हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

# Vision 2050

National Bureau of Plant Genetic Resources

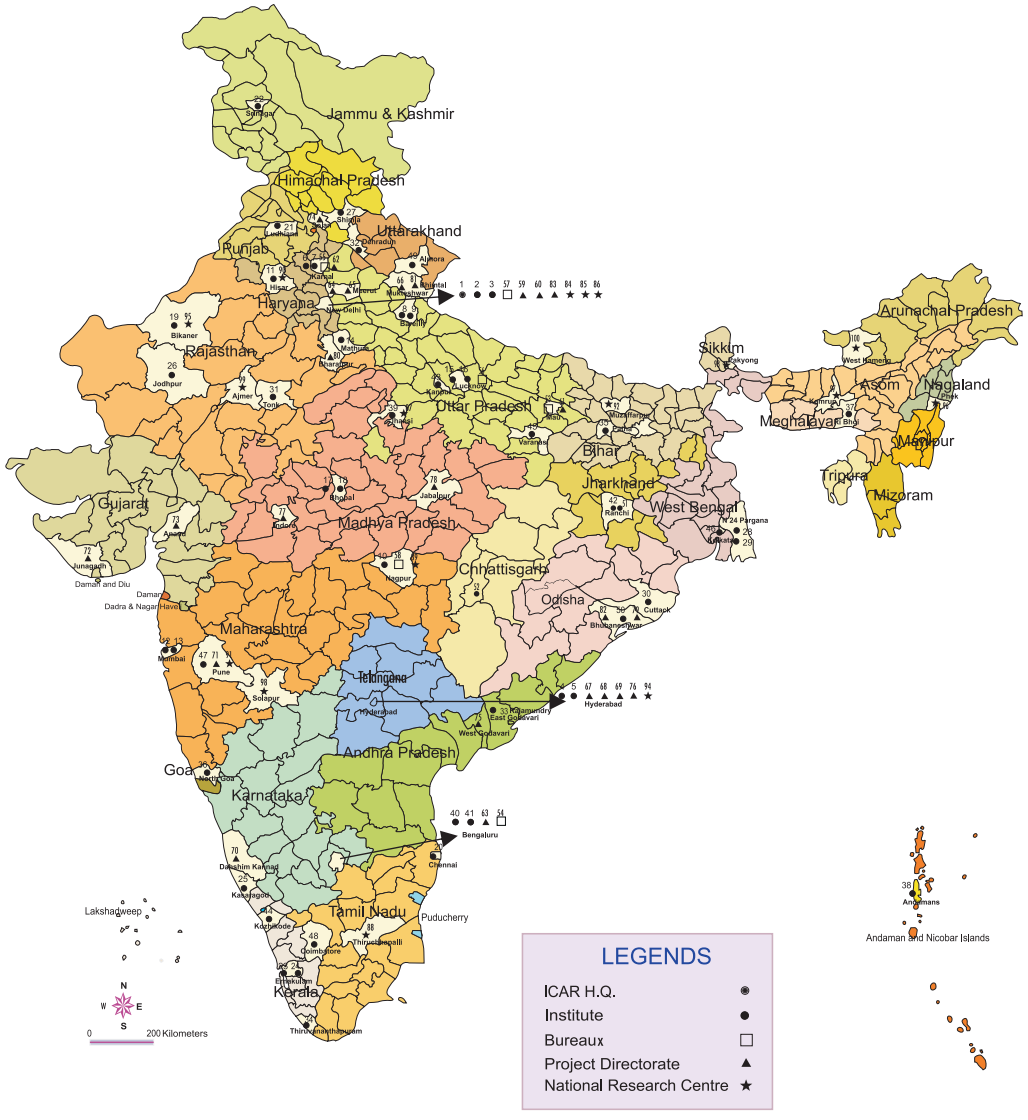
Indian Council of Agricultural Research

भाकृअनुप
ICAR

रा प आ सं ब्यूरो
NBPGR

# INDIAN COUNCIL OF AGRICULTURAL RESEARCH

## Institutes, Bureaux, Directorates and National Research Centres




### LEGENDS

- ICAR H.Q.
- Institute
- Bureaux
- Project Directorate
- National Research Centre

● 64 Research Institutes ● 6 Bureaux ● 15 National Research Centres ● 15 Project Directorates

