>
<td>TP</td>
<td>20°C</td>
<td>Wet chilling (-20°C for 48 hr)</td>
</tr>
<tr>
<td>Plantago lanceolata</td>
<td>TP</td>
<td>20°C</td>
<td>Wet chilling (-20°C for 48 hr)</td>
</tr>
<tr>
<td>Solanum viarum</td>
<td>TP</td>
<td>25°C</td>
<td>Acid scarification/GA3 (500 ppm over night)</td>
</tr>
<tr>
<td>Tagetes minuta</td>
<td>TP</td>
<td>20°C</td>
<td>Wet chilling (-20°C for 48 hr)</td>
</tr>
<tr>
<td>Vernonia anthelmintica</td>
<td>TP</td>
<td>25°C</td>
<td>Wet chilling (-20°C for 48 hr)</td>
</tr>
<tr>
<td>Psoralea corylifolia</td>
<td>TP</td>
<td>25°C</td>
<td>Acid/ sand paper scarification</td>
</tr>
</tbody>
</table>

TP = Towel Paper, BP = Blotter Paper

Cryobank
Cryopreservation i.e. storage of biological samples in viable condition at ultra low temperatures in liquid nitrogen (-196°C to -150°C), opened up possibilities of storage of seeds, particularly those of difficult materials like sub-orthodox and recalcitrant seed species and pollen. It is now considered an effective technology for the long-term preservation of germplasm in the coming years.
The cryopreservation work at the NBPGR has been undertaken on following lines: 

Development/standardization of cryopreservation protocols for orthodox seed species and to conserve their germplasm in the cryobank: About 400 seed accessions (40 sp. belonging to 20 genera) representing all major crop groups such as cereals, millets, vegetables, oilseeds, medicinal and aromatic plants have been cryopreserved at optimum moisture content of 5 to 8% in vapour phase of liquid nitrogen. Tests conducted at different times after storage revealed that the seed viability and seedling vigour remained unaltered with time in all the species. The status of cryopreservation of orthodox seed species is given in Table 7.

Table 7. Status of cryopreservation of orthodox species

<table>
<thead>
<tr>
<th>Crops/ crop groups</th>
<th>Species</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals and millets</td>
<td>Eleusine, Fagopyrum, Oryza, Panicum, Paspalum, Pennisetum, Triticum, Zea</td>
<td>210</td>
</tr>
<tr>
<td>Pulses</td>
<td>Cicer, Phaseolus, Vigna, Rhyncosia</td>
<td>117</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Abelmoschus, Allium, Daucus, Lycopersicon, Pisum, Solanum</td>
<td>254</td>
</tr>
<tr>
<td>Horticultural crops</td>
<td>Citrus, Cucumis, Musa, Pyrus</td>
<td>28</td>
</tr>
<tr>
<td>Spices and condiments</td>
<td>Carum, Coriandrum, Elettaria</td>
<td>59</td>
</tr>
<tr>
<td>Medicinal &amp; aromatic plants</td>
<td>Andrographis, Anethum, Chicorium, Catharanthus,</td>
<td>367</td>
</tr>
<tr>
<td>Oilseed crops</td>
<td>Digitalis, Foeniculum, Mentha, Ocimum, Papaver</td>
<td>208</td>
</tr>
<tr>
<td>Total</td>
<td>1 243</td>
<td></td>
</tr>
</tbody>
</table>

Development of protocols for cryopreservation of recalcitrant seed species and establish the base collection of embryos/embryonic axes: A large number of economically important plant species possess seeds, which due to their large size and desiccation/freezing sensitivity are sub-orthodox or recalcitrant in nature. Cryopreservation, being the only alternative for long-term storage of such germplasm, has been applied to tea, jackfruit, litchi, neem, almond, black pepper and cardamom and the status of their cryopreservation is given in Table 8. In the simplified method, embryos/embryonic axes were excised from the seeds, desiccated in sterile conditions and plunged into liquid nitrogen. Protocol for successful cryopreservation of embryonic axes of tea, jackfruit, neem and almond and of whole seeds of black pepper and cardamom have been devised. Eighty-five accessions of tea collected from North Eastern and Southern regions of the country, nine accessions of almond and 10 species of Citrus have thus been cryopreserved. In addition, cryopreservation protocol has been standardized for litchi (Litchi chinensis), trifoliate orange (Poncirus trifoliata) and wild banana (Musa bulbisiana).

Table 8. Status of cryopreservation of recalcitrant/intermediate seeds

<table>
<thead>
<tr>
<th>Crop</th>
<th>Species</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tea</td>
<td>Camellia sinensis</td>
<td>85</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>Artocarpus heterophyllus</td>
<td>3</td>
</tr>
<tr>
<td>Almond</td>
<td>Prunus amygdalus</td>
<td>7</td>
</tr>
<tr>
<td>Neem</td>
<td>Azadirachta indica</td>
<td>4</td>
</tr>
<tr>
<td>Cardamom</td>
<td>Elettaria cardamomum</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>101</td>
</tr>
</tbody>
</table>

Cryopreservation of pollen: Pollen from various crop species of importance to plant breeders, totalling 57 accessions have been cryopreserved in the base collection. These include Camellia sinensis (1), Cicer microphyllum (1), Sesamum sp. (1), Brassica sp. (11), B. oleracea var. italica (1), B. napus (4), B. campestris (10), B. carinata (2), B. juncea (10), B. nigra (1), Eruca sativa (2), Zea mays (3), Coix sp. (5), Teosinte (1), and Raphanus sativus (4).


Investigation of the biological mechanisms that determine the recalcitrance in seeds: Biochemical analyses of seeds and embryonic axes at different stages of maturity and after desiccation and freezing revealed that the loss of membrane integrity was the first probable change during desiccation of recalcitrant seeds. Tea, cocoa, jackfruit and litchi showed differential sensitivity to desiccation and freezing during different maturity levels.

In vitro genebank
Several species propagated vegetatively can not be conserved by conventional seed storage. For conservation of these crops, National Plant Tissue Culture Repository (NFPTCR) was created at NBPG in 1986 with the financial support from Department of Biotechnology, Government of India. Infrastructure for tissue culture was developed, and modern facilities created and germplasm of two dozen species established and successfully maintained under in vitro conditions, for short- and medium-term storage. During 1995-98, considerable progress has been made regarding in vitro conservation of germplasm of various crops.

Fruit crops
Tropical species: Suckers of several accessions of banana received from NBPG Regional Station, Thrissur, Kerala Agricultural University, Kannara and Regional Plant Resource Centre, Bhubaneshwar, Regional Research Laboratory (RRL), Jorhat, and Indian Institute of Horticultural Research (IIHR), Bangalore were introduced in vitro. Musa germplasm comprising local cultivars and synthetic hybrids obtained from International Network for Banana and Plantain (INIBAP), were also grown in culture. These accessions have been certified as free from commonly occurring viruses such as BBTV, CMV, BSV, etc. The new collections represent local cultivars of desert and vegetable types. In all, 270 accessions of Musa comprising wild (15) and cultivated (255) types were maintained at 25°C by periodic subculture (12-22 months).

Temperate species: One accession each of apple rootstock and kiwi fruit procured from Y.S. Parmar University of Horticulture and Forestry, Solan were introduced in vitro. Experiments are continuing to standardize multiplication protocol for the former and rooting of in vitro shoots, in the latter. Shoot cultures of kiwi fruit could be conserved for 6 months at 25°C. Effect of low temperature on storage of in vitro cultures of blackberry, strawberry, raspberry, grapes and Citrus was investigated. These crops could be successfully conserved at 4-10°C for 8 to 16 months. Cryopreservation experiments were also carried out in the above crops. In blackberry, cryopreservation protocol has been standardized using encapsulation-dehydration technique.

Spice crops
Zingiber species: A total of 145 accessions of five species of ginger were maintained as tissue culture by periodic subculture (8 months). With induction of in vitro rhizomes, shelf life of cultures could be extended to 24 months. Cryopreservation of shoot tips and buds (from in vitro rhizomes) was attempted following encapsulation-dehydration, encapsulation-vitrification and vitrification techniques. Plantlets could be recovered (4%) only from those shoot tips/buds which were subjected to vitrification. However, attempts are continuing to standardize the protocol for successful cryopreservation of ginger.

Curcuma and Piper species: Following the techniques of in vitro multiplication, 40 accessions of Curcuma comprising seven wild species were maintained in the repository with the average subculture period ranging from 6 to 10 months. In Piper, seven species were conserved for 10-22 months in the culture room at 25°C. Using leaf explants, somatic embryogenesis in P. nigrum and direct regeneration protocol in P. colubrinum and P. hapnium are being attempted.
Others: Multiplication protocol is being standardized in two new crops, *Vanilla plaxifolia* and *Elettaria* spp. procured from Indian Institute of Spices Research, Calicut.

**Tuberous crops**
*Ipomoea* species: In sweet potato, 22 new accessions in the form of *in vitro* plantlets were obtained from International Potato Centre (CIP), Lima, Peru. These were multiplied and established in the repository. A total of 260 accessions were maintained following regular subculture (12 months). Cryopreservation of *in vitro* shoot tips was achieved following vitrification. However, the survival frequency after exposure to liquid nitrogen was low and thawed shoot apices formed only callus.

*Dioscorea* species: Forty accessions of six *Dioscorea* species were maintained under ambient culture conditions for 12 to 14 months. Microtuber induction was achieved in five species following manipulation of temperature and light conditions. With microtubers, shelf life of cultures could be extended to 15-20 months. Following encapsulation-dehydration, cryopreservation of *in vitro* shoot tips was successful in *D. bulbifera, D. floribunda, D. wallichii* and *D. alata* with plantlet regeneration achieved in the latter two species. Employing vitrification, shoot tips of *D. alata, D. wallichii* and *D. floribunda* could be cryopreserved and plantlets regenerated from thawed shoot apices in the last two species.

*Xanthosoma, Colocasia* and *Alocasia* species: Micropropagation protocol was standardized for tannia (*Xanthosoma sagittifolium*) and three accessions were established in culture. Twenty one accessions of taro (*Colocasia* spp.) were multiplied and introduced *in vitro* whereas one accession of giant taro could be conserved for 8 months at 25°C.

*Coleus parviflorus*: Successful plantlet regeneration was achieved in this important tuber-bearing *Coleus* species and the regenerants established well in the soil.

**Bulbous crops**
In garlic (*Allium sativum*), 85 accessions were maintained *in vitro* for 16-20 months on high sucrose medium at 25°C. Many of these accessions failed to form bulblets under ambient conditions. Alteration of nutrient medium had little effect on bulblet induction. Five semi-domesticated species (*A. tuberosum, A. bakeri, A. ascalonicum, A. carolinianum* and *A. ampeleoprasum*) procured from NBPGR Regional Station, Bhowali, could be maintained for 16-22 months at 25°C and 10°C. In several other species, *A. cernuum, A. oreoprasum, A. griffithianum, A. scorodoprasum* and *A. lineare*, shoot or plantlet regeneration has been achieved and cultures are kept for storage in the culture room and at low temperature. In selected *Allium* species, cryopreservation experiments continued to optimize pre-culture conditions, dehydration time and growth media using encapsulation-dehydration technique.

*Endangered medicinal and aromatic species*: Two accessions of *Eremostachys*, an endangered medicinal plant received from Botany Department, Delhi University, were introduced in culture. Shoot cultures of 20 species of threatened medicinal and aromatic plants could be maintained for 5-22 months at varying temperatures (25°C, 10°C, 4°C). Important genera include *Valerian, Saussurea, Rauwolfia, Picrorhiza* and *Gentiana*. In the last three, inclusion of mannitol or high sucrose was beneficial in prolonging subculture period beyond 16 months. Of 21 accessions of *Mentha* received from USDA, Corvallis, USA, 18 have been successfully conserved for 12 months under culture room conditions.

**Other important crops**
In *Fagara schinifolia*, an important plant in perfume industry, shoot regeneration was achieved using axillary bud explants. *In vitro* shoots could be rooted and plantlets established in soilrite
at 27±2°C. In *Cicer microphyllum*, a cold-tolerant wild species, culture medium was optimized for shoot multiplication. Rooting of *in vitro* shoots on basal as well as growth regulator-supplemented media was very low. In *parwal* (*Trichosanthes dioica*), an important indigenous vegetable crop, *in vitro* multiplied shoots were rooted (90-95%) on basal medium. These cultures could be successfully conserved for 6 months on MS medium supplemented with cytokinins. The details of species kept in *in vitro* bank at NBPGR are presented in Table 9.

### Table 9. Status of *in vitro* conservation of different species

<table>
<thead>
<tr>
<th>Crops</th>
<th>Storage temperature (°C)</th>
<th>Optimum sub-culture interval (months)</th>
<th>No. of accessions in culture</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Allium sativum</em></td>
<td>25</td>
<td>16-20</td>
<td>85</td>
</tr>
<tr>
<td><em>Allium spp.</em></td>
<td>25, 10</td>
<td>12-22</td>
<td>14</td>
</tr>
<tr>
<td><em>Alocasia spp.</em></td>
<td>25</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td><em>Ipomoea batatas</em></td>
<td>25</td>
<td>12</td>
<td>260</td>
</tr>
<tr>
<td><em>Dioscorea spp.</em></td>
<td>25</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td><em>Curcuma spp.</em></td>
<td>25</td>
<td>6-10</td>
<td>40</td>
</tr>
<tr>
<td><em>Zingiber spp.</em></td>
<td>25</td>
<td>8, 24</td>
<td>145</td>
</tr>
<tr>
<td><em>Musa spp.</em></td>
<td>25, 15</td>
<td>12-22</td>
<td>270</td>
</tr>
<tr>
<td><em>Piper spp.</em></td>
<td>25</td>
<td>10-22</td>
<td>7</td>
</tr>
<tr>
<td><em>Citrus aurantifolia</em></td>
<td>25</td>
<td>10-12</td>
<td>1</td>
</tr>
<tr>
<td><em>Soft fruits</em></td>
<td>25</td>
<td>8-12</td>
<td>8</td>
</tr>
<tr>
<td><em>Actinidia chinensis</em></td>
<td>25</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><em>Rauvolfia serpentina</em></td>
<td>25, 15</td>
<td>15-22</td>
<td>6</td>
</tr>
<tr>
<td><em>R. canescens</em></td>
<td>25</td>
<td>15-20</td>
<td>1</td>
</tr>
<tr>
<td><em>Saussurea lappa</em></td>
<td>4</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td><em>Tylophora indica</em></td>
<td>10</td>
<td>12-15</td>
<td>2</td>
</tr>
<tr>
<td><em>Picrorhiza kurroa</em></td>
<td>10</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td><em>Gentiana kurroo</em></td>
<td>4, 25</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td><em>Pogostemon patchouli</em></td>
<td>25</td>
<td>11-18</td>
<td>2</td>
</tr>
<tr>
<td><em>Coleus forskohlii</em></td>
<td>25</td>
<td>9-10</td>
<td>8</td>
</tr>
<tr>
<td><em>Pelargonium spp.</em></td>
<td>25</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><em>Mentha sp.</em></td>
<td>25</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td><em>Other medicinal and aromatic plants</em></td>
<td>25</td>
<td>4-10</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>924</strong></td>
</tr>
</tbody>
</table>

### Field repositories

The NBPGR experimental farm at Issapur, New Delhi and its regional stations at Shimla, Jodhpur, Thrissur and Akola-Amaravati maintain field collections of perennial/tree species germplasm (fruits and ornamentals), which adds up to the cumulative effort for the national collection in the genebank (Table 10).

### Table 10. Field collections of different species maintained at different locations

<table>
<thead>
<tr>
<th>Location/Centre</th>
<th>Holdings</th>
<th>Plant species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issapur, New Delhi</td>
<td>305</td>
<td>Low chilling and minor fruits</td>
</tr>
<tr>
<td>Shimla</td>
<td>800</td>
<td>Temperate fruits, species of <em>Rosaceae</em></td>
</tr>
<tr>
<td>Jodhpur</td>
<td>350</td>
<td>Acacias, arid zone multipurpose trees, jojoba, <em>Euphorbia</em></td>
</tr>
<tr>
<td>Thrissur</td>
<td>539</td>
<td>banana, jackfruit, pepper, root and rhizomatous crops</td>
</tr>
<tr>
<td>Amravati</td>
<td>197</td>
<td><em>Simarouba</em>, minor fruits</td>
</tr>
<tr>
<td>Akola</td>
<td>62</td>
<td>-</td>
</tr>
<tr>
<td>Shillong</td>
<td>71</td>
<td>banana, guava, ornamentals</td>
</tr>
</tbody>
</table>
National Herbarium of Cultivated Plants (NHCP)
This facility is now an integral component of the national genebank at the NBPGR. A total of 12,671 specimens from 215 families, 1,086 genera and 2,665 species are represented in the herbarium. In addition, 2,053 seed samples as economic products, and some other display/specimens are maintained. During 1995-96, 260 specimens were added which represent material collected from Garhwal Himalayas, Bundelkhand region and eastern Uttar Pradesh. These include, Myrica, Gymnema, Buchnaria, Grewia, Astragalus, etc. Economic product represented the fruits of Dillenia, fibres of Grewia optica and ex situ samples of Abelmoschus. In 1996-97, 220 specimens were added, which include Cucumis hardwickii, C. sativus, Chlorophytum, Mucuna nigricans, Hydrocotyle, Manikara, etc. collected from Himalayan region, Uttar Pradesh, Madhya Pradesh and Southern region. In economic products, samples represented stem bark of Cinnamon, Listea; fruits of Caesalpinia, Illicium; roots of Cassia; gum of Azadirachta, Shorea, etc.; pods of Mucuna and rhizomes of Kaempferia, Alpinia etc. Similarly, during 1997-98, a total of 230 specimens were added which were collected during exploration trips and from regional stations. Interesting additions are species of Zizyphus, Crescentia, Hibiscus, Ocimum, Potentilla, Woodfordia, Evolvulus, Picrorhiza, Smilax, Hevea, etc.

Other PGR conservation areas

Medium-term conservation of active/working collections: Medium-term storage modules were provided at 11 different National Active Germplasm Sites. Appropriate training to their respective staff has also been given at NBPGR.

In situ conservation: a Citrus gene sanctuary was established in Nokrek biosphere reserve in Meghalaya, with the support of Ministry of Environment and Forests, under Man and Biosphere Reserve Programme of the United Nations. The basic information on resource potential was gathered/provided by the NBPGR/ICAR.

On-farm conservation: Studies have been initiated on rice-wheat system in the northern fertile plains and on tribal area crops in selected areas in the Deccan plateau.

Registration of plant germplasm
Need for registration of plant germplasm has been felt with a view to accord due recognition to improved strains of crops which do not qualify for release as varieties but are important for future use. Most of such valuable materials either remain unused/underutilized or get lost. With the commitment towards CBD's provisions of sustainable use of germplasm, recent developments concerning IPR and other related issues, due recognition of these materials has become all the more important.

Keeping these considerations in view, the Indian Council of Agricultural Research (ICAR) approved the registration of value-added germplasm at NBPGR, which is being implemented since 1996. The response had been very good and 119 applications were received, out of which 16 germplasm accessions in eight crops have been registered (Table 11). The guidelines for submission of application along with material have also been widely circulated for use by interested individuals/organizations.

Promoting germplasm use - proactive role
In view of the significant role in providing a wide and firm base to the crop improvement and other technologies, including biotechnology based research, the NBPGR has actively promoted their sustainable use in the following ways:

a) Field days are organised at the germplasm evaluation sites and the international nurseries. The participants from different organizations make selections of materials, suited to their specific requirement, based on performance of accessions in the standing crop. Subsequently, the seeds of requested materials are supplied to them after the crop harvest.
b) The scientists from NBPGR participate in the Annual Workshops/Group Meetings of the All India Coordinated Research Projects for various crops/crop groups and presented PGR status reports in these workshops and also promote PGR literacy in new areas.
New areas related to PGR
The NBPGR responds to the need based subject matter input on wide ranging matters related to PGR policy, such as, Global Plan of Action, International Undertaking on PGR, Convention on Biological Diversity (CBD) and its instruments, like Conference of Parties (CoP) and Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to the CBD, National Biodiversity Legislation, National Plant Quarantine System, Plant Germplasm Registration and other such issues that emerge from time to time.

In order to sharpen its focus, the NBPGR has undertaken certain specific activities, which include: i) organizing workshops/meetings on PGR related issues, ii) participation in meetings/subject matter workshops within the country, and iii) participation in international events/regional fora. Particular issues that have been addressed during the recent past include: i) regulation of exchange of Genetically Modified Organisms GMOs, ii) containment facility for post-entry quarantine of transgenics, and iii) other issues (terminator technology; patenting of Indian landraces/varieties outside the country, etc.).

A national workshop on conservation, management and sustainable use of agrobiodiversity was jointly organized by the NBPGR and the National Academy of Agricultural Sciences (NAAS) on October 15-16, 1997, which attracted wider participation of all stakeholders, namely the ICAR, the Ministry of Environment and Forests, the State Departments, agricultural/horticultural/forestry universities, NGOs and the private sector. The main objective was to arrive at a national consensus on policy issues related to agrobiodiversity/PGR. A national policy paper has already been published by NAAS on the basis of recommendations of the workshop and the proceedings are being processed for publication.

NBPGR has played a distinct role in providing subject matter input on PGR policy areas both nationally and at the global level. The country status report on agrobiodiversity was presented by the Director, NBPGR at Bratislava, Slovakia during the Fourth Meeting of the CoP in which, NBPGR represented the country delegation. During the meeting, India called for making the International Undertaking as a protocol to the CBD which was supported by Morocco, Tanzania and Ethiopia. India also reiterated the need for harmonizing IPRs regime under TRIPS with the CBD, protection of landraces and also appropriate compensation to those who are growing these, expeditious resolution of the issue relating to pre-CBD ex situ collections. The issues of technology related to control of plant gene expression (e.g. terminator technology) and the consequences of its use, financial mechanism to support capacity building were also particularly raised during the CoP-IV meeting, which are of common interest to the South Asian countries.

Biochemical and molecular characterization and DNA finger printing
In order to address the research and services area related to molecular characterization and DNA fingerprinting, a National Research Centre on DNA Fingerprinting was established by the ICAR at the NBPGR, New Delhi in December 1995. It included the following broader mandate related to PGR: a) development of molecular marker systems for DNA profiling of genetic resources, b) DNA fingerprinting of released varieties, parental lines of hybrids, elite strains/genetic stocks of potential value in agri-horticultural crops, c) construction of molecular maps and tagging genes of economic importance in selected crops, and d) genetic diversity and relationship analysis in selected plant species.

Molecular characterization of black gram and green gram varieties
Procedure for PCR amplification of purified DNA using random primers were optimized for V. mungo, V. radiata. Fortyfive random 10-mer primers were used for PCR amplifications of the genomic DNA from the varieties studied. Twelve of the primers were found to yield polymorphic amplification products and six other primers gave moderately polymorphic
products. The information generated is being used to develop DNA fingerprints of the *Vigna* cultivars. Eighteen varieties of *V. radiata* were also analyzed using RAPD technique. Six of primers yielded polymorphic products indicating comparatively moderate variation prevalent among the varieties analyzed.

**Analysis of genetic diversity in sesame (Sesamum indicum L.)**

A random sample of 58 sesame accessions collected from 18 states of India and 23 different sesame growing countries was used for assessing the range of diversity for molecular traits. RAPD technique was used for the analysis. Results indicated the presence of high genetic diversity in Indian collections and the range was greater than that predicted on the basis of evaluation for morphological traits. The collections from Rajasthan and Northeastern states of India were more diverse compared to those from other provinces and countries.

**DNA fingerprinting of safflower varieties**

Varietal heterogeneity and uniqueness are being investigated using RAPD technique. The level of polymorphism at RAPD loci analyzed among the 14 cultivars was moderate. So far 40 primers have been screened and only 12 were found polymorphic.

**Characterization and identification of onion (Allium cepa L.) cultivars**

Onion cultivars having distinct morpho-agronomic traits were analyzed using DNA amplification fingerprinting techniques. The primers (21 and 22 base long) designed to amplify specific simple sequence repeat loci in banana were tested individually and in pairs for PCR amplification using total genomic DNA of onions as templates. Cultivar specific patterns were obtained using these longer primers. The primers employed were also found useful for assessing diversity analysis in onions.

**DNA fingerprinting of tomato varieties**

RAPD protocol has been established for PCR conditions and component concentrations in the reaction mixture. Randomly selected 40 plants of Pusa-120 variety were analyzed for intra-varietal variation employing 5 fortuitously selected random primers [A-11, E-19, E-09, D-12, B-01 (Operon)] out of which only one primer [E-09] showed one polymorphic amplicon distinguishing 3 plants from the rest. Similar experiments were repeated in Arka Vikas and a hybrid Arka Shrestha, to ascertain the results. RAPD analysis is in progress in 15 tomato varieties.

**Thrust on underutilized crops**

An All India Coordinated Research Programme on Underutilized Crops is operating at the NBPGGR since 1982. It was conceived by the Bureau with the aim to fill the gaps in research on crops of future importance, which are presently being cultivated in limited pockets in few areas. This project is supported by the Bureau by providing testing facilities at five of its regional stations besides a regular contribution and lead in terms of PGR augmentation and evaluation. Bureau has selected/developed improved varieties in grain amaranths, buckwheat, winged bean and jojoba, which were identified and released in the regular ICAR channels. Two varieties have been identified in fababean (VH-82-1) and ricebean (PRR-1) and further two varieties released, one each in ricebean (PRR-2) and buckwheat (PRB-1), under this programme.

**Human resource development (HRD) on PGR**

The NBPGGR has developed its capabilities and strength in this particular area of PGR in three different ways, as follows:
In-country training: Training of scientific and technical manpower engaged in various PGR activities in the country, at NBPGR by its own staff and some invited faculty. Bureau is now capable and well equipped for undertaking regional level training programmes in PGR conservation and management. IPGRI may consider arranging funding support through appropriate/interested donor(s) to organize trainings at NBPGR on a periodical basis.

Post-graduate studies in PGR: A postgraduate degree leading to M.Sc. in Plant Genetic Resources has started at NBPG since 1997 in collaboration with Post Graduate School, IARI, New Delhi. It has a provision of three seats at present. Keeping in view the needs of countries in the region for human resource development in PGR, specific request from Governments can be considered to reserve a slot each for the students nominated by them on a regular basis. NBPG has made specific request to IPGRI to consider sponsoring one M.Sc. (PGR) student at NBPG by way of a Scholarship.

Agricultural human resource development (AHRD): The NBPG is already conscious of the need to orient its scientific and technical staff, on a rotational basis, towards the recent developments in the field of PGR augmentation, conservation, sustainable use, policy and research. Majority of the Bureau’s scientists have been exposed to the best PGR laboratories in the world from time to time. NBPG/ICAR will be ready to consider requests from the countries in the region to provide short-term orientation to their PGR staff.

Collaboration, linkages and PGR policy issues
The NBPG maintains active collaboration and liaison with all stakeholders in the country and also collaborates with the regional fora and international institutions/organizations on all matters of mutual interest, related to PGR. The collaboration with the Plant Protection Advisor, Government of India, relates to the quarantine of incoming and outgoing germplasm for research purpose. NBPG is a designated nodal national agency for exchange of plant material. The Director, NBPG is the competent authority to regulate importance of seeds/plants for research purposes into the country. Similarly, the requests to import transgenic material, are routed to Director, NBPG through Advisor, Department of Biotechnology (DBT), Ministry of Science and Technology, New Delhi.

The NBPG has active collaboration with Ministry of Environment and Forests (MoEF) which is the nodal agency for matters concerning the CBD and has undertaken several projects/activities of mutual interest with the MoEF. The first gene sanctuary on Citrus genetic resources has been established in the Nokrek Biosphere Reserve in Meghalaya on the basis of research data provided by the NBPG/ICAR. The NBPG has provided input in formulation of draft for the national Biological Diversity Legislation. The NBPG was part of country delegation in fourth CoP meeting held at Bratislava during May, 1998, besides participation in several international meetings related to PGR.

The NBPG collaborates with the CGIAR institutes/International Agricultural Research Centres (IARCs) e.g. ICRISAT, for joint explorations and multilocation evaluation of chickpea, pigeonpea, groundnut, sorghum and pearl millet, safety duplication of pigeonpea; ICARDA, safety duplication of lentil and germplasm exchange; IRRI, CIMMYT, INIBAP, IJO, AVRDC, for germplasm exchange and orientation of scientific staff, etc. NBPG collaborates with over 82 countries in the world, prominent ones being USA, UK, Mexico, Israel, Australia, Russia, New Zealand, Iran, Turkey and Zimbabwe.

Collaboration with IPGRI merits specific mention. The IPGRI has played significant role to support the Bureau’s efforts by offering expertise, training and funding for research. Its office for South Asia is also located in the NBPG campus. In addition to supporting joint exploration and collecting programmes in this region, the IPGRI has funded projects on core collection, cryopreservation, etc. Under the MoU for scientific and technical cooperation
between ICAR and IPGRI, the International Network for Improvement of Banana and Plantain (INIBAP), a programme of IPGRI, a workplan of cooperation has recently been agreed. INIBAP proposed to provide virus tested banana germplasm comprising popular varieties, hybrids, disease and pest-resistant cultivars for conservation and dissemination and also to help NBPGR with virus indexing of its in vitro collection by providing assistance in obtaining appropriate antisera and protocols.

Under the bilateral programmes, an INDO-USAID project has been successfully completed over a period of 9 years. The project was implemented to enhance NBPGR’s infrastructural facilities and professional competence to enable it to play an enhanced role at the regional and international level. The project had helped in strengthening research linkages between NBPGR and US National Plant Genetic Resources System. The ODA/DFID funded Indo-UK Project on PGR, aims at strengthening the network of regional stations by providing medium-term storage facilities, essential equipments and training.

NBPGR is willing to support/assist the smaller NARS in the region for strengthening their institutional capabilities in the area of PGR and human resource development. IPGRI may consider support to such joint ventures, particularly for arranging the funds.

**New thrust - National Agricultural Technology Project on PGR**

Realizing the importance of management of plant biodiversity, search for new genes, documentation of the indigenous technology knowledge (ITK) and ethnobotanical information, bio-prospecting, safe conservation of plant biodiversity, development of a national database on plant biodiversity and public awareness/training in the area of plant genetic resources, NBPGR has conceived and proposed a project on PGR under the National Agricultural Technology Project (NATP), launched by the ICAR with the world bank support. The activities under the project include: (i) survey, inventorization and germplasm collecting, (ii) germplasm maintenance/regeneration, evaluation and genetic enhancement, (iii) conservation of plant biodiversity, and (iv) documentation and information management. All the four main activities shall include need based, carefully planned on-job orientation-cum-training and human resource development (HRD) components.

**Future outlook for regional cooperation**

The future outlook of the PGR activities and projections at large includes the following components, which may also reflect the areas of cooperation in the region:

**Strengthening linkages on PGR**

Germplasm needs to be assembled from different stakeholders in National PGR Programmes in the national genebank, botanical gardens, private sector holdings, sacred groves, in situ on-farm conservation sites, IARCs all together should be brought in the purview of ‘collectively responsible units’ for PGR conservation and sustainable use. The system and the nodal elements need to be duly recognised to maintain/strengthen efficiency and transparency.

**Evaluation, valuation and characterization**

There is a need for evaluation for agronomic traits, biotic and abiotic stresses, phytochemical and molecular attributes in an environment friendly way. Specific germplasm need to be identified for saline/alkali/acidic soils/water stress/water logged areas/low input conditions, value addition, diversification. Due emphasis needs to be given on core collections, pre-breeding/genetic enhancement, germplasm valuation and validation of ITK.
Conservation

Ex situ conservation in seed repository of the national genebank at NBPG can serve as a model/buffer for the regional NARS. Areas needing added emphasis in future include, cryopreservation, in vitro conservation, DNA bank, genetic stability and seed physiology, conservation technology, in situ/on-farm conservation model(s) and participatory practices.

Exploration and collecting

For exploration and collecting in future, there is need to look for traits of economic value. Unexplored pockets/areas need to be covered and joint explorations need to be attempted specifically in the SAARC, Middle East, African and South American regions.

Quarantine, phytosanitary regulations and biosafety

There is a strong need to think and act with a regional perspective in mind, keeping in view the unknown/potential hazards from exchange of the products of new technology.

Using advanced information technology

Developing/strengthening know-how, do-how and cooperation, should be given due emphasis.

Human resources development

Sustained literacy campaign on emerging areas needs to be given attention.

PGR policy issues

There is a great need for developing biosafety measures, undertaking pest risk analysis (PRA) and implementing the CBD provisions in a transparent and equitable manner.

Recommendations

In view of the existing PGR scenario vis-à-vis responsibilities conferred upon countries as per the CBD provisions and the prevailing IPR regimes/obligations, and keeping in view the strengths and weaknesses of NARS set-ups, the IN-PGRS is committed to enhanced cooperation and coordination in the region with appropriate support from the global system, including IPGRI. The following recommendations are made:

- A South Asian Regional Genebank may be established at the NBPG. It can foster the conservation needs for crops of regional priority as defined by IPGRI from time to time (in Directories of PGR collections).
- There is an urgent need to develop consensus on germplasm exchange based on prior informed consent, germplasm collecting and sharing. Biopiracy in the region may be jointly addressed.
- A Regional Plant Quarantine Network needs to be established. There is a need to regulate exchange of in vitro materials and GMOs through strict quarantine and maintaining biosafety regulations.
- There is a need for sharing of expertise for PGR conservation and management. Sustainable use of genetic resources should receive national attention as well as a regional priority. It is, therefore important that the expertise available in the region, such as that at the NBPG, may be engaged/shared for developing appropriate multi-year programme(s) of work with defined priorities over time, including case studies and suitable monitoring indicators.
- NBPG offers to provide a lead role in terms of drafting/formulating regional stand on unresolved PGR related issues in the revision of international undertaking on plant genetic resources and implementation of the CBD guidelines, i.e., at the CoP, the SBSTTA and the Clearing House Mechanism (CHM). It is important to develop
a consensus and then present the regional viewpoint that would go a long way for the posterity, in such fora of benign importance to the humankind. The need for a Regional Clearing House Mechanism is also felt.

Acknowledgements
Contribution made by Heads of the Divisions/Units and Scientists of the NBPG in their respective PGR areas of work are appreciated. Assistance provided by Dr Sudhir Kochhar, Senior Scientist, Project Policy Planning and Technical Coordination Unit in compilation of this report is acknowledged.
Plant genetic resources activities in Nepal

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Introduction
The empirical approach of conserving any biological entity as a source of genes and to save it from extinction is being gradually realized not only in the developed countries but also in developing countries of Asia, Africa and Latin America which possess vast reservoir of plant gene pools. The Convention on Biological Diversity (CBD) held in Rio de Janeiro, Brazil in 1992 was a milestone to create awareness, utilize and conserve biological resources for the betterment of humankind. About half a century ago, a historical pioneer of plant science, N. I. Vavilov, identified the Indian sub-continent as one of the centre of crop plant diversity for some important crops. Of the 2 400 cultivated plant species as accounted by Zeven and de Wet (1982), about 1 200 plant species are recorded in this sub-continent. This diversity undoubtedly encompasses cereals, coarse grains, vegetables, fruits, forages, fibers, spices, aromatic plants and their wild relatives.

Nepal, a landlocked country sandwiched between India in the south and China in the north, is yet unexplored for many crop species. The greatest opportunity for this country is its varied climate, contributing to the development of a wide range of plant genetic variability both at species and within species level and their conservation and utilization. From near sea level to almost 14 000 ft offers a diverse climatic pattern. The fauna and flora, therefore, have an ample prospect to flourish within a small distance. Nepal has about 42% forest, of which real forestland is 37% and shrub land 4%. Total agricultural land is nearly 46% but the cultivated land is only 26%, pasture 6.5%. Lastly, Nepal possesses a vast area of melting snow peaks to the tune of nearly 30%.

Historical perspective of PGR activities in Nepal
Importance of the conservation of plant biodiversity was realised not very long ago. In fact, this realization came into action only with the establishment of International Board for Plant Genetic Resources (IBPGR) in the early seventies at international level under FAO. In reality, only in the early eighties, the then Department of Agriculture initiated the activity to collect and preserve germplasm with the responsibility given to Agricultural Botany Division. The historical account shows that several foreign collecting missions were involved to collect and conserve plant resources of Nepal. The first was a German missionary Herrlich in 1937-38. Later in 1952-53, a Japanese team led by Prof. Kihara of Kyoto University, collected a good number of plant resources and published two voluminous books under the name ‘Fauna & Flora and Peoples of Nepal Himalaya’. British scientists J. R. Witcombe and A.M. Martimore in 1971 and L.W. Beer in 1975 further added to the collection of native crops. Similarly, IBPGR since 1979 continued exploration and collecting activities.

Noteworthy is the work of FAO expert Peter Whiteman who continued to work at Jumla, one of the remote parts of Nepal in mid seventies and brought the issue of conserving crop germplasm to the attention of agricultural scientists and planners.

One dedicated research fellow in late seventies collected wild edible food crops such as dioscorea, and root crops taro, sweet potato, and few introductions like winged bean which were maintained by Plant Genetic Resources Unit (PGRU) established at the Agriculture Botany Division. A seed genebank of about 21' x 12' x 7.5' which can store orthodox seeds at 5°C and 45% RH., was established in 1984. With the IBPGR team supported by Japanese
fund, several multi-crop explorations of plant genetic resources of Nepal hills were undertaken and these collections were conserved in the seed bank at Khumaltar. Several multi-collection activities took place not only with the IBPGR initiation, but also by National Commodity Programmes under the Department of Agriculture (DoA) and later under the Nepal Agricultural Research Council (NARC).

Also, the people of Nepal with varied ethnic background, and varied migratory and settlement patterns contributed by way of adopting and cultivating diverse crops for their livelihood. Growing of many marginal crops like millets, barley, buckwheat is associated with the socio-cultural values of these people who remained as custodians for conserving them.

**In situ conservation**

**Conservation of crop genetic resources**

Conservation of biological resources *in situ*, particularly forests and wild plants, has been practised by protecting the area and providing strict security. Two research projects are currently under way with IPGRI support to understand and implement the philosophy and scientific basis of *in situ* conservation of agricultural biodiversity. One of these is "Study on the scientific basis of *in situ* conservation of agricultural biodiversity in Nepal". This is being implemented in three districts of Nepal representing three different agro-ecological zones. The high altitude agro-ecological zone is represented by Jumla as one *in situ* ecosite; the mid-hill by Kaski *in situ* ecosite and the plains by Bara *in situ* ecosite. The project so far has been successful in organizing orientation training, Participatory Rural Appraisal (PRA) survey, group mobilization, formation of Community Based Organizations (CBOs), village workshops, and biodiversity fair in Kaski. The detailed baseline survey of crop biodiversity has been completed with participatory approach. The second on-going PGR project is the "Feasibility study of on-farm conservation of bitter buckwheat genetic resources in Nepal". The study attempts to focus on target districts of high mountains. Until now, the noteworthy activity has been conducting PRA for site selection in respective eco-districts. Several parameters such as diversity of crops both inter and intraspecies diversity, diversity in agro-ecology, community interests, distance from the nearest road and prospect for marketing, etc. were considered for the site selection. Village level workshop and training to the field staff and lead farmers and motivation with the support of NGO staff were the tools to organize the villagers. The biggest event and probably the first time in Nepal was the biodiversity fair organized in Lake Watershed ecosite of Kaski district near Begnas Rupa. Fifteen CBOs participated who displayed their local landraces of rice, taro, fingermillet, sponge gourd. In other sites, organising and strengthening the CBOs are underway. Creating awareness and sensitization among farmers was the most important task to mobilise the people towards biodiversity conservation. The designing of baseline survey through participation has already been done and baseline survey will be conducted.

**Conservation of protected areas**

Particularly with respect to forest biodiversity, protected areas in Nepal are maintained under the Department of Wild Life and National Parks. There are now eight natural parks, five wild life reserves and two conservation areas spread all over the country in various eco-regions. These national parks and wild life reserves making nearly 14% of Nepal's total area have their own significance. These parks house a large number of medicinal herbs, fibre plants, and also a great number of endemic plants. Botanical explorations in Nepal have revealed that over 5,000 species of flowering plants, about 450 species of ferns and fern allies, 1,670 species of fungi and 500 species of lichens are found in *in situ* state. Of these, 246 species of flowering plants are endemic and many more are rare.
Ex situ conservation
Current crop germplasm status
Since 1983, NARC has a facility for storing orthodox seeds. This is a fabricated module with a total space of 21' x 12.5' x 7.5' with single entry system. This is maintained at about 5°C with 45% R.H. This stores not only the active germplasm, but also the breeding materials on request for a limited period. The seeds are kept either in plastic containers or in paper bags, which makes difficult to keep the germplasm in proper condition, especially when the power fails. There is now a provision of one standby generator. Current level of plant germplasm under NARC remains at about 10 000 accessions under the facility of medium-term storage, of which nearly 50% are cereals (Table 1).

Table 1. Current status of germplasm preservation in PGRU/NARC

<table>
<thead>
<tr>
<th>Crops</th>
<th>Till 89/90</th>
<th>90/91</th>
<th>91/92</th>
<th>92/93</th>
<th>93/94</th>
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<th>95/96</th>
<th>96/97</th>
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<td>–</td>
<td>–</td>
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<td>–</td>
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</tr>
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<td><strong>749</strong></td>
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<td><strong>405</strong></td>
<td><strong>424</strong></td>
<td><strong>461</strong></td>
<td><strong>1008</strong></td>
<td><strong>336</strong></td>
<td><strong>9728</strong></td>
</tr>
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</table>

Evaluation and characterization
This has been one of the most important activities right from the initiation of PGR activities. In fact, most of the commodity programmes routinely carry out characterization of germplasm for important traits. The PGR unit, either independently or in collaboration with respective crop commodity programmes, evaluated and characterized 2 749 accessions of eight crops, the highest number being for rice followed by finger millet. The National Hill Crop Programme also evaluated several hundred accessions of finger millet (629), barley (396), buckwheat (155), grain amaranth (70), and others (33). Similarly during mid eighties, grain legume programme independently evaluated the germplasm of grain legume crops. The up-to-date status of evaluation and characterization by PGRU indicated sizeable number of accessions in rice (980), finger millet (718), barley (422), soybean (216), lentil (146), buckwheat (184), broad bean (35) and taro (48). In most cases, standard IPGRI descriptors were used except in rice, for which, IRRI descriptor list was used.