# INDIAN COUNCIL OF AGRICULTURAL RESEARCH

## Agricultural Universities


### LEGENDS

- State Agricultural Universities
- Central Universities with Agricultural faculties
- Central Agricultural Universities
- Deemed Universities

# Vision 2050

रा पा आ सं ब्यूरो
NBPGR

National Bureau of Plant Genetic Resources
(Indian Council of Agricultural Research)
New Delhi
www.nbpgr.ernet.in

*Printed :* July 2015

# संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

**(राधा मोहन सिंह)**

केन्द्रीय कृषि मंत्री, भारत सरकार

# Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations rn technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

**(S. AYYAPPAN)**
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
New Delhi 110 001

# Preface

With great efforts of our plant breeders and scientists, India attained self sufficiency long ago and presently the food grain production has reached over 265 million tons. However, to keep pace of the production with the increasing population and climate change, it is of paramount importance to work towards unlocking the hidden genetic potential of the plant genetic resources for broadening the genetic base of crop cultivars. It is in this context that NBPGR envisioned on long term basis complete characterization and field evaluation to identify germplasm accessions with superior agronomic and adaptation traits. This will facilitate identification of core, mini-core, trait specific reference sets as well as genomic resources for use by researchers and breeders. The identified trait-specific accessions and genomic resources will specifically be used by the plant breeders for increasing water and nutrient use efficiency, carbon fixation efficiency, nutritional value, biotic and abiotic stress tolerance, etc.

NBPGR's long term goal is to develop scientific consensus on a broad PGR management strategy, which encompasses, inter-alia, the role and responsibility of different disciplines in research with an aim of enhanced utilization of the PGR for achieving food and nutritional security for all times to come.

This vision document of NBPGR will serve as a useful starting point and set the foundation for contemplating future possibilities for realizing full potential of PGR in constantly meeting grave challenges faced by agriculture. More importantly, it can serve as a guide for policy makers and list strategic research areas for the management of PGR for food and agriculture in a more comprehensive, systematic and equitable manner in the coming decades.

We acknowledge the able leadership of Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR and constant guidance of Dr. J. S. Sandhu, Deputy Director General (Crop Science), ICAR and Prof. S. K. Datta (former DDG, CS) and Dr. J. S. Chauhan, Assistant Director General (Seed), ICAR in envisaging the future course of PGR research as well as in preparing this document.

I appreciate the efforts of a team of young scientists, Dr. Sunil Archak (Convener), Dr. K. Pradheep, Dr. Sandeep Kumar, Dr. Jameel

Akhtar, Dr. Sherry Rachel Jacob and Dr. Dipnarayan Saha for completing a nearly clairvoyant endeavor on time. Efforts of Dr. Shashi Bhalla, Nodal Officer of the PME Cell are also appreciated.

(K.C. Bansal)
Director
ICAR-NBPGR, New Delhi

# Contents

# Context

### The Need and Rationale for NBPGR Vision 2050

Plant genetic resources (PGR) form the foundation of agricultural research and development. There has been a consistent increase in the number of germplasm accessions held in the National Genebank at NBPGR over the years. Indeed, more germplasm is now available to breeders and other users than ever before, particularly for major crops. However, there have been suggestions that utilization of germplasm collections by breeders falls short of expectations. What constitutes a satisfactory or adequate level of use of germplasm collections is often difficult to define. A long term vision for NBPGR therefore primarily involves enhancement of PGR utilization by breeders (primary users) and other researchers to an extent that it sustains both investment on genebank operations and inputs for agricultural research.

### Background Information About NBPGR's R&D

The PGR component of agro-biodiversity cover not only the whole gamut of genetic resources (from advanced cultivars to primitive landraces, domesticates, semi-domesticates, wild and weedy relatives) but also the diversity of ecosystems and agro-ecosystems within landscapes that are exploited in some way for agriculture and forestry, and the complex set of human interactions. Germplasm management involves activities including ensuring the representation of maximum diversity in *ex situ* collections, pest-free conservation, seed increase/ regeneration, characterization, evaluation, maintenance of active collections and documentation. Effective utilization of PGR in crop improvement programmes rests mainly on its systematic characterization and evaluation and identification of potentially useful germplasm. NBPGR houses a multi-crop seed genebank containing over four lakh accessions. In addition, over two thousand accessions are conserved in the *in vitro* bank and about eleven thousand accessions are conserved in the cryobank. Collection and characterization activities along with maintenance of field genebanks are carried out by ten regional stations located strategically at different eco-geographical regions of the country. NBPGR has been constantly carrying out research and development to equip genetic resources management activities with novel protocols,

trouble shooters, scaling-up, and economization. Scientific aspects of PGR management such as analysis of genetic diversity, genetic integrity, population structure, species relationships, etc. employing traditional and molecular markers have also been carried out. Pioneering efforts of NBPGR in such research programmes, especially in case of native species, have been evident from the ~100 externally-funded projects, 12 international consultancies and >500 research papers in national and international journals in the last decade.

### How NBPGR has Progressed and Helped Country

From 1984 when mere 285 accessions were held in a single module to a world class genebank ranking 2nd globally in three decades has been spectacular. It is a well-known fact that anthropogenic factors have been leading to genetic erosion. Therefore, every accession conserved at the national genebank is an accession saved from getting lost forever. Genetic resources conservation and genebanks cannot be evaluated by their immediate tangible contributions that can be measured in commercial terms. Furthermore, the facilities and the expertise developed over the years at NBPGR in PGR management are recognized globally and have made India self-reliant on managing its vast genetic resources ensuring that sovereign rights of the country are never compromised for lack of know-how or infrastructure. In the era of realignment of nations based on the availability of genetic diversity and capability to exploit them, NBPGR has ensured that India takes independent position in international negotiations.

### Salient Achievements

Up tillnow, about 2.62 lakh indigenous accessions have been collected, more than 60 thousand accessions repatriated, 6.26 lakh accessions imported and tested for quarantine clearance, and more than four lakh accessions have been supplied to breeders and researchers within the country. Nearly 1.9 lakh germplasm accessions have been characterized and more than two thousand cultivars have been DNA fingerprinted. Total of 4.14 lakh accessions are presently conserved for long term in the National Genebank. Intellectual property rights (IPRs) on genetic resources were facilitated by registering about 1100 unique accessions and by filing over a thousand applications with Protection of Plant Varieties and Farmers's Rights (PPV&FR) Authority for varietal registration. To ensure availability of trained human resources to carry out PGR conservation, 42 PG students (M.Sc. and Ph.D.) and more than 500 student trainees have been guided. Besides, NBPGR has organized

more than a dozen workshops, trainings, brainstorming sessions, and orientation programmes every year regularly. NBPGR through its constituent All India Coordinated Research Network (AICRN) on potential crops and national active germplasm sites (NAGS) has released 34 varieties. All the above numbers compare competitively with any large national genebanks of the world in the scale and quality. NBPGR also completed characterization of wheat (~22,000 accessions) and chickpea (~18,500 accessions) at the best locations during the 2011-12 *rabi*.