Collection of herbarium and maintenance
In the past, through Agriculture Botany Division, there had been some collection and maintenance of crop associated weed herbarium. Later, this activity has been undertaken by Agronomy Division, and the herbarium now contains about 1 000 specimens of 100 species.

Access to and exchange of germplasm
Access to germplasm is very important and it greatly helps in developing better varieties through direct use or through the use of material in breeding programmes. The PGRU has supplied germplasm to National Hill Crops Programme, Grain Legume Programme, and Rice Programme for their evaluation and use. However, outside the NARC system, germplasm is provided on reciprocal basis. During the last year, PGRU of NARC made available germplasm of vegetable crops to Bangladesh, rice germplasm to Bhutan and tobacco germplasm to Eastern European countries on exchange basis.
Utilization of landraces
Landraces play important role in enhancing crop productivity through the incorporation of important traits they possess such as disease and insect resistance, morphological and yield components, etc. Several crop varieties have been developed and released either through direct use of germplasm or through incorporation of useful genes from the local germplasm in the breeding programme. Nepal also possesses many local aromatic rice cultivars which represent a rich source for value addition and can be effectively used in aromatic rice breeding programme. The local landraces used for the breeding programmes are given in Table 2.

Table 2. Landraces utilized in national breeding programme

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Pedigree</th>
<th>Trait</th>
<th>Year of release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>K-2</td>
<td>Jarneli/Kn-16-361-BLK-2-8</td>
<td>Fine quality</td>
<td>1987</td>
</tr>
<tr>
<td></td>
<td>K-4</td>
<td>IR28/Pokhreli masino</td>
<td>Fine quality</td>
<td>1987</td>
</tr>
<tr>
<td></td>
<td>Palun-2</td>
<td>BG94-2</td>
<td>Fine quality</td>
<td>1987</td>
</tr>
<tr>
<td></td>
<td>Chhomrong</td>
<td>Local selection</td>
<td>Cold tolerance</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td>K-5</td>
<td>P. Masino/Kn-1B-361-BLR-2-6</td>
<td></td>
<td>1990</td>
</tr>
<tr>
<td>Maize</td>
<td>H. Comp.</td>
<td>Exotic x Local</td>
<td></td>
<td>1973</td>
</tr>
<tr>
<td></td>
<td>Ganesh-2</td>
<td>Exotic x Local</td>
<td></td>
<td>1989</td>
</tr>
<tr>
<td></td>
<td>Mana-1</td>
<td>Exotic x Local</td>
<td></td>
<td>1987</td>
</tr>
<tr>
<td></td>
<td>Rampur-2</td>
<td>Exotic x Local</td>
<td></td>
<td>1989</td>
</tr>
<tr>
<td>Barley</td>
<td>Solu Uwa</td>
<td>NB1054 (Local selection)</td>
<td>Early and bold</td>
<td>1990</td>
</tr>
<tr>
<td>Finger millet</td>
<td>Okhale-1</td>
<td>Local selection</td>
<td>High yield</td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>Kabre Kodo-1</td>
<td>Local selection</td>
<td>High yield</td>
<td>1990</td>
</tr>
<tr>
<td>Lentil</td>
<td>Sindur</td>
<td>Local selection (Lo-111-25)</td>
<td></td>
<td>1979</td>
</tr>
<tr>
<td>Chickpea</td>
<td>Trishul</td>
<td>Local selection</td>
<td></td>
<td>1979</td>
</tr>
<tr>
<td></td>
<td>Dhanush</td>
<td>Local selection</td>
<td></td>
<td>1979</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>Bageswari</td>
<td>Local selection</td>
<td></td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td>Rampur Rahar</td>
<td>Local selection</td>
<td></td>
<td>1991</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Kathmandu local</td>
<td>Local selection</td>
<td>Good taste</td>
<td>1994</td>
</tr>
<tr>
<td>Radish</td>
<td>Pyuthane rato</td>
<td>Local selection</td>
<td>Very good taste</td>
<td>1994</td>
</tr>
<tr>
<td>Asparagus</td>
<td>Khumal tane</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>Bean</td>
<td>Khumal tane</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Sarlaha green</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Kusle</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>Sponge gourd</td>
<td>Kantipure</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>Broad leaf</td>
<td>Khumal broad leaf</td>
<td>Local selection</td>
<td></td>
<td>1989</td>
</tr>
<tr>
<td>mustard</td>
<td>Marpha broad leaf</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td></td>
<td>Khumal rato pat</td>
<td>Local selection</td>
<td></td>
<td>1994</td>
</tr>
</tbody>
</table>

Activities under Department of Plant Resources
Department of Plant Resources under the Ministry of Forestry and Soil Conservation is another institution involved in several PGR activities. The important activities are as follows:

- Survey and collecting of medicinal, aromatic, horticultural and ornamental plants of economic value, wild relatives, and their preservation in the national herbarium. Till now, over 100 000 specimens have been preserved which include about 3 800 species.

- Fifty endangered species are being maintained through *in vitro* conservation.
- Tissue culture protocols of 90 species of horticultural, ornamental, orchids and medicinal and aromatic plant species have been developed. The most significant achievement of this laboratory has been the development of the "Technique of micro-shoots rooting in non-sterile sand" which significantly reduced the cost of the production of tissue cultured plants. Production of tissue cultured plants through sand rooting technique has been a regular programme of this laboratory.

The department has initiated an important project entitled "Nepal Flora Implement Project" which has been approved by the National Planning Commission. This will be implemented over a period of 10 years in three phases. The objectives of this project are to: (i) develop a database inventory of the plant resources of Nepal; (ii) explore, collect, identify and preserve the plant specimens; to conserve the endangered species; (iii) conserve through *ex situ* and *in situ*, and (iv) publish "Flora of Nepal" in a simple but comprehensive form. A 13-member Project Coordination Committee and a 10-member Steering Committee provide support to the project.

**Horticulture genetic resources**

The horticultural crops particularly the fruit crops have not been given much attention. There are many fruit species, which are indigenous to this country like citrus, temperate fruits, mango, banana, and their wild relatives. Systematic collection and their evaluation are lacking. There are horticulture farms under NARC as well as DoA where the fruit trees are maintained *ex situ*, but they have not been systematically evaluated. Many wild relatives are used as rootstocks, for instance, crab apple, wild pear, wild peach, wild apricot, etc. Some wild relatives of walnut, *aonla*, pomegranate, and kafal are directly used as commercial fruits.

**Forage genetic resources**

Almost 8.9 million ruminant livestock units are primarily dependent on forage resources available in different agro-ecological regions of Nepal. Over 100 native and 25 exotic forage germplasm are available in the country. At present, about 15 native germplasm have been evaluated and stored at the genebank for annual use.

**National biodiversity action plan**

In pursuance of the objectives of the Global Plan of Action, the formation of national biodiversity action plan is an immediate need. Formation of several committees is underway under the aegis of Ministry of Forestry and Soil Conservation. The workshop held in 1997 at Kathmandu identified five key areas of national biodiversity action plan. These are: Forests, Wetlands, Agriculture, Livestock and Rangelands. Also, forming a trust fund for GEF and other sources is under way.

**National coordination committee for plant genetic resources**

As per the recommendation of third South Asia Coordinators Meeting held in Bangladesh on January 10-12, 1995, the formation of a National Coordination Committee for Plant Genetic Resources in each country is necessary. This would soon be followed. A proposed
structure for the National Coordination Committee in Nepal would be:

Chairperson Secretary, MoA
Vice-Chairperson To be decided
Member Joint Secretary (related to biodiversity), MoA
Member Director General of Department of Agriculture
Member Director General, Department of Plant Resources
Member Director of Crops and Horticulture, NARC
Member Royal Nepal Academy of Science and Technology (RONAST)
Member NGO Representative
Member Farmer Representative
Member IUCN/Nepal Representative
Member Secretary NARC

The functions of this committee would be to formulate policies and guidelines, as well as approve the plan of action and the budget.

**Human resource development**

To strengthen the PGR activities, human resource development is vital. Both short and long term trainings are required to enhance the skills of the scientists. In NARC, 33 persons have so far received the training on varied aspects of PGR. Of course, many of these have not been fully utilized. The details of these training programmes are given in Table 3.

**Table 3. Training in plant genetic resources activities**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject of Training</th>
<th>Participants</th>
<th>Place</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>M.Sc. Agriculture study in plant genetic resources</td>
<td>1</td>
<td>UK</td>
<td>1990</td>
</tr>
<tr>
<td>2.</td>
<td>Conservation and utilization of genetic resources in indo-china region</td>
<td>2</td>
<td>India</td>
<td>1991</td>
</tr>
<tr>
<td>3.</td>
<td>Documentation training for genebank managers and documentation staff</td>
<td>1</td>
<td>Malaysia</td>
<td>1994</td>
</tr>
<tr>
<td>4.</td>
<td>Plant genetic resources training</td>
<td>2</td>
<td>Japan</td>
<td>1996</td>
</tr>
<tr>
<td>5.</td>
<td>Genebank management</td>
<td>1</td>
<td>India</td>
<td>1996</td>
</tr>
<tr>
<td>6.</td>
<td>In-country training on plant genetic resources documentation and the use of Germplasm Management System (GMS) software</td>
<td>10</td>
<td>Nepal</td>
<td>1997</td>
</tr>
<tr>
<td>7.</td>
<td>On-job training in characterization of rice germplasm</td>
<td>1</td>
<td>Philippines</td>
<td>1997</td>
</tr>
<tr>
<td>8.</td>
<td>On-job training on genebank management</td>
<td>1</td>
<td>Philippines</td>
<td>1997</td>
</tr>
<tr>
<td>10.</td>
<td>In-Country training on field collection and conservation of rice germplasm</td>
<td>10</td>
<td>Nepal</td>
<td>1997</td>
</tr>
<tr>
<td>11.</td>
<td>Plant genetic resources conservation</td>
<td>1</td>
<td>Germany</td>
<td>1997</td>
</tr>
<tr>
<td>12.</td>
<td>Collaborative research-cum-training on genetic diversity of rice</td>
<td>2</td>
<td>Japan</td>
<td>1997</td>
</tr>
</tbody>
</table>

**Total** 33
Scientific database management
With the support of IPGRI, ten scientists have received training on the use of GMS software for the database management in 1997. Plans are to document all the passport and other database in the computer system which will facilitate immediate access to the clients, and analysis and characterization of the germplasm. So far, data on about 2500 accessions have already been transferred to GMS and the rest are underway. These accessions belong to different crops, viz., amaranths (36), barley (152), beans (235), blackgram (15), broad bean (9), buckwheat (94), carrot (1), cauliflower (2), chickpea (10), cocoyam (67), cowpea (71), finger millet (249), foxtail millet (5), grasspea (82), green gram (1), hyacinth bean (1) lentil (13), maize (319), mustard (26), naked barley (36), pea (16), pigeonpea (227), radish (5), rice (440), ricebean (45) and soybean (193).

Future plan of action
- The National Coordination Committee for plant genetic resources will soon be constituted as per the proposed structure.
- The computerized compilation of germplasm inventory using appropriate software e.g. GMS will be speeded up and published.
- The condition of the seed-cum-genebank in the NARC will be upgraded to accommodate more accessions.
- A strong collaboration with IPGRI and other organizations of South Asian countries particularly with NBPGR will be established.
- Use of biotechnological approaches in PGR work will be enhanced and collaborative research activities in this field will be strengthened.
- Collecting, evaluation and conservation of horticultural crops of native origin particularly the endangered species will be taken up on priority.
- Long-term germplasm storage facilities need to be developed for which IPGRI’s support is needed.
- Human resource development has been considered essential. Support for higher studies leading to post-graduate degree in Plant Genetic Resources and the training programmes on various aspects of PGR need to be provided by International Organisation like IPGRI.
- The area of bio-informatics has been considered very important for modern information system. Home page for PGR activities in Nepal is planned to be opened.

Reference
Conservation and sustainable use of plant genetic resources in Sri Lanka

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¹Director, and ²Scientist, Plant Genetic Resources Centre, Gannoruwa, Peradeniya, Sri Lanka

Introduction
Sri Lanka covers an area of 65,610 square kilometers and it has a wide range of topographic, edaphic and climatic variation. The island consists of a South Central mountainous region which rises to an elevation of about 2,500 m surrounded by lowland plains with an average elevation of 75 m above sea level. One hundred and three rivers, including nine major ones, drain the hilly region and lowlands into the sea. This variation, along with other socio-cultural diversity, contributes to Sri Lanka’s rich plant diversity which includes nearly 4,000 taxa of flowering plants of which about 23% are endemic.

Crop genetic resources
The Sri Lankan society is predominantly agrarian. Although the country is moving towards industrialization, the agriculture sector still continues to be important in the economy of the country and contributes substantially to foreign exchange earnings and to GDP. About 51% of the economically active population is engaged in agriculture and related activities. Therefore, the prosperity of the country depends on the rational land use, proper management of the soil and water resources and significantly on biodiversity including plant genetic diversity.

Based on thousands of years of experience and a deep knowledge of their agricultural systems, Sri Lankan farmers have maintained a rich crop genetic diversity. This diversity is affected and threatened with the wide spread use of high yielding varieties. But, there are areas which are out of reach to high yielding varieties, sometimes due to climatic conditions which do not support their existence. In addition, extensive deforestation, land degradation and opening up of new lands for settlements disrupt the genetic diversity of crops and their wild relatives.

The twelve “regions of diversity” of cultivated plants as proposed by Zeven and de Wet (1982) include Sri Lanka in the Indo-Burma Mega Centre of cultivated plants. Ecological diversity, island biogeography, cultural diversity, the geographical location of the country in the trans-oceanic east-west route coupled with antiquity of agriculture of the country, have played a major role in the evolution of a rich genetic diversity in several crop plants and their wild progenitors and relatives.

Sri Lankan agriculture has been also enriched by introduction of several crop plants of economic importance since historical times. The introduced types, depending on the time of introduction and the areas of introduction, also exhibit secondary genetic diversity. Thus, the current crop plants, wild and weedy relatives and the well-adapted introductions from all over the world constitute the important components of agro-biodiversity. Crop species that exhibit significant gentic diversity are as follows:

Cereals  :  Rice (*Oryza sativa*), finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italica*), and proso millet (*Panicum miliaceum*)

Legumes  :  Green gram (*Vigna radiata*), black gram (*Vigna mungo*), horse gram (*Macrotyloma uniflorum*), velvet bean (*Mucuna prurien*s), lima bean (*Phaseolus lunatus*), rice bean (*Vigna umbellata*), yard
long bean (Vigna unguiculata), hyacinth bean (Lablab purpureus),
sword bean (Canavalia gladiata)

Vegetables : Eggplant (Solanum melongena), cucurbits, snake gourd
(Trichosanthes anguina), Bitter gourd (Momordica charantia),
Coccinia spp., cucumber (Cucumis sativus, C. melo), bottle gourd
(Lagenaria siceraria), okra (Abelmoschus spp.), jackfruit (Artocarpus
heterophyllus), Amaranthus spp., ceylon spinach (Basella alba),
Centella asiatica, Alternanthera sessilis, Celosia argentea, Ullucus
tuberosus, plantain (Musa), Ipomea spp., Moringa oleifera, Sesbania
grandiflora

Root and tubers : Dioscorea spp., Colocasia spp., Alocasia spp., Xanthosoma spp.,
Canna spp., Coleus rotundifolius, Amorphophallus spp.

Oilseeds : Sesame (Sesamum indicum), castor (Ricinus communis)

Spices and condiments : Turmeric (Curcuma domestica), ginger (Zingiber officinale),
cardamom (Elettaria cardamomum), black pepper (Piper nigrum),
cinnamon (Cinnamomum verum), chilli pepper (Capsicum spp.),
cloves (Eugenia caryophyllata), citronella (Cymbopogon nardus),
tamarind (Tamarindus indica), betel (Piper betel)

Fruits : Melons (Citrullus lanatus), banana (Musa), papaya (Carica
papaya), mango (Mangifera indica), Citrus spp., guava (Psidium
guajava), durian (Durio zibethinus), Syzygium spp., Annona spp.,
jackfruit (Artocarpus heterophyllus), wood apple (Limonia
acidissima), cashew (Anacardium occidentale), Aegle marmelos,
mangosteen (Garcinia mangostana), pomegranate (Punica
granatum), Phyllanthus emblica

Wild relatives of crop plants
The floristic diversity of 227 species of wild relatives of crops in Sri Lanka has been identified
todate. These species which are of agri-horticultural importance, generally occur as members
disturbed communities within the major vegetation types. Open canopy forest areas,
secondary forests, disturbed grasslands and shrub jungles are rich in these plants. However,
the relatives of fruit plants are largely associated with semi-evergreen, intermediate and wet
evergreen forests. There are large number of wild species of agri-horticultural importance in
different crop groups, namely, cereals (30), legumes (17), vegetables (39), oilseeds (3), fruits
crops (90), fibre crops (6), root and tubers (16), spices and condiments (16) and others (10).

The wild relatives recorded for the different genera are summarised below (Figures given
in parentheses indicate the number of species):

Cereals
Coix (2), Digitaria (2), Echinochloa (4), Eleusine (2), Hygroryza (1), Leersia (1), Oryza (5),
Panicum(3), Paspalum (4), Pennisetum (2), Setaria (4)

Legumes
Atylosia (4), Canavalia (1), Lablab (3), Macrotyloma (2), Mucuna (2), Trigonella (1), Vigna (4)

Vegetables
Abelmoschus (4), Aerva (1), Alternanthera (1), Amaranthus (2), Asparagus (1), Basella (2),
Bryonopsis (1), Cardiospermum (1), Chenopodium (1), Celosia (1), Centella (2), Citrullus (1),
Coccinia (1), Ctenolepis (1), Cucumis (1), Cyca (1), Drecia (1), Enulia (1), Erythrina (1),
Ipomoea (1), Lasia (2), Solanum (8), Trichosanthes (2), Woodfordia (1)
Root and tubers
Alocasia (3), Amorphophallus (1), Canna (2), Colocasia (2), Cyathea (1), Dioscorea (6)

Oilseeds
Sesamum (2)

Spices and condiments
Alpinia (1), Amomum (1), Brassica (2), Cinnamomum (3), Curcuma (2), Elettaria (1), Kaempferia (1), Myristica (1), Tamarindus (1), Zingiber (2)

Fruits
Aegle (1), Annona (3), Antidesma (1), Artocarpus (2), Carissa (2), Chrysophyllum (1), Citrus (7), Dialium (1), Drypetes (1), Diospyros (1), Elaeagnus (1), Elaeocarpus (7), Euphoria (1), Limonia (1), Flacourtia (2), Garcinia (6), Grewia (6), Madhuca (3), Mangifera (1), Manilkara (2), Minusop (1), Musa (2), Nephelium (1), Podadenia (1), Phyllanthus (8), Phoenix (3), Punica (1), Psidium (1), Rubus (2), Salacia (1), Spondias (2), Syzygium (4), Zizyphus (5)

Fibre crops
Boehmeria (1), Corchorus (2), Crotalaria (3)

Others
Bixa (1), Borassus (1), Caryota (1), Cassia (1), Ixora (1), Lentinus (Mushroom) (1), Polygonum (1), Saccharum (1), Vetiveria (2)

The above is not an exhaustive list of crop wild relatives in Sri Lanka, but serves to show the range of diversity available. Recent advances in plant biotechnology have enhanced their value immensely. The most common use of wild species has been to incorporate pest and disease resistance to modern cultivars. But, there are numerous other traits which remain untapped. There is an urgent need to have a better understanding of the genetic diversity component of these resources to serve as a basis for developing programmes for their conservation and use.

Extent of existing diversity
Of the cultivated crops in the country, rice exhibits a wide range of rich diversity. Work done at the International Rice Research Institute identifies Sri Lanka as one of the important geographical origins for useful traits (Jackson and Huggen 1993). Most outstanding are the cultivars with broad based resistance to the brown plant hopper and tolerance to salinity and adverse soil conditions. Ethnobotanical surveys conducted among the farmers have drawn attention to many other qualities and traits. Many of the indigenous food crops are reputed for their nutritional and medicinal or "health food" qualities.

Limited evaluation conducted todate, reveals sources of resistance to pests and diseases among the vegetable germplasm. Among the other cereals, drought tolerance trait is significant. There are large number of indigenous fruit plants which remain underutilized. Sources of resistance to pests have been identified among the legumes. A concerted and systematic effort is needed to unlock this valuable genetic resource for their economically important traits.

The sustainable use of plant genetic resources has been central to the sustenance of the people of Sri Lanka since historical times. The multiple values of these resources were used in different ways according to needs. Since the 1950's and with increase in population pressure, there has been a progressive erosion of the biodiversity in Sri Lanka. The economic development activities such as irrigation schemes, agricultural expansion, urban development
etc. made heavy demands on biodiversity and directly and indirectly aggravated the depletion of the genetic resources.

The quest for more productive crops to satisfy the demands of the increasing population set in motion the erosion of the crop genetic base. In considering the strategies to conserve biodiversity and promote its sustainable use, the underlying socioeconomic causes of the biodiversity loss need to be addressed. The choice of conservation strategy or a combination of strategies, however, is basically determined by the composition of a given gene pool. Broad based community participation is encouraged to sustain the momentum generated with regard to conservation of plant genetic diversity.

Institutional support for plant genetic resource conservation

In Sri Lanka, the national plant genetic conservation activities are largely formulated and implemented through the government agencies functioning under the Ministry of Agriculture and Lands. Many other government agencies contribute to PGR activities either with regard to their specific mandate crops or in an advisory capacity (Table 1).

Table 1. Government sector institutions concerned with PGR activities

<table>
<thead>
<tr>
<th>Ministry</th>
<th>Department</th>
<th>Organization</th>
<th>PGR category/activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture and Lands</td>
<td>Agriculture</td>
<td>Plant Genetic Resources Centre, Botanical Gardens</td>
<td>Plant genetic resources of ornamentals/rare species</td>
</tr>
<tr>
<td></td>
<td>Export, Agriculture, Livestock and Animal Husbandry</td>
<td></td>
<td>Spices and beverage crops, pastures, forages</td>
</tr>
<tr>
<td>Public Administration, Home Affairs and Plantation</td>
<td>–</td>
<td>Tea Research Institute, Coconut Research Institute, Rubber Research Institute</td>
<td>Tea, Coconut, Rubber</td>
</tr>
<tr>
<td>Health and Indigenous Medicine</td>
<td>Wildlife Conservation, Indigenous Medicine</td>
<td>Bandaranayake Memorial, Ayurvedic Research Institute</td>
<td>Wildlife including forests, Medicinal plants</td>
</tr>
<tr>
<td>Forestry and Environment</td>
<td>Forest</td>
<td>Environment Division, Central Environment Agency</td>
<td>Policy on Biodiversity Issues, National Conservation Strategy, Forest Genetic Resources Advisory Group</td>
</tr>
<tr>
<td>Science and Technology</td>
<td>–</td>
<td>National Science Foundation</td>
<td>–</td>
</tr>
</tbody>
</table>

Department of Agriculture (Ministry of Agriculture and Lands) is responsible for the national programme on crop genetic resources. The Plant Genetic Resources Centre (PGRC), specifically established for this purpose in 1989, leads the programme. Management of the botanical gardens and plant quarantine related functions also come under the purview of the Department of Agriculture.
Forest Department (Ministry of Forestry and Environment) is responsible for the conservation, management and utilization of the natural forests in the country. While the Department of Wildlife Conservation (Ministry of Public Administration, Home Affairs and Plantation) is in-charge of the management of the national parks and other categories of protected area, Department of Export Agriculture (Ministry of Agriculture and Lands) maintains living collections of spices and beverage crops and Department of Livestock and Animal Husbandry, maintains forages and pasture species.

The other government agencies which contribute to the national PGR conservation efforts are as follows:

- Ministry of Public Administration, Home Affairs and Plantation: The Tea Research Institute, Rubber Research Institute and Coconut Research Institute maintain germplasm of their respective mandate crops. A programme on conservation of medicinal plants has been initiated by the Bandaranaike Memorial Ayurvedic Research Institute (Ministry of Health and Indigenous Medicine).
- The Ministry of Forestry and Environment coordinates all policy matters related to environment which also includes biodiversity issues. National Science Foundation (Ministry of Science and Technology) functions in an advisory capacity.

Apart from the above government organizations, there are around 800 community based NGOs which are actively involved in environmental conservation programmes.

### Conservation approaches

In the national genetic resources conservation programmes, the two basic conservation approaches *in situ* and *ex situ*, are being used as complementary conservation strategy. The composition of the gene pool and associated biological factors are used to determine the appropriate method or a combination of methods suitable for the particular gene pool.

#### In situ conservation

**Forest genetic resources**

*In situ* conservation programmes are carried out through the legally established protected area networks which are scientifically managed for the conservation of particular ecosystems and the species and genetic diversity contained within the systems. Sri Lanka has one of the oldest and extensive networks of protected areas, extending to over 14% of the land area. Most of the protected area network (9053 km²), comprising Strict Nature Reserves, Nature Reserves, National Parks and Sanctuaries, is established under the Fauna and Flora Protection Ordinance and managed by the Department of Wildlife Conservation. The remainder (1178 km²) consists of Sinharaja National Heritage Wilderness Area, National Man and Biosphere reserves (MAB), Forest Reserves (FR), Proposed Forest Reserves (PR). Other State Forests (OSF) and Conservation Forests (CF) are managed by the Forest Department. The current projects in the area of forest and biodiversity conservation are indicated in Table 2.

A comprehensive, scientific and systematic survey ‘the National Conservation Review (NCR)’ has already been conducted in most natural and near natural forests including grasslands and mangroves. The long-term objective of NCR is to assess the biological diversity being represented in the existing protected area networks and define an optimum set of sites necessary to conserve the available diversity.

**Wild relatives of crops**

The indigenous genepool of medicinal plants, wild types and wild relatives of crops are found mainly in the wild. The candidates targeted for *in situ* conservation are: (i) fruit crop genetic resources, (ii) species with recalcitrant seeds, (iii) wild relatives of rice, legumes and...
Table 2. Current projects in forest and biodiversity conservation

<table>
<thead>
<tr>
<th>Project</th>
<th>Funding organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Sector Development Project</td>
<td>World Bank</td>
</tr>
<tr>
<td>Participatory Forest Project</td>
<td>ADB</td>
</tr>
<tr>
<td>Forest Master Plan Revision</td>
<td>(FINNIDA/ODA)</td>
</tr>
<tr>
<td>Biodiversity Skills Enhancement Project</td>
<td>World Bank</td>
</tr>
<tr>
<td>Medicinal Plants Project</td>
<td>World Bank</td>
</tr>
<tr>
<td>Wet Land Conservation Project</td>
<td>Netherlands</td>
</tr>
<tr>
<td>Mangrove Conservation Project</td>
<td>NORAD</td>
</tr>
<tr>
<td>Forest/Land Use Mapping Project</td>
<td>British (DFID)</td>
</tr>
<tr>
<td>National Conservation Review Project</td>
<td>UNDP/FAO (IUCN)</td>
</tr>
<tr>
<td>Sinharaja Conservation Review</td>
<td>Norwegian (NORAD)</td>
</tr>
<tr>
<td>Knuckles Conservation Project</td>
<td>NORAD</td>
</tr>
<tr>
<td>Wildlife Conservation and Protected Area Management Project</td>
<td>UNDP/FAO</td>
</tr>
<tr>
<td>NAREPP/Biodiversity Conservation Component</td>
<td>U.S. (USAID)</td>
</tr>
</tbody>
</table>

spices, and (iv) medicinal plants. This list is preliminary as there is inadequate data available to assess the status of intra-specific variability of these wild relatives.

PGRC has initiated a long-term study to monitor and assess the prospects for conserving wild relatives of crops in situ in the Yala National Park. Ecogeographic surveys to determine the distribution of particular species, patterns of intra-specific diversity, habitat conditions, companion species, extent of habitat disturbance through grazing etc. are being conducted. Changes in population structure over time are monitored. The study aims to determine the minimum requirements for conservation of these species.

**On-farm conservation of landraces**

Until early 1960's, farmers were the custodians of the complete range of genetic diversity available in the traditional cultivars. By the early 1980's especially with regard to landraces of rice, almost 90% has been replaced with modern cultivars. Still there are pockets where farmers maintain landraces for their various direct and indirect benefits of: (a) consumptive use value with regards to quality characteristics, local food preparations etc., (b) productive use value such as medicinal value, marketability for premium quality etc., (c) non consumptive use value for suitbaility for particular ecosystem, cultural values etc., (d) option value in maintaining the landrace components to face future uncertainties in agricultural, environmental and socioeconomic systems, and (e) existence value of these resources which are concerned with spiritual, socio-cultural and aesthetic factors.

However, in the present socioeconomic context, the suitability of "On-farm conservation" as a viable strategy for maintaining crop genetic resources needs to be evaluated scientifically. Answers needs to be obtained for key questions concerning the following:

1. General issues relating to the concept, nature, scope, distribution of sites, etc.
2. Genetic issues concerning the genetic consequence of on-farm conservation, the factors which lead to genetic changes in population, the suitability for maintaining broad genetic diversity. There is greater concern about understanding the loss of genetic diversity than the loss of varieties per se and how to maintain this diversity through landraces.
3. Socioeconomic and environmental factors with regard to the traditional farming systems through which crop genetic diversity can be conserved and also enhanced.
The feasibility of establishing "community seed banks" also needs to be studied. Preliminary discussions have been initiated with some of the community based NGOs to start a pilot project in this regard. Ethnobotanical studies on traditional farming methods of preserving seed materials, keeping seed moisture low, and preventing damage from pests are also being carried out.

**Home gardens**

Home gardens are commonly found in many rural areas of Sri Lanka. The size of the gardens vary from 100 m² to about 1000 m². As altitude increases, the home gardens become smaller with greater density of plants and plant species and lesser diversity. A well defined plant association and canopy structure that reflect a variety of complementary functions are displayed in the system. At the outer perimeter, coconut and fruit trees predominate and canopy is progressively reduced with the planting of spice trees. Vegetables occupy the inner perimeter. Near the well or open drainage areas, indigenous yams are grown. Medicinal plants are frequently grown under shade. Ornamental plants mostly occupy the front portion of the garden near the house.

For several perennial fruit crops such as banana, mango, jackfruit, *Citrus*, avocado, mangosteen, durian, rambutan, guava, and papaya, the bulk of the genetic diversity is still conserved through this system. Trees for fuelwood also form part of this self sustaining arrangement. Home gardens constitute valuable system for conservation of genetic diversity. Nevertheless, the importance of home garden for genetic resource conservation has still not been widely recognized and little inventory work has been done so far.

**Ex situ conservation**

Sri Lanka has a strong national programme on ex situ conservation of genetic resources especially with regards to plants of agri-horticultural importance. This programme has been accelerated during the past decade. Most common methods used at present for ex situ conservation and the corresponding plant genetic resources categories to which these methods are applied are given below in Table 3.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Plant genetic resources categories</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed genebank</td>
<td>All crop plants and their wild relatives which produce orthodox seeds</td>
<td>PGRC</td>
</tr>
<tr>
<td><strong>In vitro</strong> genebank</td>
<td>Vegetatively propagated crops</td>
<td>PGRC</td>
</tr>
<tr>
<td>Field genebank</td>
<td>Vegetatively propagated crops, tree crops, plants that produce recalcitrant seeds, medicinal plants and spice trees</td>
<td>PGRC, HORDI, BMARI, CRI, RRI, DEA.</td>
</tr>
<tr>
<td>Botanical gardens</td>
<td>Tree species, ornamentals, medicinal plants</td>
<td>BG</td>
</tr>
<tr>
<td>Arboretum</td>
<td>Forest trees</td>
<td>FD</td>
</tr>
<tr>
<td>Cryopreservation</td>
<td>Vegetatively propagated crops and seed crops (Experimental stage)</td>
<td>PGRC</td>
</tr>
</tbody>
</table>
Conservation of crop genetic resources

Food crops
The conservation of PGR was a long felt need of the Department of Agriculture (DoA). In early 1950s, the DoA started a programme to develop rice varieties. The activities on collecting, evaluation and pure line selection of landraces and primitive cultivars were initiated. Later, several cultivars were introduced from foreign countries for hybridization programme. The collected germplasm, improved varieites, and selections were sent to the International Rice Research Institute (IRRI) for long-term conservation. In late 1970s, the collection and introduction of other crop germplasm (field crops, vegetables and condiments) were given much attention with the initiation of their crop development programmes. Recently, programmes have been intensified to conserve fruit tree germplasm. Most of the collected and introduced germplasm were maintained by growing them in the field until the establishment of the PGRC.

Plantation crops
The conservation of genetic diversity in the three major plantation crops, viz., tea, rubber and coconut and other minor crops such as spices (pepper, cloves, nutmeg, cardomom, coffee) and sugarcane is carried out by relevant research institutes/organization (Table 1). Genetic diversity of following plantation crops is maintained in field genebanks:

Tea
The Assam tea, *Camellia assamica*, was introduced into Sri Lanka in 1839 and commercial cultivation was started in 1867. Conservation and improvement of tea is carried out by the Tea Research Institute. The germplasm is maintained as vegetatively propagated clones.

Rubber
Rubber was introduced into Sri Lanka in 1876 from the Kew Gardens. Almost all the clones have been bred from the original seedling brought by Wickam. In the recent times, direct introductions have been made from Latin America and also Malaysia. A total of 9046 clones are being maintained as live collection by the Rubber Institute of Sri Lanka in 3 wet zone locations.

Coconut
Conservation of coconut germplasm is carried out by the Coconut Research Institute at 3 locations in the intermediate zone. These field genebanks are nearly 8 years old. Local germplasm as well as introductions are being maintained. Thirty nine germplasm accessions are presently available in the field genebanks.

Spices and beverage crops
Conservation of genetic resources of aromatic crops is carried out by the Export Agriculture Research Centre of the Department of Export Agriculture. Three field genebanks have been established for this purpose (Table 4). Additionally, 20 accessions of nutmeg (*Myristica fragrans*) and 10 accessions of clove (*Eugenia carophyllata*) are maintained *in situ* at two locations in Kandy and Matale.

Medicinal plants
In Sri Lanka, a large number of plant species have been used in traditional medicine for centuries. Therefore, collection, conservation and propagation of this germplasm are important to protect these species. At present, there are 3 major medicinal plant gardens in Sri Lanka which are located in 3 different bioclimatic zones (Pattipola, Haldumulla, and Girandurukotte). The propagation and cultivation of medicinal plants are carried out in
these gardens. In some gardens, selected medicinal plants are cultivated on commercial scale. The main research information centre for medicinal plants is the Bandaranaike Memorial Ayurvedic Research Institute (BMARI) situated in Navinna (Colombo district). The three other extension centres are in Kandy, Nuwara Eliya and Colombo. A number of rare species are propagated and cultivated in these centres.

Conservation of medicinal plant resources have been initiated in the recent years by BMARI which conducts research on indigenous medical systems. Four field genebanks are being established to suit the specific ecological requirements of the target plant species. The location and area planted are given in Table 5.

### Table 5. Field genebanks for medicinal plants

<table>
<thead>
<tr>
<th>Location</th>
<th>Ecological zone</th>
<th>Crop species</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haldumulla</td>
<td>Up country wet zone</td>
<td><em>Cinnamomum spp.</em></td>
<td>7</td>
</tr>
<tr>
<td>Pattipola</td>
<td>Up country wet zone</td>
<td><em>Cymbopogon winterianus</em></td>
<td>7</td>
</tr>
<tr>
<td>Nawinna</td>
<td>Low country wet zone</td>
<td><em>Piper betel</em></td>
<td>15</td>
</tr>
<tr>
<td>Girandurukotte</td>
<td>Low country dry zone</td>
<td><em>Elettaria cardamomum</em></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Intermediate zone</td>
<td><em>Piper nigrum</em></td>
<td>167</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Theobroma cacao</em></td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Coffea spp.</em></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Areca catechu</em></td>
<td>65</td>
</tr>
</tbody>
</table>

Additionally, medicinal plants are also maintained by the Botanical Gardens in 3 locations (Table 6).

### Forest genetic resources

The natural forest cover has declined from an estimated 84% of the total land area in 1881 to about 25%, according to mapping project conducted in 1992 by the Department of Forests, Sri Lanka. It has declined mostly in the wet zone where 11.3% area remains forested as compared to the 23.2% in the dry zone. The per capita forest cover is only 0.10 ha in Sri Lanka. Major factors causing this decline are high population density, land alienation, forest clearance for agriculture, non-sustainable timber extraction and encroachment of the forest lands etc.

The natural forest vegetation types broadly follow the different bioclimatic zones and floristic regions described earlier. Even within a bioclimatic zone, the habitat conditions change within short distances in elevation, temperature, rainfall, soils, drainage and topography. These micro-niche differences find parallel reflection in the occurrence of different species associations or complexes within a particular forest type. There is also a growing threat to some indigenous species such as *Caryota urens* and *Cycas circinalis* which are being collected and exported. Of the lower plants, 28% of the ferns and fern allies are considered threatened. In addition to natural forests, nearly 124 000 ha of forest plantations are managed by the forest department. The trees planted and managed are the conifers, eucalyptus, teak and mahogany.
Botanical gardens

The botanical gardens in Sri Lanka were really the precursor to the present Department of Agriculture. In the early era, the gardens served the mission of introduction and acclimatisation of economic species. For example, the introduction of coffee, tea and rubber into Sri Lanka was so successful that even today its beneficial effect to the local agricultural economy continues. Presently, the botanical gardens come under the purview of the Department of Agriculture (Table 6).

Table 6. Botanical gardens in Sri Lanka

<table>
<thead>
<tr>
<th>Location</th>
<th>Year of establishment</th>
<th>Ecological zone</th>
<th>Area (ha)</th>
<th>Plant species category</th>
<th>No. of accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peradeniya</td>
<td>1821</td>
<td>Mid country Wet zone</td>
<td>60</td>
<td>Trees and shrubs (local and exotic)</td>
<td>5000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Herbs</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Medicinal</td>
<td>75</td>
</tr>
<tr>
<td>Hakgala</td>
<td>1867</td>
<td>Up country Wet zone</td>
<td>30</td>
<td>Trees, herbs and shrubs</td>
<td>1000</td>
</tr>
<tr>
<td>Gampaha</td>
<td>1876</td>
<td>Low country Wet zone</td>
<td>13</td>
<td>Trees, herbs and shrubs</td>
<td>500</td>
</tr>
<tr>
<td>Ganewatte</td>
<td>1951</td>
<td>Dry and Intermediate zone</td>
<td>23</td>
<td>Medicinal</td>
<td>150</td>
</tr>
<tr>
<td>Pallekele</td>
<td>1990</td>
<td>Up country Intermediate zone</td>
<td>0.4</td>
<td>Medicinal</td>
<td>100</td>
</tr>
</tbody>
</table>

The botanical gardens are also responsible for the development and maintenance of the National Herbarium and conservation of endangered plant species. In addition to their role in plant resources conservation, the botanical gardens offer unique opportunities in creating public awareness of the need for and method of conservation of plant resources.

Plant Genetic Resources Centre

The Plant Genetic Resources Centre (PGRC) is the nodal organization for promoting and facilitating the conservation and sustainable utilization of PGR to improve agricultural productivity, thereby contributing to agricultural development and food security. PGRC was established in 1988 with a mandate to plan and conduct plant exploration, collecting, introduction, evaluation, documentation and conservation of genetic diversity of food crops and their wild relatives. Sixteen cold storage modules (4 units at 1°C and 12 units at 5°C) are available for the conservation of seeds of orthodox species. Vegetatively propagated materials and recalcitrant species are being conserved in green houses, tissue culture repository, or in the field. PGRC conducts research on various aspects of PGR conservation. Studies on application of biotechnology (tissue culture and molecular technique) are also being carried out with the aim of evaluating and improving selected crop species. The highlights of the PGRC activities are as follows:

**Exploration and collecting**

PGRC has carried out 78 explorations upto April 1998 and 12,849 samples of different crops have been collected/received/introduced. These included: rice (3,983), coarse grains (927), grain legumes (2,108), vegetable legumes (133), solanaceous vegetables (324), cucurbit
vegetables (113), vegetable crucifers (3032), leafy vegetables (19), other vegetables (36), Allium garcinial (25), root and tuber crops (319), spices and condiments (511), oilseed crops (376), fruit crops (512), cotton (1), medicinal plants (87), wild rice species (134), and others (108).

Collection of fruit tree germplasm
PGRC recently initiated a plan to conserve fruit trees. A wide range of fruit germplasm was collected such as durian, mango, pomelo, wood apple, annona and guava. Budwood of these fruits were collected and conserved in the field and green houses. About one hundred samples of banana including two wild species (Musa acuminata and Musa balbisiana) have been collected and established in PGRC field. PGRC is collaborating with National Agricultural Research Institutes for collecting, conservation, and documentation of fruit genetic resources. The details of the fruit germplasm collected are given in Table 7.