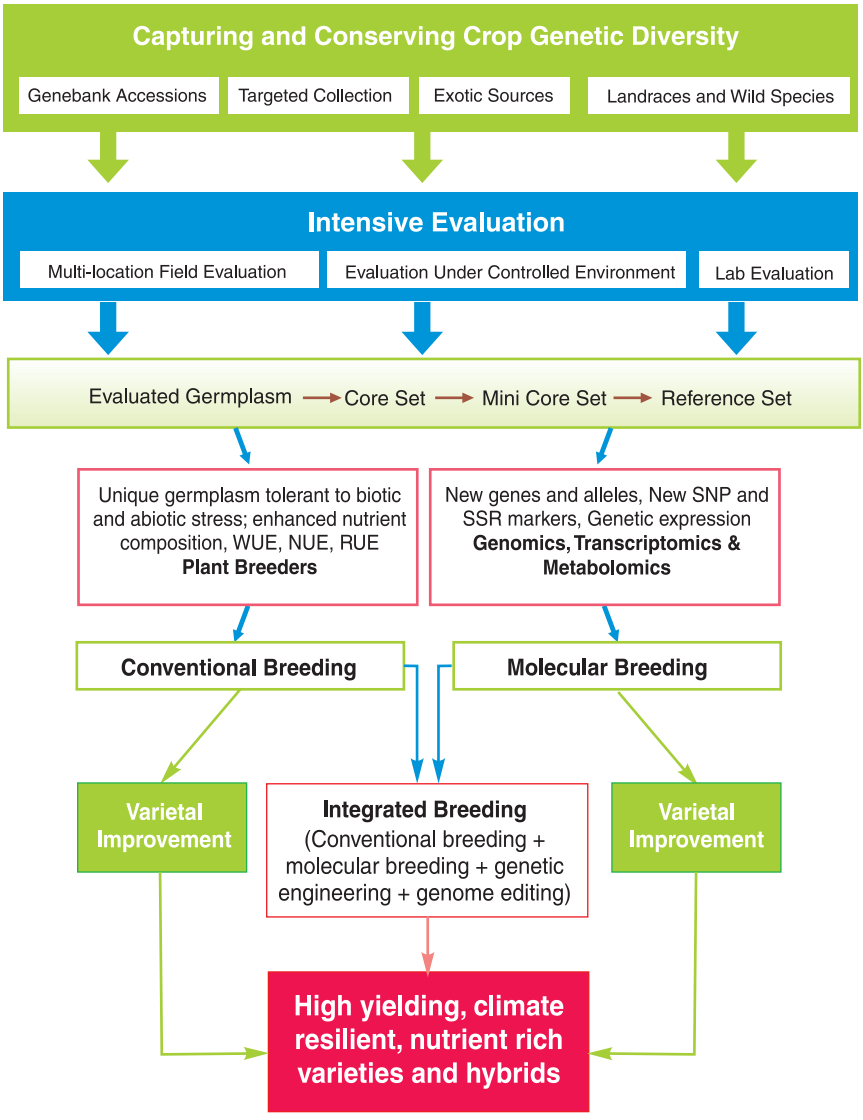
### How NBPGR Fits into Larger Picture of ICAR and Helps Achieve ICAR's Vision

The Indian Council of Agricultural Research (ICAR) is an apex organization in the country spearheading agricultural research, education and extension activities for productivity enhancement and diversification of Indian agriculture. Significant efforts of ICAR are directed towards natural resource management, climate resilience, and economic transformation through technological interventions. NBPGR is the nodal organization in ICAR to carry out research, education and service activities in managing PGR. NBPGR has been implementing the vision of ICAR by promoting utilization of PGR for varietal development; introducing and popularizing diverse crops and genotypes; searching pre-adapted climate resilient genotypes,conducting research on 'on-farm' conservation and transferring different technologies including GM detection protocols. The science-led and technology-driven agricultural research envisioned by ICAR is duly supported by developing suitable infrastructure and appropriate institutional mechanisms for PGR management as well as policy backstopping.

### Specific Reasons to Prepare a Long Term Vision for NBPGR

Requirement for novel alleles and diverse genotypes will never cease in developing new crop varieties. Biotic and abiotic stresses, that adversely affect crops, necessitate that varieties possess broader genetic base. Climatic change and urbanization pose challenges that can devastate genetic wealth. Global regimes affecting access and use of PGR are shifting towards greater state control. Increasing role of private funding and involvement beyond seed production and marketing into agricultural research is already a reality. Technology development is taking place at a mind boggling speed and information is becoming power. In this scenario, management of PGR needs to shed traditional constraints retaining the mandate and objectives. NBPGR has to take lead and play pro-active role to prepare itself, the ICAR and the country for addressing imminent challenges and contributing towards sustainable food and

nutritional security. A long-term vision to internalize the expected changes and continue to provide leadership in PGR management is, therefore, order of the day.




**Enhanced Utilization of PGR for Sustainable Agriculture**

**WUE:** Water use efficiency; **NUE:** Nutrient use efficiency; **RUE:** Radiation use efficiency; **SNP:** Single nucleotide polymorphism; **SSR:** Simple sequence repeat marker

# Challenges

OUTPUTS from agricultural research are expected to be scale independent with no spatial and temporal limitations in application. Agricultural research in India has the responsibility to ensure sustainable food security as well as to prop up agri-trade. Increasing food demand, shrinking arable land, reducing availability of quality irrigation, escalating threats of pests and diseases, growing unpredictability of climate and diminishing efficacy of hitherto successful technologies –together pose a great danger to agriculture and food security. They are grave enough to challenge the very agricultural research set up in India. It is imperative that consequences of these challenges are envisaged in advance and remedies planned.