Table 7. Collection of fruit germplasm

<table>
<thead>
<tr>
<th>Crops</th>
<th>Scientific name</th>
<th>No. of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>Mangifera indica</td>
<td>38</td>
</tr>
<tr>
<td>Rambutan</td>
<td>Nephelium lappaceum</td>
<td>6</td>
</tr>
<tr>
<td>Durian</td>
<td>Durio zebethinus</td>
<td>79</td>
</tr>
<tr>
<td>Pineapple</td>
<td>Ananas comosus</td>
<td>7</td>
</tr>
<tr>
<td>Avacado</td>
<td>Persea americana</td>
<td>8</td>
</tr>
<tr>
<td>Banana</td>
<td>Musa spp.</td>
<td>204</td>
</tr>
<tr>
<td>Wild banana</td>
<td>Musa balbicina</td>
<td>9</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>Artocarpus heterophyllus</td>
<td>4</td>
</tr>
<tr>
<td>Guava</td>
<td>Pisdium guajava</td>
<td>11</td>
</tr>
<tr>
<td>Jambu</td>
<td>Syzgium spp.</td>
<td>3</td>
</tr>
<tr>
<td>Pomegrate</td>
<td>Punica granatum</td>
<td>5</td>
</tr>
<tr>
<td>Bael</td>
<td>Aegle marmelos</td>
<td>2</td>
</tr>
<tr>
<td>Wood apple</td>
<td>Limonia acidissima</td>
<td>4</td>
</tr>
<tr>
<td>Water melon</td>
<td>Citrullus lanatus</td>
<td>6</td>
</tr>
<tr>
<td>Soursop</td>
<td>Annona spp.</td>
<td>6</td>
</tr>
<tr>
<td>Star fruit</td>
<td>Averrhoa carambola</td>
<td>16</td>
</tr>
<tr>
<td>Citrus</td>
<td>Citrus spp.</td>
<td>43</td>
</tr>
<tr>
<td>Pomelo</td>
<td>Citrus maxima</td>
<td>7</td>
</tr>
<tr>
<td>Sweet orange</td>
<td>Citrus sinensis</td>
<td>26</td>
</tr>
<tr>
<td>Mandarin</td>
<td>Citrus reticulata</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>502</strong></td>
</tr>
</tbody>
</table>

Goraka (Garcinia quaesita)
A survey was carried out to identify ‘Goraka’ trees having good quality fruits. Districts covered were Matara, Galle, Kalutara, Gampaha, Ratnapura, Kegalle, Kandy and Matale. Planting materials and fruits were collected from 140 ‘goraka’ trees. Fifteen trees having good quality fruits were identified promising.

Tamarind (Tamarindus indica)
A programme was started to identify tamarind trees having desirable characters. A rare type of tamarind, locally referred to as ‘Rath Siyambala’ was collected from Hingurakgoda. It bears fruits having dark red pulp. Planting material (seedlings) was collected from five selected trees.
**Underutilized plants**

Plants and seeds of *Brachystelma* were collected from Pitawala Patana (open grassland in Laggala, Matale District). It is a small plant having an edible fleshy tuber (size 1-5 cm x 1-3.5 cm). This is the only species of *Brachystelma* (*Asclepiadaceae*) recorded from Sri Lanka.

**Introduction and characterization**

A total of 1,105 accessions were introduced from foreign countries. A total of 5,855 accessions belonging to 21 crop species were characterized in detail.

**Conservation**

A total of 9,951 accessions of more than 125 plant species is presently conserved in the PGRC seed genebank. The major collection conserved up to the end of 1997 include: rice and wild relatives (3782), other cereals (826), grain legumes (1444), vegetable legumes (849), solanaceous vegetables (916), cucurbit vegetables (582), leafy vegetables (132), other vegetables (243), spices and condiments (292), *Brassica* spp. (93) oilseeds (340), fruit crops (166), fibre crops (65), and miscellaneous plants (221). A total of 2,079 seed accessions were distributed to 1770 local and 309 foreign institutions as shown in Table 8.

**Table 8. Seed distribution status up to July 1998**

<table>
<thead>
<tr>
<th>Year</th>
<th>International organizations</th>
<th>Local organizations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>–</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>1990</td>
<td>15</td>
<td>38</td>
<td>53</td>
</tr>
<tr>
<td>1991</td>
<td>08</td>
<td>77</td>
<td>85</td>
</tr>
<tr>
<td>1992</td>
<td>–</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>1993</td>
<td>–</td>
<td>259</td>
<td>259</td>
</tr>
<tr>
<td>1994</td>
<td>38</td>
<td>491</td>
<td>529</td>
</tr>
<tr>
<td>1995</td>
<td>01</td>
<td>185</td>
<td>186</td>
</tr>
<tr>
<td>1996</td>
<td>247</td>
<td>280</td>
<td>527</td>
</tr>
<tr>
<td>1997</td>
<td>269</td>
<td>269</td>
<td>269</td>
</tr>
<tr>
<td>1998</td>
<td>97</td>
<td>97</td>
<td>97</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>309</strong></td>
<td><strong>1770</strong></td>
<td><strong>2079</strong></td>
</tr>
</tbody>
</table>

**In vitro conservation**

A total of 301 accessions of different crops, namely, potato (152), sweet potato (70), cassava (65), dioscoria (7), aroid (6) and innala (1) are being maintained *in vitro*. A total of 4,749 accessions of crops germplasm (landraces and breeder’s stocks) were received for conservation.

**Edible bamboo**

During 1995, PGRC supported the initiation of cultivation of edible bamboo (*Dendrocalamus asper*) in Sri Lanka. The basic germplasm stocks were introduced from Thailand. *In vitro* and *in vivo* methods were used for micropropagation, acclimatization and for inducing vigour.

**Ornamental plants**

A number of wild plant species in Sri Lanka have been exploited due to attractive flowers and foliage. A programme on the micropropagation of these species is currently going on. Techniques for micropropagation have been developed for *Asplenium, Osbeckia, Anoectochilus* and *Aloe*.
Tissue culture and biotechnology

Wide hybridization

Useful characters such as resistance to viral and fungal diseases are found in wild crop relatives. These can be transferred to cultivated types using conventional and biotechnological tools. Some of the successful examples are as under:

Okra

i) Hybrids obtained from a cross between a wild species (*Abelmoschus angulosus*) and a cultivated okra were evaluated. The plants produced through embryo rescue using the wild species as the female plant were found to be fertile. These plants were propagated *in vitro* to induce fertility. Hybrids obtained in other direction were fertile.

ii) Wide crosses were also attempted between another species (*A. moschatus*) and okra. Production of the first generation hybrids using the wild type required embryo rescue. The culture conditions were established to grow the young embryos and raise the hybrids. The hybrids are currently being evaluated.

Brinjal

i) Crosses were performed between cultivated brinjal and a wild relative. Progeny of a cross between "Ahasatu" (*Solanum macrocarpon*) and brinjal is being analyzed.

ii) Probable hybrids obtained from a cross between brinjal (*S. melongena var insamum*) and Elabatu were evaluated. Comparison of morphological characters with their parents provided evidence to confirm the hybridity.

iii) A similar cross was made between "Ahasbatu" (*S. macrocarpon*) and Elabatu (*Salanum melongena var insanum*). Fruit formation in hybrids was very rare. The nature of low fertility was established using cytological studies.

Callus and protoplast culture

Brinjal

Establishment of protoplast culture technology for brinjal would be useful for application of innovative methods of breeding for crop improvement. Protoplast were isolated from brinjal leaf tissues and "Thibbatu" cell suspension cultures using previously known enzymes solutions. Further work is being continued to compare tissue types for efficiency of protoplast release, their culture and plant regeneration.

Innala (*Coleus rotundifolius*)

Tissue culture methods offer a tool to induce genetic variability that is not available in nature. This opportunity is being exploited in innala. Plants derived from innala callus cultures were transferred to green house. Morphological, cytological and bio-chemical analyses confirmed that some plants are genetically different types. This technique is applied to produce a large number of plants and isolate favourable plant types.

Chilli

Cell suspensions were established from hypocotyl derived calli of chilli (*Capsicum annuum* MI-2) using a liquid medium. These suspensions will be used in future to isolate protoplasts.

Information management of PGR

The major purpose of the documentation system is to serve as a central database which supplies accurate and current information. PGRC has a system in place to coordinate information compilation, maintenance and dissemination. Presently, the database holds about 104 700 records as passport data. It also contains the characterization data of 18 crops, namely, maize, sorghum, cowpea, soybean, green gram, black gram, groundnut, bean, yard
lond bean, lima bean, tomato, brinjal and related spp. capsicum, pumpkin, okra, amaranth, sesame, and mustard. Information on fruit tree germplasm at different institutes and centres of the DoA was incorporated into the database.

**Awareness programmes**

There is an active school awareness programme, especially for the GCE (Adv. Level) students conducted by trained officers. In addition, special programmes on PGR activities are conducted for the university groups, farmers, NGOs and others (Table 9).

**Table 9. Visits to PGRC by schools and NGOs**

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of schools</th>
<th>No. of organizations</th>
<th>No. of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>93</td>
<td>35</td>
<td>5767</td>
</tr>
<tr>
<td>1996</td>
<td>151</td>
<td>47</td>
<td>10 371</td>
</tr>
<tr>
<td>1997</td>
<td>230</td>
<td>58</td>
<td>14 272</td>
</tr>
</tbody>
</table>

**Publications**

PGRC prepared and published 38 crop descriptor lists for use in characterization and preliminary evaluation of crops and their wild relatives. The first plant genetic resources catalogue with passport information was published and distributed during 1996.

**Seminars**

An International Seminar on ‘Present Status and Future Prospects of Plant Genetic Resources Conservation and Utilization’ was jointly organized by PGRC and Japanese International Cooperation Agency (JICA) at Kandy from 9-10 December 1996. A total of 52 participants from 7 countries attended the seminar. The Sri Lankan participants were from PGRC, other crop research and development institutes and centres of DoA, and from universities. Foreign participants were from Bangladesh, China, Indonesia, Japan, Pakistan and the Philippines. Country reports on PGR conservation status and 10 other papers of topical interests were presented by the participants. Nine posters were also presented.

The country reports from five participating countries gave a good account of the actual situation with respect to PGR in each country. The subject of long-term preservation and utilization of PGR was discussed and the position understood. Resolutions were adopted to facilitate the exchange of PGR, information and evaluation data between the participating countries. It was also resolved that the participating countries should meet periodically to discuss and exchange information about PGR activities.

**Collaborative programmes**

Following projects completed by undergraduate students from the Faculty of Agriculture, University of Peradeniya were supervised by PGRC staff and the facilities to complete the projects were also provided by PGRC:

1. Cytological and morphological studies in an interspecific hybrid between *Solanum macrocarpon* and *S. melongena* var *insanum*.
2. Evaluation of tissue cultured innala (*Coleus rotundifolius*) plants for possible genetic variations.
3. Study on the variability in okra germplasm.

Technical support was provided to the Menikdena Arboretum and Archaeological Reserve Project of the Trinity college, Kandy and Departmnet of Archaeology. This is the first such project in Sri Lanka where a school has taken an initiative to establish an arboretum-cum-archaeological reserve in order to develop a site of multidisciplinary interests including
conservation and education. Menikdena Arboretum and Archaeological Reserve, situated in Matale District, which was developed within three years from 1995 to 1998, has now become a popular spot for the school children, university students, tourists and general public.

**References**


Plant genetic resources activities in South Asia

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Introduction
Conservation and use of plant genetic resources (PGR) is one of the major concerns today for sustained livelihood of the humankind. These invaluable resources are subject to threat due to overexploitation, modernization of agriculture and environmental degradation and, thus, attract attention for their conservation for posterity and future use. There is a growing awareness to safeguard these resources and both the Convention on Biological Diversity (CBD) and the Global Plan of Action (GPA), point towards responsibilities of the countries for the conservation and use of plant genetic resources for the benefit of present and future generations. The International Plant Genetic Resources Institute (IPGRI) came into existence in 1993 to focus attention on the need to collect and conserve the diversity of crops and related species. It is the legal successor to the International Board for Plant Genetic Resources (IBPGR) and autonomous international scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). IPGRI works in partnership with other organizations, undertakes research and training and provides scientific and technical advice and information (IPGRI 1996). The fundamental principles on which IPGRI operates are: (i) people and their development are the foremost reasons for conservation of PGR, (ii) promoting exchange of genetic resources, and (iii) carrying out its work through supporting and facilitating other organizations rather than doing the work itself (Ramanatha Rao 1997).

IPGRI’s mandate, mission and objectives
IPGRI’s mandate is to advance the conservation and use of PGR for the benefit of present and future generations. Its mission is to encourage, support and engage in activities to strengthen the conservation and use of plant genetic resources worldwide with special emphasis on the needs of developing countries. IPGRI has the following four main objectives (IPGRI 1993):

1. To assist countries, particularly in the developing world, to assess and meet their needs for the conservation of plant genetic resources and to strengthen links to users
2. To strengthen and contribute to international collaboration in the conservation and use of plant genetic resources
3. To develop and promote improved strategies and technologies for the conservation of plant genetic resources
4. To provide an information service on plant genetic resources

Programme structure
The strategy of IPGRI “Diversity for Development” elaborately deals with IPGRI’s projections. Its programme is built on the basis of multi-disciplinary projects, comprising a series of activities currently new strategy, taking IPGRI into the new millennium is under preparation.

IPGRI has three programmes, viz., Plant Genetic Resources, International Network for Improvement of Banana and Plantain (INIBAP), and System-wide Genetic Resources Programme (SGRP). The Plant Genetic Resources programme is operated through two thematic groups and five regional groups. The thematic groups, viz., Genetic Resources Science and Technology (GRST) and Documentation, Information and Training (DIT) are located at the Headquarters at Rome. The regional activities are carried out under 5 regional
groups, namely, 1) Sub-Saharan Africa (SSA) at Nairobi, Kenya; 2) Central and West Asia and North Africa (CWANA) at Aleppo, Syria; 3) Asia, the Pacific and Oceania (APO) at Serdang, Malaysia; 4) The Americas (AM) at Cali, Colombia, and 5) Europe (EUR) at Rome, Italy. The location of IPGRI regional and sub-regional offices is given in Fig. 1.

**Fig. 1.** IPGRI regional and sub-regional offices

**Asia, the Pacific and Oceania (APO) region**

APO Group Structure ensures close staff interaction at all levels between Serdang, Beijing and Delhi offices (Fig. 2) in carrying out the programmes in the region. The area of operation of Asia, the Pacific and Oceania (APO) region is spread over 45 countries with a little over

**Fig. 2.** IPGRI-APO group structure
half of the world’s population. It possesses a rich agricultural heritage and is a seat of origin and diversification of several crop plants. It is characterized by diverse agroecological features from highlands, semi-arid to humid tropics to coastal plains exhibiting sharp climatic fluctuations from temperate to tropical - extremely cold to extremely hot, dry desertic climate. Also, it is known for its rich ethnic diversity and the native communities have selected and used diverse native germplasm. The APO region includes four centres of diversity, namely, 1) Chinese-Japanese Region, 2) Indochinese-Indonesian Region, 3) Australian Region, and 4) Hindustani Region. Domestication has taken place in crops such as rice, foxtail millet, eggplant, pigeonpea, cucumber, onion, cabbage, taro, yam, banana, citrus, mango, litchi, jackfruit, breadfruit, peach, coconut, arecanut, several spices and condiments such as black pepper, ginger, turmeric, clove, and cardamom. A host of medicinal and aromatic plants occur. Also, the genetic diversity has been much enriched through extensive exchange in crops, which now influence the agricultural economy and are important food and industrial crops of this region.

**PGR activities in South Asia**

South Asia is an agro-biodiversity rich region, which, among the twelve regions of diversity of crop plants assumes great importance as a seat of diversification, evolution and domestication of several crop plants. It is climatically, agro-ecologically, ethnically and botanically very diverse (Arora and Ramanatha Rao 1995). The Hindustani Centre holds diversity of 166 cultivated plant species (Zeven and de Wet 1982). Also, rich variability in wild relatives of crop plants occurs (Arora and Nayar 1984). IPGRI Office for South Asia coordinates PGR activities in six countries, namely, Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka. These countries greatly vary in size, terrain, agroecology and crop diversity. A large area is covered by dry to humid tropical climate as of Bangladesh, India, Sri Lanka; Maldives has exclusively a humid tropical - littoral environment; and Bhutan and Nepal located in the Himalayan ranges are largely subtropical/temperate. Distribution and extent of crop diversity accordingly varies through the length and breadth of this whole terrain.

The major task is to promote and strengthen PGR activities in the region with focus on their conservation and use. The South Asia Office liaises with IARCs and other regional and global organizations/FAO/NGOs. Such linkages are necessary operational components of work to strengthen PGR activities in the region. Currently, the emphasis is on the following activities:

| Table 1. Germplasm collecting, characterization, evaluation and conservation |
|-----------------|-----------------|-----------------|-----------------|
| **PGR Activities** | **Year** | **Collaboration** | **Crops** |
| Exploration and collecting | 1990-92 | NBPGR, India-BARI, BARC, Bangladesh | Eggplant, okra |
| | | NBPGR, India-NARC, Nepal | |
| | | NBPGR, India-PGRC, Sri Lanka | Eggplant, okra |
| | | NBPGR, India-BARI, Bangladesh | Sesame, maize |
| Characterization and evaluation | 1990-93 | NBPGR published catalogues and distributed to NPs | Okra, eggplant, sesame |
| Conservation | 1990-93 | NBPGR genebank; also with specific NPs which collaborated for (long/medium/short-term) conservation | Eggplant, okra, sesame, maize |
Strengthening national programmes
IPGRI supports the strengthening of national programmes through advice by correspondence and staff visits, holding national workshops for creating public awareness, and need based collecting and characterization of germplasm. Visits to national programmes had helped in assessing the needs and provide help and assistance in drafting country proposals. These included PGR proposals from Bhutan to Dutch Government and from Nepal and Bangladesh to Japan Government.

Exploration and collecting
The major focus on exploration and collecting activities has been to facilitate joint exploration in the region and to provide guidelines/logistic support, within-country exploration, assess gaps in collecting and assist in preparing country reports to prioritize germplasm collecting activities. The details of collecting activities supported by IPGRI are given in Table 1. IPGRI does not support germplasm collecting in general, unless a very high priority has been indicated by national programmes due to genetic erosion or similar other emergency situation.

Characterization, evaluation and documentation
The important regional activities include preparation of descriptors, assess the status of evaluation efforts of national programmes, preparation of crop catalogues and information synthesis. Besides these, IPGRI supported other activities including preparation of descriptors, bibliography and directory of germplasm collections. Details of evaluation and documentation efforts in South Asia region are given in Table 2. Ethnobotanical information has been gathered on taro and yam. PGR information on six priority fruit tree species has been synthesized in the form of country status reports (Table 3). IPGRI-APO supported a project in 1991 at the Hill Crop Improvement Programme, Kabre, Nepal on the evaluation of barley, buckwheat, amaranth, finger millet and proso millet. Germplasm of coconut is being evaluated for all important characters. Out of 132 accessions, characterization of 74 accessions has already been completed.

Conservation
IPGRI supports activities relating to the development of complementary conservation strategies involving in situ and ex situ approaches, greater emphasis being given to ex situ conservation technologies vis-a-vis functioning of genebanks, The major activities include

<table>
<thead>
<tr>
<th>Crop</th>
<th>Year</th>
<th>Activity</th>
<th>Accessions</th>
<th>Descriptors</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okra</td>
<td>1990</td>
<td>Catalogue on okra germplasm part I</td>
<td>558</td>
<td>43</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td></td>
<td>1991</td>
<td>Catalogue on okra germplasm part II</td>
<td>432</td>
<td>40</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td></td>
<td>1993</td>
<td>Catalogue on okra germplasm part III</td>
<td>500</td>
<td>38</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>Catalogue on wild <em>Abelmoschus</em> spp. germplasm</td>
<td>241</td>
<td>29 Delhi</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37 Akola</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td>Eggplant</td>
<td>1995</td>
<td>Catalogue on eggplant</td>
<td>1188</td>
<td>60</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td>Sesame</td>
<td>1993</td>
<td>Catalogue on sesame</td>
<td>2068</td>
<td>39</td>
<td>NBPGR, India</td>
</tr>
<tr>
<td>Finger millet</td>
<td>1996</td>
<td>Evaluation of finger millet germplasm</td>
<td>4628</td>
<td>37</td>
<td>AICRP (Small Millets)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>UAS, Bangalore, India</td>
</tr>
</tbody>
</table>
ex situ conservation of assessed material in the genebank, base/active collections, field genebanks and in vitro conservation and cryopreservation. IPGRI also provides guidelines for seed conservation aspects and provides technical/scientific advice and assistance. International Coconut Genebank has been established at Kidu, Karnataka, India and the germplasm collections are being planted with 100 plants per accession.

**Human resource development**

IPGRI-APO has supported both specific and broad-based short PGR training courses. Several such regional trainings have been organized in collaboration with NBPGR/ICAR, such as: (i) FAO/IBPGR/NBPGR regional training course on conservation and utilization of crop genetic resources of local agricultural importance in South Asia and Indo-China (1991); (ii) On-job PGR training for South Asia region conducted by NBPGR for participants from Bhutan, Nepal and Maldives (1992); (iii) IPGRI/ICAR/IRRI/ICRISAT regional training course on seed genebank management (1996); and (iv) IPGRI/UTFANET/IIHR regional

| Table 3. Status reports on genetic resources of tropical fruit species |
|------------------------|-----------------------------|
| **Species** | **Countries** |
| Mango | Bangladesh, India, Indonesia, Philippines, Thailand, China, Sri Lanka |
| Citrus | China, Japan, Indian, Nepal, Sri Lanka |
| Rambutan | Indonesia, Malaysia, Thailand |
| Durian | Indonesia, Malaysia, Thailand |
| Jackfruit | Bangladesh, Sri Lanka |
| Litchi | China |

| Table 4. Training programmes organized in South Asia |
|------------------------|------------------------|------------------------|
| **Course** | **Dates** | **Location** | **No. of participants/countries** |
| Regional training course on conservation and utilization of crop genetic resources | 21 Oct.-11 Nov. 1991 | NBPGR, New Delhi, India | 18/9 |
| Regional on-job training on seed processing and conservation | 1-12 Sept. 1992 | NBPGR, New Delhi, India | 2/2 |
| Regional on-job training on characterization and evaluation procedures | 8-17 Oct. 1992 | NBPGR, New Delhi, India | 2/2 |
| Use of germplasm management system (GMS) software in documenting and managing PGR | 24-29 Aug. 1996 | BARI, Dhaka, Bangladesh | 13/1 |
| Regional training course on seed genebank management | 8-22 Dec. 1996 | NBPGR, New Delhi, India | 25/16 |
| Conservation and use of germplasm of tropical fruits in Asia | 18-31 May, 1997 | IIHR, Bangalore, India | 17/13 |
| National training course on PGR documentation and use of GMS software | 15-20 June, 1997 | NARC, Kathmandu, Nepal | 13/1 |
training course on conservation and use of germplasm of tropical fruit species (1997). Short-term trainings on data documentation and database management have been organized in collaboration with the national programme, viz., NARC, Nepal and BARI, Bangladesh. The concerned PGR curators/genebank staff have been trained in using Germplasm Management System (GMS) software, to take up in-country programme in systematic documentation of plant genetic resources in genebank. Details of these training programmes are given in Table 4. Further, IPGRI- APO had supported sponsoring scientists to M.Sc. course at Birmingham University (from Sri Lanka and India), IPGRI Vavilov-Frankel Fellowship (candidate from India), and regional/global short courses, trainings on case to case basis.

**Promoting PGR awareness**

For promoting awareness on PGR, National PGR Workshops offer an effective mechanism by bringing together scientists and others interested in PGR in a country. Two such National PGR Workshops have been organized in collaboration with NARC, Nepal and BARC, Bangladesh to assess national perspectives and needs. The details of these workshops are given in Table 5. IPGRI shares the concern on PGR and related issues with national programmes and help them to execute agro-biodiversity projects with aid from diverse donors i.e., IARCs, WWF, UNDP, UNEP, FAO, and also from the Global Environment Facility (GEF). IPGRI provides scientific and technical help in developing such projects and programmes in the region. IPGRI has now to play an enhanced role in view of the CBD and GPA activities being in operation.

**Regional collaboration**

IPGRI aims at strengthening PGR links between countries and regional and non-governmental organizations with strong interest in PGR conservation and use.

**Collaboration with NGOs**

Collaboration with M.S. Swaminathan Research Foundation (MSSRF), Madras (now Chennai), Tamil Nadu, India has been one of the most important activities with NGOs. The work included evaluation and cataloguing, conservation in the community genebank, conservation of endangered and rare plants, ethnobotanical studies, and genetic diversity studies on mangrove species. The in situ conservation work with LI-BIRD, Pokhara, Nepal is another example.

**Table 5. Workshops/conferences organized/supported by IPGRI**

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Institute/Location</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-12 October, 1990</td>
<td>International Workshop on Okra Genetic Resources</td>
<td>NBPG, New Delhi, India</td>
<td>International</td>
</tr>
<tr>
<td>28-30 September, 1993</td>
<td>Asian Regional Workshop on Sesame Evaluation and Improvement</td>
<td>NBPG, Regional Station, Akola, India</td>
<td>Regional</td>
</tr>
<tr>
<td>28 November - 1 December, 1994</td>
<td>National Workshop on Plant Genetic Resources: Conservation, Use and Management</td>
<td>NARC, Kathmandu, Nepal</td>
<td>National</td>
</tr>
<tr>
<td>27-29 December, 1995</td>
<td>Regional Workshop on Lathyrus Genetic Resources in Asia</td>
<td>IGAU, Raipur, India</td>
<td>Regional</td>
</tr>
<tr>
<td>26-29 August, 1997</td>
<td>National Workshop on Plant Genetic Resources</td>
<td>BARC, Dhaka, Bangladesh</td>
<td>National</td>
</tr>
<tr>
<td>8-10 December, 1997</td>
<td>Regional Working Group Meeting on Lathyrus Genetic Resources</td>
<td>NBPG, New Delhi, India</td>
<td>Regional</td>
</tr>
</tbody>
</table>
Regional networks

Regional collaboration is also strengthened through networking based on geographical division or crops/commodities. In South Asia, regional collaboration is being promoted through the periodic meetings of National PGR Coordinators on rotational basis. Such meetings bring together the country coordinators and other experts from South Asian countries and enable them to discuss important issues and establish closer links between them. Three meetings of South Asia Coordinators (SAC) have so far been held and the fourth one is being organized in Nepal during September 1998. The details of these meetings are given in Table 6.

Table 6. South Asia Coordinators (SAC) meetings organized

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Institute/location</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-24 March 1990</td>
<td>First South Asia Coordinators (SAC) Meeting</td>
<td>NBPGR, New Delhi, India</td>
</tr>
<tr>
<td>17-19 December 1992</td>
<td>Second SAC Meeting</td>
<td>PGRC, Peradeniya, Sri Lanka</td>
</tr>
<tr>
<td>10-12 January 1995</td>
<td>Third SAC Meeting</td>
<td>BARC, Dhaka, Bangladesh</td>
</tr>
<tr>
<td>1-3 September 1998</td>
<td>Fourth SAC* Meeting</td>
<td>NARC, Kathmandu, Nepal</td>
</tr>
</tbody>
</table>

* Renamed as SANPGR

Crop networks

Crop networks are very effective tools to enhance collaboration on particular aspects including conservation and utilization of PGR. For several crops, a strong research base exists with national programmes and IPGRI has used their expertise and organized workshops/meetings to promote activities on crop networks. Such meetings have been organized for okra, sesame and *Lathyrus* and the details are given in Table 5.

Developing improved technologies

Developing and promoting improved strategies and technologies for PGR conservation and use is one of the important objectives of IPGRI. The following important studies are currently going on with IPGRI support:

- Genetic diversity and feasibility study on on-farm conservation in buckwheat in Nepal
- Studies on diversity of ecotypes in safflower and sesame in India
- Adaptation of sesame genetic resources to environmental factors in India
- Strengthening the scientific basis for *in situ* conservation of agriculture biodiversity in Nepal
- Developing cryopreservation techniques for vegetatively propagated and recalcitrant seed species in India
- Phenology of bamboos in India
- Genetic diversity and conservation of bamboo in India
- Genetic diversity and conservation of rattan species in India
- Ecogeographic survey and phenology of rattan in Nepal
- Assessment of the conservation status of genetic resources of the Western Ghats in India

Information dissemination

The South Asia office distributes IPGRI publications in the region which include: IPGRI-FAO Plant Genetic Resources Newsletter; Annual Report; Geneflow; Workshop/Working Group Proceedings; Crop Network Proceedings; Crop Descriptors; PGR special publications/
Policy papers etc. The IPGRI-APO Regional Newsletter is regularly brought out from South Asia office (3 issues in a year) and has a mailing list of 2500. On the whole, the office also provides/coordinates advisory/information service on all aspects of PGR as per queries received.

Thus, IPGRI has played a significant role in South Asia in strengthening national programmes, improving their PGR activities and capabilities with greater emphasis on conservation and use of underutilized crops and tropical fruits, strengthening regional collaboration through regional and crop networks, promoting human resource development and enhancing public awareness and dissemination of information. Much changes can be expected in the development of PGR programmes in view of Convention on Biological Diversity (CBD) and Global Plan of Action, (FAO 1996), and IPGRI Office for South Asia will play a greater role to collaborate/coordinate such PGR activities with national programmes in the region as per their needs and priorities.

References
IPGRI-APO activities on plant genetic resources in the region—An overview

V. Ramanatha Rao 1, K.W. Riley 1, P. Quek 1, Bhag Mal 2 and M. Zhou 3

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Introduction

Plant genetic resources (PGR) constitute major component of the biological diversity. Effective conservation and sustainable use of PGR is a concern to the whole humankind. Presently, the PGR is being eroded at a fast rate and there are several natural and human made factors, such as environmental destruction, over-exploitation, replacement of traditional cultivars and modernization of agriculture. Many countries and organizations have been working to redress the situation over the last two and a half decades. The need for collecting and conserving plant genetic resources for future use, mainly due to unpredictable future needs, is well recognized. Nevertheless, there is a need to step up the efforts so that the plant genetic resources can be effectively managed before they disappear for ever.

Asia, the Pacific and Oceania (APO) region consists of about 45 countries, with little over half the world's population living in this region. Due to the diverse climatic and ecogeographical conditions, a great amount of genetic diversity is found in this region. Agroecological features vary from highlands, semi-arid tropics to humid coastal plains with climate varying from temperate to tropical. Additionally, the cultural diversity, the rich mosaic of people and cultures, each selecting and using genetic resources to suit their particular needs, is another factor of primary importance in the development of the enormous diversities found in cultivated plants in the region (Ramanatha Rao et al. 1996a). The APO region is a major centre of plant domestication and diversity and includes the Indonesian, Indo-Chinese and Melanesian centres. Domestication of crops such as eggplant, pigeon pea, cucumber, soybean, onion, cabbage, peach, foxtail millet, oriental rice, banana, citrus, yam, taro, mango, coconut and breadfruit has occurred in this region (Frankel and Hawkes 1975; Harlan 1961, 1971, 1992; Purseglove 1976; Zohary 1970). In addition, through extensive exchange of material within the region and other regions (notably from Americas) the genetic diversity in both indigenous and introduced species is extremely large (Ramanatha Rao et al. 1996a). The International Technical Conference in June 1996 at Leipzig came up with the Global Plan of Action (GPA), focusing on agrobiodiversity (FAO 1996). CBD and GPA provide excellent guidelines for the effective conservation and use of biodiversity.

Many of the countries in the region are undergoing rapid changes in terms of trade, exports, urbanization, land-use pattern and market-driven and uniform farming practices. Despite positive aspect of such changes, these have contributed to significant loss of diversity in APO region. The loss is in terms of both biological diversity and agro-biodiversity. Though, in recent years, the importance of both biodiversity and genetic diversity has been better recognized, increased support has not been forthcoming.

The importance of conserving and sustainably using these plant genetic resources has been highlighted in two recent global conventions - the Convention on Biological Diversity (CBD) held in 1992 and the International Technical Conference on the Conservation and Use of Plant Genetic Resources for Food and Agriculture (FAO 1996). Both conventions recognized countries' responsibilities to conserve and use their PGR, but also the importance of equitable sharing of the benefits derived from these resources and technologies related to their utilization. The Global Plan of Action (GPA) included national programme strengthening as one of the 20 priority activities.
The International Plant Genetic Resources Institute

To focus attention on the need to collect and conserve the diversity of crops and related species, the International Board for Plant Genetic Resources (IBPGR) was established in 1974. A little over the last two decades, commendable efforts have been made by several countries and International Agricultural Research Centers (IARCs) to collect and conserve the diversity found in crop genepools. Collections now stand at well over 6 million accessions stored in over 100 genebanks around the world. Most of these accessions have been collected, conserved, documented and regenerated by countries for use both within and outside the country. By reaffirming that each country has a long-term responsibility to conserve its own genetic resources, the CBD has placed the responsibility on the countries themselves to maintain and sustainably use the PGR. The CBD has also reaffirmed the rights of the countries to benefit from their own PGR.

IPGRI's mandate, objectives and organizational structure

IBPGR was established in 1974 to promote and coordinate the work on plant genetic resources globally and was linked to the Food and Agricultural Organization of the United Nations (FAO) for administrative purposes. By 1994, IBPGR has grown into a fully independent institute known as International Plant Genetic Resources Institute (IPGRI). IPGRI is a member of the Consultative Group on International Agricultural Research (CGIAR). IPGRI also has the International Network for the Improvement of Banana and Plantain (INIBAP) as a programme.

Both agriculture and biological diversity are undergoing rapid changes caused by a number of interacting factors. In future, it will be important not only to conserve the eroding PGR, but also to better understand the linkages between agricultural and economic systems that affect diversity and sustainable production. The decline in biodiversity, environmental degradation and land use changes are also factors that have helped to increase public awareness in the region and therefore local control over these resources is needed. The increase in the NGO movement in the region is an example of the increased awareness and of the action that is now being taken on these issues in the region. A broad vision is needed for more effective strategies for PGR management. The IPGRI strategy has evolved taking into account all these factors. The mission of IPGRI is to advance the conservation and use of PGR for the benefit of present and future generations. IPGRI operates on the following fundamental principles that: (i) people and their development are the foremost reasons for conservation of PGR, (ii) genetic resources should be available, without restriction to all bonafide users and, (iii) IPGRI should carry out its work through supporting and facilitating other organizations, rather than doing the work itself.

IPGRI has the following four programme objectives (IPGRI 1993):
1. To assist countries, particularly developing nations to assess and meet their needs for conservation of plant genetic resources, and to strengthen links to users
2. To strengthen and contribute to international collaboration in the conservation and use of plant genetic resources
3. To develop and promote improved strategies and technologies for plant genetic resource conservation
4. To provide an international information service on plant genetic resources

The basis to achieve these objectives is a set of multidisciplinary projects, comprising a series of activities. These form a sort of network or matrix between the five regional offices and the headquarters in Rome. Currently, IPGRI's strategy for 1999-2003 is being developed.
There are three programmes; namely, Plant Genetic Resources, INIBAP, and CGIAR Genetic Resources Support. There are two thematic groups at the Headquarters in Rome: (i) Genetic Resources Science and Technology (GRST), and (ii) Documentation, Information and Training (DIT). IPGRI’s regional activities are carried out under 5 regional groups: (1) Sub-Saharan Africa (SSA) in Nairobi, Kenya, (2) Central and West Asia and North Africa (CWANA) in Aleppo, Syria, (3) Asia, the Pacific and Oceania (APO) in Serdang, Malaysia, (4) the Americas (AM) in Cali Columbia and (5) Europe (EUR) in Rome, Italy.

In the APO region, three offices carry out the regional activities. The main office is located in Serdang, Malaysia and the two coordinating offices are located in Beijing, China (East Asia) and New Delhi, India (South Asia). The priorities for work in the region are determined through extensive consultation and are periodically updated.

**IPGRI in Asia**

From the beginning, IPGRI (and its forerunner IBPGR), has been very active in Asia (Arora *et al.* 1991; Ramanatha Rao and Riley 1995b; Ramanatha Rao *et al.* 1996b; Riley 1996b). Given the complexity of issues related to PGR, it is recognized that there are numerous areas in which IPGRI should be involved in the region. However, with the limited resources available, activities need to be prioritized. All activities are aimed to achieve the objectives and are based on extensive consultation with partners in the region. IPGRI’s priority setting framework includes 3 elements, viz., (1) the external setting, (2) the needs of the partners, and (3) the internal setting, including IPGRI’s strategy and programme structure and Medium Term Plan (Riley and Iwanaga 1996).

**Strengthening national programmes**

IPGRI’s first objective is to strengthen national programme capabilities, through a number of activities. These include staff visits and correspondence to assess status and provide advice; organizing national workshops through which National Committees can function more effectively; stronger regional collaboration; sub-regional meetings and networking for sustained collaboration among neighbouring countries; and emergency collecting when warranted, etc. Visits to national programmes by APO staff provide an opportunity to assess the situation and to provide necessary advice and information. Assistance is also given to national programmes in preparing proposals for funding that help strengthen the work on plant genetic resources management. Assistance is provided to organize the national PGR workshop involving, as many as possible, organizations that have a stake in the nation’s PGR. This serves as the forum, at the national level, to discuss various PGR related issues including PGR committees, structure of the NP, public awareness, etc. Presently IPGRI supports only need based collecting, characterization and evaluation.

**National visits**

Since the establishment of IPGRI-APO office in the region, IPGRI staff has visited most of the countries in the region at least once, and several repeat visits have been made to many countries. Such visits help IPGRI to understand needs and opportunities in these countries and provide advice if requested. The impacts of the visits so far are: (i) development of closer rapport with partners and institutions, (ii) assessment and understanding of different programmes and (iii) development of proposals for work on PGR.

Visits to national programmes will remain a major mechanism to obtain the views of the countries, help in assessing the needs of NPs and provide advice and help in developing any proposals. Relatively speaking, this will remain to be a cost-effective tool in advancing the cause of PGR conservation and use in the region.
**National workshops**

IPGRI’s assistance to national programmes in the region takes many forms. It provides advice on the development of appropriate national plans and strategies for the conservation and use of PGR and help to promote awareness on these policies and activities among the decision makers. Many countries in the region maintain genetic resource collections or genebanks. Often links with users of genetic resources such as plant breeders, regional or international programme scientists or communities or NGOs are not strong resulting in poor utilization of the available resources. This situation needs to be improved by fostering links through, for example, national workshops which allow the identification of country priorities and are an important element of IPGRI’s regional effort. In the past 5 years, seven national PGR workshops (Bangladesh, Cambodia, Lao PDR, Mongolia, Papua New Guinea, Vietnam and Thailand) were organized. Two PGR policy workshops were also organized in Nepal (Upadhyay et al. 1994) and Bangladesh, (Hossan et al. 1997).

**Emergency collecting and evaluation**

IPGRI does not, in general, support germplasm collecting unless it has been given high priority by a NP due to reasons of genetic erosion. Additionally, some collecting may be supported when it has been planned in conjunction with ecogeographic and/or genetic diversity studies or if donor support has been given specifically for collecting and characterization work. In the past few years, IPGRI supported collecting in Mongolia, where very little germplasm collecting has been carried out in the past. In 1993-94, IPGRI collaborated with INIBAP and supported the National Institute of Agricultural Sciences, Vietnam in collecting, characterization and conservation of indigenous banana germplasm. In 1995, in a mission funded by Japan, the northwest and northeast Vietnam were explored. The Pyongyang Crop Genetic Resources Institute, Korea, was supported in the collecting of genetic resources of food crops and legumes in DPR Korea during 1995, which were eroding at a fast rate. Collecting of vegetables and fruits through IPGRI support was undertaken in Vietnam in 1996. IPGRI-APO facilitated a Japanese complementary-funded programme on joint characterization and evaluation of Nepalese plant germplasm. A complementary funded effort on collaborative research programme on in situ conservation of PGR in Nepal is under process of development.

For the future, APO does not have any plans for collecting and evaluating germplasm, although it will remain open to requests which will be dependent on the priority attached to such activities by the NPs in the region and the availability of funds.

**Training**

Human resource development is an important aspect of strengthening national programmes. On broad level, the national PGR coordinators are kept informed about opportunities available in a wide range of PGR-related courses and postgraduate programmes, and assistance is provided in placing selected trainees into such courses. IPGRI also organizes short courses annually in the APO region. Training is an important aspect of IPGRI’s regional activities, including assisting universities in the region in the development of curricula. During 1993-97, the following training courses were organised in collaboration with several relevant organizations:

- Documentation training for genebank managers and documentation staff. 22 August - 9 September 1994, MARDI, Malaysia; 27 participants from 15 countries.
- Conservation of vegetatively propagated crops. 6 - 24 November 1995, NPGRL, IPB, UPLB, the Philippines; 18 participants from 18 countries.
- Silviculture, genetic improvement and conservation of rattans. 20 - 26 April 1996 at Luasong Forestry Centre, Sabah, Malaysia; 22 participants from 11 countries.
- Use of Genebank Management System (GMS) software in documenting and managing PGR. 24 - 29 August 1996, BARI, Bangladesh; 13 participants.
- Training course on bamboo. 5 - 20 October 1996 in Fuyang, China. Two participants from two countries.
- Seed genebank management. 8 - 22 December 1996, NBPG, New Delhi. 25 participants from 16 countries.
- Conservation and use of germplasm of tropical fruits in Asia. 18 - 31 May 1997, IIHR, Bangalore. 17 participants from 13 countries.
- International coconut germplasm collecting and conservation training course. 1-12 September 1997, Philippines Coconut Authority, Zamboanga Research Center, San Ramon. 14 participants from 8 countries.
- Regional bamboo training course. 11-16 May 1998, KIB, Kunming and XTBG, Xishuangbanna, China. 15 participants from 12 countries.
- A short training course on GMS and DIPVIEW software. Laos PDR. 8-12 June 1998. 13 participants.
- Computer use, documentation and data analysis course for South Pacific. 3-7 August 1998. Suva, Fiji.
- Practical training in PGR documentation, 10-28 August 1998 at SEARCA Headquarters, UP Los Baños, College, Laguna, Philippines.
- A regional training course on genetic diversity, will be organized in collaboration with National Biotechnology Laboratory and Training Centre (NBLTC) Danzhou and Chinese Academy of Tropical Agricultural Sciences (CATAS), Haikou, China, from 16-27 November 1998.

IPGRI is also supporting the University of the Philippines at Los Baños (UPLB) in initiating M.Sc. Programme in PGR, with assistance from the Asian Development Bank (ADB). This will provide graduate training opportunities in the region with support being channelled through a consortium of Southeast Asian universities called SEARCA. Also assisted the Indian Agricultural Research Institute (IARI) and the National Bureau of Plant Genetic Resources (NBPG), New Delhi as well as the University Putra Malaysia (UPM) and University Kebangsaan Malaysia (UKM) to develop similar capabilities. Sri Lanka has also made a request which is being followed up.

**In-country linkages**
In most countries, the genebank-user linkages are poor. In many cases, valuable PGR are being lost from farmers' fields due to the poor linkage between the two (Riley and Ramanatha Rao 1995). Genebank managers and breeders must work together. This can be best achieved through evaluation, by both the genebank and breeding programme staff, to identify productive cultivars from local germplasm as well as to identify desirable genotypes from the accessions in the genebank. This could lead to joint monitoring of the benefits accrued from the use of PGR and help in making the value of conservation of PGR visible, which is essential to obtain sustained support from the policy makers. Better links between curators and crop improvement scientists will result in paying increased attention to the question of genetic erosion due to the release of new and improved cultivars for general cultivation. They can collect local material well ahead of the release of the material which should be made a pre-requisite to release of new variety and associated production technology. The breeder and conservator can also identify locations where the new varieties may not be very useful and hence the local cultivars can continue to be in cultivation, thus ensuring on-farm conservation of landraces.
International collaboration
IPGRI's second objective is to promote international collaboration for the conservation and use of PGR (IPGRI 1993), by encouraging and supporting the formation of networks, based on both crops and geographical regions/sub-regions. This is now very appropriate in the context of GPA, making regional and international collaboration as the corner stone for the PGR conservation and use (FAO 1996). The involvement of FAO, other UN organizations, International Centres (such as ICRISAT, CIP, IRRI and IPGRI) and regional programmes such as RECSEA-PGR, SANPGR and EA-PGR will be important in helping in exchange of germplasm, advise on information, technologies and public awareness that can improve the management of PGR in a country. The international linkages can assist in national efforts for technology transfer, exchange of information and scientific and technical cooperation (Ramanatha Rao and Riley 1994 a and b; Riley and Ramanatha Rao 1995). IPGRI is involved with a series of crop networks and regional networks in APO that enhance exchange of information, germplasm and technologies among countries and institutions in these networks. Such networks can also help to prioritize research and training activities that IPGRI and network members can jointly undertake (Ramanatha Rao and Riley 1996; Riley 1996a; Riley and Bari 1997; Riley et al. 1995; Zhang 1995).

Regional networks
The IPGRI offices in Serdang, Beijing and New Delhi are presently acting as secretariats in facilitating 3 sub-regional networks - RECSEA-PGR (Regional Cooperation in South East Asia on Plant Genetic Resources), EA-PGR (Regional Network for PGR Conservation and Use in East Asia), and SANPGR (South Asia Network on Plant Genetic Resources). The need for a Pacific sub-regional network has also been recognized. These regional networks help to focus on common needs and opportunities among countries in strengthening PGR activities in the region through collaboration. Such networks, which generally meet once in two years, also assist in enhancing personal linkages among PGR workers in the region and assist in exchanging information and germplasm. Three regional workshops, viz., in Bangladesh for South Asia (Arora and Ramanatha Rao 1996), Indonesia PGR Symposium for Southeast Asia (Williams et al. 1996) and East Asia PGR Coordinators meeting in China (Ramanatha Rao et al. 1995) have so far been organized that have helped to bring together the PGR workers in the respective sub-regions.

Crop networks
Crop networks focus on the conservation and use of a particular crop genepool or groups of plant species. Such networks vary greatly in size and style of operation, depending on priority and funding. IPGRI works closely with other partners who often take the lead in developing and sustaining these networks. A brief description of different crop networks that IPGRI supports or is involved in the region is given below:

Okra network
Okra is an important vegetable in Asia and Africa, and is particularly important to South Asia. The formation of an okra germplasm network was recommended by the International Workshop on Okra Genetic Resources held in 1990 at NBPG, New Delhi. Active collaboration of four national programmes/partners was also suggested, viz., NBPG, India, NPs in the Philippines, Brazil and IDESSA, Cote d’Ivoire, with NBPG taking the lead. IPGRI-APO supported the following activities during 1993-95: (i) germplasm collecting in South Asia by NBPG from India, jointly with NARC in Nepal and BARI in Bangladesh, (ii) development of four catalogues representing over 2 000 indigenous and exotic accessions and information dissemination to the concerned partners, (iii) regeneration, seed increase, maintenance, conservation and cataloguing of okra accessions in the ORSTOM/IBPGR
collection by Institute des Savenes (IDESSA), Bouake, Cote d'Ivoire, (iv) study on genetic diversity in cultivated and wild *Abelmoschus* spp., to elucidate species relationships in okra and its wild relatives, undertaken in collaboration with NBPGR, and (v) transmission of over 1 700 accessions of okra to NBPGR through IPGRI's Seed Unit from Singapore, which now holds the world's collection of okra.

The Coconut Genetic Resources Network (COGENT)

Thirty five countries around the world are active members of COGENT which aims to increase benefits to coconut producers through improved conservation and use of coconut germplasm. This network has a coordinator based in the IPGRI-APO office, and is managed through a Steering Committee. COGENT has been able to attract considerable donor support and is active in collecting and evaluating germplasm, promoting multiple uses of coconut, and setting up regional coconut genebanks, and a common database of coconut collections around the world. The establishment of COGENT as a global coconut genetic resources network has provided a mechanism for collaboration in coconut research and training among member countries and with partner institutions. It has also increased the awareness of member countries about the enormous potential of using coconut genetic resources for improving coconut productivity and also about the need to protect and use these resources in a sustainable manner. Collaboration with advanced laboratories enabled developing country researchers to update their knowledge and use new research techniques and strategies, and to jointly undertake basic research to address fundamental problems, which could not otherwise have been possible due to lack of equipments and expertise in developing countries. By the end of 1997, a total of 72 coconut researchers were trained and 62 country projects were funded. The development of the Coconut Genetic Resources Database and its dissemination provided coconut breeders information on a wider range of genetic resources for use in breeding work which has increased interest in germplasm exchange. The development of collecting strategy and conservation strategy on coconut provided sound guidelines for researchers and policy makers in coconut producing countries. The initial collecting and conservation work in several countries have effectively promoted conservation of germplasm in areas at risk. The initiation of planning for the development of a multi-site International Coconut Genebank and the acceptance of four countries to host these projects are important achievements. COGENT supported accelerated gathering of characterization data of national collections projects in five countries to evaluate natural selections and hybrids suitable for particular environments for use by low-income smallholder farmers. A project to identify multi-purpose uses of the coconut and suitable germplasm for the purpose has been started. A project to evaluate the performance of hybrids and varieties and farmers' preferences in 18 countries is planned. Development of a pest risk analysis protocol is aimed to further strengthen the safe movement of coconut germplasm. A meeting to assess the results of research on CCCVd-Is was conducted and IPGRI/FAO guidelines for safe movement of coconut germplasm suitably amended. Several other activities are in progress (Batugal *et al.* 1995; Ramanatha Rao *et al.* 1998; Santos *et al.* 1996).

The International Network for Bamboo and Rattan (INBAR)

This network was set up by the International Development Research Centre (IDRC) of Canada and is presently based in Beijing, China. INBAR became an independent, autonomous institute at the end of 1997. INBAR aims to improve, the livelihood security (increase benefits from subsistence applications; enhance other sectoral uses; promote micro/small enterprise development; add value to traditional knowledge), ecological security (forestry conservation through wood substitution; increasing value of products; plantation improvement; conservation of bamboo and rattan biodiversity) and food security (using bamboo and rattan for rehabilitation of degraded lands, soil conservation and watershed management).
IPGRI is responsible for the Biodiversity and Genetic Resources Working Group of INBAR which is undertaking a series of studies to locate and characterize the diversity of these species in Asia. Such work is expected to result in effective conservation of the priority species through integration with the activities carried out in the entire network. The support from IPGRI, which includes a consultant’s time, is made possible through funding from Japan which is expected to continue (Ramanatha Rao and Rao 1998; Rao et al. 1996; Rao and Ramanatha Rao 1995a; Rao and Ramanatha Rao 1995; Rao and Ramanatha Rao 1997).

**Tropical fruit species**

The great diversity of fruit species in Asia, their potential for providing benefits to local communities and threat of genetic erosion of many of these species are reasons for identifying the conservation and use of tropical fruits in Asia as a priority activity. A series of studies have been undertaken to assess the status of the genetic resources of priority species in Asia, and undertake training, conservation and evaluation in specific locations. Efforts are underway to link these activities into networking with partners in the region, principally through the Underutilized Tropical Fruit Asia Network (UTFANET) which is now starting up with involvement from the International Council for Underutilized Crops (ICUC), FAO and other organizations. Better understanding between IPGRI and UTFANET on complementary fruit activities seems to be emerging. Priority species include rambutan, durian, *Citrus* species, mango, jackfruit as well as other minor species native to Asia (Arora 1995a, Arora 1995b, Arora and Ramanatha Rao 1995).

**Underutilized crops**

Buckwheat, *Lathyrus*, safflower, sesame and taro have been identified as priority underutilized crop species for focus in the region. These crops are locally important and are generally grown in marginal areas where both ecosystem and genetic diversity are high. IPGRI collaborates with partners in the region in carrying out specific studies on conservation related aspects and promotes networking and collaboration on these crops. For example, a sesame meeting was organised in India in 1994 which resulted in informal networking that included evaluation and exchange of germplasm among 12 Asian countries, the development of core collections, and sesame germplasm adaptation studies. The world’s sesame collection held in Korea has now been regenerated. A consultancy with the Australian Centre of International Agricultural Research (ACIAR) and the Secretariat for Pacific Commission (SPC) was supported to assess needs for taro genetic resources conservation, improvement and sustainable production and a proposal for a taro network in the Pacific was developed. This is now being funded by AusAid and IPGRI is involved in the project management and is providing technical and scientific backstopping. *Lathyrus* germplasm directory and descriptors, *in situ* conservation studies in buckwheat, and a compilation of the medicinal uses of safflower are examples of collaborative activities being carried out in other underutilized crops. In each case, a network meeting has brought together the key researchers on these crops who continue to share information and germplasm (Arora and Riley 1994; Dajue et al. 1993; Ramanatha Rao 1994; Ramanatha Rao and Ming-De 1993; Ramanatha Rao and Riley 1995 a and b; Zhou and Arora 1995 and b; Mathur et al. 1998).

**Networks with other International Agricultural Research Centres**

IPGRI collaborates with other IARCs which take the lead in developing networks with NARS for the conservation and use of their mandate crops. For example, in 1995 IPGRI collaborated with the International Potato Centre (CIP) in developing a concept paper and in holding a workshop with national programme scientists that addressed a strategy for conserving sweet potato biodiversity in Asia in May 1996 (Ramanatha Rao 1996; Ramanatha Rao and Schmiediche 1996; Riley 1996a). A network called the Asia Network for Sweet
Potato Genetic Resources (ANSWER) was formed. A series of activities including training, joint database of collections, rationalization of collections and use of molecular methods to study genetic diversity were undertaken. In case of rice, IPGRI participates in a steering committee of the project concerned with conserving the rice gene pool through further collecting programmes; and in situ conservation studies in rice being carried out by the International Rice Research Institute (IRRI) and national programmes.

IPGRI sees networks as tools that can promote more effective collaboration and efficiently use available resources. For strengthening national programmes, promoting exchange of information and developing improved technologies for conservation and use, the available resources are limited. To a great extent, working in a network mode will alleviate the problem to a considerable degree. Consultations were held to further strengthen this idea under Asia Pacific Association of Agricultural Research Institutions (APAARI).

Conservation strategies and technologies
IPGRI's third objective is to develop and promote improved strategies and technologies for PGR conservation. This is closely linked to effective germplasm management and the development of complementary conservation strategies. A number of technologies and research approaches are now under development which can offer national programmes improved methods for PGR conservation and use. Complementary conservation strategy is a process that determines various methods of conservation (both ex situ and in situ approaches) that are needed for effective conservation of any given gene pool. Advances in in vitro conservation have made such methods practical for a wide variety of species (Engelmann and Ramanatha Rao 1996; Ramanatha Rao et al. 1998; Ramanatha Rao and Riley 1994a and b; Withers 1993). Further research on practical methods of low moisture seed technologies is still required before such technology can be used for maintaining seed with less or no refrigeration. IPGRI supported work on determining suitable seed moisture content (MC) for long-term storage along with experiments on a simple and low-cost method for ultradry storage which was conducted at ICGR, China. Cryopreservation methods are under development, and may soon be more widely used for long-term storage of base collections (Engelmann and Ramanatha Rao 1996; Sakai 1995).

Work on conserving plant genetic resources has always been concerned as much with the effective use of the resources as with conserving variation per se. With the increasing number of genebanks and size of collections, one of the major issues is the need to improve the accessibility of collections to users. Generally, plant breeders (and most users) are interested in having fairly small number of genotypes which possess the traits needed in breeding programmes. The development of core collections (minimal set of accessions chosen to contain the genetic diversity present in the whole collection), is one of the ways suggested to increase accessibility and use, as noted in the Global Plan of Action. India and China showed considerable interest in developing core collections of their sesame collections. IPGRI provided support for this work which also provided information on optimum procedures for core collection development in national genebanks. The work in China was carried out at Oilseed Crops Research Institute (OCRI), Wuhan and at NBPGR, New Delhi in India. Maintenance of genetic diversity is a very important aspect of genetic resources activity, since crop improvement objectives change over time and future needs can not be predicted. Regeneration of germplasm held in genebanks is one of the most important genetic resources activities which influences the preservation of the variability in and among the accessions. The best way of conserving the genetic integrity and making it cost-effective is the long-term storage of seeds under optimum conditions. However, regeneration is necessary from time to time, either due to the loss of viability of seeds over time and/or lowering of seed stocks held in genebanks. Guidelines have been developed to assist the genebank curators in adopting the required procedures.
The work on the determination of effective pollination control methods and isolation techniques was carried out in collaboration with FAL/IPP, Braunschweig and IPK, Gatersleben, Germany with funding from Germany (Schittenhelm et al. 1997). Work on determination of the extent of loss in genetic diversity in germplasm conserved in ex situ collections for 3-6 genepools using morphometric, biochemical and molecular techniques was carried out in collaboration with the genebank, Bari and University of Potenza, Italy. Studies on regeneration methods for germplasm seed in genebank were supported at the Institute of Crop Germplasm Resources (ICGR), Chinese Academy of Agricultural Sciences (CAAS), Beijing, China. The survey on regeneration procedures, resulted in putting together information on the managerial, as well as the genetic aspects of regeneration procedures. An analysis of the data, which was completed during early 1995, highlighted the fact that the most of the regeneration in genebanks is carried out for seed stock reasons and less for viability loss. Additionally, there were significant differences in the way the similar material was maintained in different genebanks. The analysis was presented at a consultation meeting on the regeneration of germplasm of seed crops and their wild relatives in December 1995 at ICRISAT. In collaboration with National Plant Genetic Resources Laboratory (NPGRL) and Institute of Plant Breeding (IPB), University of the Philippines Los Baños (UPLB), Philippines, the work on the determination of the extent and distribution of genetic diversity in ex situ collections, as affected by breeding systems has been in progress.

Rapid advances in molecular and isozyme markers enable studies on genetic diversity of collections to be carried out much more precisely. Possibilities for such technologies include improved monitoring of genetic diversity in seed banks and for measuring and locating genetic diversity in the field to assist in collecting and in in situ conservation (Ayad et al. 1997). The improved understanding of extent of genetic diversity is essential for its efficient use in development of desirable cultivars that are urgently required to meet the increasing demands of ever increasing population.

In situ conservation approach has received much attention recently (Hodgkin et al. 1993; IPGRI 1994; Jarvis and Hodgkin 1997). It is well recognized that farmers have been conserving high levels of diversity as part of traditional farming and agroforestry practices. More studies are planned to establish the scientific basis for in situ conservation and to understand how in situ conservation can be included as an important component in a complementary conservation strategy. Although the spread of high-yielding varieties may result in rapid genetic erosion, for a number of reasons it may not always be so. Linear replacement of traditional technology has been questioned (Just and Zilberman 1983). It has been shown that farmers, especially the subsistence farmers in marginal areas, tend to maintain and manage fairly high levels of genetic diversity on farms (Altieri and Montecinos 1993; Brush et al. 1994; Brush 1992; Brush et al. 1992). In any case, the work that is being pursued does not aim to dissuade farmers from adopting new varieties that increase food security or income, but rather to:

- Understand what is happening in the local crop development process
- Determine and understand the situations (food culture, rituals, specific preference; farming system etc.) in which local cultivars are maintained by farmers
- Identify nodal farmers who are the first link in the seed diffusion process
- Identify the key factors which affect farmer decisions to maintain local cultivars
- Understand how farmer decision-making affects the amount of genetic variation
- Find ways to assist the continued selection of local landraces that conserves local useful genes or population

Work is in progress in Nepal and Vietnam as part of IPGRI’s global project on ‘Strengthening the scientific basis for in situ conservation of agricultural biodiversity’. Efforts are also underway to study the feasibility of in situ conservation of buckwheat germplasm in Nepal and China.
Increased emphasis on the socioeconomic and cultural aspects of conservation and use of PGR at the community level can help to ensure that conservation of PGR is part of the development process. The role of farmers and local communities in maintaining and sharing PGR is enhanced and recognised, particularly in less favoured or marginal agricultural areas where diversity is high. Appropriate methods, including the Rapid Rural Appraisal (RRA) techniques (Sthapit and Subedi 1997), conservation technologies (Jarvis and Hodgkin 1997) and indigenous knowledge documentation (Quek and Zhang 1997) are being developed. Several ideas on developing a system required for documentation of in situ conservation activities are being considered.

Forestry genetic resource (FGR) is another major area that requires urgent attention. IPGRI now has a major activity on FGR, including the work on bamboo and rattan (Ramanatha Rao and Rao 1995; Rao et al. 1996; Rao and Ramanatha Rao 1995a and b; Rao and Ramanatha Rao 1996a and b). It mainly aims at improving the scientific basis for in situ conservation, improving methods for ex situ conservation and building an international information system on forestry species/PGR (Ouedraogo et al. 1994). A major area of focus will be research and technology development for seed conservation as storage is the major problem because most tropical forest species produce recalcitrant seeds. Locating diversity and studying the impact of extraction will be other areas on which there will be focus in the near future.

International information service
IPGRI's fourth objective is to provide an information service to world's PGR community of both practical and scientific developments in this field. Technical and scientific publications will be the major media through which the results of studies and new technologies will be conveyed to national programmes. The types of information provided include descriptor lists to assist genebank curators and other PGR users, information that can be used to collect, manage and use germplasm samples, directories for different crops/commodities providing information on where particular germplasm is conserved and available for exchange etc. The list of IPGRI publications (1997) contains all the titles published so far. Additionally, an effective public awareness programme has been put in place to increase the awareness on PGR issues among the general public as well as policy makers (public and corporate levels) so that PGR conservation will receive appropriate support at all levels.

It would be useful to highlight the work on PGR documentation and information management. IPGRI's aim is to develop the national capacity to develop and sustain an effective national PGR information network, a network information system (NIS) (Mathur and Quek 1997). Of particular importance is the support provided to the partners to document and make better use of their own germplasm in genebanks. A Data Interchange Protocol (DIP) has been developed to enable one genebank to receive and read information from another genebank using a compatible format. The DIP is now being used to exchange data on banana accessions in the region, and its application is being extended to use in Geographic Information Systems (GIS). A software known as Genebank Management System (GMS) developed by IPGRI is used to train genebank curators in genebank documentation and management. GMS training has been carried out in Bangladesh, Malaysia, Indonesia, Vietnam, Nepal and Mongolia. GMS is also serving as the genebank management software in several countries in the region including Malaysia. The work on information management also supports development of tools for information exchange such as the data interchange protocol (DIP) which has been tested (Yongsheng et al. 1995). It is well recognized that a well organized and maintained information system is an essential part of an effective conservation programme. IPGRI will support national programmes to develop such national PGR information systems (Quek and Ramanatha Rao 1995; Quek and Zhang 1995).
In all the areas of technology development, rapid progress is being made. It is important that national PGR programmes should keep in touch with what is going on around the world. International collaboration is one of the ways to keep this up-to-date information on new developments and their adoption at national level. IPGRI also assists providing such information to its partners through newsletters and publications. Additionally, it organizes or supports conferences or meetings to facilitate interaction of PGR researchers. Some examples in the recent years are: Workshop in users' perspectives to promote multipurpose uses and competitiveness of coconuts in May 1996; Regional coconut genebank planning workshop in February 1996; Regional workshop in *Lathyrus* resources in Asia in December 1995; Third Southeast Asian symposium on genetic resources in August 1995; International workshop on *in vitro* conservation of PGR in July 1995; International symposium on research on conservation and use of PGR in June 1995 and SPC/DAL/IPGRI/FAO Taro Seminar in June 1995. Support was provided for meetings on seed technology, citrus germplasm conservation focusing on rootstocks and biotechnology in 1997.

**Conclusion**

IPGRI considers the national programmes as the basis for a global system of PGR. Strengthening national programmes in terms of organization, technology, human resources and information is the basis of IPGRI's work on PGR. National programmes can best use such assistance when there is a clear recognition of the importance of PGR in a country and identification of organizations/individuals responsible for taking the work forward. From the initiation of the APO programme in the region, IPGRI has been supporting the organization of meetings to help the PGR workers to come together, discuss freely and chalk out a programme of action for the country. The programme should also consider all the issues discussed together and identify appropriate level of activity for each country as well as for working in collaboration. IPGRI is willing to support, mainly in the areas of techniques and advice, to assist national PGR programmes.

**References**


Riley, K.W. 1996b. IPGRI's Regional Programme Asia, the Pacific and Oceania. Pp. in Proceedings of Asia Pacific Regional Consultation on Plant Genetic Resources, 27-29, November 1996. IPGRI office for South Asia, New Delhi, India.


CBD, GPA, IPR and related policy issues and their implementation in India

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Introduction
Biodiversity refers to variety of life forms and is recognized at three levels, namely, species level, genetic level and ecosystem level. The earth’s ecosystems, species and genes are the products of over 3.5 billion years of evolution. India is one of the 12 mega biodiversity centres in the world. The country is divided into 10 biogeographic regions, viz., Trans-Himalayan, Himalayan, Indian Desert, Semi-Arid, Western Ghats, Deccan Peninsula, Gangetic Plains, North-East India, Islands and Coasts. Biogeographically, India is situated at the trijunction of three realms, namely, Afro-tropical, Indo-Malayan and Paleo-Arctic realms, and, therefore, has characteristic elements from each of them. This assemblage of three distinct realms makes the country rich and unique in biological diversity.

Humans have become selective and are dependent on a few species. Earth has about 250,000 plant species. Since history, man has tried about 300 plant species and is presently using about 150 species. Twenty crop species provide 90% of the calories for humankind. Rice, wheat and maize meet about 60% of the calories and protein requirements. Besides, in these major crops also, landraces are giving way to a handful of improved varieties. However, it is not known which species may be needed in future.

Nature has endowed India with a large variety of plants comprising about 49,000 species of which 18,000 are flowering plants. Many of these are of ethnobotanic importance and about 5,000 species are endemic. According to estimates, there are more than 50,000 species of insects, 4,500 species of molluscs, 6,500 species of invertebrates, 2,000 species of fish, 140 species of amphibians, 420 species of reptiles, 1,200 species of birds and 340 species of mammals in India (Rao 1995).

Agro-biodiversity
Agro-biodiversity comprises the diversity of domesticated crops/semi-domesticated species or their wild relatives, landraces/cultivars of crops, domesticated stocks/breeds of animals, strains of fish and agricultural microbes that are (or could be) exploited and utilized for research and development including food security and well being. Antiquity of agriculture and ethnic diversity in the Indian sub-continent have played a major role in the diversification of crop resources in this region. In addition, there has been a continuous stream of introductions of new crops and their cultivars since the ancient times.

Indian sub-continent is also recognized as one of the 12 primary centres of origin of crop plants and is rich in agricultural biodiversity. The Indian region is an important centre of origin and diversity of more than 20 major agri-horticultural crops including rice, beans, cotton, sugarcane, citrus, mango, banana, yams and several common vegetables and popular spices. This area is particularly rich in numerous medicinal and aromatic plants. Rich genetic diversity occurs in the country for crop plants (166 species) and their wild and weedy relatives (324 species). The Indian region is also well known for its native plant wealth with over 800 species of ethnobotanical interest. All these collectively form an invaluable reservoir of genes needed by plant breeders for development of superior crop varieties.

Crops in which rich diversity occurs in India include rice, wheat, barley, pigeon pea, chickpea, mung bean, urd bean, small millet, horse gram, moth bean, rice bean, cluster bean, amaranth, buckwheat, rapeseed-mustard, sesame, forage grasses, okra, eggplant, Citrus,
banana and plantain, jackfruit, mango, tamarind, _jamun_, jute, cotton, ginger, turmeric, pepper, cinnamon and cardamom. Among tuber crops rich variability exists in sweet potato, taros and yams. Native sources are also available in _Coleus_ species, sword bean, velvet bean and plantation crops including arecanut and coconut. Diversity also occurs in several minor fruits such as _ber_, and different kinds of berries and nuts. Both indigenous and well-adapted exotic set of materials form a well-balanced matrix of crop diversity in the Indian sub-continent. It is, thus, the prime task of the plant conservationists to carry out conservation programmes to preserve the rich heritage in perpetuity for the benefit of future generations to be used in crop improvement through plant breeding and biotechnology tools.

Humans are also the cause of biodiversity decline. Rapid growth of human and livestock population, expansion of township, and developmental activities are some major threats to biodiversity. The spread of high yielding varieties could always smother traditional and wild relatives having unique genetic traits. The loss of genetic diversity, which is irreversible, is already being felt strongly. In India, for example, a handful of rice varieties are cultivated in the regions where collectively once over 30,000 different varieties/stocks flourished (FAO 1995). It is to be noted that loss of genetic diversity is irreversible.

**Provisions of CBD**

The Convention on Biological Diversity (CBD) was signed by 171 countries including India during the United Nations Conference on Environment and Development (UNCED)/Earth Summit held at Rio de Janeiro in Brazil in June, 1992 and was ratified on 29 December 1993. India ratified the Convention on 18 February 1994 and the CBD came into force on 19 May 1994. At present, there are 174 Parties to this Convention. Provisions of the CBD affirm the sovereign rights of each nation over its biological resources that earlier were the common heritage of humankind.

The three main objectives of the CBD, as outlined in Article 1, are: (i) the conservation of biological diversity, (ii) the sustainable utilization of its components/biological resources, and (iii) fair and equitable sharing of benefits arising out of the utilization of genetic resources including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into accounts all rights over these resources and to technologies, and by appropriate funding.

Articles of CBD can be fruitfully used to promote international exchange and trade in genetic resources and also to preserve global diversity (Putterman 1994). There is an urgent need to stake claims of national sovereignty on the material that has originated and/or was domesticated in India and Indian sub-continent. This calls for a comprehensive strategy for conserving and sustainably using the plant genetic resources (PGRs).

**The Global Plan of Action (GPA)**

In 1983, the UN Food and Agriculture Organization (FAO) Conference adopted a non-binding International Undertaking on Plant Genetic Resources which addressed access to Plant Genetic Resources for Food and Agriculture (PGRFA). The Conference of Parties (CoP) met at Nairobi in November, 1993 and decided that the access to PGR benefit sharing and farmers’ rights etc., may be negotiated by the FAO Commission on Plant Genetic Resources (CPGR). The Undertaking is currently being revised by the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA since 1993; earlier known as CPGR) in the light of the provisions of the CBD which affirm the sovereign rights of each nation over its biological resources and which call for the fair and equitable sharing of benefits arising from the use of genetic resources. The issues in focus are scope, access and farmers’ rights. FAO Commission developed the State of the world report on Plant Genetic Resources and also developed the Global Plan of Action (GPA) identifying 20 priority areas under four
groups, viz., (i) *in situ* conservation and development: surveying and inventorying plant genetic resources for food and agriculture; supporting on-farm management and improvement of plant genetic resources for food and agriculture; assisting farmers in disaster situations to restore agricultural systems; and promoting *in situ* conservation of wild crop relatives and wild plants for food production; (ii) *ex situ* conservation: sustaining existing *ex situ* collections; regenerating threatened *ex situ* accessions; supporting planned and targeted collecting of plant genetic resources for food and agriculture; and expanding *ex situ* conservation activities; (iii) utilization of plant genetic resources: expanding the characterization, evaluation and number of core collections to facilitate use; increasing genetic enhancement and base-broadening efforts; promoting sustainable agriculture through diversification of crop production and broader diversity in crops; promoting development and commercialization of underutilized crops and species; supporting seed production and distribution; and developing new markets for local varieties and "diversity-rich" products; and (iv) institutions and capacity building: building strong national programmes; promoting networks for PGRFA; constructing comprehensive information systems for PGRFA; developing monitoring and early warning systems for loss of PGRFA; expanding and improving education and training; and promoting public awareness of the value of PGRFA, conservation and use. Both these documents were adopted at the Fourth International Technical Conference on the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture held in Leipzig, Germany.

Conceived by the FAO Commission on Genetic Resources for Food and Agriculture in response to the Agenda 21 and the UNCED process, the GPA on PGR conservation and sustainable utilisation had been under preparation for two years prior to the Leipzig Conference. A 'costed' Global Plan utilizing the data from the State of the World Report was the ultimate goal of the Conference.

There are certain aspects of the GPA where difference of opinion, especially by USA, has been indicated. These include farmers' rights, access of private sector to *ex situ* germplasm collections and financing. It was stated that funding should come from developed countries and/or other sources and should, where possible, seek to facilitate the leveraging of other funding sources and mechanisms.

**The Global Environment Facility (GEF)**

The resource crunch at global level has been a known fact and several countries are looking to GEF for supplementary funding. Countries of the Southeast Asia have received GEF funding. For example, GEF in partnership with the World Bank and the Government of India has funded a five year Eco-development Project with an outlay of US$ 74 million that will involve local communities, national institutions and NGOs into collaborative action at eight threatened priority sites in India where haphazard development endangers biodiversity. This, it is felt, will effectively integrate rural livelihood with conservation. Similarly, Pakistan has received some US$ 310 000 to prepare its national action plan and to identify 3 to 5 protected areas. Same is true for Sri Lanka.

**PGR initiatives in India**

ICAR has, from time to time, undertaken major initiatives in PGR related activities (Paroda 1996) which are mentioned below:

- Three institutions, namely, National Bureau of Plant Genetic Resources (NBPGR), National Bureau of Animal Genetic Resources (NBAGR) and National Bureau of Fish Genetic Resources (NBFGR) have been established. A Bureau on Agriculturally Important Microorganisms is contemplated to be established during the IX Five Year Plan
The NBPG has ten operating Regional Centres/Base Centres located in different agro-ecological regions of the country.

National Genebank with a capacity to preserve one million accessions was established at NBPG, New Delhi on 18 November 1996 (NBPG 1997).

National Research Centre for DNA Fingerprinting was established in the year 1995 with a mandate to characterize all genetic resources including plants, animals and fish by using recent techniques.

A single window system has been established for global exchange of PGR.

Special provisions worth Rs. 30 crores (about US$ 7.5 million) have been made under the World Bank aided project 'National Agricultural Technology Project' (NATP) for exploration, collecting, evaluation, characterization, conservation and utilization of agro-biodiversity for sustainable crop production.

Two special projects, viz., National Plant Tissue Culture Repository and Genebank for Medicinal and Aromatic Plants are also functioning at NBPG.

For transgenics, import and early handling mechanism have been provided and containment facilities are envisaged for further strengthening.

For Plant Variety Protection (PVP), needed facilities and support will be extended.

A mechanism has already been put in place for registration of plant germplasm, strains and parental lines etc.

Exploration, evaluation and bio-prospecting is assured for agro-biodiversity.

National Plant Quarantine System is envisaged.

Thrust and priorities on agro-biodiversity are being accorded during the IX Five Year Plan.

A think-tank is assured with continuous dialogue with all concerned including NGOs.

A national action plan, in view of the new PGR/IPR regime has also been chalked out.

**Major impacts of PGR initiatives**

India has got a remarkable success in harnessing the natural resources coupled with development and utilization of improved technology in the fifty years of post-independence era showing a 275% increase in the food grain production. It resulted in a buffer stock of 36 million tons in 1994-95. This achievement could be made in spite of a population-growth at the rate of 2.1% per annum. The food grain production increased from 50.8 million tons in 1950-51 to an all time high of 199.32 million tons in 1996-97 with an impressive annual compound growth of about 2.7%. The increase has been largely through steady productivity increase from 522 kg ha\(^{-1}\) in 1950-51 to 872 kg ha\(^{-1}\) in 1970-71, 1546 kg ha\(^{-1}\) in 1994-95 and 1601 kg ha\(^{-1}\) in 1996-97. It is to be noted that during 1970 to 1997, the area under food grain crops remained almost static i.e. around 125 million hectares. A record production of 69.27 million tons of wheat in the year 1996-97 made India the second largest producer of wheat, next only to China, in the world.

Besides attaining self reliance in food production, through sustaining and stabilizing the green revolution, the country achieved the status of being the second largest producer of fruits and vegetables in the world due to significant advances made in horticultural crop production technology and management of resources. About 170 000 accessions of various crop plant species and their relatives have been safely conserved *ex situ* under long-term storage in the national genebank at the NBPG.

Utilizing indigenous and exotic PGR, about 2 500 varieties of food crops (2172) and vegetables (365) have been released and notified which have helped the farmers in augmenting production and productivity of crops and enhancing farm income. Besides
development of cultivars, many useful parental lines/genetic stocks have been developed. ICAR has recently introduced a system of registration of such enhanced PGRs.

New crops like soybean, sunflower, jojoba, guayule, oil palm, kiwi fruit, tree tomato and low chilling cultivars of apple, pear, peaches and almond were introduced from other countries. Recent example is that of soybean which now covers about 5 million hectare area in the country and contributes about Rs. 2000 (about US$ 50 million) crores worth of foreign exchange.

Some of the exotic accessions of cultivated crop species were adopted directly as improved varieties such as Pusa Harbhajan in pea, La Bonita, Sioux and Roma in tomato, Peredovick in sunflower, California Wonder in capsicum, Nantes in carrot and several others. Many selections like NRC 7 (Ahilya 3) of soybean are also basically exotic accessions.

The GPA, through its Activity 12, promotes the development and commercial application of underutilized crops and species. In India, efforts under a coordinated project on underutilized and underexploited plants made during past 15 years resulted in identification of potential new plant resources for food, fodder and industrial uses. Fourteen improved varieties in 7 different crops have been recommended/released for cultivation, viz., Annapurna, GA 1 and Suvarna in grain amaranth, Himpriya, VL 7 and PRB 1 in buckwheat, RBL 1, RBL 6 and PRR-2 in ricebean, VH 81-1 (Vikrant) in fababean, AKWB 1 in winged bean, Arizona 2 and HG 8 in guayule and EC 33198 in jojoba.

**Indian varieties and genes of international significance and use**

Indian subcontinent/"Hindustani" centre has provided the world with a trove of genetic diversity. Indian varieties and parental lines in differents crops have been used in many countries. For example, Indian sugarcane varieties have been used as basic breeding stocks and for commercial cultivation in many countries. The early Coimbatore (Co) varieties like Co 213, Co 281, Co 290, Co 312, Co 313 and Co 475 were extensively used as parents in breeding programmes in Java (Indonesia); Louisiana and Hawaii (USA), Queensland (Australia) and West Indies. Indian sugarcane varieties are extensively cultivated in many countries, namely, Nigeria (Co 396, Co 421, Co 775, Co 957); Sudan (Co 453, Co 617, Co 775, Co 1007); Sri Lanka (Co 453, Co 527, Co 775, Co 997); Central Romania (Co 331, Co 853); Australia (Co 210, Co 213, Co 281, Co 290); USA (Co 281, Co 290); Jamaica (Co 331); Pakistan (Co 421, Co 997, Co 1148); Spain (Co 290, Co 413, Co 421); and Indonesia (Co 617, Co 997, Co 1148).

In wheat, rice, chickpea and many other crops, novel genes present in native strains/stocks are being used internationally. In rice, India's germplasm had been utilized to improve both tropical and temperate rice in many Asian countries (Siddiq 1996). For instance, Intan, Mas and Peta, the most popular varieties of Indonesia, are the products of the cross of the Indian variety Latisail with the Chinese variety Cina. Peta is a parent of the miracle variety IR 8. Hence, over 80% of the dwarf varieties of rice cultivated today in Asia have germplasm from Latisail. India's GEB 24, known for its grain quality occurs in the ancestry of many Asian rice varieties. Other frequently used sources include Indian rice varieties/strains, viz., Mudgo (possessing resistance gene bph 1) and Ptb 33 (having gene bph 3) for resistance to brown plant hopper along with CO 18, Ptb 18 and Ptb 21 for resistance to plant and leaf hopper, stem borer, gall midge and rice tungro virus.

The countries that have used Indian wheat germplasm include those of Latin America, Africa, Asia, Arab and Gulf countries and others such as the erstwhile USSR and Canada. Indian wheat varieties 'Kharchia Local'/'Kharchia 65' for salt tolerance, 'Hindi 62' for heat tolerance and 'NP 4' for grain quality are some examples in this regard. Indian wheat varieties released in Asian countries are listed in Table 1.
Table 1. Indian wheat varieties released in Asian countries during the post-dwarf era

<table>
<thead>
<tr>
<th>Country</th>
<th>Variety (name and year)</th>
<th>Indian variety/line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Darulaman 1 (1980)</td>
<td>HB 102-101</td>
</tr>
<tr>
<td></td>
<td>Balkh 66 (1987)</td>
<td>HO 2322</td>
</tr>
<tr>
<td></td>
<td>Nangerhar 64</td>
<td>WL 711</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Balaca (1981)</td>
<td>'Pratap'</td>
</tr>
<tr>
<td></td>
<td>Baw 28 (1983)</td>
<td>UP 301/C 306</td>
</tr>
<tr>
<td></td>
<td>Kancham (1983)</td>
<td>UP 301/C 306</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Bajokal (1992)</td>
<td>HD 2380</td>
</tr>
<tr>
<td>China</td>
<td>NP 798 (1964)</td>
<td>NP 798</td>
</tr>
<tr>
<td>Myanmar</td>
<td>Manywa white</td>
<td>NP 4</td>
</tr>
<tr>
<td></td>
<td>Sharbati Sonora (1968)</td>
<td>'Sharbati Sonora'</td>
</tr>
<tr>
<td></td>
<td>UP 262</td>
<td>UP 362</td>
</tr>
<tr>
<td>Nepal</td>
<td>Janak (1995)</td>
<td>'Janak'</td>
</tr>
<tr>
<td></td>
<td>Nepal 30 (1975)</td>
<td>N 10B/K68/BB</td>
</tr>
<tr>
<td></td>
<td>UP 262 (1978)</td>
<td>UP 262</td>
</tr>
<tr>
<td></td>
<td>Lumbini (1981)</td>
<td>H&amp;D 1209</td>
</tr>
<tr>
<td></td>
<td>Triveni (1982)</td>
<td>HD 2189</td>
</tr>
<tr>
<td></td>
<td>Sidhartha (1983)</td>
<td>HD 2204</td>
</tr>
<tr>
<td></td>
<td>Vinayak (1983)</td>
<td>LC 55</td>
</tr>
<tr>
<td></td>
<td>Nepal 297 (1985)</td>
<td>HD 2320</td>
</tr>
<tr>
<td></td>
<td>Annapurna 2 (1988)</td>
<td>CPAN 1796</td>
</tr>
<tr>
<td></td>
<td>Nepal 251 (1988)</td>
<td>HUW 251</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Arz (1973)</td>
<td>HD 1931 SIB</td>
</tr>
<tr>
<td></td>
<td>HD 2009 (1978)</td>
<td>'Arjun'</td>
</tr>
<tr>
<td></td>
<td>WL 711 (1978)</td>
<td>WL 711</td>
</tr>
<tr>
<td>Thailand</td>
<td>Pharae 60 (1987)</td>
<td>UP 262</td>
</tr>
</tbody>
</table>

In sorghum, although contribution of 'Zera Zera' from Ethiopia and eastern Sudan and of 'Togo' type of African varietal group are significant, Indian sorghum germplasm has been utilized similarly in various countries being the unique source of resistance to major pests like shootfly, stem borer and midge.

In maize, existence of primitive forms of maize, such as the multicobbled 'Sikkim Primitive' (aptly called the "Living Fossil") confirms the long history of the crop in this Indian region, far away from its centre of origin in South America.

In case of pigeonpea, several landraces have been used for developing the varieties released in other countries either through ICRISAT or directly (Table 2). Among these are landraces from Madhya Pradesh/Central India and Karnataka such as ICP 6, ICP 6393, ICP 7018, and ICP 7035 which have contributed towards development of varieties which were released in Australia, Myanmar, Nepal, Venezuela, Fiji, etc.

Indian pigeonpea landrace ICP 7217 (Turk-Thoga) which originated from Karnataka, (India) was released directly as a variety, La Carrera, in Venezuela. Similarly PR 5193 which was selected from the fields of ethnic communities of Atta pad, Western Ghats, India was released directly as a variety, Aroa, for crop-livestock system in Venezuela.