Changing climate, anthropogenic destruction of habitats and quest for additional swathes of land for cultivation have been threatening the agricultural production systems in general and existence and distribution of plant biodiversity in particular. Pace of conservation needs to match the rate of depletion of genetic resources. Scientific management of PGR requires cooperative and coordinated activities among genebanks, crop research institutions and cultivators. Addressing the above-mentioned challenges, calls for basic research in the areas of genetics and conservation techniques. However, the turn of the century has witnessed disproportionate engagement with only frontier technologies relegating taxonomy, population genetics, basic studies of non-food security plants, etc. as unattractive to scientists and students. This is accentuated by perceptible reduction in funding to PGR management activities. Therefore, attracting not only funds but young researchers to the PGR research is a major challenge.

### How R&D Envisioned by NBPGR can Address these Challenges?

PGR management poses unique challenges that require planning in advance. Following are salient challenges and how NBPGR envisions addressing each one of them:

- Conserving maximum genetic diversity in the genebank with least possible duplication and minimal reduction in the redundancy are faced by all genebanks of the world. This can be achieved by employing all modern tools, available as well as upcoming, to tag each accession; to track the movement from collection to conservation to evaluation to utilization

- *Ex situ* conservation in genebanks is input-intensive. Looking beyond traditional genebank systems means researching on development of cost-effective low-energy or zero-energy alternatives such as conservation at ambient temperature (ultra-desiccation) and permafrost
- Scientific approach to on-farm conservation including population size, sampling, allele frequency distribution, and economics Difficulty in germplasm introduction due to the advent of various international regimes related to biodiversity, IPRs and movement of biological material [Convention on Biological Diversity (CBD), Trade Related Aspects of Intellectual Property Rights (TRIPs) Agreement, World Trade Organization-Sanitary and Phytosanitary (WTO-SPS) Agreement etc.). This needs effective implementation and eventual exploitation of multilateral [International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)] and bilateral systems for facilitated exchange of germplasm for research
- Delay in the process of germplasm import and export even in case of approved cases tarnishes the image of the system. Clear policy guidelines and rulebooks along with establishing on-line system to track import permit cases by indenters, import permit issuing office, National Genebank and quarantine officials can improve the system
- Liberalization in trade and global access is leading to greater movement of seeds/plants, planting material and consequently, enhancing the chances of introduction of exotic pests. Modernizing the existing plant quarantine system based on multi-disciplinary approach is need of the hour
- Making National Genebank pest-free requires systematic programme for screening each existing accession (pre-2005) *ab initio*
- Gapsin characterization of conserved germplasm requires mission-mode programmes for time bound completion of characterization in collaboration with crop-based institutes and State Agricultural Universities (SAUs)
- Trait-specific preliminary evaluation of conserved germplasm requires carefully planned and well-funded phased evaluation programmes at hot spots/established facilities, in collaboration with crop-based institutes and SAUs
- Detailed multi-location evaluation of germplasm in institutional mechanism (not project based) with AICRP centres, SAUs, CG centres, etc. for tolerance to priority biotic and abiotic stresses
- Detailed evaluation of germplasm for biochemical profiling including quality traits calls for up-grading biochemistry labs of NBPGR as centre of advanced analysis of crop germplasm with adequate funding

- Systematic documentation programmes including registration of trait-specific germplasm and DNA fingerprinting of elite germplasm to ensure individual/community/sovereign rights
- Augmenting germplasm from the crop groups such as forages, ornamentals, medicinal & aromatic plants, green manures, etc.
- Lack of trained human resource in the field of exploration and germplasm collection calls for emphasis on developing skilled manpower and use of modern tools
- Developing local intelligence and infrastructure to collect, regenerate, characterize and evaluate the germplasm (particularly crop wild relatives) from NEH region, and tribal areas of central and eastern India, and remote, inaccessible and protected areas and areas with insurgency problems [but endowed with rich diversity in crop and crop wild relatives (CWR) genepool]. A top down approach to identify more NAGS (ICAR institutes, SAUs or KVKs) in these areas and establish project based PGR centres so as to enable actual phenotypic expression of germplasm, which is important for evaluation. Systematically devising consensus based strategies to explore challenging areas under special missions through linkages with local grass root level organizations, surveying local markets and fairs, etc.
- Explorations are going to be focused, fewer and specialized. Ensuring appropriate sample size of collected germplasm accession reaches genebank requires creation or consolidation of infrastructure for seed regeneration of collected germplasm, like simulating artificial environment for niche-specific wild species, cages or semi-permanent structures for seed multiplication of cross pollinated and often cross pollinated species.
- Authentic documentation including documentaries of exploration trips to prepare teaching and training material on collection activities
- Exploration and collection of CWR is challenging in the absence of comprehensive identification keys and appropriate strategies for collecting wild species producing only a few fruits or seeds with unknown seed storage behaviour. Solution is to develop illustrative field identification keys using leaf, fruit and seed characters and developing appropriate collection practices.
- Basic research on gap analysis, tracking population structure changes in CWR over time, protection of biodiversity, and economic prospecting necessitates developing PGR Resource Maps of India emphasising inventorization of landraces, primitive cultivars and wild relatives existing in the country and systematic geo-referencing of the existing germplasm