Thus, there are numerous such Indian sources already in use internationally (Siddiq 1996) and there will be many more yet to be identified. The search has to be strengthened
Table 2. Pigeonpea cultivars (with Indian material in their pedigree) released by ICRISAT

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>CP No.</th>
<th>Origin/pedigree</th>
<th>Country and year of release</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunt</td>
<td>14057</td>
<td>Prabhat × ICP 7018</td>
<td>Australia, 1983</td>
<td>ICP 7018 originated from Madhya Pradesh, India</td>
</tr>
<tr>
<td>Megha</td>
<td>14057</td>
<td>Prabhat × ICP 7018</td>
<td>Indonesia, 1987</td>
<td>ICP 7018 originated from Madhya Pradesh, India</td>
</tr>
<tr>
<td>Pragati (ICPL 87)</td>
<td>11543</td>
<td>T 21 × ICP 6393</td>
<td>Myanmar, 1992; India, 1986</td>
<td>ICP 6393 originated from Madhya Pradesh, India</td>
</tr>
<tr>
<td>Quantum</td>
<td>13194</td>
<td>T 21 × ICP 6393</td>
<td>Australia, 1985</td>
<td>ICP 6393 originated from Madhya Pradesh, India</td>
</tr>
<tr>
<td>Quest</td>
<td>13194</td>
<td>(Prabhat × HY 3C) × (ICP 7018 × ICP 7035)</td>
<td>Australia, 1988</td>
<td>ICP 7018 and ICP 7035 originated from Madhya Pradesh, India</td>
</tr>
<tr>
<td>Kamica</td>
<td>7035</td>
<td>Landrace from India</td>
<td>Fiji, 1985</td>
<td>Landrace from Madhya Pradesh, resistant to wilt and SM, released directly as a variety</td>
</tr>
<tr>
<td>Rampur Rhar</td>
<td>6997</td>
<td>Landrace from India</td>
<td>Nepal, 1992</td>
<td>SM resistant landrace from Madhya Pradesh, India, released directly as a variety</td>
</tr>
<tr>
<td>La Cerrera</td>
<td>9905</td>
<td>Sel. ICP 7217</td>
<td>Venezuela, 1991</td>
<td>Selection from a landrace ICP 7217 (Turk-Thoga) which originated from Karnataka, India, released directly as a variety</td>
</tr>
<tr>
<td>Aroa</td>
<td>11916</td>
<td>Landrace from Western Ghats, India</td>
<td>Venezuela, 1991</td>
<td>A high performing ratoonable landrace selected from the fields of ethnic communities of Attapad, Western Ghats, India (PR 5193) released directly a variety for crop-livestock system in Venezuela</td>
</tr>
</tbody>
</table>

for novel genes which are significant in the wake of the proposed Plant Variety Protection Legislation. There is a great need to strengthen bioprospecting efforts to benefit from this rich wealth of the country.

The new intellectual property rights (IPRs) regime

Since 1945 and up to 1994 i.e. for seven rounds, the General Agreement on Tariffs and Trade (GATT) dealt with tangible goods with emphasis on tariffication and reduction and gradual diversification of all barriers to tariffs. The Uruguay round of Global Trade Negotiations concluded with signing of General Agreement on Tariffs and Trade (GATT) on 15 April 1994 at Markesh, Morocco by more than 120 countries including India. It also set to create World Trade Organization (WTO). It was with this Uruguay round in 1994 that the scope was extended to include non-tangible goods like trade in services and technologies, agriculture, environment and intellectual property rights. Agreement on Trade Related Aspects of
Intellectual Property Rights (TRIPS), within the GATT, mandated certain level and forms of legislation on Intellectual Property Rights (IPR). Article 27(3) (b) reads as follows: "Parties may exclude from patentability plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and micro-biological processes. However, parties shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof. This provision shall be reviewed four years after the entry into force of the Agreement establishing the WTO (the World Trade Organisation)."

This article obliges members to provide for the protection of plant varieties either by patents or an "effective" *sui generis* (of its own kind, unique, separate or independent) system or a combination of these. Since the Indian Patents Act (1970) excludes agriculture and horticulture from patentability, India is obliged to put into place an effective *sui generis* system for plant variety protection. None of the IPRs mandated changes were required for five to ten years, depending on product and country and further extensions could be granted. However, many countries are well on the way to adopting a legislation.

**Forms of Intellectual Property Rights**
The TRIPS Agreement does not define in detail the term "intellectual property right". IPRs are usually defined as rights granted by a state authority for certain products of intellectual effort and ingenuity (OECD 1996). There are four forms of traditional IPR, viz., i) patents, ii) plant breeders' rights, iii) trade secrets and iv) trademarks. A fifth form of the IPRs i.e. Material Transfer Agreements (MTAs) has also now emerged as a potent way of exercising such rights.

Both patents and plant variety protection (PVP) are needed for agriculture. Form like trademark has recently become important for India in regard to geographic appellation/ indication for products like Basmati rice, Darjeeling tea, Dashhari mango etc.

It has been argued that because of the farmers' privilege and research exemption under PVPs, the PBR Law really protects the variety name rather than the germplasm itself (Lesser 1997). Therefore, apparently there is a degree of substitutability between trade marks and PBRs. This, however, would not apply to patents because the emphasis there is on identified novel characteristics rather than the entire plant.

**Implications of IPR**
It is often stated that IPRs lead to greater investment in research and development of products and facilitate access to the material. In USA, it was concluded that PBRs did have a significant impact on private investment and in increasing the number of private breeders specially in case of soybean (Butler and Marion 1985; Brim 1987; Lesser 1997). There are, however, some suggestions that the initial investments by the private sector were over-responsive. Similarly, a provisional study shows that the Argentine private sector increased its investments in plant breeding, but only after the law was enforced (Jaffe and van Wijk 1995).

**The International Union for the Protection of New Varieties of Plants (UPOV)**
Although specific protection to plant material was granted in the United States as early as 1930 under the Plant Patent Act, significant plant protection or Plant Breeders' Rights (PBR) could be realized after inception of UPOV in 1961. UPOV (the French acronym for 'Union Internationale pour la Protection des Obtentions Vegetables' i.e. 'International Convention for the Protection of New Varieties of Plants') is an intergovernmental organization which cooperates in administrative matters with the World Intellectual Property Organization (WIPO) and has its headquarters in Geneva, Switzerland.
The purpose of the UPOV is to recognize and to ensure an intellectual property right to the breeder of a new plant variety. The member States of UPOV grant such a right in accordance with the provisions of the Convention under their national legislation. Thus, PBRs in the member States are granted on an internationally harmonised basis. To be eligible for protection, varieties have to be distinct, uniform and stable (DUS). Protected varieties remain available for use as a source of variation for the development of other varieties.

The convention laid down common rules for PBR which were signed in Paris in 1961 and entered into force in 1968. The original convention has been revised in 1972, 1978 and 1991. The UPOV (1978) and UPOV (1991) Acts differ with regard to: (i) membership, (ii) discovery and further developments, (iii) national treatment, (iv) scope, (v) minimum coverage of genera or species, (vi) period of protection, and (viii) special title/patent protection.

The UPOV convention was originally signed by six European countries and had only 19 members until 1990. Presently, UPOV has 37 member States. The UPOV (1991) Act has been ratified by several countries and UPOV 1978 Act is closed for new members. The closure of the 1978 Act will leave only option to accede to 1991 Act which demands rapid enforcement of rather relatively stringent provisions as compared to 1978 Act.

It is to be noted that requirements under TRIPs do not necessitate joining UPOV. Views both in favour and against joining UPOV have been expressed in India. Opinion of not to join UPOV (Sahai 1996) mainly rests on the ground that UPOV system is based on components that are alien to us like commercial agriculture, seed research in private domain etc. as being practised in industrial counties. There are, however, several benefits in joining UPOV. Besides facilitating a uniform formulation of the extent and scope of plant breeders' rights, the Convention also provides national treatment/reciprocity, right of priority, a uniform and acceptable system of testing and a multinational fora for PVP needs to the member countries.

Proposed Indian *sui generis* system for plant variety protection

**Requirements for a *sui generis* system for PVP**

Besides meeting the minimum requirements laid down by the TRIPS agreement, a *sui generis* system of protecting plant varieties should also take into account the objectives of other related international treaties and emerging principles of the international community. Some of the relevant treaties include the Convention on Biological Diversity (CBD) and the International Labour Organization Convention 169 with special reference to the issues of plant genetic resources and Traditional Resource Rights (TRR). A wide range of instruments such as the Rio Declaration, Agenda 21, the International Undertaking on Plant Genetic Resources (IUPGR), the UNESCO/WIPO Provisions for National Laws on the Protection of Folklore and the Draft Declaration on Indigenous Rights (DDIR) are also relevant.

The issue of PVP as related to plant genetic resources has been comprehensively discussed by Leskien and Flitner (1997). Under the *sui generis*, the country may have one of its own kind of legislation which may or may not follow or could partially follow the model law of UPOV (UPOV 1996). The obligation and guiding principles for shaping a *sui generis* system of PVP could be summarised as follows:

i) The *sui generis* system of PVP has to be a legally enforceable IPR

ii) TRR and farmers' rights (FR), both tangible and intangible, should be recognized. These include farmers not only as cultivator but also as breeder of varieties and as conserver and enhancer of genetic resources along with rights related to indigenous and farming communities' knowledge, innovation and practices which should be protected and encouraged.
iii) States have the sovereign rights over their own natural resources including genetic resources. Biological diversity shall be conserved, enhanced and sustainably used. Access to genetic resources shall be subject to Prior Informed Consent (PIC) and, after PIC is granted, on mutually agreed terms. Benefits arising from the utilisation of genetic resources shall be shared in a fair and equitable way on mutually agreed terms. PVP shall be supportive of and not run counter to these objectives.

iv) In order to be effective, the system would require an enforcement procedure including a remedial action against any act of infringement of the system.

v) Principle of national treatment, and not merely reciprocity, should be followed by which nationals of other countries are accorded a treatment no less than what is accorded to the nationals of our own country. Most-favoured-nation treatment to SAARC countries may also be considered.

The PVP legislation should include certain provisions in recognition of farmers rights, establishment of National Community Gene Fund etc. Traditional varieties developed by farmers such as 'Maldandi' sorghum, 'Basmati' rice etc. should be brought under the purview of proposed PVP legislation. There is a need for cataloguing and characterizing all traditional and also extant varieties. The PVP legislation is now entitled as 'Plant Variety Protection and Farmers Rights Act' so as to acknowledge the traditional knowledge system culminating in the development of traditional varieties. Farmers should be recognised both as conservers and also as breeders. The benefit sharing should be ensured to go to such holder communities which evolved the traditional varieties or will do so in future. In case where an individual farmer or community could not be specifically recognized, the benefits accruing shall go to the National Community Gene Fund. There should be a harmonization between the proposed PVP legislation and biodiversity legislation. Besides the need for a comprehensive and reliable varietal testing system, the issues of essentially derived variety, compulsory licensing, farmers' and communities' rights etc. also need attention (Tiwari 1998).

**The Indian sui generis system**

The Indian bill is to be called "Plant Variety and Farmers' Rights Protection Bill-1998" (PV&FRP Bill). It may have the following aspects: Short title, extent and commencement; Definitions; The Plant Varieties and Farmers' Rights Protection Authority; The Registry; Procedure for and duration of application for registration; Power of Authority and duration and effect of registration; Surrender and Revocation of Certificate (of registration); Rectification and correction of register; Compulsory License; Finance, Accounts and Audit; Infringement; Offences and Penalties and Procedures (including Tribunal); and Miscellaneous.

The main features of the proposed legislation are that farmers' rights have been protected and farmers have also been recognized as breeders of plant varieties. Farmers' Rights to save, use, exchange, share or sell his farm produce have been protected except in case where a sale is for the purpose of reproduction under a commercial marketing arrangement.

Researchers' rights are also to be protected to use plant variety for experiment or research or as an initial source of variation for the purpose of creating other varieties accepting the repeated use of a protected variety for commercial production of another variety.

The protection to a variety will be given subject to its conforming to distinctness, uniformity and stability (DUS). DUS-testing along with varietal characterization using biochemical and molecular markers as well as DNA finger printing has to be attended to. ICAR has expertise and is further getting geared up to facilitate varietal testing and also using biochemical markers to stake national claims to Indian varieties including the traditional ones to ensure the benefits accruing to us. An authority at national level has been proposed to lay down procedures for plant variety protection and also to deal with policy to ensure smooth functioning of the system. A Registry is proposed to be in place in the authority for facilitating the registration of plant varieties along with provision of branch officers.
A National Community Plant Variety Fund may be proposed for supporting the on-farm conservation and sustainable use of landraces and traditional varieties and genetic resources. Although this has been one of the debatable issues, especially with regard to its operationalization and instrument of legality, it would be desirable to establish such a fund. Researchers' rights to have free and complete access to protected varieties for bonfide research and for development of new varieties of plants have also been recognized. A compulsory licensing system has been proposed so that proprietor of a plant variety may not hold it and its multiplication and distribution is ensured in public interest. Issues of extant varieties and essentially derived varieties have also been spelt out. An Appellate Board, civil remedies including penal provisions and conformity to other laws have also been ensured.

The Indian 'Plant Variety Protection Legislation' is being finalized for its enactment and the necessary mechanism to implement the new IPR regime has to be evolved.

**Preparedness for PVP legislation with reference to varietal testing and characterization**

Distinctness, uniformity and stability (DUS) testing along with varietal characterization using biochemical and molecular markers as well as DNA fingerprinting has to be undertaken. In India, there is a need to develop guidelines for varietal testing or adopt UPOV Test Guidelines (UPOV 1997) especially the characteristics (as given in Chapter VII of the 10 chapters of UPOV guidelines for each crop/species). Threshold of distinctness applied for different types of characteristics in the DUS tests of varieties is also to be determined and followed. Out of several techniques considered by UPOV for variety testing, biochemical and molecular markers have become increasingly relevant (Cooke 1988; Vos et al. 1995; Morrell et al. 1995; Zhang et al. 1993).

ICAR has already set up a National Research Centre for DNA Fingerprinting at NBPGR, New Delhi which will cater to requirements not only for plants but also for animals and fish. The system is also mandated to address the identification and staking claims of national sovereignty on Indian agro-biodiversity as per the CBD provisions and also as per the requirements of the proposed Indian Biodiversity Legislation. Meanwhile, a system has already been provided under the ICAR whereby registration of genetic resources, elite material, parental lines etc., can be done so that the valuable material is made available for meeting wider goal of food and nutritional security in the country.

For testing of varieties, it would be desirable to have a system which is accepted by other partner countries. Provision similar to the EU Common Catalogues, with needed modifications, could probably be adopted for Indian sub-continent/SAARC countries so that the results of variety testing carried out in a country could be accepted in another member country. A consolidated SAARC countries’ list of such tested varieties could be circulated and timely updated. This will have a desired effect on crop improvement and seed market accessibility in the region. It is hoped that if the system as suggested above is put in place, the farmers may have greater access to new varieties. Easy access to good planting material is to be vindicated by favourable policy environment.

**IPR vis-a-vis transgenics**

PVP may have several off-shoots. In case of transgenics, which may be common in near future, the situation is more complex. The "essentially derived variety" clause may involve several negotiations before the improvement for one or a few genes in existing cultivar is made and the new cultivar is commercialised. Further, a transgenic plant may involve several patents/protections which may not be available with one institution or private company. Any IPR holder of one of these patents could block the commercial utilization of the product. Testing of transgenics will also be different owing to biosafety requirements.
Commercialization of transgenics would, therefore, depend on either purchase or licensing which most of the SAARC countries may find difficult to afford or else by having mutually agreed alliance with trans-national companies. A partnership between public and private sector is also emerging on the scene.

**GMOs and biodiversity**

Concerns have been expressed with regard to genetically modified organisms (GMOs) vis-à-vis biodiversity. Article 19.3 of the CBD on the "Handling of Biotechnology and Distribution of its Benefit" states that "The parties shall consider the need for and modalities of a protocol setting out appropriate procedures, including, in particular, advance informed agreement, in the field of safe transfer, handling and use of any living modified organism resulting from biotechnology that may have adverse effect on the conservation and sustainable use of biological diversity." Country like India, which is rich in biodiversity, has to take special measures to safeguard its biodiversity while resorting to GMOs for high productivity and quality of crops to ensure food and nutritional security.

India has a large number of small farmers who use farm-saved seeds. This calls for a caution in resorting to the technology like "terminator gene" which is a patent on "Control of plant gene expression", US Patent No. 57 23 765, taken by the Delta and Pine Land Co. and the USDA for controlling the viability of progeny seed without harming the crop. The technology alters the seed so that it will not germinate if re-planted a second time, thus preventing seed saving by farmers. The patent is broad in scope and is applicable to plants and seeds of all species including transgenics.

The terminator technology is aimed at preventing the germination of farm-saved seed. Farmers of developing countries like India use huge amount of farm-saved seed collectively but on a small scale individually. If the technology referred to is applied in such countries, the farmers will be at a disadvantage. The Plant Protection Adviser (DAC, MoA) has recently issued a memorandum to the Import Permit Issuing Authorities to be prepared and vigilant not to allow the material containing terminator technology to be imported in the country.

The Government of India has a mechanism in place for import, testing/evaluation including biosafety and related handling of transgenics which is being run by the Department of Biotechnology in collaboration with the ICAR.

**The need for a national biodiversity legislation**

Plant genetic resources are to be considered in relation to IPR and related regulatory framework (Leskien and Flitner 1997). The Indian National Biodiversity Legislation is on the anvil. The legislation, which could be called "Biological Diversity Act", should be an umbrella Act and should cover all biological resources occurring and naturalized in India. Besides, affirming that the biological resources are sovereign property of the State, the legislation should also encompass and respect and protect all indigenous and traditional knowledge of local communities associated with the biological resources as this forms intangible component of biological resources. The Act should be an effective instrument in achieving equitable sharing of benefits. It should promote conservation and sustainable use of biodiversity and prevent activities which are detrimental to this cause. Moreover, while addressing to the vital issues of biodiversity, undesirable restrictions on research and development in the country should not be imposed.

The access to bioresources should be regulated by a National Biodiversity Authority. State Governments may establish State Biodiversity Boards for the purpose of implementation of the proposed Act. At the local level, there may be Biodiversity Management Committees. There may be mutual transfer agreements, contracts on mutually agreed terms which could
be entered into for such access. Quantum of monetary and other benefits shall form part of the mutually agreed terms. No export of bioresources should take place without the permission of access granted by the National Biodiversity Authority constituted under the legislation. The access should be denied in case of threatened species/strains generally and also in specified circumstances like threat to environment, biosafety, etc. The Act, in particular, should address to the following:

- Conservation and sustainable use of biodiversity
- Minimizing adverse impacts on biodiversity
- Knowledge of local people related to biodiversity
- Activities with prior informed consent (PIC)
- Equitable sharing of benefits
- Prior permission regarding commercial application
- Notification of biological diversity heritage sites
- Power to notify threatened species
- Repositories for different categories of biological resources

There should be National Biodiversity Fund supported by State Biodiversity Funds and Local Biodiversity Funds for channelising the benefits to the country and its people. Along with grants/loans from the Central Government, fees, royalty, tax and other monetary benefits could be imposed for composing the National Biodiversity Fund.

Farmers' rights are important considerations in framing any regulatory mechanisms. As per the FAO Resolution 5/89, the farmers' rights are "rights arising from the contribution of farmers in conserving, improving and making available PGR for the purpose of ensuring full benefits to farmers for their contributions".

Farmers have their established stand as innovators/enhancers of biodiversity having traditional knowledge and ethos. Indigenous and traditional knowledge systems are both coded and non-coded and are formal and informal. Coded systems include treaties on Ayurveda, Unani and Sidha systems of medicine and health care. A wealth of information is non-coded which is in the form of local knowledge and practices and innovations.

The *Honey Bee* network (Gupta *et al.* 1998) has been very successful in bringing together people engaged in eco-restoration and construction of knowledge about precious ecological, technological and institutional systems. More than five thousand innovative practices, mainly from dry regions, have been documented over the last six years. Most breeders have not documented information regarding the providers of landraces or the culinary characteristics perceived to be important by local people. In the absence of information, it would be very difficult to revisit the exact sites and to ensure equitable sharing of benefits that may arise as a result of value addition.

Legal recognition of these knowledge systems should be provided in the National Biodiversity Legislation. Mechanisms should be devised for sharing of benefits with the holders and creators of such knowledge if identified. Benefits could be deposited in a National Biodiversity Fund, which as stated above could be created by the Central Government for this purpose, if the knowledge etc. cannot be attributed to an identifiable entity.

There had been suggestions that local bodies should be assisted to promote conservation, and sustainable use of biological wealth in their respective block/area. Conservation of common biological property, community assets and knowledge, habitat preservation and on-farm conservation of agro-biodiversity needs promotion by involving NGOs and local bodies. Notification of biological diversity heritage sites and repositories, as stated earlier, and promotion of their function as well as regulation through guiding principles is warranted.

Collecting of biological resources from wild as well as from places/sources other than the wild should be regulated. A National Database Network should be created and certain
participating organizations/entities should share the information. Heavy penalties should be imposed to deter a person/entity for contravention of the legislation (Act) so that the bioresources are conserved and utilized sustainably and also that the country and the local communities get their due share.

National Action Plan on Biodiversity has also been proposed which encompasses all biological resources indigenous or naturalized in India which are the sovereign property of the State. The Plan aims to achieve conservation and sustainable use of biodiversity, participation of communities and related people/agencies, realize consumptive and non-consumptive value of biodiversity, ensure benefits and benefit sharing of biodiversity along with other related aspects.

**The designated germplasm in the CG centres**

There is one more aspect concerning CG centres which relates to the use of the designated germplasm held by the CG centres and others, especially in context of the essentially derived variety concept using transformation as stated earlier. The CG centres at present hold an estimated 300,000 of germplasm samples. This designated germplasm mostly consists of national duplicates which are being held in trust by the CG centres on behalf of the FAO. A need for international legal framework to protect the national interests has been felt (Wood 1993). The genetic resources thus held should not only continue to be made available but the benefits accruing should also be extended to the nations concerned.

The recent case of attempted patenting of such germplasm related to two chickpea lines, viz., ICRISAT’s accession ICC-14880 which is a farmer’s variety from Andhra Pradesh, India along with a second IC1CV-88202 variety which is derived from an Iranian farmer’s variety. This patenting involved Seed Grain and Biotechnology Australia. Agra Corp Pvt. Ltd., a subsidiary of the Grain Pool of Western Australia. Owing to the proactive roles of NARS, ICRISAT and Rural Advancement Foundation International (RAFI), Canada, the patent was abandoned.

The FAO-CGIAR Agreement on Genetic Resource Collections which was signed on 26 October 1994 for a term of four years is nearing completion. It has been opined by several agencies that the agreement may be reviewed and may not be allowed to be ‘rolled over’ for the next term so that national sovereignty of different concerned countries could be recognized over these and the benefits accruing therefrom could be equitably distributed. It is to be noted that the Head of CGIAR, has called for a voluntary moratorium on patenting of the designated germplasm. A moratorium on supply of germplasm samples to countries which have not recognized the Convention on Biological Diversity may also help as it is clear that CG collections are not in ‘public domain’ but are under the provisions of CBD.

**Geographic indications**

Act 22 under Sec. 3 of GATT states that “Geographical indications are, for the purposes of this agreement, indications which identify a good as originating in the territory of a member, or a region or locality in that territory where, a given quality, reputation or other characteristics of the good .”

A Geographical Appellation Act would safeguard area specific products like the Basmati rice from encroachment by foreign enterprises, in much the same way the term “Champagne” is reserved for a product from a particular region in France.

The country needs to bring in legislation to protect geographic indication as part of the Trade Marks Act or as a separate legislation. A review of the existing agricultural products in India and steps to get them registered under geographical appellation in all relevant countries are also needed.
Quantitative restrictions under GATT agreement
As per provision of Article XVIII of GATT Rules, countries can impose quantitative restrictions (QR) on imports only so long as they have Balance of Payments (BOP) difficulties. In the current round of BOP consultations, it was argued that India can no longer maintain QRs on imports as International Monetary Fund (IMF) has declared that India’s BOP situation is comfortable. This is a issue of great concern for India and other developing countries in the post-GATT scenario with a possible threat of dumping. Out of about 2,700 items which are put under some sort of quantitative restrictions, 800 are agricultural commodities. For making the produce from Indian crops competitive, it is necessary that the cost of production is brought down by increasing the productivity especially in crops where hybrid technology could be harnessed.

A phasing out is needed in regard to removal of quantitative restrictions. Crops/commodities could be grouped under four phases, viz., those immediately free and those requiring two/three years, four/five years, seven/ten years for removal of restrictions. Cereals, coarse cereals, oilseeds and edible oils, citrus fruits and pulses etc. are some of the broad crop groups given the longest phase-out period. Moreover, suitable regulatory measures like tariff may also be thought of to regulate the inflow and avoid possible dumping.

Sanitation and phyto-sanitation (SPS) and related issues
In view of the sanitation and phyto-sanitation requirements of the new world order, a relook is needed in the SPS system of the country. As per WTO’s SPS agreement, India is required to officially notify other member countries of the proposed changes in requirements which might affect international trade and may be required to justify the action or respond to comments. It should be as per IPPC requirements. The Plants, Fruits and Seeds (Regulation of Import into India) Order 1989 (PFS Order) issued under Destructive Insects and Pests Act (1914) is being revised suitably to meet the need of global trade and exchange. There is an urgent need to develop a National Plant Quarantine System which should be harmonized with those in other countries, especially the trade partners and the neighbouring countries.

Under Article 2 (2), SPS measures have to be based on scientific principles. Also, under Article 5 (7), a member country may, if need be, adopt SPS measures on the basis of available pertinent information from other member countries or an international organization.

Many countries including India have been conducting Pest Risk Analysis (PRA) in an informal or even ad hoc manner. However, PRA in future have to be conducted in accordance with internationally agreed guidelines so that there is greater harmonization and standardization of procedures. A notification subject to revision every year should be made on crop pest-affected areas and pest-free areas for important pests/pathogens of quarantine importance. The continuous monitoring of pests done by the Directorate of Plant Protection, Quarantine and Storage (DOPPQS), India and the newsletter issued by them is of great use in this aspect. There is a need to establish linkages with the bordering countries/SAARC countries.

Catalogues of potentially dangerous pests that are not present in our country should be prepared/updated. Phytosanitation standards for seed/propagule in agriculture and sanitation standards for human beings have to be in consonance.

There is also a need to guard against such imposed trade restrictions especially on Indian export which do not have scientific basis. This may be done through Dispute Settlement Understanding especially using the provisions of Articles XXII and XXIII of GATT 1994.

Summing up
The region comprising Indian sub-continent is rich in agro-biodiversity. Major initiatives including establishment of a genebank have been taken in India. In view of the advent of
biotechnology and the new IPR regime, necessary regulatory mechanisms in the aspects of Plant Variety Protection, inclusion of microorganisms for patenting, National Biodiversity Legislation, Geographic Indication along with revamping of existing mechanisms are expeditiously needed. Implementation of the GPA has commenced but further impetus is required. An arduous interaction among the countries of the region is required to capitalise on the collective strength and complimentarity. India is well-poised on conceptual, operational and regulatory aspects of biodiversity but concerted efforts are needed by all concerned including NGOs, farmers and farming communities to take advantage of the genetic wealth of the Indian mega-centre of biodiversity.

References


National goals, policies, programmes and legislation in Sri Lanka

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The organization of the "national programme" for genetic resources, and its policy/political and legal framework emerged as a result of several decades of historical evolution, adjustment and adaptation. Fairly stable and functional institutional framework and legislation pertaining to natural resources management is now in place in Sri Lanka.

It is noteworthy to mention that section 28(f) of the constitution of Sri Lanka has embodied into it that it is the duty of every person to conserve and protect the nature. It reads as follows: "The exercise and enjoyment of rights and freedom is inseparable from the performance of duties and obligations and accordingly, it is the duty of every person in Sri Lanka to protect the nature and conserve its richness." This legislation pertaining to natural resources management dates back to the 19th century.

The Fauna and Flora Protection Ordinance of 1938 and its subsequent amendments protect the flora and fauna in National Reserves (Strict Natural Reserves, National Parks, Nature Reserves, Jungle Corridors, Refugia, Marine Reserves and Buffer Zones) and Sanctuaries. The provisions of the ordinance, particularly with the far reaching amendments brought in by Fauna and Flora Protection (Amendment) Act of 1993, is fairly adequate to give legal protection to flora and fauna within the different categories of protected areas referred to above.

Well formulated resource management and environmental conservation policies were undertaken during the 1980s. To give greater emphasis on the constitutional pledge to protect the environment, the National Environmental Act (No 47 of 1980) was introduced. To implement this, the Central Environmental Authority (CEA) was set up in 1981 as the state agency to look after the formulation and implementation of policies and strategies for the protection and management of the environment in Sri Lanka.

Sri Lanka has recognized the objectives of the World Conservation Strategy (WCS) of 1980, and prepared a National Conservation Strategy (NCS) which was initiated in 1982 by a task force appointed by the President. This programme was coordinated by the Central Environmental Authority (CEA). The NCS recommended that "natural forests should be identified and made involved by statute and land for economic exploitation be demarcated and systematically managed.

To safeguard the environment and manage the natural resources at the national level, the National Environmental Action Plan (NEAP) was developed in 1991, which emerged basically from the recommendations formulated in the NCS. In the NEAP, the practical approaches and required management strategies were envisaged for their implementation for a five year period (1992 - 1996).

The national plant genetic resources activities are organized in various cooperating departments and institutions in different ministries. The major institutions are the departments in the Ministry of Agriculture and Lands, National Science Foundation (NSF), the Central Environmentmetal Authority, Department of Indigenous Medicine, Coconut Research Institute, Rubber Research Institute, Tea Research Institute and Sugarcane Research Institute.

A new Cabinet Ministry of Environment and Parliamentary Affairs (MEPA) was initiated in March 1990 to formulate and coordinate all policy matters on environmental issues. In August 1994, the environmental issues were assigned to the Ministry of Environment, Highways, Transport and Women's Affairs. However, the environment component was later merged with the Ministry of Forestry and Environment.
The National Environmental Act which was passed in 1980 led to the establishment of District Environmental Agencies (DEAs) in the administrative districts. Devolution of power to the Provinces was effected by the Thirteenth Amendment to the Constitution in 1987 which enhanced the management of the environment and natural resources at the provincial level with the participation of non-governmental organizations (NGOs) which further enhanced effective public participation in decision making and activities that affect the environment and natural resources. Surveys of 1980s indicated that there were over 800 community based NGOs who were principally concerned with environmental conservation. These NGOs generate public awareness on environmental issues, and advocate environmentally sound public policies.

**National legislation**

Quarantine laws allow the international transfer of seeds and *in vitro* materials, and no loss of materials through quarantine has been experienced. National laws restrict unregulated collection and export of flora, as well as planting out of certain imported genetic resources to comply to quarantine regulations.

Sri Lanka's protected areas network, comprising about 18% of the land area, is mainly administered and managed by the Forest Department and Department of Wildlife Conservation. A systematic and comprehensive evaluation of various forest sites was carried out by National Conservation Review (1991 - 1996) by a technique of ranking, according to the conservation value of each site, which became very useful in the classification of the protected areas network.

The protection of flora outside National Reserves and Sanctuaries is covered by Section 42 of the Fauna and Flora Protection Ordinance. The number of protected species of plants has been increased from 9 to over 450 through the Fauna and Flora Protection (Amendment Act of 1993). A manual for the identification of the protected plants and animals is under preparation under the supervision of the Steering Committee on Biological Sciences of National Science Foundation (NSF).

Incentives are not provided to farmers for the on-farm conservation of traditional varieties. The sale and distribution of seeds are predominantly restricted to the certified and registered seeds which comes under the seed certification scheme. However, imported exotic vegetable seeds from registered companies are used for local cultivation. Farmers’ varieties are not legally traded but can be used by any other private individual.

Legislations on Intellectual Property Rights (IPR) are yet to be formulated. However, this does not affect the current genetic resources programme, and no external assistance is needed on legal matters concerning plant genetic resources.

Policies on exchange of plant genetic resources are to be based on additions to the Fauna and Flora Protection Ordinance. A National Experts Committee on Biodiversity has been set up by the Ministry of Forestry and Environment to guide and advise it on actions that are necessary to fulfil Sri Lankas' obligations and to promote the conservation and sustainable use of biodiversity as set out in the Convention on Biological Diversity.

**Other policies**

Production and marketing of the certified seeds of improved varieties are mainly handled by the Department of Agriculture. Certain amounts of certified seeds are produced by the registered seed growers with the provision of some incentives such as the availability of credits, subsidies and the provision of fertilizer and seed etc. This scheme restricts the use of recommended varieties for cultivation for increased production.

The national PGR programme staff and other PGR experts are involved in the planning of: (a) major agricultural development projects, (b) recommendation committee for the
protection of fauna and flora in National Reserves, (c) preparation of the Biodiversity Action Plan (d) National Experts Committee on Biological Diversity and (e) Biotechnology Steering Committee within the relevant government departments and authorities.

International collaboration - UNCED

Sri Lanka adopted Agenda 21 with emphasis on conservation and sustainable utilization of plant genetic resources for food and sustainable agriculture, and the conservation of biological diversity.

FAO and CGIAR

Through the FAO system, exchange of PGR was made possible, and the introduced materials were extensively used in crop improvement programmes. With the formation of the International Board of Plant Genetic Resources (IBPGR), Sri Lanka participated at the inaugural meeting of South and Southeast Asian Plant Genetic Resources Group in May 1978. The first Sri Lankan proposal for collecting and conservation of PGR in an organized manner was presented in 1978, and a National Plant Genetic Resources Team was formed at the national level for collecting and conservation of agro-biodiversity.

The genetic evaluation and utilization programme of the CGIAR commodity centres, and the regional research centres have greatly enhanced the development and adaptability of high yielding cultivars of crops for enhancing the national yield levels. The support from CGIAR and regional research centres came both directly from the institutes and also through the centre staff based in Sri Lanka. The national programme staff were greatly benefited from short, medium and long-term postgraduate training received from CGIAR centres.

The International Rice Research Institute (IRRI) has assisted Sri Lanka in maintaining 2,500 local rice varieties in the IRRI genebank until 1988 as genebank facilities were not available in Sri Lanka at that time. Collaborative CGIAR research and development programmes were undertaken locally with the participation of national scientists.

Recognizing the urgent need to establish infrastructure facilities for plant genetic resources conservation in Sri Lanka, a firm request was made at the International Technical Conference on Crop Genetic Resources held at FAO in Rome in April 1981, which resulted in IBPGR sending an Expert Team, headed by Prof. Y. Izuka, in 1982 to evaluate the need, and selection of the Department/Institute, and the location for the setting-up of the facility. With the provision of Grant Aid funds from the Japan International Corporation Agency (JICA), the development of the Plant Genetic Resources Centre (PGRC) was initiated in 1987. Sri Lanka has no bilateral intergovernmental initiatives with the other governments.

National needs and opportunities

The national needs and the opportunities relating to PGR in Sri Lanka are mentioned below:

1. A computerized database system needs to be developed by collecting all the relevant data to maintain information on the biodiversity of Sri Lanka, as available information are scattered and isolated among several institutions, agencies and individuals
2. Useful information from international sources also should be maintained and frequently updated
3. The Section 42 of the Fauna and Flora Protection Ordinance not only prohibits the collecting of indigenous and endemic plant species listed in Schedule V, but also the sale or export for sale of these plants. Such activities are now carried out openly and suitable action must be taken through the ordinance to curb this illegal practice. The provisions of Section 42 of the ordinance taken together with Schedule V should be vigorously implemented. Adequate training needs to be provided to enhance the skill of staff and other officers responsible for implementation. Section 2 of the ordinance is helpful in identifying some of the species which are commonly subjected to removal and sale.
4. Concerted studies should be undertaken to identify other species of plants that are threatened so that these should be added to the schedule V.

5. Adequate safeguards have to be taken to prevent unregulated exports of endemic plant species. With increasing biotechnological research in developed countries, export of endemic and rare species should be made after effecting necessary regulatory measures to derive benefits to Sri Lanka from such research undertakings.

6. The export of flora is covered under Section 45 of the ordinance which states that regulations may be made prohibiting or regulating the export from Sri Lanka of "any specified plants, whether or not such plant is included for the time being in the Schedule V".

7. The provision in the ordinance is quite inadequate to regulate the export of plant genetic resources from the country. Scientists and conservationists are of the view that with the exception of a few species that are artificially propagated and exported for commercial purposes, there should be careful control of the export of naturally occurring indigenous plant genetic resources from the country. Export of species will be allowed only when:
   a) The export of the species will not endanger the survival of the species in Sri Lanka
   b) The export will not pose a threat to the natural habitats of the species in Sri Lanka
   c) The relevant Articles of the Convention on Biological Diversity, as far as they are applicable to Sri Lanka and the importing country, are complied with
   d) The export is in conformity with the Convention on Trade in Endangered Species of Fauna and Flora

8. Ongoing research programmes on biodiversity carried out under various Ministries and Institutions need to be collated and reviewed periodically, and the research needs focusing on the conservation and sustainable use of biodiversity identified.

9. Review of existing literature and indigenous knowledge on the biodiversity of Sri Lanka should be conducted and action taken to establish a central database.

10. A system needs to be developed to ensure that local communities affected by conservation measures are benefited by it.

11. Many protected areas in Sri Lanka are small and, isolated and are surrounded by villages, making protection difficult. There is an urgent need for a review of the current protected areas and establishment of a national and properly representative protected area system for the country and for more effective conservation of the protected areas. It is also essential to assess the prospects for in situ conservation outside the protected areas.

12. A strategy needs to be developed to optimally sensitize the public on biodiversity conservation and related issues.
National policies on PGRFA and their implementation in Nepal

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Nepal is rich in genetic diversity and possesses at least 110 plant species having species names (botanical) as nepalense/nepalensis/napaulensis. Wild species and wild relatives of most of the present day cultivated crop species (except maize and potato) have been identified as valuable genetic resources for crop improvement activities. Diversity in medicinal plants is enormous. For example, jatamansi (Nardostachys jatamansi), yarsagumba (Cordyceps sinensis), panchaunie (Orchis latifolia), etc. are well-known herbal medicinal plants. Use of herbal medicinal plants is still the principal system of therapy in different parts of Nepal.

The Convention on Biological Diversity (CBD) was signed by nearly 160 countries in June 1992 at Rio de Janeiro, Brazil. The Convention is primarily a broad legal framework which became an international agreement after ratification by 30 countries on 29 December 1993. The intrinsic value of biodiversity and change in the earlier proposition of common heritage of humankind to the sovereign rights of the states over their own biological resources were duly recognized in the Convention. The CBD not only conferred sovereign rights on biological resources but also placed responsibility to promote conservation and utilization of these resources in a sustainable way for the betterment of humankind. Nepal is a signatory to the CBD. Agenda 21 adopted at the United Nations Conference on Environment and Development (UNCED) also puts emphasis on appropriate exploitation of biological resources. These are significant global efforts directed towards the conservation and sustainable utilization of biodiversity at ecosystem, species and genetic diversity levels.

The Food and Agriculture Organization (FAO) of the United Nations organized the “Fourth International Technical Conference on Plant Genetic Resources” at Leipzig, Germany in June, 1996. The conference was attended by the official delegations of governments, non-government organizations and international institutions. The participants dealt with scientific and policy matters based on country reports and recommendations of sub-regional meetings. The Status of World's Plant Genetic Resources and Global Plan of Action (GPA) for the conservation and sustainable utilization of PGR were prepared and approved in the conference. The plan has identified in situ/ex situ conservation, utilization of PGR and strengthening national programmes as prioritized sectors for implementation at the national and international levels. The brief outline of the GPA covering 20 priority activities under four broad areas, is given below:

**In situ conservation and development**
- Survey and inventory of plant genetic resources for food and agriculture
- On-farm management and improvement
- Restoration of agricultural systems in disaster situations
- Conservation of wild crop relatives and wild plants for food production

**Ex situ conservation**
- Sustaining existing collections
- Regenerating threatened accessions
- Supporting planned and targeted collections
- Expanding ex situ conservation activities

**Use of plant genetic resources**
- Characterization and evaluation of collections to facilitate use
- Increasing genetic enhancement and base-broadening efforts
- Promoting sustainable agriculture
- Promoting the development and commercialization of underutilized crops
- Supporting seed production and distribution
- Developing new markets for local varieties and diversity-rich products

**Institution and capacity building**
- Building strong national programmes
- Promoting networks for PGR
- Constructing comprehensive information systems
- Developing monitoring and early warning systems for loss of PGR
- Expanding and improving education and training
- Promoting public awareness of the value of PGR conservation and use

The Global System for the Conservation and Utilization of Plant Genetic Resources for Food and Agriculture (PGRFA) is comprised of the Commission on Genetic Resources for Food and Agriculture (CGRFA); the non-binding International Undertaking (IU) on Plant Genetic Resources; the Global Plan of Action (GPA) and International Fund for Plant Genetic Resources; the World Information and Early Warning System (WIEWS); Codes of Conduct and Guidelines for the Collection and Transfer of Germplasm; the International Network of Ex situ Collections under the auspices of FAO; and the International Network of In situ Conservation Areas and its crop related networks.

The CGRFA coordinator oversees and monitors the development of the Global System for the Conservation and Utilization of PGRFA and has designated the revision of the IU as its utmost priority. The focus is on access to genetic resources, farmers' rights, benefit sharing the necessity for prior informed consent and recognition of the association among access, benefit sharing, and farmers' rights. Other interesting issues would be harmonization of bilateral arrangements, commercialization, and IPR with getting benefits into and out of the multilateral system to those that deserve them.

**Farmers' rights**
Farmers' Rights (FR) are defined as "rights arising from the past, present and future contributions of farmers in conserving, improving and making available plant genetic resources, particularly those in the centres of origin/diversity". The FR indicate the full participation of farmers in conservation, use of PGR and benefit sharing. They have to be protected and respected in national legislation. Article 12 of the Undertaking on FR has been discussed in detail, but few, if any, actual decisions have been made. Efforts to conserve PGR must be undertaken at the local level with full participation of the communities concerned, particularly focusing on women farmers, and include measures for credit facilities and market provisions.

**Intellectual property rights**
World Trade Organization (WTO) and Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) demand patent protection for any invention in all fields of technology, including agriculture and plant breeding. WTO members are required to provide for protection of plant varieties either by patents or by an effective sui generis system e.g. Plant Breeders' Rights. The new requirements will simply favour large national and international seed companies limiting the traditional seed flow system. This situation has provoked a vehement and controversial discussion in developing countries where farmers and their indigenous knowledge are essential for conservation and sustainable utilization of PGR.
Patenting of both Process and Product is a reality, largely because of huge investment of private sector in biotechnology. Access to new technology is becoming very costly for developing countries. Patents and plant variety protection must not limit the researchers and the farmers' exemption, which have favoured to some degree the small and medium-sized farmers and plant breeders, respectively. New initiatives must not contain agricultural development, thereby, current IPR policies and practices should be properly assessed and harmonized, and partnerships with the private sector be developed for the betterment of the humankind. The International Plant Genetic Resources Institute (IPGRI) and the International Food Policy Research Institute (IFPRI) should undertake policy research issues to ensure global food security. It is well recognized that easy flow of germplasm and technology have contributed to the advances made in present day agricultural research and development.

National efforts after GPA

In situ conservation
IPGRI, together with national partners in Burkina Faso, Ethiopia, Hungary, Mexico, Morocco, Nepal, Peru, Turkey and Vietnam has formulated a global project to strengthen the scientific basis of in situ conservation of agricultural biodiversity. The three main objectives of the project are to: i) support the development of a framework of knowledge on farmer decision making processes that influence in situ conservation of agricultural biodiversity; ii) strengthen national institutions for planning and implementation of conservation programmes for agricultural biodiversity and iii) broaden the use of agricultural biodiversity and the participation in its conservation by farming communities and other groups. To achieve these objectives, three main strategies which are agreed upon are: i) multi-disciplinary work in the areas of population genetics, ecology, agronomy and social sciences carried out by multi-institutional teams from formal institutions and community-based organizations; ii) community participatory breeding and agronomic work, including community and locally based conservation activities involving market development, non-market incentives, and community-based training that will support sustainable agriculture; and iii) international coordination and scientific synthesis to create a global framework for supporting in situ conservation by farmers.

Ex situ conservation
The objectives of PGR management are to: i) conduct research to better understand diversity threats to PGR, sustainable utilization and conservation of PGR, ii) promote utilization of wild and domesticated germplasm through characterization, evaluation and appropriate breeding schemes, values on PGR need to be enhanced by incorporating ethical, cultural and economic values, iii) develop monitoring at all levels of biodiversity, particularly genetic, species and ecosystem level, iv) investigate the role of different elements of biodiversity in the major ecosystem processes, v) develop scientific conservation and documentation system, vi) initiate modern technological approaches to germplasm enhancement, vii) train and strengthen research workers on conservation and utilization of PGR, viii) participate in exchange of germplasm and strengthen collaborative research activities with the National and international organizations related to PGR, and ix) create awareness of the significance of conservation/preservation among the custodians of germplasm.

The project will establish infrastructure facilities and supply equipment for the conservation and utilization of PGR. After the completion of the project, Nepal would be able to conserve and utilize PGR in sustainable manner as per the commitment under CBD. Technical cooperation will be further required to enhance research capabilities in this field.
**Human resources development**
Nepal Agricultural Research Council (NARC) has developed a scientific plan to enhance skills and knowledge of the scientists and technicians. PGR is one among the priority sectors and there is a great concern about developing an integrated PGR system in the country. A list of training programmes organized on different aspects of PGR has been given in Table 1.

**Table 1. Training in plant genetic resources activities**

<table>
<thead>
<tr>
<th>Training course</th>
<th>Participants</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-country training on PGR documentation and the use of Germplasm Management System (GMS) software</td>
<td>10</td>
<td>Nepal</td>
<td>1997</td>
</tr>
<tr>
<td>In-country training on field collecting and conservation of rice germplasm</td>
<td>10</td>
<td>Nepal</td>
<td>1997</td>
</tr>
<tr>
<td>On-job training in characterization of rice germplasm</td>
<td>1</td>
<td>Philippines</td>
<td>1997</td>
</tr>
<tr>
<td>On-job training in genebank management</td>
<td>1</td>
<td>Philippines</td>
<td>1997</td>
</tr>
<tr>
<td>PGR conservation and utilization for sustainable agriculture</td>
<td>1</td>
<td>Germany</td>
<td>1997</td>
</tr>
<tr>
<td>PGR conservation</td>
<td>1</td>
<td>Germany</td>
<td>1997</td>
</tr>
<tr>
<td>Collaborative research-cum-training on genetic diversity of rice</td>
<td>2</td>
<td>Japan</td>
<td>1997</td>
</tr>
</tbody>
</table>

Recently, postgraduate courses on plant genetic resources have been initiated in India, the Philippines and Malaysia and the technical staff will be provided opportunities for higher studies in order to update their knowledge in this important field.

**National Coordination Committee on PGR**
Nepal Agricultural Research Council (NARC) has proposed to constitute a National Coordination Committee (NCC) with representation of Ministry of Agriculture, Ministry of Forestry, National Planning Commission, NARC, NGOs and farmers. NCC on PGR would assist in synthesizing a national policy and developing and coordinating PGR System in the country. The NCC is being constituted as per the recommendations emerging from the South Asia National Coordinators meeting on PGR held at Dhaka, Bangladesh.

**Existing national legislation**
The following national legislations have been enacted in Nepal and are currently in force for protection and conservation of plants, forests, wild life etc.:  
- Plant Protection Act, 1972 (Plant protection regulations enforced in 1974)  
- The Private Forest Nationalization Act 1956  
- The Wildlife Protection Act 1958  
- Forest Protection Special Act 1968  
- Forest Products Sales and Distribution Rules 1971  
- National Parks and Wildlife Conservation Act 1973  
- The Wildlife Conservation Regulation 1975  
- The Panchayat Forest and Panchayat Protected Forest Rules 1978  
- The Panchayat Protected Forest Rules 1978  
- The Leased Forest Rules 1978  
- The Private Forest Rules 1984
Issues and proposals
Implementing the CBD and GPA will require national commitment to introduce PGR concerns in the economic sectors of agriculture, forestry, and fisheries to ensure the conservation and sustainable use of these valuable resources. It would also require regional level coordination for the purpose since PGR does not follow the rules of political boundaries. The relationship with NGOs, Community Based Organizations (CBOs) and farming communities is equally critical. Human and institutional capacity have to be developed for national PGR System. Developing countries will require external support for training, research and institution building.

Major policy issues to be considered are mentioned below:

a) Regulating access to biological resources
b) Recognizing the rights of indigenous people and local communities
c) Harmonizing IPR, Farmers' Rights and Plant Variety Protection
d) Transfer of Technology
e) Equitable benefit sharing

National PGR Coordination Committee has to be effective to deal with policy issues. For a country like Nepal, establishment of PGR Conservation Centre should receive high priority to ensure the continuity of national and international efforts.
Policy issues related to CBD, GPA, TRIPS and their implementation status in Bangladesh

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In the recent past, there has been significant developments at the global level in the field of plant genetic resources (PGR) conservation and utilization which have resulted in the establishment of a series of legislations, regulations and policies to be opted by the countries which are signatories to different conventions. Some of the policy issues relating to the Convention on Biological Diversity (CBD), the Global Plan of Action (GPA) for conservation and sustainable use of biological diversity and the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement and the status of their implementation in Bangladesh are mentioned here.

The Convention on Biological Diversity
The Convention on Biological Diversity (CBD) provides mechanisms and guiding principles relating to sovereign rights of countries to conserve and exploit their resources, adopting measures for conservation, developing national legislation, training and education, as well as research relating to conservation of plant genetic resources. Progress on these aspects is given below:

Sovereign rights over biological resources
CBD bestows sovereign rights to a country over its biological resources. CBD Article 3: gives countries the sovereign rights to exploit their own resources and the responsibility to conserve and sustainably use their biological resources.

In situ conservation
The Convention asks to preserve and maintain indigenous knowledge, innovations and practices relevant for conservation and sustainable use of biological resources and to promote their application with the approval of the holder of such knowledge, innovations and practices. Thus, CBD Article 8 states, "in situ conservation of biological diversity as the main approach".

National legislation
The Convention asks countries to develop national legislation for conservation and sustainable use of biological resources in consonance with traditional cultural practices that are compatible with conservation and sustainable use of biological resources. CBD Article 10 states that each contracting party shall, as far as possible and as appropriate, undertake measures to: integrate conservation and sustainable use of biological resources into national decision-making; use of biological resources avoiding or minimizing adverse impacts on biological diversity; protect and encourage customary use of biological resources per traditional cultural practices; support remedial action in degraded areas and encourage cooperation between its governmental authorities and its private sector in its efforts for conservation.

Incentives for conservation and use
The Convention advocates adoption of measures that act as incentive for conservation and sustainable use of biological resources. Countries should strive to adopt economically and socially sound incentives for the conservation and sustainable use of components of biological diversity.
Research, training and education
The Convention advocates (i) training and education for identification, conservation and sustainable use of biological diversity; (ii) research towards conservation and sustainable use of biological diversity and (iii) cooperation in the use of scientific advances in biological diversity research.

Public awareness
The Convention advocates creation of public awareness on the importance of biodiversity and the measures for their conservation and sustainable use through media and educational programmes.

Access to genetic resources
The Convention bestows the responsibility of developing legislation for access to genetic resources to national governments and that the access is through prior informed consent and mutually agreed terms, and with the aim of equitable sharing of benefits arising from the use of these genetic resources.

The Global Plan of Action
The Global Plan of Action (GPA) for conservation and sustainable use of biological diversity identifies twenty priority areas for member countries under four groups.

Implementation of CBD, GPA and TRIPS agreements
In order to implement the CBD, GPA and TRIPS agreements, the following steps have been taken in Bangladesh:

1. Formation of the National Committee on PGR (1996) - This committee will advise the Government and make recommendations on matters related to PGR
2. Inventory of PGR - A project proposal has been developed for preparing inventory of plant genetic resources of the country. Bangladesh Agricultural Research Council (BARC) is expected to provide the financial assistance for the project
3. Listing of plant species and varieties of Bangladesh - This list is being prepared based on information supplied by agricultural research institutions, National Herbarium, universities and NGOs dealing with PGR
4. Establishment of the National Plant Genetic Resources Institute (NPGRI) - In order to improve the national ex situ conservation and PGR management capacity, a project proposal for the establishment of NPGRI has been prepared which is under consideration of the Government
5. Biodiversity and Community Knowledge Protection Act - The draft of the Act has been prepared and this is being discussed at various levels
6. New Plant Varieties Protection Act - The draft of the Act has also been prepared and is being discussed at various levels

Biodiversity and Community Knowledge Protection Act
The salient features of the draft Biodiversity and Community Knowledge Protection Act are enumerated below:

- To protect the rights of communities that have the knowledge of plant diversity and have managed, conserved, enhanced and reproduced these resources
- To protect and strengthen the informal knowledge systems of communities
- To operate on the principle of access to traditional resources and knowledge by any member of the community
- To ensure conservation and sustainable use of PGR and related knowledge and improve these further
To protect and support the rights, knowledge, innovations and practices of local communities and national institutes with respect to conservation, use, and management of PGR

To provide an appropriate system of access to PGR and related knowledge based on prior informed consent of the state and of the concerned community

To promote an appropriate mechanism for a fair and equitable sharing of benefits arising from the use of PGR and related knowledge, technologies, as well as ensuring the participation and agreement of concerned communities in making decisions as regards the distribution of benefits that may arise from such uses

To promote and encourage national capacity building relevant to conservation, enhancement and sustainable use of PGR

To ensure the transfer and movement of PGR and local knowledge in a transparent manner

To safeguard the interests of innovators, both in the public and the private sector

New Plant Varieties Protection Act

The salient features of the draft New Plant Varieties Protection Act are given below:

I. General principles

1. The new plant varieties protection act will be interpreted only within the context and framework of and in conjunction with the Biodiversity and Community Knowledge Protection Act (BCKP Act) of Bangladesh

2. The scope of this Act will strictly be limited only to the commercial transactions of varieties without violating the rights of the communities stipulated in the BCKP Act of Bangladesh and may be applied to:
   - Newly innovated plant varieties of which the inventor or owner of the variety, or the right holder of the protected variety wishes to engage in activities of monetary gains from the commencement of his or her invention
   - All other varieties for which the registration and commercial permit is required for economically gainful transactions

3. This Act will not in any way affect the Farmers' Rights as owner and user of plant varieties that are being enjoyed as per the customs and traditions

4. This Act will not in any way affect the rights of farmers to have unencumbered access to biological resources of Bangladesh and related knowledge, intellectual practices and cultures, nor it will affect the rights to collect, conserve, propagate and use propagation materials of protected variety as long as it is strictly for personal and non-commercial use and are not exchanged by the user in the commercial market for monetary gains

5. This Act will not in any way limit the rights of farmers as innovators and as inventor the right to be recognized and rewarded individually or as a group, or both, for the innovation. Farmers can apply for such a reward under the BCKP Act of Bangladesh and will be entitled to receive the award through the National Biodiversity Authority. This will not prohibit farmers to apply under this Act for rights stipulated in the New Plant Varieties Protection Act of Bangladesh

II. Protection of new plant varieties

The specific principles applicable to protection of new plant varieties will be as under:

1. A new plant variety, which shall be protected as a new invention, is a protected plant variety proclaimed by the appropriate authority and shall be a plant variety
which have the following characteristics:
- New plant variety
- Plant variety with **consistent** specific traits
- Plant variety with **stable** specific traits
- Plant variety with **distinctive** specific traits.

2. A new plant variety possessing adverse effect on the environment, health and the welfare of the public shall not be protected.

3. A new plant variety, which is transgenic, shall not be eligible for protection unless:
   - Environmental impact assessment is done by the Bio-Safety Commission
   - The owner of the transgenic variety agrees in writing to pay compensation for hazards and damages, if caused by the use and handling of a transgenic variety
   - The applicant agrees that the transgenic nature of the new plant variety will be clearly declared to the public and will appear clearly on the label/logo, etc.

4. A new plant variety is a plant variety, of which no propagation materials has been utilized for more than the specified period prior to the date of filing the application for protection.

5. Innovation of all plant varieties by any National Public Research Institute will be considered automatically as the property belonging to the People of Bangladesh. Any innovation done with financial support of the State or with resources from public finance, or development fund will also be considered as a common property.

6. Innovation of a new plant variety of any NGO or any other organizations who uses or have used local or foreign development fund that are, in principle, funds donated for the public good, will also be considered as public property and no protection can be claimed for those varieties.

7. This, however, will not bar any individual or group of individuals to apply for reward for contributions in research. The reward, if granted, will be over and above the wages/remuneration of the person or persons received regularly from the employer.

8. The term of new plant variety protection is stipulated to be as follows:
   - Annuals and bi-annuals - 10 years
   - Perennials - 15 years
   - Woody plants - 25 years.

### III. Commercial transactions of community variety, local variety and wild plant species

Salient features and guidelines applicable in case of commercial transactions of community variety and wild plant species will be follows:

1. All community variety, local and indigenous variety and wild species in Bangladesh will be stipulated by this Act as protected in perpetuity on behalf of the people of Bangladesh, confirming that the people of Bangladesh are their sole owners, custodians and stewards.

2. With the objectives to protect environment, promote conservation of indigenous and local plant varieties and enhance biodiversity in order to ensure food security, quality of life and general development of the community economy, the individuals comprising a community shall have rights including the right to utilize community varieties, local varieties and wild species or any part of plant varieties freely, without any hindrance and limitation.

3. However, if any individual, group or community decides to engage in commercial transaction of plant variety or materials to propagate plants, it will be permitted by this Act only after receiving commercial permit from the appropriate authority.
4. Any individual utilizing a local indigenous plant variety or wild plant variety for improvement or development for commercial purposes must do the following:
   - Have a commercial permit
   - Pay the fee to secure commercial permit
   - Make an agreement to pay a part of the revenue in accordance with criteria, procedures and conditions stipulated by the appropriate national authority
   - Get clearance from the appropriate national authority that such commercial transactions will not have any negative effects on the biodiversity and the indigenous local knowledge and culture related to it
   - An agreement with local community, from where the plant variety has been collected, developed and improved, that the benefit of the commercial gain will be equitably shared

5. If the appropriate national authority determines that such commercial user of community varieties, local varieties and wild species is projecting, offering hints or in any manner trying to establish himself or herself as the originator of such varieties, the permit will be cancelled

6. If the agreement to share revenue with community from where the material has been collected is not realized by person engaged in commercial activity, the permit will be cancelled

7. Shared revenue shall belong to the community that conserves, develops or utilizes the community varieties, local varieties and wild plants

8. In case more than one communities conserve, develop or utilize a plant variety, the community which utilizes the plant variety shall receive fifty per cent of the share of the total shared revenue, the remaining shared revenue shall be deposited in the plant protection fund

9. In case any individual in the community is the one who conserves, develops and access the plant variety, the person shall receive thirty per cent of the revenue that the community receives

10. The community which conserves, develops or utilizes the local indigenous plant variety will get the priority in receiving commercial permit

11. The community which is the right owner of a local indigenous plant variety shall have exclusive right to sell, offer, have in possession for sale or distribute by any means of the propagation materials

12. The community which is the right owner shall have the duty to conserve the local indigenous plant variety

**Conclusion**

Bangladesh is a signatory to the Convention on Biological Diversity as well as the TRIPS Agreement. So are the other countries in South Asia. The CBD has declared that States have the sovereign right over their biological resources and shall "develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity". The TRIPS Agreement states, "Members shall provide for the protection of plant varieties either by patents or by an effective **sui generis** system or by any other combination thereof". While each country has to develop its own PGR policy, the developing countries need to have policies that are reasonably homogeneous.

South Asia is unique in its PGR and is a major centre of diversity. Farmers in the region have made use of the diversity and have developed their farming practices based on the diversity. In doing so, they have developed thousands of landraces of major crops. The IPR systems of developed countries not only overlook the contributions the farmers of South
Asia have made, but also their technologies and policies are aimed at making the farmers of the South dependent on the corporate seed companies of the North. It is, therefore, important that the countries in South Asia develop PGR policies from a common platform in order to overcome the problem envisaged from patenting of plant varieties.

Reference
National biodiversity assessment in Bhutan – Policies and strategies

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Policy and legislation

Bhutanese people have a culture and life style which are closely related to the surroundings in which they live. They have often developed sustainable methods of managing the resources they use. The national policy and strategy resolved in the proceedings ‘Towards Sustainable Development in Unique Environment’ published by the Ministry of Planning, stressed the following needs:

- Sustainable use of natural resources, including biodiversity
- Strengthening existing institutions, including environmental impact assessment
- Promotion of conservation ethics and environmentally sound farming systems
- Community participation in the management and protection of natural resources
- Revision of the forestry policy and legislation, and
- Human resource development

The overall policy objective on biodiversity is that the conservation and utilization of biodiversity should be an integral component of economic development. The principles underlying the policy are: (i) biological diversity issues will be integrated into the economic development plans and programmes, (ii) special attention will be given to support action plans for parks and protected areas and effective buffer zone management, and (iii) documentation and information systems will be developed for conservation and sustainable utilization of biodiversity resources.

Within the framework of the policy objectives, the priority areas are: (i) strengthening of institutions/programmes responsible for conservation and management of biological resources, and (ii) education and training as a conduit to effective implementation and cultivating mass support to the relevant initiatives.

Biodiversity legislation comes directly under the Forest Legislation. At present, the majority of Bhutan’s environmental legislation concerns the conservation of forests and the protection of wildlife and wildlife habitat. Amongst these, the most prominent is the Forest and Nature Conservation Act, 1995 which provides legal instrument to the protection of the country’s biodiversity. It provides a framework for the establishment and management of protected areas, social forestry and species conservation. The National Plant Quarantine Act, 1993, provides legal measures to control the movement of diseases, insects and other pests of economic and environmental significance. Other regulatory measures are mediated through occasional issuance of rules, notifications, office orders and circulars, some of which are indicated below:

Medicinal plants

1. The 1974 National Forest Policy categorizes medicinal plants and herbs as resources yet to be fully exploited. Hence, the policy specifies that these resources need to be surveyed for efficient management and use

2. The Director of Forests Order of 25 May 1988, has two provisions: (i) ban on exports of medicinal plants, and (ii) initiation of joint efforts by the Department of Forests and the National Institute of Traditional Medicine (NITM) to collect and cultivate medicinal plants failing which the responsibility for their cultivation will lie with Research, Extension and Irrigation Division of the Ministry of Agriculture (REID)
Resin

3 April 1985: Revised rules on resin tapping from chirpine (Pinus roxburghii) were approved.

Natural dyes

1. 4 January 1980: The Royal Government waived the royalty and sales tax on collecting and sale of lac and waste products therefrom. This was to revive the dying art of lac cultivation and associated activities. No monopoly is now permitted.
2. 8 September 1985: Exports of vegetable dyes were curtailed. Natural dyes are now for domestic use only.

Bamboo and cane

1. 7 November 1978: The government decided that villagers in the Phuntsholing could henceforth collect bamboo and cane without paying tax or royalty. This is to encourage the production of handicrafts for sale and domestic use.
2. 7 May 1979: Mongar and Zhemgang villagers were granted permission to transport ‘bangchungs’, ‘palangs’ (both traditional bamboo containers) and other products made of bamboo or cane anywhere, as long as they are for gifts and not for sale.
3. 2 September 1984: To encourage handicraft production, the government allowed Dhrumjar (Mempa) Trongsa villagers to collect bamboo and cane for sale or domestic use without paying tax or royalty.

No legislation, rules or regulations have yet been enacted for essential oils, mushrooms and other forest products. Others of relevance to diversity are: (i) Bhutan Land Act, 1979, (ii) Mines Act, 1976, (iii) Plant Quarantine Act, 1993 and (iv) Forest and Nature Conservation Act, 1995.

In September 1996, the National Environment Commission (NEC), with assistance from the Asian Development Bank, undertook a major revision of the EIA process, which culminated in the release of two draft documents in May 1997: The “Institutionalizing and Strengthening of the Environmental Assessment Process in Bhutan” and the “Environmental Assessment Sectoral Guidelines”. On 2 June 1997, the NEC released “The Middle Path”, a national environment strategy document thereby establishing an operational framework for integrating environmental concerns into the development agenda.

Strategy and planning

Self-reliance, sustainability, institutional strengthening and human resource development, balance and equitable development are mentioned as objectives to be addressed during Eighth Five Year Plan (8th-FYP).

Specific objectives for the Renewable Natural Resources (RNR) sector are national food security, conservation of natural resources, sustainable economic production and enhancement of rural income. The role of the Royal Government of Bhutan in the RNR sector should be one of facilitator, extending the range of available opportunities through constructive regulatory measures, appropriate fiscal policies, provisions of infrastructure, and cost- effective research, technical support and advisory services.

During the 8th-FYP, governmental interventions in the RNR sector will be brought within a stronger ‘Programme framework’ approach. The following activities in the sector will be grouped under six principal programmes: (i) management and planning services, (ii) farm system development, (iii) crop and livestock production services, (iv) forest management services, (v) export horticulture development, and (vi) human resources development.

The overall planning and decision making bodies are the National Environment Commission (NEC), Ministry of Planning (MoP) and Royal Civil Service Commission (RCSC).
All the Heads of the important ministries are members in these commissions. The important policies and plans are endorsed or rejected by these apex bodies. The NEC is the lead agency responsible for entering into international dialogues. At the implementation level is the Ministry of Agriculture (MoA), which is responsible for the conservation and sustainable utilization of biological diversity.

**Institutional framework**

The NEC is the national focal point for environmental policies, and the RGOB’s instrument to the undertakings under the Convention on Biological Diversity (CBD), which in turn constitutes the framework for international effort in the field of biological diversity. The MoA and the RNR sub-sectors are responsible for the management of the bioresources.

**The National Environment Commission**

NEC is an agency for policy decisions on environment related issues in the country. It has a high level sectoral mandate to ensure that the environmental concerns are incorporated in all growth and development oriented projects and programs in the country. As a national focal point for CBD, it fulfills the national commitment to participate in the Conferences of Parties (COPs) to the CBD.

The CBD provides the broad-based policy framework for national and international effort in the conservation and sustainable utilization of biological resources, and fair and equitable sharing of benefits arising from their uses on mutually agreed terms and prior informed consent, and recognizing the sovereign rights of the country over its biodiversity. The NEC is the ultimate referral authority on biodiversity policy at the national level to ensure that national priorities are not sacrificed in the process of meeting international commitments.

**The Ministry of Agriculture (renewable natural resources sector)**

Within the Ministry of Agriculture (MoA) itself, there are existing and emerging units which are directly or indirectly involved with biodiversity as the basic functional units. In future, consolidating smaller units into larger and more manageable aggregations should facilitate smooth transition to a viable system. However, such merger would entail rational decision based on the technical and managerial compatibility between the units. Nonetheless, biodiversity is one area that illustrates strong congruity suited to the process of integration. This would be a challenge for the future and has been elaborated further in the subsequent section of this paper.

There is a comprehensive network of national parks and protected areas covering more than 26% of the country. The Nature Conservation Section (NCS) of the Forestry Services Division (FSD) is responsible for their management. Detailed plans have been drawn up for three largest sites within the protected area system. What needs to be seen now is the operationalization of these plans beyond the simplistic statement on biological inventory and infrastructural preconditions. Considering this figure of more than 26% land cover, the institutional capacity is highly incommensurate to the task confronting NCS. It is virtually impossible for institutes of its size to play custodian, let alone manager, to more than one quarter of the country’s wilderness. Compared to the resources in arable agriculture channeled to manage and maintain about 10% of the country (and still claims to be undersized), the situation confronting nature conservation undertaking is larger than life. Early policy decisions were made with good intent notwithstanding that the assessment was made without considering the resource base.

The Research Section of the REID of MoA is given the national mandate to deal with the PGR affairs. It operates through the four Renewable Natural Resources Regional Research
Centres (RNRRCs) strategically located at the centers of four discrete agricultural ecosystems embossed through geographic isolation and imposed upon by natural barriers. Each of these RNRRCs has a national mandate to coordinate the programmes on forestry, livestock, field crops or horticulture. In addition, they have regional mandates to implement component activities of all the farming systems within its mandated area. These RNRRCs have projects and activities directly related to conservation and utilization of biodiversity. However, such activities are not performed in a coordinated and standardized manner. For example, the methodologies and approaches, and even the information databases maintained, vary between centers. Therefore, information exchange is constrained and protocols are not repeatable to validate technologies developed.

Bhutan as yet does not have a national programme on the plant genetic resources for food and agriculture (PGRFA). In 1990, the research program of MoA drew up a proposal with expert input from the National Bureau of Plant Genetic Resources (NBPGR), India and the International Plant Genetic Resources Institute (IPGRI), but the proposal could not be operationalized due to the lack of trained national staff and limited financial support. A new proposal has been formulated in 1996 by a joint Bhutan/Dutch mission for funding under the SDA program. The project has been endorsed by the MoA and currently being assessed for full support by the Dutch Government.

Land use management is an integral part of biodiversity conservation and utilization strategy. Within the ecosystems approach, matching living components with the non-living environment in an interactive but mutually supportive manner constitutes the basic principle of a dynamic conservation design. Any sound biodiversity management practice must account for the evolutionary association between the genetic, biotic, abiotic and human factors and the complex interaction that determines the balance and resilience of an ecosystem setting. The Land Use Planning Section (LUPS) within the Planning and Policy Division (PPD) of MoA is presently engaged in assessing agricultural expansion to new/underutilized land without eroding the natural resource base and at the same time minimizing the environmental hazards.

**Bhutan Trust Fund**

Beyond the RNR sector are two institutions supporting the conservation and utilization of biological resources, namely, Bhutan Trust Fund (BTF) and National Institute of Traditional Medicines (NITM). The Bhutan Trust Fund was established in March 1991 as an innovative financial mechanism which will help Bhutan continue conservation activities and will ensure that the country can uphold its commitment to the environment inspite of the pressures to reduce conservation activities and focus on economic development. The activities include:

- Developing a national system of protected areas
- Drawing up and implementing management plans for protected areas
- Providing institutional support to environmental organizations and training natural resource professionals
- Surveying Bhutan’s rich biological resources
- Developing a natural resource database, and
- Designing and piloting integrated conservation and development projects

The National Institute of Traditional Medicines (NITM) is the other institute described briefly in a latter section.

**Protected areas**

As per the national policy, a land area of 26.23% has been declared as protected out of a total of 10 513 Km² (which is 30-40% of the forest area). This is as against the global standard of 12% desired for each country. There are nine parks and protected areas which are evenly distributed across the country (Table 1).
Table 1. Existing protected areas in Bhutan
Source: Nature Conservation Section, Forestry Services Division, 1995, Thimphu

<table>
<thead>
<tr>
<th>Name of protected area</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torsa strict nature reserve</td>
<td>644</td>
</tr>
<tr>
<td>Jigme Dorji national park</td>
<td>4200</td>
</tr>
<tr>
<td>Black mountain national park</td>
<td>1400</td>
</tr>
<tr>
<td>Thrumshingla national park</td>
<td>768</td>
</tr>
<tr>
<td>Royal manas national park</td>
<td>1000</td>
</tr>
<tr>
<td>Sakten wildlife sanctuary</td>
<td>650</td>
</tr>
<tr>
<td>Bomdiling wildlife sanctuary</td>
<td>1300</td>
</tr>
<tr>
<td>Phibsoo wildlife sanctuary</td>
<td>278</td>
</tr>
<tr>
<td>Khaling/Neoli sanctuary</td>
<td>273</td>
</tr>
<tr>
<td>Total</td>
<td>10,513</td>
</tr>
</tbody>
</table>

In situ conservation of flora and fauna including the wild relatives of domesticated species is the ultimate objective of these conservation areas. By the end of 1997, management plans for three national parks, the royal manas national park, the jigme dorji national park and the black mountain national park have been prepared. During the 8th Five Year Plan, management plans for four additional areas, namely, bomdiling wildlife sanctuary, thrumshingla national park, khaling wildlife sanctuary and the sakten wildlife sanctuary will be completed. The park managers have already been posted at the first three parks, and another has been identified for the bomdiling wildlife sanctuary.

To accommodate the needs, aspirations and the rights of the people living within and around the parks and protected areas, and to accommodate the timber needs of the local communities, these areas have been zoned to include enclave, buffer, and multiple use zones. In addition, the following areas have been identified as conservation areas (Table 2). Such areas are multiple use areas but each requires some special regulations to ensure the protection of local species of conservation importance.

Table 2. Conservation areas in Bhutan

<table>
<thead>
<tr>
<th>Name</th>
<th>Area</th>
<th>Special features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dochu la</td>
<td>Thimphu</td>
<td>Endemic rhododendrons, birds, red panda</td>
</tr>
<tr>
<td>Pele la</td>
<td>Wangduephodrang</td>
<td>Scenery, langurs, red panda, birds</td>
</tr>
<tr>
<td>Yutong la</td>
<td>Trongsa</td>
<td>Scenery, pine forests, birds</td>
</tr>
<tr>
<td>Durtsachu</td>
<td>Bumthane</td>
<td>Hot springs, geology, scenery</td>
</tr>
</tbody>
</table>

Crop genetic resources diversity
Bhutan’s agricultural system is in an initial phase of modernization. Bhutanese farmers primarily cultivate the traditional crop varieties and also depend upon forest resources for their subsistence. The major crops traditionally cultivated in the country are maize, rice, wheat, barley, buckwheat, potato, apple, cardamom, oranges and a wide range of millets, vegetables, pulses and oilseeds. A few modern varieties of the major crops are being cultivated. In some cases, the area planted with modern varieties is gradually increasing.

Subsistence farming based on traditional culture practised by local farmers has preserved diversity in grain and vegetable crops. Indigenous agroforestry is an integrated approach to land use that is characterized by the maintenance of trees and other woody perennials in fields and pasture lands which are used for construction purposes, simple farm tools, firewood, medicine, livestock feed and human food. Home gardens or kitchen gardens hold indigenous germplasm in the form of folk varieties or obsolete cultivars, landraces and rare
species thrive side by side and are preserved. These field genebanks provide a considerable amount of species diversity but very little genetic diversity within species. However, at the community level, the resulting genetic diversity thus conserved can be very high indeed.

Local farmers still maintain landraces and continue to grow them even when they experiment with and adopt some modern high yielding varieties (HYVs). The reasons for this practice are as diverse as the crops themselves, and are generally based on storage properties, nutritional and processing quality, cooking ease, secondary products, and historical and cultural reasons such as dietary diversity, the use of folk varieties in traditional foods or religious ceremonies and unique market niches. There are agronomic reasons too, such as better adaptation to traditional inter-cropping systems, early or late maturity, or greater resistance to local biotic and abiotic stresses. Yield stability in areas with unpredictable seasons is also a consideration in farmers retaining landraces in addition to planting improved varieties.

The factors that promote in situ conservation in the Bhutanese farming communities are the fragmentation of land holdings, marginal agricultural conditions associated with heavily leached, steeping mountain slopes and heterogeneous soils, economic isolation, cultural values and particularly the preference for diversity. In some areas, crop diversity may be generated naturally from genetically uniform germplasm within few seasons of cultivation.

The Horticulture Research Station under the RNRRC-Yusipang has good collection of fruits and nuts. The collection serves multipurpose roles for the researchers, students, trainees, extensionists and farmers in the country. Hence, the collection is self supporting, by combining conservation activities with revenue from fruit production for the export and domestic processing markets.

Bhutan believes that preserving and strengthening the natural resource base is central to a sustainable development process. However, in the absence of the national capability to assume conservation and utilization activities on a large scale, the ex situ needs have not been put into proper perspective. So far, limited formal germplasm collecting has been undertaken in Bhutan. An IPGRI mission to Bhutan in 1981 collected 483 samples of food plants, legumes and vegetables. The mission noted serious threat to indigenous wheat and rice varieties. In 1983, a joint ROGB and International Rice Research Insitute (IRRI) mission collected 184 accessions from traditional rice growing areas, high and medium altitude rice growing areas, but most remote areas were not visited. Recently, the RNRRC-Bajo with support from IRRI, has collected 154 samples of cultivated rice from 68 villages located at 400 m to 2500 m altitude, and traversing about three quarters of the country’s rice growing regions.

Extensive collecting of ornamental plants from Bhutan have been recorded. A total of 163 horticultural species were listed as introduced to other countries from Bhutan. Among others, the list included 52 rhododendron, 34 primula and 8 *Meconopsis* species.

**Livestock diversity**

The conservation of native breeds of livestock (cattle and yaks in particular) are of paramount importance in livestock development programmes where extensive cross-breeding programmes are undertaken. The risk of over-dilution of the indigenous blood in the long run is foreseeable under such circumstances which needs to be avoided.

"Nublang Farm” has been established in the eastern region of the country where only indigenous breed is reared and bred. Studies are being conducted on this breed to improve and preserve the indigenous cattle population. Priority is placed on breeding to generate reliable scientific data as the basis for appropriate future actions.

The “indigenous yaks” are also being conserved. The conservation of other domestic species particularly pigs and sheep is being considered, but as yet strategies have not been worked out.
Medicinal plants biodiversity
The National Institute for Traditional Medicine (NITM) merits added consideration with respect to the rational and sustainable use of biological resource components in the formulation of traditional medicines. Probably, it is the only institution that has successfully tapped the indigenous knowledge system and demonstrated its social and economic benefits accrued to the mainstream populace. Traditional medicine is still practised throughout Bhutan, with its more than 300 species of medicinal plants. The NITM is a well organized Institute staffed with traditional and western trained doctors. The Institute regularly collects plants to produce medicine as per formulae cited in ancient medical scriptures. The NITM combines traditional medicine with acupuncture to treat all types of diseases.

Aquatic diversity
For the present, the only conservation effort outside the protected areas (where no fishing is allowed) is the strict vigilance over the issuance of fishing licenses and monitoring that the regulations are strictly followed.

Training, capacity building, education and public awareness
The actual work specifically targeting biodiversity conservation and use is minimal. What has been achieved so far in this direction are mere spin-offs of greater objectives. This is firstly because the research programmes and the scientific and technical capability are weak. Secondly, the development priority in real economy gave little room for biodiversity education, which in turn thwarted the efforts to promulgate awareness among the planners, policy makers, general public and even within the scientific community.

At the government level, the concern for biodiversity is emerging. A number of persons are being trained in conservation related activities. The natural resources management courses are on the rise, with a few already absorbed into conservation programmes. In the context of present socioeconomic and demographic trend, the need for education and awareness on conservation and utilization of biodiversity must be addressed urgently.

The curriculum of the Bhutan Forestry Institute (BFI) of the Forestry Services Division (FSD) has been revised to include wildlife management, protected area management and biodiversity conservation. Every year, the BFI trains forest guards who are recruited by the various sections of the FSD. The Natural Resources Training Institute (NRTI) provides three years training in the fields of Animal Science, Agriculture and Forestry. It also provides refresher courses for in-service RNR staff on a yearly basis.

During the 7th Five Year Plan, the RGOB accorded further recognition to the role of communities in forestry development. In order to support and facilitate the participatory forestry development, the government drew up and adopted a set of social forestry rules. These cover model concepts in participatory development and utilization, including private forestry, community forestry and lease forests.

In 1979, initial efforts led to the declaration of 2 June as a ‘Social Forestry Day’ which is now held annually. On this day, trees are planted around households and public institutions such as community schools. However, the greatest success has been achieved in planting trees at schools. Initially, social forestry schemes sought to encourage community participation as a primary means for afforestation of degraded lands in the vicinity of rural villages. The community forestry programmes aim to motivate and educate user groups to build confidence for improved management of forest resources.

The Royal Society for the Protection of Nature (RSPN) has been the most active organization with regard to improving public awareness and education. In the last nine years, the RSPN has established a network of schools, nature clubs, and several research projects including some on fuelwood consumption, water quality, eco-tourism as well as
workshops on environmental issues for village headmen and representatives of the National Assembly. It also addresses a wide variety of conservation issues, using different educational methods, public meetings, magazines, debates, seminars and workshops. It also plans to start, for the first time in collaboration with the International Crane Foundation, USA, investigations on the Black Necked Crane’s breeding grounds and migratory routes. Cranes in Bomdeling and Phobjikha will be radio collared and colour banded and electronically monitored with the data transferred via satellite.

**Regional and international collaboration/cooperation**

The Convention on Biological Diversity supersedes the FAO Undertaking and as such is a binding. In the Convention, national sovereign over biodiversity is explicitly recognized. At the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992, Bhutan signed the Convention on Biological Diversity. The 73rd session of the National Assembly ratified the Convention and by that the commitment of the Royal Government of Bhutan to conserve its biodiversity was further strengthened.

An agro-biodiversity Project will be implemented within the framework of the Sustainable Development Agreement (SDA) between Bhutan and The Netherlands. Consequently the principles of sustainable development: reciprocity, equality and participation, will be built into the project. Relevant agreements reached between Bhutan and the Netherlands in the context of SDA are also taken into account. Given the objective and scope, this project will be integrated as one of the themes upon which the national biodiversity strategy and action plan will expand.

The proposal for support to the strengthening of National Herbarium and the completion of the monograph ‘Flora of Bhutan’ has been endorsed by the RGOB, with financial assistance from DANIDA for implementation from 1 May 1998.

At the regional level, IPGRI has supported the national capacity development through numerous short-term training programmes on biodiversity research and development. However, the benefit from these training programmes were not realized in the absence of the institutional and policy support for a national biodiversity program. The officials from MoA continue to participate in the regional workshops, seminars and meetings of the South Asia – PGR Coordinators Network and International Center for Integrated Mountain Development (ICIMOD).

The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India has provided technical assistance in germplasm collecting and seed storage management. Apart from the biodiversity newsletters, which are regularly distributed to individual agriculture researchers and research stations, certain publications and periodicals are also provided free of cost. The Government of India had supported a survey of forest resources in Bhutan during 1974-1980. It is still the most comprehensive forest inventory covering 29 176 km² or 72% of the total land area, excluding the permafrost in the north. Seventy eight tree species were inventorized and the data mapped at 1:50 000 scale.