- Collection of germplasm already existing in the genebank, missing out on minor details of the exploration trip, etc. requires explorers to carry hi-tech hand-held gadgets that record route, images, sound and data seamlessly and assist them in processing the samples for conservation
- Establishing fingerprinting systems in major crop species within the NBPGR's mandate including allele frequency distributions in populations, novel high throughput platforms, developing marker systems to link with DUS testing
- Value addition to the germplasm to create demand by characterizing germplasm using established functional markers (genes and QTLs)
- Strengthening and commissioning of the National Genomic Resources Repository with necessary space, regular flow of funds and manpower to ensure conservation of genomic resources

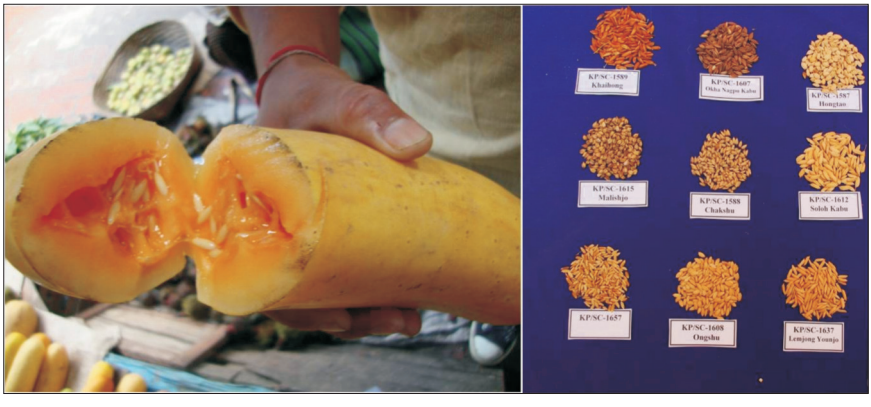
### Emerging challenges

- The threat to land races posed by the modern breeding programmes that favour tailored products which requires structured and sustainable on farm conservation of land races in their native agro-ecological environments
- Exotic pests may pose serious threat to the PGR and biodiversity
- Need of implementing domestic quarantine for inter-state movement of PGR at a sophistication of international quarantine regulations; however, this is possible when regulations in agriculture are sorted out between Centre and State
- Farmers are being increasingly aware of their rights and the trend is of offering germplasm to explorers only in exchange of money. The situation has to be recognized as real and NBPGR/ICAR needs to develop practical and flexible models benefit sharing for pre- and post-commercialization stages
- Legal hassles for germplasm explorers as a result of regulatory regime implemented by National Biodiversity Authority (NBA), forest department, other government and autonomous bodies, etc. This requires recognition of germplasm exploration and collection as priority activity by government departments and agencies. NBPGR's explorers to be granted necessary exemptions for collection activities

### Resource base

Resource base of NBPGR includes the strong network consisting of researchers located at the headquarters housing genebank and

laboratories, ten regional stations and collaborating institutes. Same set of researchers seamlessly transform from collectors to evaluators to conservers. That way NBPGR has already been managing the PGR without spending on external expertise in spite of changing priorities and handling multiple crop species. The same set of germplasm holdings form the base for identifying the useful traits, which keeps changing based on taste, commerce, environmental stress, production systems, etc. The genebank collections over the years have served the purpose of traditional breeders, taxonomists, molecular breeders, and other researchers without any additional investment. However, genebank maintenance requires continuous external financial support. NBPGR has initiated research and developmental activities on low-cost conservation (ultra-desiccation), zero-energy conservation (permafrost) and input independent conservation (on-farm) models. All the three need serious fillip to eventually serve as resource bases for self-reliance.