Biodiversity is an important area for developing cooperation between Bhutan and both multilateral and bilateral donors. A few of the projects focused on or relating closely to biodiversity are:

- Biodiversity Strategy and Action Plan, UNDP and GEF
- A series of environmentally related projects of the UNDP
- Sustainable Development Cooperation (SDC) between the Netherlands and Bhutan, where biodiversity has been considered one of the priority areas for cooperation
- Assistance to NEC by DANIDA
- Assistance to NITM by the EU
- Assistance to NEC with the EIA process, by the ADB
- Integrated forest management projects with Austria, Germany, FAO, and the World Bank, and others
- Biodiversity conservation in Black Mountains National Park with the Netherlands-SNV
- The Bhutan Trust Fund for environmental conservation, whose donors include the GEF, Finland, the Netherlands, World Wildlife Fund, Norway, Denmark, and Switzerland
- Forest resources management and institutional development project (UNDP)
- Assistance in the integrated horticulture master plan (UNDP)
- Assistance in the integrated horticulture development programme (UNDP)
- Punakha-Wangdi Valley development project (UNDP)
- Integrated warm water fisheries project (UNDP)
- Technical Assistance Program to the First Eastern Zone Agricultural Project (UNDP)
- Assistance to essential oil development project (UNDP)
- Integrated forest management project in Ura, Bumthang (supported by Austria)
- Tourism development (Austria)
- Assistance to the LUPP (DANIDA)
- Assistance to the NITM (European Community)
- Development of a national re-afforestation strategy (FAO and Japanese Government)
- Punakha-Wangdue-Gasa integrated forest management project (Germany-GTZ)
- Integrated forest development project (Switzerland-helvetas)
- Food processing (natural resources use) (Switzerland-Helvetas)
- Manufacture of energy-efficient wood stoves (Switzerland-Helvetas)
- Assistance to the Irrigation Section of MoA (Netherlands-SNV and Save the Children-USA)

Others in the pipeline include: (i) The Bomdeling Wildlife Sanctuary through DANIDA, (ii) Agro-biodiversity Center (ABC) Project under SDA, and (iii) The National Herbarium and Flora of Bhutan Project with DANIDA assistance.

World Wildlife Fund (WWF) - Bhutan Program is the principal international NGO which has assisted Bhutan with biodiversity for many years. WWF (jointly, WWF-US and WWF-International) has provided important support for biodiversity conservation since 1977, including training programs and other efforts to enhance staff capabilities, surveys and inventories of biodiversity, assistance to national park development and institutional support.
Crop networks

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A network can be defined as a group of people or organizations that agree to share information or other resources in such a way that greater benefits are derived than had the resources been used in any other way. This definition makes it clear that a network can function at many different levels, among different partners provided that benefits are derived by the partners. In general, there can be either informal or formal networking. Informal networks can share information, germplasm, and work on common problems and even share research or technology among informal groups of interested scientists or other people. However, formal networks often have a definite work programme, a budget, an executive or steering committee and working groups, and an institutional function. Formal networks make collaboration among members more visible and defined (Riley 1996). A review of IPGRI’s involvement in networks (Riley et al. 1995) showed that networks could be effective mechanism for strengthening national programmes, promoting collaboration, developing conservation strategies, and exchanging and disseminating information on plant genetic resources.

Crop networks
Crop networks focus on the conservation and use of single crop genepools. Members for such network can include those countries around the world where the crop is important or institutes where collections are stored. The concept of crop networks was introduced by IBPGR in 1989 (Hintum et al. 1991). Crop networks generally operate by commitments from members who look after all or parts of collection of a particular gene pool. Each crop network is to include specialists who will study the genepool to understand its genetic structure and taxonomy, to identify the need and locations for further collecting. As a tool for improving the global status of crop genetic resources, IBPGR proposed the implementation of genetic resources networks based on the concept of the crop genepool. Such networks are conceived as partners in learning and problem solving. The network activities should not only be based on exchange of information on methodologies and results and on the scientific consultation in planning, but should also include the sharing of material and data, defined commitments for all partners of the network and also the acceptance of special duties/responsibilities by the partners which are in the best position to provide services bringing benefits to all participants of the network. The crop and its genepool is the building block which allows to bring together specialists from different fields and agreeing on a collaborative action plan; the conservation of genetic diversity only becomes meaningful when applied to the crop genepool concept. The activities of crop network should include: inventory of all existing accessions, use of a common descriptor list, widening the scope of the international databases, further circulation of information, rationalization of collections, safety duplication, an integrated conservation approach, and promoting the use of germplasm, etc.

In the past, many crop networks with support from IBPGR/IPGRI have been established which include Beta, Musa, rice, barley, coconut, cassava, sweet potato, and okra. IPGRI’s involvement in these networks varies greatly ranging from simply monitoring through a focal point within IPGRI to the development and maintenance of a major network as part of IPGRI’s core programme. In recent years, a number of crop networks have focused in the Asia, the Pacific and Oceania region with IPGRI’s involvement. These include Coconut Genetic Resources Network (COGENT). A number of smaller networks focus on conservation
and use of minor crop genepools in the region including sesame, safflower, *Lathyrus*, sweet potato (ANSWER), taro (TAROGEN), and on tropical fruit species.

The crop networks must be developed in close partnership with the member countries and organizations. This often requires extensive consultation in order to ensure that all parties are committed to the common objectives and the plan of the network. Sharing of information should be an essential component of all these networks.

A number of principles for the organization of regional and crop networks have been formulated by IPGRI (Riley 1996), which are: (i) A network must have quantifiable objectives, (ii) Concrete action plan with agreed activities, time table and mechanism to measure progress is required, (iii) Participating countries/organizations must accept the agreed commitments, (iv) Participants must be willing to share agreed/designated germplasm and information, (v) A realistic plan for sustained funding is needed, (vi) A steering/governing body with members having a representational role should be established, (vii) The coordinator must be empowered with a clear responsibility and with the resources (time and fund) to carry out a facilitator's role to serve the network, and (viii) The development of a database of germplasm holdings to serve the network is very important

**References**


Riley, K.W., M. Zhou and V. Ramanatha Rao. 1995. Regional and crop networks for effective management and use of plant genetic resources in Asia, the Pacific and Oceania. XVIII Pacific Science Congress on Population, Resources and Environment: Prospects and Initiatives, 5-12 June, Beijing, China

Information network for promoting the use of plant genetic resources in South Asia

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Introduction
The conservation and sustainable utilization of plant genetic resources (PGR) is the key to improving agricultural productivity and sustainability thereby contributing to national development, food security, and poverty alleviation. Plant Genetic Resources for Food and Agriculture (PGRFA) consist of the diversity of genetic material contained in traditional varieties and modern cultivars grown by farmers as well as wild relatives of crops and other wild plant species that can be used for food, feed and fodder for domestic animals, fibre, clothing, shelter, wood, timber and energy, etc. One of the major challenges facing food security in the next generation is the effective management of plant genetic resources worldwide. In this context, plant genetic resources databases are very important at national, regional and global levels to back up conservation of rapidly disappearing genetic stocks for possible future use and also for immediate utilization of already conserved and evaluated/characterized germplasm in the ongoing crop improvement programmes. Success of both the activities is, to a larger extent, dependent upon the availability of information on accessions stored in the genebank. There is also a need for an extensive evaluation and documentation of PGR, which may assist in avoiding problems arising due to Intellectual Property Rights (IPR) and at the same time, there is a need for monitoring and controlling the factors leading to genetic erosion.

Need for PGR documentation system
It is now widely recognized that, in order to strengthen PGR conservation and to enhance its utilization, there is a strong need for the development of better and more accessible information and documentation systems. Documentation skills are essential for any genebank. Genebanks will have problems in managing their collections if they do not update, and store accurate and reliable information in a systematic and easily accessible way. Much of the information acquired and generated by a genebank is of interest and immense value to the scientific community. Genebanks commonly distribute their accessions together with relevant information. However, not all the information generated in the genebank is of interest to other scientists but is vital for its own activities and managing resources. A documentation system will, therefore, allow genebanks to use information to plan their day to day activities and to maximize the use of their often-limited resources. Also, without an effective documentation system, genebanks cannot develop a clear sense of direction and cannot easily communicate or collaborate with other institutions.

Further, genebanks differ from one another based on their activities and the organizational approaches they adopt. As a result of this, the documentation systems followed by different genebanks may be different in someways catering to the needs of the genebank. In any case the common feature of an effective genebank has to be that, the information retrieved from a documentation system must be accurate, reliable and up-to-date to be of significant value and the process of storing and retrieving information should be simple and straightforward. The documentation system should not be rigid in its operation. It should be able to cope with different requests for information and should be able to accommodate changes in
genebank procedures. Therefore, in a documentation system, users needs must be taken into account while organizing data and designing the system.

**Information networking for plant genetic resources databases**

Networks have been recognized as effective tools to enable countries to carry out their responsibilities to conserve, use and share resources, information and technology. In the Global Plan of Action (GPA) for Conservation and Use of Plant Genetic Resources, networks are included as an important activity. Crop and Regional Networks are one of the 20 priority activities approved in GPA at the International Technical Conference on Plant Genetic Resources held in Leipzig, Germany in June 1996 (FAO, 1998).

**Development of networks**

According to Riley (1996), the useful definition of a network is “a network can be defined as a group of people or organizations that agree to share information or other resources in such a way that greater benefit is derived than had the resources been used in any other way”. This definition makes it clear that a network can function at many different levels, among different partners provided that benefits are derived by the partners. In general there can be either informal or formal networking.

- Informal networks can share information, germplasm, work on common problems, and even share research or technology among informal group of interested people or scientists.
- Formal networks often have a defined work programme, a budget, an executive or steering committee and working groups, and take on an institutional function. Formal networks make the commitment and collaboration among members more visible and defined.

**How do networks develop?**

Networks can take many different forms, but can see a progression towards increased formalization and complexity in the phases of network development as shown in Fig. 1 (Riley 1996). This also indicates that networks can also evolve towards increased collaboration among members, rather than entirely rely on inputs from a central agency. Also linkages with a country, coordinated in turn by a country coordinator, can strengthen collaboration and increase the benefits from a network derived by each country. Better benefits and sharing lead to more sustainable and effective networks.

Regional PGR networks focus on the national PGR committees in each member country of a region and attempt to strengthen common activities carried out through these national committees, while, crop networks focus on the conservation and use of single crop gene pool. Members can include those countries around the world where the crop is important or institutes where collections are stored. Since 1989, IBPGR has implemented the idea of crop networks (IBPGR 1991). Crop networks operate by commitments from members who look after all or parts of the collection of a particular gene pool.

A common activity in these PGR networks involves establishing an Information Network either on a national/regional basis or centralized crop databases. With the increased availability of computer hardware and software, and the recent developments in information technology, new approaches to coordinate collaborative structures have become available. Within crop networks, the central crop database concept is an important example that combines information on the accession in several germplasm collections of a given crop or group of crops.

Information networking was recognized as an important component of a viable and effective PGR management system in the region (Quek 1993). This is in line with the Convention on Biological Diversity (CBD) and this enables information and/or germplasm...
to be shared within and among countries. In most instances, PGR information is available in genebanks. It is essential that genebanks participating in information networks have proper documentation and information available for dissemination, to avoid problems of under-utilization of accumulated collections of germplasm held in many genebanks and research centres.

The objectives of an information network are:

- To promote information exchange within and between the organizations/countries
- To promote utilization and sharing of genetic resources among participants
- To complement each other's development and avoid duplication of efforts
- To enhance coordination of research and training
As indicated earlier, PGR documentation and information systems usually get low priority and figure only after collecting, characterization and evaluation of accessions. For a strong PGR programme, all available germplasm accessions must be documented and the information must be available to the end users. Failing this, all the germplasm collected, characterized and evaluated would be used only by the concerned institutes where the PGR centre is located or, in some cases, not even by the researchers of the same institute as they have no information about the desired traits available in the collection.
Therefore, it is important that the genebank documentation system be developed with a vision of linking to national databases and then to regional, and global databases. Cooperating centres are viewed as individual entities in the network, having their own staff, software, databases, documentation procedures and problems to look after. It is very difficult to change any documentation system that has been in place for many years unless minimal staff time is required. Hence, there should be no compulsion for the cooperating centres to change their existing manual or computerized documentation system. What is more important is the information available in the documentation form that they have developed. Initial information exchange is based on whatever is available and some form of computer data exchange programme may be needed for the cooperating centres with computerized records.

Information networking involves the process of making the national programmes (NPs) ready for information exchange and then undertaking the exchange of information. Our experience shows that NPs are reluctant to change their existing systems and even if they wish, most of them do not have the resources to do so. By allowing NPs to use existing system, the cost of human resource and equipment for developing network information system for information exchange is greatly reduced. The approach in APO region is to develop an easy-to-use format for exchange of data among genebanks using their existing systems. The Data Interchange Protocol (DIP), which has been developed by IPGRI-APO, can be used to facilitate exchange of information between the genebanks, developing electronic germplasm catalogues/directories, developing database of PGR scientists/researchers etc. An issue that crops up with the DIP format is as to how it should be used for linking existing genebank documentation system data to other software such as visual analysis tools like Geographical Information System (GIS) and Regeneration Decision Support System, analytical tools like statistical software and data mining.

References
Complementary conservation strategies

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Introduction
Plant genetic resources (PGR) collections are assemblies of genotypes or populations representing cultigens (landraces as well as advanced cultivars), genetic stocks and related wild and weedy species and these may be conserved in the form of plants, seeds, tissues etc. (Frankel and Soulé 1981). Landraces may contain coadapted gene complexes that have evolved over decades (Harlan 1992) and are the most important of the plant genetic resources. Advanced cultivars, genetic stocks and wild relatives of crop plants play an important role in crop improvement and therefore need to be preserved (Frankel 1990). Over the years, there has been much loss of genetic diversity, but the remaining genetic diversity in the genepools still retains vast potential for present and future uses. Generally speaking, plant genetic resources are non-renewable and it is essential that these important resources are conserved and used, be it at species level, genepool level or at the ecosystem level. The limitations of a narrow genetic base of many present-day varieties are well recognized. Genetic diversity is a natural defence mechanism against the genetic vulnerability, which has been built into the genetic structure of traditional cultivars (Anon 1973; Brown 1983). Countries which still have a significant amount of genetic diversity and species diversity have a responsibility on themselves as well as to the world at large to conserve it and make it available for use (Ramanatha Rao 1995). This paper considers different approaches to conservation and the process that optimizes different approaches to conserve effectively the maximum genetic diversity in any genepool.

Approaches to conservation
There are two approaches to conservation of PGR, ex situ and in situ. Ex situ approach generally comprises of storing the seed in cold storages, maintaining plants in the field genebanks or botanical gardens, in vitro storage, and storage of cells, tissues, pollen or DNA-all of which are outside the native habitat/environment of the plant concerned. In contrast, in situ approach is about conserving genetic resources in the natural habitat and some of the methods are maintaining reserves/protected areas, conservation on-farm and in home gardens. A brief summary of different methods and recent developments in each of them is given here.

Ex situ conservation
Conservation of seed
Conservation of seeds is an efficient and reproducible technique in which the seeds are dried to appropriate lower moisture content and stored at a low temperature. This method is almost universally applied to the orthodox seed species. Initially, many collections were maintained without the help of appropriate storage facilities to extend the viability of seeds. Due to this, frequent regeneration of the conserved accessions had become necessary leading to loss of genetic diversity in genebanks (Frankel and Hawkes 1975). In addition, maintaining genetic purity of the conserved accessions can be problematic due to differential survival in storage, selection during regeneration, outcrossing with other entries and genetic drift (Allard 1970). However, good storage conditions coupled with proper grow-out tests are expected to reduce the effects of such problems (Ramanatha Rao 1980). It is now well recognized that seeds should be maintained under conditions in which the life processes in seeds are minimized to facilitate their storage for many years with minimal loss in genetic
diversity, genetic purity and viability. In most cases, it is possible to set limits with loss of viability as indicator of the genetic shifts in the stored seed material.

Extended life span of seeds stored under optimum conditions (cool and dry) helps to minimise the frequency of regeneration and it, in turn, results in more cost-effective maintenance of germplasm. It also minimizes genetic erosion resulting from genetic drift in small populations that may be grown for regeneration; genetic shifts resulting from natural selection when material is grown out in the field; and the risks of human error (Frankel and Hawkes 1975; Ramanatha Rao 1991; Clark et al. 1997). Guidelines for proper handling and storage of seeds of many different crop species are available from IPGRI and FAO (FAO/IPGRI 1994; IBPGR 1982, IBPGR a,b,c and d).

The work has been carried out on alternative methods of storage of seeds such as the maintenance of seeds in imbibed storage, storage of seeds in liquid nitrogen at temperatures below -196°C and storage of ultradry seeds. As opposed to ‘orthodox’ seeds which can be dried to very low levels of seed moisture content (below 7%), there are a number of species whose seeds cannot be dried to low moisture levels for optimum storage. Such seeds have been referred to as ‘recalcitrant’ (Roberts and King 1986) and imbibed storage (at higher levels of seed moisture) may be of considerable importance; however, no practical methods have so far been developed. Significant amount of work has been done on understanding the genetic basis of recalcitrance and such information will be necessary to develop methods of storage of recalcitrant species (Chin and Pritchard 1988; Chandel et al. 1995). Very low temperature storage using liquid nitrogen, called cryopreservation, also appears to be promising, with a more extended life span than seeds stored under long-term storage at -20°C (Stanwood 1980; Normah and Seti Dewi Serimala 1995). Another area in which considerable work is required is storage of ultradry seeds (dried to seed moisture content of 2-5%) at room temperature conditions. It is now known that such low levels of seed moisture content would help greatly in extending the seed longevity under ambient conditions, when stored in hermetically sealed containers (Ellis and Roberts 1991; Zhou et al. 1995; Ellis et al. 1996). Further research is necessary before ultradry seed technology can be adopted.

Conservation of plants
Many field crops, horticultural and forestry species are either difficult or impossible to conserve as seeds as they do not set seeds and reproduce vegetatively or their seeds are recalcitrant. Hence, they are conserved in field genebanks. There are several disadvantages of field genebanks. They run a risk of being damaged by natural calamities, infection, neglect or abuse. To be an effective conservation method, *ex situ* conservation of tree species using field genebanks requires a substantial number of trees in individual genotypes and requires more space and is relatively expensive to maintain (Jarret and Florkowski 1990). In some cases, however, the field genebanks are less expensive to maintain (Epperson et al. 1997). Nevertheless, field genebanks have several important advantages; they provide easy and ready access to conserved material for research as well as for use. For a number of plant species, the alternative methods have not been fully developed (Ramanatha Rao and Riley 1995). Hence, the establishment of field genebanks will play a major role in any conservation strategy. At the same time, efforts to develop and refine other methods, such as *in vitro* conservation and on-farm conservation, should be continued.

Conservation of tissues/cells
The use of tissue or cell cultures is another method of *ex situ* conservation of germplasm. There are a number of plant species which cannot be conserved as seeds and present different problems. Generally, conservation of such material as plants in the field requires greater space, labour and funds and they also run the risk of being damaged by natural
calamities and disease and pest infections. Hence, the conservation of tuber, root, shrub and tree species becomes very difficult indeed. In recent years, several techniques to conserve such vegetatively propagated species have been developed and some of them are undergoing rigorous testing. For some species, the *in vitro* conservation is the only method available. Though tissue culture offers great potential for conservation of germplasm of vegetatively propagated species, the major technical hindrance that comes in the way is firstly due to the genetic instability of the material conserved as tissue culture due to somaclonal variation at the time of regeneration of the tissue into seedlings and secondly due to the length of storage as tissue being limited. Significant work is being done on both aspects and for some species, tissue culture maintenance is relevant due to improved techniques resulting in low levels of somaclonal variation. Work on cryopreservation of tissues, is also making rapid progress. Once these techniques are further refined, their large-scale adoption will be possible (Engelmann and Ramanatha Rao 1996; Ramanatha Rao and Riley 1994a; Ramanatha Rao and Riley 1994b; Simpson and Withers 1986; Withers 1993; Verdeil *et al.* 1997).

Additional research is needed to refine *in vitro* techniques and to make this method fully operational for the medium and long-term conservation of problem species. However, these techniques have good potential for conservation purposes and are expected to play a greater role in a not too distant future in the overall approach to conservation of plant germplasm.

**Conservation of pollen**

Initially, pollen storage was mainly developed as a tool for controlled pollination of asynchronous flowering genotypes, especially in fruits (Alexander and Ganeshan 1993). In addition, pollen storage has also been considered as an emerging technology for genetic conservation (Harrington 1970; Roberts 1975; Withers 1991). Since the conserved material is haploid in nature, this method may not be considered as a viable method for genetic conservation of genotypes. However, cryopreservation of pollen is likely to be more successful than other storage techniques routinely employed for pollen (e.g., under organic solvents, desiccation freeze drying, low temperature) in assisting hybridization of species in which flowering is asynchronous or for use in next season (Ramanatha Rao *et al.* 1998). Hence, this method can help in better utilization of available genetic resources. Pollen can be easily collected and cryopreserved in large quantities in relatively small space. In addition, exchange of germplasm through pollen poses fewer quarantine problems compared with seed or propagules. In recent years, pollen cryopreservation techniques have been developed for many species (Bhat and Seetharam 1993; Towill 1985) and cryobanks of pollen have been established for fruit tree species in several countries (Alexander and Ganeshan 1993; Ganeshan and Rajasekharan 1995).

**DNA storage**

In principle, storage of DNA is simple and widely applicable and seems to be relatively cheaper. The progress in genetic engineering has resulted in breaking down the species and genus barriers for transferring genes (Council 1993). Several transgenic plants have been produced with genes transferred from distantly related species as well as from viruses, bacteria, fungi and even mice. Such efforts have lead to the establishment of several DNA libraries world-wide, which store total genomic information of germplasm (Mattick *et al.* 1992). However, strategies and procedures have to be developed on how to use the material stored in the form of DNA. The role and value of this method for PGR conservation is not completely clear yet.

**Botanical gardens**

There are about 1 500 botanic gardens and arboreta in the world (WWF-IUCN-BGCS 1989). The objectives of most of the gardens include: (i) maintenance of essential ecological processes
and life support systems, (ii) preservation of genetic diversity, and (iii) ensuring sustainable utilization of species and ecosystems. However, the botanical gardens can only play a limited role in germplasm conservation and propagation and probably play a greater role in public awareness and education. Botanical gardens are mainly used to display a wide array of different and exotic species and/or for intensive study of the taxa. As only limited material can be maintained in this manner, it can not reflect wide genetic diversity. It is possible that a few well managed gardens can have certain groups of species as living collections which will be akin to field genebanks.

In situ conservation

In situ conservation approach is dynamic as opposed to the semi-static nature of ex situ conservation. The main justification for choosing in situ conservation over ex situ is the ability to maintain the evolutionary potential of species and populations (Frankel 1970; Frankel and Soul 1981; Ledig 1988; Ledig 1992). However, given the fact that human activities can cause habitat destruction and loss of biodiversity in some cases, and the maintenance of biodiversity in other cases, it will be necessary to complement it with ex situ conservation. In general, research and monitoring is needed at three levels for successful in situ conservation: (i) assay of genetic variation represented within a target species in a particular area (ideally by studies of intraspecific morphological and molecular variation and the diversity as recognized by local users, including farmers); (ii) regular inventory of species numbers; and (iii) observation of general ecological condition and habitat alteration, including farming systems (Berg 1996).

In any in situ conservation effort (wild or on-farm), the monitoring aspect is the most important one. In the final analysis, it is the information on genetic diversity - how much and where it is located and how it is changing over space and time, which is the most important for conservation and more so for utilization of that diversity. In situ conservation programme may fail due to lack of such monitoring system in place. Monitoring also helps to be in contact with farmers and communities and helps to pass on any new information to them on aspects of conservation and use.

Biosphere reserves/protected areas

In general, the biodiversity at the species and ecosystem level can only be conserved through in situ conservation (McNeely 1996). Various types of protected or semi-protected areas that are identified to be rich in diversity of ecosystems and/or species are used in this method. Conservation of wild species crop relatives in genetic reserves involves the location, designation, management and monitoring of genetic diversity in a particular, natural location (Maxted et al. 1997). Similarly, this is the most important method for fruit and forestry species and their relatives. However, it must be noted that genetic reserves are often not very accessible for use. Additionally, the monitoring and management may not be optimal due to difficult conditions under which these are maintained. For the same reason, characterization and evaluation will be limited. The reserves are also vulnerable to natural and human-made disasters.

In situ conservation method, using reserves and protected areas is an economical method. Additionally, one reserve can be planned to contain several plant species. However, since the areas have to be large to facilitate conservation of sufficient size of the population, the overall cost of conservation can be quite high. Some of the estimates range from US$ 1.8/ha/year, in Thailand to US$ 28/ha/year in Indonesia, depending on several factors. However, in a number of cases, the allocation is much smaller than what actually is needed, for example, US$ 0.75/ha/year in Indonesia for some of its reserves (Widjaja 1998).

On-farm conservation

In situ conservation of agro-biodiversity or on-farm conservation involves the maintenance of traditional crop cultivars (landraces) or farming systems by farmers within traditional
agricultural systems (Hodgkin et al. 1993; Ramanatha Rao et al. 1997). Traditional farmers use landraces, which are developed by the farmer and strongly adapted to the local environment (Harlan 1992). This method of conservation has been gaining importance in recent years, though farmers have been using it for centuries (Sthapit and Joshi 1996).

In the evolution of diversity on farm, the effects of growers’ practices are of paramount importance, the baseline diversity being the one that is determined by the local adaptation of the genotype. In most cases, there is little information available on the status of the genetic diversity on-farm. It is now possible to monitor and estimate genetic diversity using molecular markers (Hodgkin and Debouck 1992; Ramanatha Rao et al. 1997; Ramanatha Rao and Riley 1994a and b), in conjunction with agro-morphological traits. Such a study in China on taro germplasm has been funded by IPGRI. However, the limited resources available for such work make it difficult to implement. In the past, measurement of genetic diversity in most perennial tree species using morphometric traits was difficult and laborious; use of molecular markers will assist in better understanding of the structure of genetic diversity both at a specific site and across regions.

Systematic documentation of farmers’ knowledge of diversity and uses is needed (Quek and Zhang 1997). Community participation, control of land rights in local communities, education, extension and development of environmental awareness are crucial to success of on-farm conservation. In addition, any in situ conservation programme must benefit the local communities. Management by local communities can often be developed to effectively link conservation and use (McNeely 1994 and 1996). It is important to consider indigenous knowledge, peoples participation and cooperation between local people, researchers conservationists and non-governmental organizations (NGOs). The establishment of areas of intensive management or high yielding plantations is another important way to promote long-term sustainability of in situ conservation of agro-biodiversity. In this context, conservation activities by commercial and private agencies may be promoted as these groups have the capacity to fund such activities. Since it will be necessary to foster sustained conservation and use of resources to derive long-term benefits from the exploitation of the resources, the commercial sector and private agencies will be interested in such activities. This can lead to much wanted linkages among public, community and private sectors in plant genetic resources conservation (Riley 1995). The methods of management and benefits to local communities in maintaining and using this diversity must be considered while implementing an in situ (or on-farm) conservation programme.

**Home gardens**

Home garden conservation is very similar to on-farm conservation, although, the scale is much smaller. In most rural situations, home gardens tend to contain a wide spectrum of species, such as vegetables, fruits, medicinal plants as compared to on-farm plots (Evenson 1986). This technique being akin to on-farm conservation, has the same advantages. Home garden, as a single unit, has very little value in terms of conservation, but a community of them in a given area may contribute significantly to the conservation and direct use of genetic diversity. Most of such diversity could be somewhat unique/rare as the people tend to grow unique materials in their gardens and also underutilized species. However, the system is vulnerable to changes in management practices. Home gardens are also known to be the testing grounds for some of the wild and semi-wild species. Thus, in rural areas, the home gardens will continue to play a significant role in genetic diversity conservation as well as development.

**Complementary conservation strategy**

There are two main approaches to conservation of PGR, *ex situ* and *in situ*, which are complementary in nature. As no single method can conserve all the diversity in a given
gene pool, there is a need to employ a combination of methods. The balance between different methods employed depends on factors such as the biological characteristics of the gene pool, infrastructure and human resources, number of accessions in a given collection and its geographic site and the intended use of the conserved germplasm. For any given gene pool, the extent of a particular method used may differ from that used in another gene pool (IPGRI 1993). Once the target gene pools, considering both taxonomic and geographical aspects, are determined and their genetic structures identified, the next steps in developing a complementary conservation strategy (CCS) can be taken.

Though from a functional point of view, CCS appears to be an amalgamation of different conservation methods, in reality, it is a decision-making process leading to conservation of genetic diversity existing in a target gene pool. A large amount of information on various parameters is required for establishing the knowledge base to develop a CCS that is the most appropriate for a given gene pool. Such information includes:

- Information on the importance of the gene pool
- Extent and distribution of genetic diversity within the gene pool
- Life history traits and reproductive biology of target species
- Storage characteristics of these species
- Knowledge about those who are using and conserving the diversity
- Location and size of the germplasm collections
- Cost-effectiveness of the methods used
- Conservation objectives
- Human resources and infra-structural facilities available
- Legal issues and access to material conserved, etc.

In order to successfully link all the different elements involved and to facilitate the conservation of a gene pool in the most secure, sustainable, accessible and cost-effective way, CCS is necessarily a participatory and dynamic process. In practice, different combinations of conservation methods are used so that one method complements the other. Such a system can provide a strategy that optimally conserves the maximum diversity within the target gene pool in the most efficient and cost-effective way, and also strongly supports the use of the genetic resources either in crop improvement or directly by local people.

The importance of conserving and sustainably using the plant genetic resources has been highlighted in two global agreements, the Convention on Biological Diversity (CBD) and the Global Plan of Action (GPA) adopted in Leipzig, Germany in 1996. Both international agreements not only recognize countries’ responsibilities to conserve and use their plant genetic resources, but also the importance of equitable sharing the benefits derived from the use of resources and technologies related to their utilization.

Therefore, CCS needs to be operational at the national level helping in making decisions on how to conserve PGR of a species existing in a country. It is expected to provide the tools to identify the role and importance of germplasm at the country level as a component of an entire gene pool spreading across countries and often also over macro-regions. The latter leads to the concept of regional and international collaboration in plant genetic resources conservation, an aspect that has been strongly highlighted by both GPA and CBD. Thus, CCS can also function at regional and global levels.

Though the basic ideas on CCS have been under discussion by scientists for over a decade, there has not been enough emphasis on research aimed at bringing together the different elements in CCS development with gene pool conservation approach and with focus on the needs of the stakeholders i.e. those who conserve, use and depend on the germplasm in question. Following an in-house workshop in late 1997 on complementary conservation strategy, IPGRI accorded a high priority to the development of CCS. The
workshop focused on CCS as a decision-making process and outlined elements of a work plan for the development of an institutional strategy in promoting CCS and recommended that IPGRI undertake generally applicable case studies in order to develop decision-making processes and methodologies in specific situations.

**Genepool**

Focusing conservation on genepool basis appears to be the best approach, since it will help to conserve the maximum genetic diversity of any group of crop or forestry plant species (IPGRI 1993). For effective collecting and conservation, it is important to determine the genepool of a species. Most commonly, three types of genepools have been distinguished (Harlan and de Wet 1971):

- **Primary genepool:** This corresponds with the botanical species. It consists of cultivated species and its weedy and wild relatives, which can hybridize with ease among themselves and produce fertile $F_1$s.
- **Secondary genepool:** This consists of phylogenetically related species, which can be crossed with the species of interest, and may produce partly fertile, but weak $F_1$s.
- **Tertiary genepool:** It consists of species that are phylogenetically related and normally do not intermate. However, they may be crossed using complex techniques, producing weak and often sterile $F_1$s.

Except for monotypic species, all others are expected to have relatives that fall into this classification. With the advent of modern biotechnological techniques that can transcend species/generic barriers, the definition of genepools is slightly blurred. However, this concept still helps to group the target species and its related species into specific categories. Once the target species and the genepools are determined, next steps in developing a CCS can be taken. To formulate a conservation strategy, the conservationist needs to consider a number of factors in relation to the genepool (Ramanatha Rao and Arora 1998). These factors can be used to formulate the following questions. What follows is, by no means, exhaustive, but covers most of the ground:

**Biological characteristics**

**Genetic diversity**

- What is known about the genetic diversity within the genepool, at each level?
- What is its extent and distribution?
- What special traits or unique diversity should one be looking for?

**Life cycle**

- Does the genepool include only short lived or long lived or a mixed group?
- What is the age of the plant when it becomes useful for either breeding or for other purposes?

**Reproductive biology**

- Do all target species reproduce sexually or asexually, or with a combination of the two?
- If reproduction is sexual, then is it a selfing or outcrossing species?
- What is the level of outcrossing?
- Are there any other biological traits that will interfere with true seed production?

**Storage characteristics**

- Are the species under consideration orthodox or recalcitrant?
- Should the storage be for short, medium or long-term?
Location and facilities

Location
- Where is the germplasm collection located?
- Can all the species in different genepools be maintained or grown in the same location?
- How different is the location from its original habitat?

Infrastructure
- How accessible is the area of collection?
- How accessible the material will be and for whom?
- What facilities, for different types of conservation, are available?

Human resources
- What is the level of training of the staff?
- Can the level be upgraded periodically?
- Does it have the needed critical mass?

Objectives of collection

Objectives
- Is the aim to conserve genes or genotypes?
- Is it completely to stop evolutionary processes or to provide opportunity to evolutionary factors to operate?

Improvement strategy
- Is the collection linked to the user community?
- How urgent is the need to import; what legal arrangements exist for transfer and access to genetic material?
- What are the legal issues that govern the acquisition of land and other related facilities?

Importance of the crop
- How important is the crop?
- Is it important enough for the local people to participate in in situ conservation effort?

Once the information on most of the above aspects is available, an appropriate conservation strategy may be developed for a given genepool. A combination of methods, from both in situ and ex situ approaches, should be applied in a way that one method complements the other. Such a system can provide a strategy that optimally conserves the maximum diversity within the target genepool.

Conclusion
It is now well understood that no single method can help to conserve most genetic diversity in any given crop or genepool in a given location. Therefore, there is a need for a complementary conservation strategy that makes use of, optimally, all relevant techniques/methods available and still leave place for any future developments and refinements. Such a strategy should not only be able to meet most of the needs in PGR conservation but also assist in efficient use of the materials conserved. It should be pragmatic and critical, especially in determining the methods to be used. It does not advocate methods, simply because the method is available, but only because it is the most appropriate one under the given conditions. A good complementary conservation strategy does not categorise crops or species
in to definitive classes. It is dynamic, and lends itself to meet the challenges of changes that are occurring in the field of genetic resources as it is open to new technologies and new needs. A large knowledge base is required to develop a good complementary conservation strategy; much information is available in the literature and some information still needs to be generated through further research.

References


McNeely, J.A. 1996. The role of protected areas for conservation and sustainable use of plant genetic resources for food and agriculture. Pp. 27-41 in In situ Conservation and Sustainable use of plant genetic resources for Food and Agriculture in developing countries, Report
of DSE/ATSAF/IPGRI workshop, 2-4 May 1995 Bobb-Rottgen, Germany. IPGRI and
DSE, Rome.
Normah, M.N. and M.N. Seti Dewi Serimala. 1995. Cryopreservation of seeds and empryonic
axes of several Citrus species. Pp. 817-823 in Basic and Applied Aspects of Seed Biology
Dordrecht.
Journal, Editorial article in IPGRI-APO Newsletter N0. 23, August 1997.
of the International Workshop on Groundnuts, 13-17 October 1980. ICRISAT, Patancheru,
Andhra Pradesh, India.
Ramanatha Rao, V. 1991. Problems and methodologies for management and retention of
Workshop on Conservation of Plant Genetic Resources. (B. Becker, eds.). Bonn. ATSAF/ IBPGR.
103-109 in Proceedings of East Asia Coordinators Meeting on Plant Genetic Resources,
IPGRI, Office for EastAsia, c/o CAAS, Beijing, China.
Conservation Workshop, 6-7 October 1997, Brisbane, Australia (P. Broadbent, S.R. Sykes,
K.B. Bevington and D. Hailstono, eds.). ACIAR/IPGRI-APO.
Ramanatha Rao, V. and K.W. Riley. 1994a. The use of biotechnology for the conservation
Ramanatha Rao, V. and K.W. Riley. 1994b. The use of biotechnology for the conservation
on Agrotechnology in the Commonwealth: Focus for the 21st Century. (C.S. Loh, S.K.
presented at the COGENT-ADB Project and Steering Committee Meeting 1-15 September.
CPCRI, Kasargod, India. (Mimeographed)
Towards a coconut conservation strategy. Pp 4-20 in Proceedings of Regional Coconut
Genebank Planning Workshop, 26-28 February 1996 (V. Ramanatha Rao and P. Batugal,
eds.). Pekanbaru, Indonesia. IPGRI, Serdang.
in plant genetic resources of Asia. Pp. 1-19 in Biodiversity Conservation of Plant Genetic
Resources in Asia (Y.G. Park and S. Sakamoto, eds.). Japan Scientific Societies Press,
Tokyo.
(V. Ramanatha Rao, K.W. Riley, Z. Zhang and M. Zhuo, eds.). IPGRI, Office for East Asia,
c/o CAAS, Beijing, China.
Roberts, E.H. 1975. Problems of long-term storage of seed and pollen of genetic resources
Resources - The Conservation of Difficult Material (L.A. Withers and J.T. Williams, eds.).
IUBS/IGF/IBPGR, Rome.


On-farm conservation of crop genetic resources through use

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Introduction

Crop genetic resources (CGR) can be conserved both ex situ and in situ. Ex situ conservation refers to conserving these resources outside their place of development, for example, in genebanks and botanical gardens. In situ conservation of crop resources refers to conservation in the place where plants developed their present day characteristics. In situ conservation is concerned with maintaining species' populations in the natural habitats where they occur, either as uncultivated plant communities or in farmers' fields as part of existing agroecosystems (Frankel 1970; Brush 1995). Traditionally, in situ conservation has been used for the conservation of forests, wild species and areas valued for their wildlife or ecosystems, whereas ex situ conservation has been the predominant approach for the conservation of plant genetic resources (PGR) for food and agriculture (Frankel 1970; FAO 1996).

In contrast to ex situ conservation, in situ conservation permits populations of crop species to be continuously affected by evolutionary and adaptation processes. In case of on-farm conservation, farmer developed varieties or landraces continue to evolve, influenced by natural selection as well as by selection pressures imposed by the farmer, and, thereby provide opportunities for continuous crop adaptation and improvement (Fig.1).

New landraces continue to evolve with changing environment as long as the process of on-farm conservation exists (Fig. 1). In the past, farmer experimentation on naturally existing genetic variation produced present day landraces and these landraces evolved by natural and farmers' selection are important raw materials for conventional plant breeding. Therefore, the maintenance of traditional varieties and landraces in situ should be an essential component of sustainable agricultural development.

Occasional or sometimes frequent gene flow between landraces and related wild species that may be present in the production system has been recorded. On-farm conservation in farmers' fields needs to be continued to promote this evolutionary process. Gene flow from the wild relatives to farmers' landraces, and from landraces to improved cultivars is a dynamic process and should be maintained if plant breeding has to meet the growing needs of the world's population (Vaughan and Sitch 1991; Bellon et al. 1997).

Farmers continue to grow landraces when there is a benefit in doing so. At any time, local varieties may be replaced by improved varieties. This paper deals with some options to enhance the benefits to farmers of local crop varieties so that they continue to be maintained in farmers' fields.

Factors influencing the genetic diversity of crops

In most developing countries, farmers practise de facto conservation of landraces as an integral part of their farming systems and have done so for centuries (Alteri and Merrick 1987). CGR have passed from generation to generation of farmers and are subject to different natural and human selection pressures. Environmental, biological, cultural and socioeconomic factors influence farmers' decision of whether to select or maintain a particular crop cultivar at any given time (Jarvis et al. 1998).

In the process of planting, managing, selecting, roguing, harvesting and processing, farmers make decisions on their crops that affect the genetic diversity of the crop populations. Over time, a farmer may alter the genetic structure of a population by selecting for plants
with preferred agro-morphological or quality characteristics (Fig. 2). Thus, landraces may be a product of farmer selection as well as farmer breeding (Riley 1996).

**Threat of loosing biodiversity**

Important factors that motivated farmers to maintain high biodiversity in the past included risk alleviation to ensure food security and the ability to meet various qualitative preferences and requirements (Roder 1995, Sperling and Berkowitz 1994). On-farm conservation of CGR tends to be more prevalent in complex, diverse, risk-prone environments where local livelihoods depend on subsistence farming. Questions that often arise are, "Why should farming community conserve crop genetic resources if they are not useful to them? Why should a subsistence farmer maintain low yielding landraces if there are better options available?" The process of *in situ* conservation should not be to dissuade farmers from adopting new species or cultivars that address food security or income, but rather to understand and determine ways and means to assist the continued selection of local cultivars that conserve local germplasm (Jarvis and Hodgkin 1998).

There is a growing pressure on farmers who maintain significant amount of crop genetic diversity as local cultivars. Increased population, poverty, land degradation, environmental change and the introduction of modern crop varieties, have contributed to the erosion of CGR (Jarvis *et al.* 1998). Farming communities are currently practitioners for *in situ* conservation. Local crop resources will not be saved unless they are used by farmers.

Jarvis *et al.* (1998) argued that *in situ* conservation has the potential to: (i) conserve the processes of evolution and adaptation of crops to their environments, (ii) conserve diversity at all levels - the ecosystem, between the species, and within species, (iii) improve the livelihood of farmers, (iv) maintain or increase control and access of farmers over their genetic resources, (v) involve farmers directly in value addition process, and (vi) integrate farmers into the national PGR system for conservation.

Genetic erosion of CGR is largely a consequence of the introduction of new varieties, reduction of land used for agriculture, and labour constraints. The potential threat of losing
local resources forever has been realized. However, threat will persist if farming communities who maintain landraces do not see benefit of managing biodiversity.

Farmers may choose to replace their local cultivars with modern varieties due to some of the following reasons:
- Disease and pest susceptibility
- Poor quality of local varieties
- Presence of unpreferred traits such as maturity not matched to the existing system, shattering, poor storability, low market value, etc.
- Poor yields of local landraces
- Access to better seeds
- Access to better opportunities
- Better technical support from extension system for improved seed
- Input and credit disincentive policy
- Lack of market promotion for local varieties (Catarci et al. 1998)

**Strategy for implementing in situ conservation on-farm**

*In situ* conservation of agro-biodiversity cannot be achieved through "subsidies" "compensation" and "museum or reserve" strategies (Roder 1995). Many conservationists agree that the system that relies on farmers' compensation or subsidies results in lowering production level and will not be successful in conserving biodiversity and genetic resources at the farm level (Roder 1995). While direct compensation to farmers is not intended, it is important that the global investment in farmer welfare, through participatory plant breeding, empowerment of farming community through skill transfer/training, and institutionalizing community seed bank, be seen as indirect compensation in recognition of their role in on-farm conservation. This kind of indirect compensation may reach more farmers and thus be more equitable than a system of payment to a few farmers (Brush 1992). The values of such strategy will consolidate if level of education, public awareness and *in situ* sensitive policy relief is considered.
The essence of in situ conservation strategies is to encourage farmers to maintain the process as well as special habitat that generated and maintained such diversity in the first place. On-farm conservation is, therefore, conceptualized as a process of introducing, selecting, managing and exchanging diversity under constantly changing conditions. The strategies to maintain in situ conservation of agricultural biodiversity will work if it is: (i) beneficial to farming communities, (ii) complemented by ex situ methods, (iii) politically viable and accepted by local communities, scientists, conservationists, farmers, consumers and government officials, and (iv) implemented through multi-institutional networks.

Options for increasing the value of local crop genetic resources
Effective management and conservation of CGR on-farm take place where the crops and landraces are valued and used to meet the needs of local communities and contribute to development (Jarvis et al. 1998). Value of CGR can be classified according to use, economic, ecological and cultural context and such value that interacts with market incentives and policy environments. In order to maintain and use landraces by farmers, genetic resources must be: (a) competitive with other options a farmer might have, and (b) contribute to the security and possible increase in a farmer's income (Jarvis et al. 1998).

Value may be added to crop resources in two ways: first, the material itself may be improved by adding value in terms of use, economics, food security and culture, and second, the demand for the material or some derived product may be increased by providing market, non-market incentives, policy relief and making aware of ecological and environmental value (Fig. 3). The first option is to seek improved quality, disease resistance, yield, taste or other preferred characteristics, through participatory plant breeding. Another approach with considerable potential and perhaps most neglected aspect, is support in developing their own skills in selection and seed production (Jarvis et al. 1998). The second option includes adding value to crop resources by better processing, presentation, awareness and marketing, to increase the value and benefit that farmers receive from the use of the genetic resources.

Improvement of crop genetic resources by participatory plant breeding
Value may be added to the farmer cultivar itself by understanding farmer-preferred traits and improving traits such as yield (Sthapit et al. 1996a and b), pest and disease resistance (Sthapit et al. 1996a and b), palatability to animal (Ceccarelli et al. 1996), taste (Sthapit et al. 1996a and b), nutrition (Friis-Hanson 1996), seed colour meeting market quality requirements (Kornegay et al. 1996) and other characteristics by participatory plant breeding (Weltzien et al. 1996a and b; Sthapit and Subedi 1997; Sthapit, et al. 1996 a and b; Witcombe et al. 1996).

Participatory plant breeding (PPB) is a process of collaboration between scientists and farming communities in breeding activities in order to increase the value of crops by an improvement of their genetic material (Ezyguirre and Iwanaga 1996). PPB is also linked to strategies for the on-farm conservation of crop biodiversity, which see farmers' decision making process and as an evolutionary process and important source of genetic variation (Fig. 1). Therefore, PPB may play a role in 'adding value' to local diversity, increasing its chance of being maintained by farmers (Voss 1996). According to Witcombe et al. (1996) and Ceccarelli et al. (1996), PPB is more likely to be successful in producing farmer-acceptable variety than in a conventional breeding programme due to the following:

- Genotype x environment (GxE) interaction are greatly reduced, because selection is always in the target environment, and under farmers actual management conditions
- At least one parent is well-adapted to the local (target) environment
- The impact of genotype x year interactions is also reduced
Fig. 3. Options for adding value of genetic diversity of crops

- Large F<sub>2</sub> and F<sub>3</sub> populations are grown to increase the possibility of identifying transgressive segregants, and
- Farmer participation at different stages

A classic approach in formal breeding programmes is to focus on genetic yield potential, minimizing GxE interactions, and seeking broad adaptation as a means to maximize programme impact (Kang 1990). This usually assumes that variance in environment (both in terms of agro-ecology and management) is minimized, and thus requires optimal conditions or high inputs. Not all farmers or regions are able to do this. For all of these cases, GxE will have to be exploited (Riley 1996). This option is only possible through PPB in which decentralized testing and evaluation is an in-built component. The products of PPB add value for local adaptation.

PPB provides a range of options of seed choices that assist farmers to manage diverse situations and also cater to a wide range of criteria (Witcombe et al. 1998). These criteria may include yield-stability (Ellis 1993), biomass production (Haugerud and Collinson 1990), palatability for human consumption (Smale et al. 1995), or other quality and culinary traits (Ashby et al. 1995), as well as adaptation to conditions of timing and photoperiod (Bunting and Pickersgill 1996), storage ability (Teshome 1996), soil moisture (Richards 1986), or soil fertility (Bellón and Taylor 1993).

PPB aims to assist farmers in improving their local landraces in ways appropriate to their needs. Sthapit et al. (1996a and b) has shown that, utilizing farmers' knowledge and variety acceptable, new cultivars can be bred in the high altitude of Nepal. Box 1 highlights a case study demonstrating value addition through participatory plant breeding (Sthapit et al. 1996a and b; Witcombe et al. 1996).

PPB can link with on-farm conservation (few professionals define it as farmers' breeding) activities to support a range of objectives as shown in Fig. 1, and enrich the process of on-farm conservation through the following:

- Access to genetic variation for farmers at local scale
- Community seed banks
- Local adaptation and specificity
- Empowerment by transfer of professional skill and setting research goals by community
- Landrace enhancement through pathogen elimination
Improvement for local adaptation
Generally farmers value local landraces for its good adaptation to local conditions with better yield stability. Local selection may be necessary for adaptation, especially to stress environments (Atlin 1997), particularly if meeting farmers’ goals for yield stability are important (Ellis 1993; Ceccarelli et al. 1996). Local adaptation may arise from on-farm selection through PPB. In PPB, the landrace is chosen as a parent to give genes for local adaptation, and a released cultivar is chosen to give genes for other preferred traits, for example, high yield potential. When landrace and modern cultivar are crossed and there is maximal farmer selection in the target environment at early stage of segregating lines, then breeding strategy most closely resembles in situ conservation of landraces. The systems mimic the traditional practices of some curious farmers who perform selection on naturally existing genetic variation and produce landraces that have preferred traits by selecting under target environment. Nonetheless, it cannot be ruled out that some "unidentified useful" genes present in the landrace will also be lost in the process, so ex situ conservation will still be important. Therefore, PPB conserves and creates genetic diversity in farmers’ fields in situ whereas ex situ conservation preserves genetic resources (Witcombe et al. 1996).

Skill development of local farmers
Farmers' ability to do research is often neglected until recently. The best way with considerable value addition potential, is to consolidate the capacity of farmers by transferring skills in crossing, selection and seed production. This ties with empowerment and with long-term change, and can take two broad starting points. One recognizes that some farmers have good knowledge and skills in picking diversity for better use, and that these may not be appreciated by own community. A second approach looks to add to farmers' existing skills by analysing 'what farmers don't know'. Understanding of such questions can spur a burst of innovation. Skill development in mass selection and bulk population development may consolidate the process of on-farm conservation rather than seeking farmers, participation in a specific cultivar development.

Value addition
During 1985 to 1988, a total of 528 exotic cold tolerant lines and 79 indigenous landraces of rice were evaluated in International Rice Cold Tolerance Nursery and National Rice Cold Tolerance Nurseries at target environments ranging between 1500-2000 m in high mountains of Nepal (Sthapit 1992). The majority of exotic cold tolerant varieties failed to set grain at Lumle (1675 m) and Chhomrong (2000-2200 m) because of chilling injury at anthesis, where mean temperature is below 17°C (Sthapit 1991) and with diseases associated with cold such as blast and bacterial sheath brown rot. This is not surprising as the target condition is a marginal environment for rice cultivation and research efforts at national and international centres do not focus on such marginal conditions. In this agro-ecosystem, population of local landrace such as Chhomrong was found to be the best available variety after testing large number of exotic and released materials (Sthapit 1987). The landrace, Chhomrong Dhan, was first introduced by a farmer some 30 years ago from North East India. In comparison to most exotic cold tolerant materials, it has good cold tolerance with blast and ShBR resistance (Sthapit et al. 1995). It can adapt to aquatic as well as rainfed upland conditions. Landrace population was evaluated systematically and selections were made for better cold tolerance, ShBR and blast resistance and best panicles were bulked again to test in multi-locational trials (Sthapit 1991). In 1991, the Variety Releasing and Registration Committee (VRRC) of Nepal Seed Board released this variety in the name of Chhomrong Dhan for areas above 1500 to 2200 m asl. This variety has spread in new high altitude areas of Nepal stretching from Dhankuta in the eastern region to Bajura in the far-western region.
This is an excellent example of participatory variety selection (PVS) where Nepali high altitude farmers were deprived of excellent indigenous material existing within Nepal. This is also an example of value addition on the local materials by improving competitiveness of local landraces. There may be many more such examples which research system can explore, assess and utilize in PPB.

The need of PPB at Lumle was realized in 1992 during the field visit at Chhomrong where a participating women farmer requested the breeders to improve grain colour and the quality of the local rice. This was the first time breeders realized that it is good idea if farmers set breeding goals for the crops that they wish to evaluate. Chhomrong Dhan has a coarse grain with red colour. Farmers do not like red rice for social reasons. For this, breeding work has to be done but Lumle Agriculture Research Centre does not have sufficient suitable land and other resources to justify breeding work at the station for specific breeding objectives. It was felt that PPB approach would be more resource efficient and provide a more relevant test of the material. Farmers were given $F_5$ bulk families, harvested from the most promising $F_4$ rows, for evaluation in their fields. The process is simple and is well documented by Sthapit et al. (1996a). With the results of the case study conducted in Chhomrong and Ghandruk villages of Kaski district. Sthapit et al. (1996b) demonstrated the potential of PPB for minimizing resource use, utilizing farmers knowledge, developing farmer-preferred white-grained rice varieties and enhancing biodiversity of rice genepool.

The work has not only successfully produced excellent cultivars which are spreading fast in farmers' fields but also provided empirical evidence of PPB concept. The results revealed that PPB can generate both specific and widely adapted varieties. The varieties developed jointly with farmers e.g. M-3 were far superior and outperformed the best entries from the conventional system. This variety was released in 1997 by VRRC for location specific conditions (Joshi et al. 1997). Added value of these cultivars are preferred white grain color, good fodder quality, field resistance to ShBR and blast disease along with the important traits that Chhomrong Dhan possessed. Some PPB products such as Nilgiri-1, M-4, and Himchuli were adopted by a few farmers only when they saw value of these cultivars for specific niches. The advantage of using locally adapted parents and selection in the target environment can be seen over the introduction of international nurseries which usually perform poorly. PPB is likely to offer more choices to farmers because there were significant differences between farmers' and researchers' strategies for selecting the testing site.

One of the PPB product, M-3, has been grown over a wide area for some years now. However, the M-3 has been found by farmers to be more prone to seed shattering than Chhomrong Dhan, the local variety. This trait does not prevent farmers from adopting it, because the disadvantage is outweighed by its higher yield and better quality. The identification of this weakness is one of the strengths of using PPB methods. Now the next breeding goal set by farmers is to rectify shattering problem. It is important to continue PPB programme to address this specific problem so that farmers' participation continues.

**Pathogen elimination in local landraces**

Most of the landraces are time tested locally adapted farmers’ varieties with some good traits of taste and storability but farmers cannot afford to grow them because of poor economic incentives. Analysis of yield limiting factors may provide options to add value to a specific variety. For example, most of vegetatively propagated crops such as local potatoes, citrus, taro, etc., are poor yielding because of presence of pathogen in planting materials (e.g. virus in local potatoes). Sthapit et al. (1995) also screened rice variety tolerant to the bacterial sheath brown rot and blast diseases from high altitude rice landrace, Chhomrong Dhan, which is more competitive than the other cold tolerant rice varieties. Through modern
technology or simply transferring the skills of selection, these constraints can be eliminated easily and farmers may grab the local materials again with some improved traits to ensure economic returns.

**Access to genetic diversity**

*Seed availability through PPB*

A key process for crop development is the creation of diversity. Traditionally, farmers achieved this goal by exchange of seed or introduction of new varieties from formal sector or gene flow from weedy and wild species to cultigens. Farmers get hold of these varieties through various means: informal exchanges, travelling seed merchants, formal releases, mini kits, gifts, markets, visits, day labourers 'haunting' lines in trial at a breeding station, etc. Farmer-managed systems could be more dynamic if influx of new material at the farm level is improved (Louette 1994; Dennis 1987), and the general interest of farmers to try new material is well-documented. Community genebank linked with diversity fair and PPB may enhance the access to germplasm with great ease. On-farm conservation of CGR, without access to new germplasm, local or exotic, is, therefore, unreal situation. The process of on-farm conservation will survive long if access to range of germplasm (segregating or fixed) is provided with transfer of skills in selecting and managing such diversity. Witcombe et al. (1996) and Joshi et al. (1997) put forward an idea of seed of choice using participatory variety selection approach. This system not only adds diversity to the system but also allows farmers to develop skills in varietal research and parent selection for PPB.

**Community genebank**

The community genebank (CGB) at the grassroot level could be a very good entry point of *in situ* conservation project. The concept of community genebank could be evolved within the community through exchange of ideas and visits, and learning by doing exercise because the access of germplasm is the most frequently cited constraint of agricultural development for farming community (LARC 1995). The genebank may be a new concept to rural society but every farming household has a seed store with the specific objective of *ex situ* conservation for short period until the next planting is due. This seed storage can be viewed as a household level genebank. At this level, no clear separation is possible between the conservation process and use. In fact, conservation depends on continued use. In majority of cases, farmers do keep seed in their store because access to farmer-preferred germplasm will be easy as the materials are under their direct control.

Farmers may some times prefer local materials, but are not able to access it, due to social barriers in germplasm access (Sthapit et al. 1996a and b), or lack of information. The CGB may enhance access to exchange seed and knowledge at community level in more equitable manner. In Bangladesh, Naya Krishi Andolon (new agricultural movement) of UBINIG, has started "Beej Sampad" (literally meaning Seed Wealth of Community) programme since last three years that has been recognized as a success (Mazhar 1996). This concept contrasts with the conventional concept of genebank. Women farmers, who traditionally maintain and control seed in Bangladesh, do not form any centralization of seed wealth as genebank. Instead women farmers initiated two types of seedbank: one at the household and another at the community level. The objectives are:

- To develop options for easy access of appropriate seed or exchange new or special variety
- To maintain inventory of community resources and multiply endangered variety
- To empower women farmer in controlling PGR, and
- To create awareness among farmers

The community seedbank "Beej Sampad" is managed by women farmers themselves and
takes care of seed drying, storage, germination test and follow up network of seed multipliers. Seeds are also sold to outside community or traders and income derived is used to manage community seed wealth. The UBINIG Centre has also maintained one community genebank called "Beej Sundar" for research, training and documentation purpose. The community seed bank has successfully incorporated indigenous storage knowledge of women farmers and materials in seed preservation and germination. Seed is stored in small quantity (not more than 10-15 kg per/variety) and earthen pots are used for cereal seed whereas, coloured glass bottles for vegetable seeds. Containers are well maintained and labelled with farmers name, date of storage, quantity, variety names, use value, etc. An experienced woman farmer looks after day to day management of seed stores. Expert women farmers regularly monitor seed quantity, quality and drying exercise as a part of their duty. Seeds are generally not stored for more than two to three years and therefore dynamic process of on-farm evolution is taken care of. Vegetatively propagated seeds such as potato, sweet potato, yams, taro is also stored in diffused light system and seeds of sponge gourds, pumpkins are kept according to farmers practice.

The community genebanks should be judged by its role in providing easy access to new and novel germplasm to farmers with affordable cost. Fig. 1 shows the potential links for informal exchange or PPB and through formal breeding for improvement. With regards to complementing in situ and ex situ conservation, since community genebanks must show utilization as well as conservation, this implies that those novel materials may be evaluated for wider cultivation, while some materials will inevitably disappear.

CGB can only maintain limited number of accessions and their replicates, particularly unique, rare or endangered variety or species. Thus, formal genebanks can play a significant complementary role in conservation of genetic materials as well as a source of new germplasm. In turn, the formal genebanks can greatly benefit from the supply of germplasm from the communities as well as in characterizing the accessions. This needs establishment of structure at convenient location at village level with similar domain. The most important is operation of the genebank by local people, preferably women farmer as UBINIG has demonstrated. Experience suggests that CGB may function better as a small number of home gardens or small stores rather than large communal plots and storage.

Alternatively, it could be just used as a rural concept where local community is aware of total diversity of local genetic resources and their value. Community genebank, herein, refers to maintenance and use of different species and varieties by individual household in a community. It could operate as a network of such households who are actually involved in maintenance and use of endangered landraces and marketing of the rare products. CGB has to provide a more direct service to farmers for access of local CGR, evaluation, characterize and to encourage their participation in crop improvement and the use of product. Certainly, the practice and sophistication of CGB reflect the strength of local institutions in their leadership, group cohesiveness, community interest and farmers' cultural contexts.

The purpose of such concept is to raise the awareness of community on conservation of agro-biodiversity and organize diversity fairs on a regular basis to exchange seed and knowledge within and between communities. This may not necessarily mean collecting and storage at one location but rather networking of households within the community and the group plan together in conservation process by actually growing one or more of endangered varieties.

Experience of CGB elsewhere highlights a number of organizational lessons in community genebanking. Firstly, establishing a community genebank should be a clear priority amongst the farmers. This is an issue of household access vs. community access of materials. There should be a tangible added value of having a community genebank in relation to individual home gardens or seed stores. Second, women's role and potential in seed conservation and utilization are significant and must be understood in relation to the organizational demands
of a community genebank and women's home gardens.

**Diversity fair**

Diversity fair, a unique approach to on-farm conservation has proved highly successful in increasing awareness of traditional knowledge and the maintenance of biodiversity (Tapia and Rosa 1993). Local participants in an IPGRI-coordinated project to strengthen the scientific basis of on-farm conservation came up with the idea of a diversity fair during a community workshop in the Begnas village in Nepal.

While seed fairs are not new, small-scale farmer exchanges are disappearing in Nepal because of commercial forces in the seed market. As a result, indigenous knowledge about the properties and management of local genetic resources have started to erode. The community-organized diversity fairs are focused exclusively on indigenous landraces. The organizers promoted the fair through local channels and developed a competition strategy. Prizes were awarded to farmer groups exhibiting the greatest diversity of targeted crop varieties. Women were particularly encouraged to participate.

The first prize was awarded to a group that displayed a total of 43 rice landraces including upland rice and wild rice, 15 landraces of finger-millet, 18 varieties of sponge gourd and 7 varieties of taro. Altogether, the diversity fair exhibited 291 rice, 120 millet, 125 taro and 65 sponge gourd varieties. In addition to the farmers and local school children, the event was well attended by local politicians, research managers, breeders and development workers (Rijal et al. 1998).

The diversity fair forged a new understanding of the importance of diversity among the
villagers, but it also created new possibilities to economic expansion. The event prompted the community to develop a standard means of exchange that will allow them to generate income from their genetic resources. It also inspired local groups to establish community seedbanks for the conservation of local diversity whereas NGOs see possibility to link with formal and informal system through participatory plant breeding.

From the experience of Nepal, it has been realized that the diversity fair can be important village level activity of on-farm conservation between farmer groups at a regular interval in order to:

- Recognize farmers who maintain a large genetic diversity, posses a good deal of associated knowledge base, and act as source of information for others
- Prepare inventory of crop genetic resources
- Locate and document areas of maximum diversity which can be used in monitoring
- Identify and locate most ‘rare or endangered’ landraces and their habitats
- Identify key custodians who maintain high genetic diversity
- Identify main source of informal seed supply within the community
- Understand reasons of growing diverse genetic resources in terms of use, and economic, cultural, religious, breeding and ecological values, and
- Empower local community to control over their genetic resources and develop ownership using the concept of community genebank, linking both informal and formal seed supply systems

Adding value through market incentives

**Exploiting price incentive by better processing and marketing**

Market incentive also plays important role in conservation of crop genetic resources. Basmati (a local aromatic fine rice of South Asia), Lua Tam Xoan (Red river delta, Vietnam) and Thai sticky rice (Thailand) are some of the examples of rice crop that are well conserved by farmers because of consistent demand in local, national and international markets. There are, however, many cases where opportunities are lost because of lack of research or awareness about the marketing potential for the local resources. High quality rice such as Tilki from Dang valley, Kalanamak from Rupendehi district, Jetho Budho, Pahele, Bayernni, Brimphool, Ramani, Samunderphinj etc. from in situ village of Kaski district in Nepal are yet to provide full benefit to farming community. Medicinal value, as perceived by farmers of Bayernni, Aanga and Anadi rices are to be translated into economic value (Rijal et al. 1998). Opportunities are lost because there are no efforts to market products using this valuable information.

**Creating awareness of consumers on local products**

There are some examples where values of buckwheat, amaranths, foxtail millet, finger millet, proso millet and suji have not been increased because at the lack of better food processing and product research, lack of consumer awareness and education. UBINIG of Bangladesh has promoted foxtail millet for rice pudding as substitute for rice. Importance and value of buckwheat bread and nooddles in Japan are well established but transfer of food processing technology and its commercialization has not taken place yet in Nepal. Aromatic sponge gourd (Basaune ghiraula), banana (Basaune rani kera) and huskless buckwheat (Bhate phaphar) are few other precious local resources which are yet to be exploited. Nepalese amaranth, locally known as Latte, from Jumla area has high demand as a holy cereal, Ramdana, in India particularly for Kumbha Mela. This is a seasonal market but market links could be established for local products in new markets in many Hindu pilgrims places.

**Linking market with food culture**

Demand of local products can be increased by hygienic and attractive packing and
presentation. For example, in Pokhara valley of Nepal a local entrepreneur "Gunilo" produces the local product of taro such as Tandre and Gaba. Similarly, Women Cooperative in Kathmandu started to sell Qwati packets. Demands for such local products have increased in cities when they link market with food culture of indigenous people.

**Linking market with agro-eco-tourism**
What is the appeal of eco-tourism to a community if the profits from the venture go elsewhere? Market links for local products can also be increased through local food festival in those areas where tourism is an important part of rural economy. There are many tourists who like to eat authentic local food in local surroundings. If the skills of local people are developed for small-scale restaurants, it will provide benefits to farmers. In recent years, restaurants near tourist or trekking areas began to market local varieties of rice and traditional cuisine by promotional activities such as food fairs. Diversifying such opportunities are still lacking at institutional level.

**Policy incentives**
Appropriate policy depends on good information, and this is particularly true for crop genetic resources (Tripp and Heide 1996). Analysing agricultural policy (e.g. policies relief related to research, seed, input, fertilisers, credit, extension services and market) to identify incentives and disincentives that influence farmer decision making about variety selection and conservation (Tripp 1997; Witcombe 1997). The identification of an optimum mix of development and conservation initiatives is one of the most difficult tasks faced by policy makers and the necessity to develop location specific strategies adds to the complexity of the challenge.

In many instances, seed companies will be able to respond more effectively to farmers' needs than the public sector but if it has unbalanced growth, then knowledge and skills of vegetable seed production and maintenance will be eroded with the material lost. Appropriate regulatory policies are important in supporting alternative farmers efforts such as PPB or farmer-breeding for specific adaptations and seed production and distribution. Farmers have the ability to adapt the appropriate material and innovate in terms of production and crop husbandry with the support/link of formal breeding and genebanking, at least in targeting of materials.

**Education through the formal sector**

**Education in schools through curriculum development**
Erosion of indigenous knowledge on CGR are increasingly high amongst the younger generation. In the context of increasing urbanization, a policy to revise curriculum development on values of in situ conservation of agricultural biodiversity is urgently needed. Competitions of biodiversity related essays, poems and project work will enhance awareness level from childhood.

**Education of agricultural extension workers**
A constraint to a farmer’s decision to grow a local cultivar may be information and pressure from extension workers to adopt material and techniques of modern varieties. Training of extension workers on the value of local crop resources and the development of agricultural packages that include local resources can help to remove such disincentives.

**Strengthening the capacity and empowerment of grassroot**

**Strengthening the capacity**
In situ project does appreciate working jointly with CBOs, NGOs and NARS on community genebank which means putting the development perspective before conservation research. In many countries, particularly with NGOs initiative, CGB has been a popular activity in
most of the on-farm conservation programmes. However, its sustainability has been a question. These informal institutions are parts of informal seed supply systems and these systems can be easily linked with ex situ conservation of formal system (Fig. 4). The value of such decentralized community genebank will be clearer when activities such as informal research and development (Joshi and Sthapit 1991; Joshi et al. 1997), PVS (Joshi and Witcombe 1996) and PPB (Sthapit et al. 1996a and b) are integrated. A number of activities such as diversity fair and CGB organized by CBOs with support from NGOs or formal sector, could strengthen on-farm conservation of crop genetic resources and contribute to the improvement of farmers' livelihoods through the following:

- Support and improvement of farmer selection of cultivars using PPB
- Improved links between ex situ and in situ conservation at local and national scales, including the increased use of landraces which meets farmers' and users' needs from community seed bank or national genebank
- Promotion of on-farm seed production by farmers and support for informal seed exchange mechanisms

All the above require greater collaboration between the formal sector of PGR institutions and the informal sectors including CBOs.

**Empowerment at grassroots**

Farmers' empowerment indicators include: skills, independence, monetary gain, organizational management and capacity to make own demand to institutions which so far has failed to provide the services. Farmers' ability and knowledge of breeding have been generally undervalued if not ignored by professional plant breeders. Farmers, like plant breeders, have their own selection criteria by which they evaluate new cultivars. Community participation in PPB in villages empowered participating farmers in research and technology development. Farmers participating in participatory plant breeding programmes benefit from early access to new material, gain recognition from the community, and learn new selection techniques. In Nepal, farmers involved in PPB have gained all of these benefits, and have sold seed of the new variety at a higher price than the local landrace.

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**References**


Bellón, M.B. and J.E. Taylor. 1993. ‘Folk’ soil taxonomy and the partial adoption of new seed


Friis-Hanson, E. 1996. The role of local PGR management in participatory breeding. Pp. 66-76 *in Participatory Plant Breeding-Proceedings of a workshop on participatory plant breeding, 26-29 July 1995, Wageningen, the Netherlands. IPGRI, Rome.*


Jarvis, D. and T. Hodgkin. 1998. Farmer decision making and genetic diversity: Linking multi-disciplinary research to implementation on farm *in Genes in the field: issues in on farm conservation of crop resources, (S. Brush, ed.).*


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Training needs for plant genetic resources in South Asia

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Introduction
The South Asia region is very diverse agroclimatically, topographically and culturally and is very rich in plant genetic resources (PGR). It is the seat of diversification of number of crops such as: rice, grain legumes, minor millets, spices, oilseeds, and a number of tropical fruits and vegetables (Arora 1995). The region faces the threat of genetic erosion. For successful conservation and use of PGR, development of human resources in various spheres of PGR is essential. The Convention of Biological Diversity (CBD) states in Article 12 that each country shall:

"(a) Establish and maintain programmes for scientific and technical education and training in measures for identification, conservation and sustainable use of biological diversity and its components and provide support for such education and training for specific needs of developing countries."

Training needs
The Global Plan of Action (FAO 1996) has identified priority activity areas under four groups. Each group has elements of training. These are summarized below:

I. In situ conservation
   (i) Surveying and inventorying of plant genetic resources
       Surveying and inventorying provide the basis for a rational conservation programme. Unfortunately the countries in the region have hardly made inventories of their PGR. Training should be undertaken in areas of taxonomy, population biology, ethnobotany, ecological and agro-ecological surveying.

   (ii) Supporting on-farm management and improvement of plant genetic resources
       On-farm activities for conservation and management of PGR are a means to improve existing practices in selected communities. They are complementary to and not a substitute for formal conservation, varietal development and seed supply systems. Facilities should be created for on-farm conservation, management and improvement of PGR. As a general practice, seed and planting materials should be distributed to farmers to encourage experimentation by farmers.

       The focus of training programmes should be to help farmers incorporate new knowledge and technologies to become better technicians while researchers become better enablers of farmers participatory research. For this, training should be aimed at four different levels: (i) scientists (ii) technical support staff (iii) extension workers (including NGOs) and (iv) farmers.

       Training of (and by) farmers should emphasize enhancing the identification of plant traits, selection/breeding, utilization and maintenance of local crops. Training programmes should be designed in close collaboration with National Agricultural Research System (NARS) and farmers and their organizations and be based on needs as they see them. Programmes should consider different uses of biological resources by women and men including women’s concern for multiple uses and processing requirements of crops.
II. Ex situ conservation
To strengthen national and regional ex situ collections, training in the following areas would be required:

(i) Sustaining existing ex situ collections
For sustaining the existing ex situ collections, training should be given to the staff in the following areas:

a Improved conservation methods including in vitro and cryopreservation
b Methods of identifying priority germplasm and duplications
c Methods of identifying duplicates and testing of viability of accessions
d Procedures for rational conservation and duplication of vegetatively propagated species
e Technologies for conserving genes, genotypes and gene complexes

(ii) Supporting planned and targeted collecting of PGR
Germplasm collecting is a specialized activity which needs due attention. Training should be undertaken in scientific collecting methods for PGR.

(iii) Expanding ex situ conservation activities
Training needs to be imparted on in vitro techniques and other new and appropriate technologies including encapsulation technique for ex situ preservation, particularly for vegetatively propagated and recalcitrant plants.

III. Utilization of plant genetic resources
Plant breeders and other users of PGR are interested in having genotypes that possess or are likely to possess traits needed in breeding programmes. Identification of those traits through characterization and evaluation and establishment of core collections are measures that can lead to better utilization of collections.

(i) Expanding characterization, evaluation and number of core collections to facilitate the use of PGR

a Training should be imparted on targeted characterization and evaluation techniques on crop-specific basis. This could embrace the following technologies:
   - Improved methods for germplasm characterization using, inter alia, biochemical and molecular methods
   - Improved diversity stratification procedures
   - Methods for validating core collections
   - Methods for linking core collection to the main collection (sampling strategies)
   - Improved methods of using PGR including targeted trait detection.

b Specific training needs to be given to farmers, including women farmers, participating in on-farm evaluation programmes to enhance the necessary relevant skill

(ii) Increasing genetic enhancement and base broadening efforts
Approaches to genetic enhancement include: (a) introgression of useful traits identified through characterization and evaluation into locally adapted or elite material for further use in breeding programmes; and (b) base broadening of breeders’ material through incorporation of wide genetic diversity. It is extremely important to impart training on methodologies for genetic enhancement including pre-breeding, with emphasis on problems associated with important crops.
(iii) Promoting sustainable agriculture through diversification of crop production and broader diversity of crops
   a. Training for scientists and extension workers to develop and make use of multiline, mixtures and synthetic varieties, polycropping, integrated nutrient management and appropriate plant breeding methodologies
   b. Training in the use of integrated pest management strategies, including the use of horizontal resistance, pyramiding of race-specific resistances, and the strategic development of resistance genes
   c. Training in strategic use of a range of varieties

(iv) Promoting development and commercialization of underutilized crops and species
Training scientists, extension specialists, farmers and local communities, with particular emphasis on women, in:
   (a) identifying underutilized species with potential for increased sustainable use;
   (b) developing and implementing sustainable management practices for underutilized species of importance
   (c) developing post harvest processing methods for underutilized crops
   (d) developing marketing methods for such crops

(v) Supporting seed production and distribution
For effective seed production and distribution, the farmers need to be trained in the field of seed technology in order to improve physical and genetic quality of farmer-saved seeds.

IV. Institutions and capacity building
Building strong national programmes for PGR is the key to their conservation and utilization. Thus, capacity building in various aspects of conservation and utilization and developing practical and institutional linkages between conservation and utilization are essential.

(i) Genebank management
For efficient genebank management, training is required in the following areas:
   a. Training on genebank management
   b. Training on data management including compilation and exchange of data

(ii) Constructing comprehensive information systems for PGR
Training is needed on the development and use of computer-based information system to manage information relating to PGR and make it easily and widely accessible to users.

(iii) Improving education and training
Specialized training is essential in the area of policy and public awareness for matters related to PGR.

Conclusion
The above is an overview of training needs in the field of PGR. However, national PGR programmes in the countries of South Asia are heterogeneous (Arora 1995). It would, therefore, be necessary to identify priority needs in individual countries. Institutional capacity, structures and programmes should be reviewed to address the deficiencies.
References
South Asia Coordinators' Meeting
on
Plant Genetic Resources
1-3 September 1998

Venue: Nepal Agricultural Research Council, Kathmandu (Nepal)

Programme

Monday, 31 August 1998
Arrival of participants

Tuesday, 1 September 1998
9.00 - 10.00 hrs. Registration

10.00 - 11.00 hrs. Inaugural Session

11.45 - 13.30 hrs. Session I: Review of Follow-up Actions on the Recommendations of the Third SAC Meeting

Chairman: Dr V. Ramanatha Rao
Co-Chairman: Dr R.K. Arora

Bangladesh
Dr M. Obaidul Islam

Bhutan
Mr P. Pradhan

India
Dr P.L. Gautam

Nepal
Dr M.P. Upadhyay

Sri Lanka
Dr K.H.M. Jayasuriya

IPGRI
Dr Bhag Mal

General Discussion

[Tea/Coffee: 11.00 - 11.30 hrs.]

11.45 - 13.30 hrs. Session I: Review of Follow-up Actions on the Recommendations of the Third SAC Meeting

Chairman: Dr V. Ramanatha Rao
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Bangladesh
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Dr M.P. Upadhyay

Sri Lanka
Dr K.H.M. Jayasuriya

IPGRI
Dr Bhag Mal

General Discussion

[Lunch: 13.30 - 14.30 hrs.]

14.30 - 18.00 hrs. Session-II: Status of National PGR Programmes
(Country Reports)

Chairman: Dr R. P. Sapkota
Co-Chairman: Dr P. N. Mathur
14.30 - 14.50 hrs. Bangladesh Dr M. Obaidul Islam
14.50 - 15.10 hrs. Bhutan Mr P. Pradhan
15.10 - 15.30 hrs. India Dr P. L. Gautam

[Tea/Coffee: 15.30 - 15.50 hrs.]

15.30 - 15.50 hrs. Nepal Dr K.K. Sherchand
15.50 - 16.10 hrs. Sri Lanka Dr A.H.M. Jayasuriya
16.10 - 18.00 hrs. Discussion

Wednesday, 2 September 1998

09.00 - 10.30 hrs. Session-III: IPGRI Activities in the APO Region
Chairman: Dr P. Choephyel
Co-Chairman: Dr M.P. Upadhyay

09.00 - 09.30 hrs. PGR Activities in South Asia Dr Bhag Mal
09.30 - 10.00 hrs. Overview of IPGRI-APO Activities Dr V. Ramanatha Rao
10.00 - 10.20 hrs. Discussion

[Tea/Coffee: 10.20 - 10.40 hrs.]

Chairman: Dr S. P. Tiwari
Co-Chairman: Dr A.H.M. Jayasuriya

10.40 - 11.10 hrs. Dr S.P. Tiwari
11.10 - 11.30 hrs. Dr A.H.M. Jayasuriya
11.30 - 11.50 hrs. Dr R.P. Sapkota
11.50 - 12.10 hrs. Dr M. Gul Hossain
12.10 - 12.30 hrs. Mr P. Pradhan
12.30 - 13.30 hrs. - Discussion

[Lunch: 13.30 - 14.30 hrs.]

14.30 - 18.00 hrs. Session V: Strengthening PGR Collaboration
Chairman: Dr A.H.M. Jayasuriya
Co-Chairman: Mr P. Pradhan

14.30 - 16.00 hrs. Crop Networks Dr P. L. Gautam

[Discussion to be initiated by]

[Tea/Coffee: 16.00 - 16.20 hrs.]

16.20 - 17.00 hrs. Information Network Dr P. N. Mathur
17.00 - 18.00 hrs. Germplasm Exchange Dr P. Choephyel
Thursday, 3 September 1998

09.00 - 10.45 hrs.  **Session VI: Promoting PGR Conservation and Use**

  Chairman: Dr P. L. Gautam  
  Co-Chairman: Dr M. Obaidul Islam  

  09.00 - 09.30 hrs.  Complementary Conservation Strategies  
                      Dr V. Ramanatha Rao  
  09.30 - 10.00 hrs.  On-farm/In situ Conservation through Use  
                      Dr B. Sthapit  
  10.00 - 11.00 hrs.  Discussion  

  [Tea/Coffee: 11.00 - 11.20 hrs.]  

11.20 - 12.20 hrs.  **Session VII: Identifying Research and Training Needs**

  Chairman: Dr. Md. Gul Hossain  
  Co-Chairman: Dr. K. K. Sherchand  

  11.20 - 11.50 hrs.  Research Needs  
                     Mr P. Pradhan  
  11.50 - 12.20 hrs.  Training Needs  
                     Dr Md. Gul Hossain  

12.20 - 13.30 hrs.  **Session VIII: Finalization of Recommendations**

  Chairman: Dr V. Ramanatha Rao  
  Co-Chairman: Dr Bhag Mal  

  [Lunch break: 13.30 - 14.30 hrs.]  

15.00 - 16.00 hrs.  **Plenary Session**

  Chief Guest: Dr Dhruva Joshy  
  Chairman: Dr V. Ramanatha Rao  
  Co-Chairman: Dr Bhag Mal  

  Presentation of Recommendations  
  Dr P.N. Mathur  
  Chief Guest's Remarks  
  Dr Dhruva Joshi  
  Chairman’s Remarks  
  Dr V. Ramanatha Rao  

  Closing remarks  
  Dr Bhag Mal  
  Vote of thanks  
  Dr K.K. Sherchand
South Asia Coordinators' Meeting on Plant Genetic Resources
1-3 September 1998

*Venue*: NARC, Kathmandu Nepal

**List of participants**

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Acronyms

ABP - Agro-biodiversity Programme, Bhutan
ACIAR - Australian Centre of International Agricultural Research
ADB - Asian Development Bank
AM - The Americas
ANSWER - Asian Network on Sweet Potato Genetic Resources
APAARI - Asia Pacific Association of Agricultural Research Institutions
APO - Asia, the Pacific and Oceania
AVRDC - The Asian Vegetable Research and Development Centre
BAP - Biodiversity Action Plan, Sri Lanka
BARC - Bangladesh Agricultural Research Council
BARI - Bangladesh Agricultural Research Institute
BFI - Bhutan Forestry Institute
BJRI - Bangladesh Jute Research Institute
BMARI - Bandaranaikye Memorial Ayurvedic Research Institute, Sri Lanka
BRRI - Bangladesh Rice Research Institute
BFRI - Bangladesh Forest Research Institute
BSRI - Bangladesh Sugarcane Research Institute
BTF - Bhutan Trust Fund
BTRI - Bangladesh Tea Research Institute
CAAS - Chinese Academy of Agricultural Sciences
CBD - Convention on Biological Diversity
CBOs - Community Based Organizations
CCS - Complementory Conservation Strategy
CEA - Central Environmental Authority, Sri Lanka
CGB - Community Gene Bank
CGIAR - Consultative Group on International Agricultural Research
CGR - Crop Genetic Resources
CGRFA - Commission on Genetic Resources for Food and Agriculture
CHM - Clearing House Mechanism
CIMMYT - Centro Internacional de Mejoramiento de Maiz Y Trigo, Mexico
CIP - Centro International de la Papa, Peru
COGENT - Coconut Genetic Resources Network
CoP - Conference of Parties
CPGR - Commission on Plant Genetic Resoruces
CPRM - Common Property Resoruces Management
CWANA - Central and West Asia and North Africa
DARE - Department of Agricultural Research and Education, India
DBT - Department of Biotechnology, India
DDIR - Draft Declaration on Indigenous Rights
DEAs - District Environmental Agencies
DIP - Data Interchange Protocol
DoA - Department of Agriculture
EA-PGR - Regional Network for Conservation and Use of Plant Genetic Resources in East Asia
EUR - Europe
FAO - Food and Agriculture Organization of the United Nations
GEF - Global Environment Facility
FGR - Forestry Genetic Resources
<table>
<thead>
<tr>
<th>Acronym</th>
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<tbody>
<tr>
<td>FR</td>
<td>Farmers Rights</td>
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<td>FRDS</td>
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<td>FSD</td>
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<td>GATT</td>
<td>General Agreement on Tariffs and Trade</td>
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<td>GEF</td>
<td>Global Environment Facility</td>
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<td>GIS</td>
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<td>GMS</td>
<td>Genebank Management System</td>
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<td>Global Plan of Action</td>
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<td>IARCs</td>
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<td>IC</td>
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<td>ICAR</td>
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<td>ICARDA</td>
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<td>Abbreviation</td>
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<td>PPB</td>
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<td>RAFI</td>
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<td>RECSEA-PGR</td>
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<td>REID</td>
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<td>RGOB</td>
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<td>RNR</td>
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<td>RRA</td>
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<td>System-wide Genetic Resources Programme</td>
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<tr>
<td>UNCED</td>
<td>United Nations Conference on Environment and Development</td>
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<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<tr>
<td>UPLB</td>
<td>University of the Philippines Las Baños</td>
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<tr>
<td>UPM</td>
<td>University of Putra, Malaysia</td>
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<tr>
<td>UPOV</td>
<td>The International Union for the Protection of New Varieties of Plants</td>
</tr>
<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>UTFANET</td>
<td>Underutilized Tropical Fruit Asia Network</td>
</tr>
<tr>
<td>WCS</td>
<td>World Conservation Strategy</td>
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<tr>
<td>WIEWS</td>
<td>World Information and Early Warning System</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
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<tr>
<td>WWF</td>
<td>World Wide Fund for Nature, Switzerland</td>
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