**Exploration and collection activities have a major thrust on collection of diversity among known landraces particularly from North East India.** L: Orange-fleshed cucumber from Imphal, Manipur; R: rice landraces collected from Mon district, Nagaland

# Operating Environment

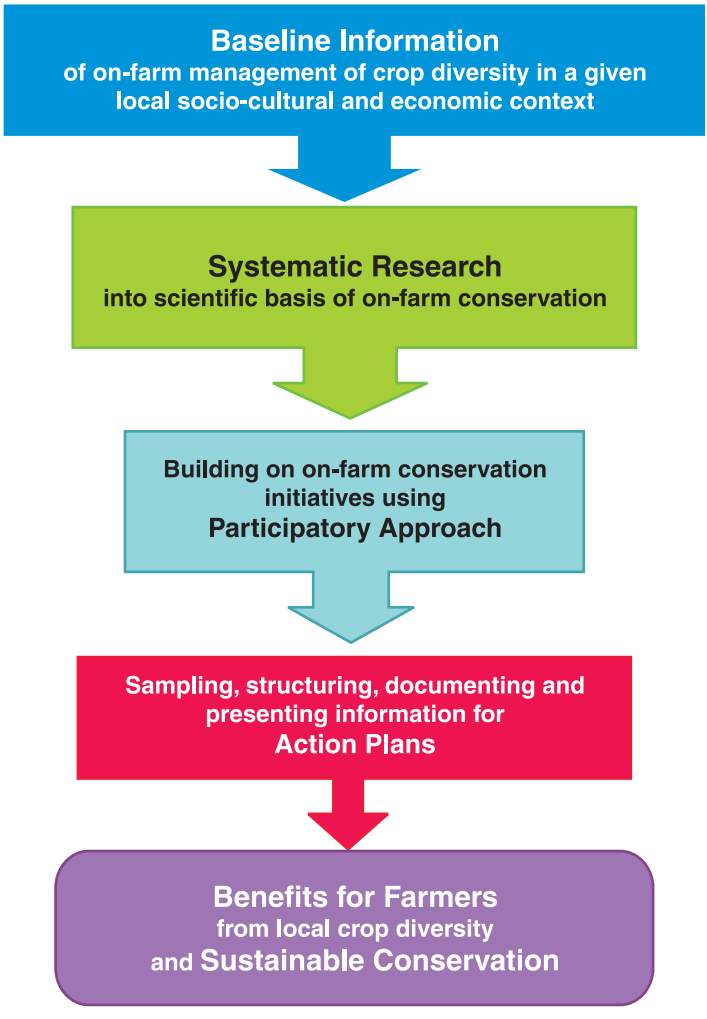
MANAGEMENT and use of PGR is essentially a service activity supporting plant breeders with the supply of trait specific genotypes. Demand for specific PGR determines priorities of the whole activity. Survival of PGR in nature is influenced by climatic conditions and it also forms a major part of the mitigation strategies against natural adversities that threaten agriculture . Crop cultivation undergoes various stress regimes arising due to changing climate and intensification of agriculture. Search for genetic resources to breed suitable varieties need screening of PGR and hence determine the priorities. PGR are part of socio-politically sensitive issues globally. PGR also are part of seed-commerce and related global power struggles. Access to PGR and benefit sharing will be governed by internationally accepted norms and will control prioritization of funds flow. It is amidst such an operating environment with significant extraneous factors that PGR management is carried out.

### Germplasm Augmentation

- Germplasm collection for utilization is the order of the day. Breeders are interested in few but selected collections showing desirable traits. Hence, more preparedness in collecting few precious germplasm (landraces, primitive cultivars, CWR) with utmost precision and within a time-frame, is expected
- Exploration vehicles equipped with inbuilt instruments/tools linked with information and communication tools (ICT) installed for automatic reading of essential parameters such as geographic coordinates, field/soil, and climatic data; with portable devices for recording the physiological/biochemical parameters will help in collecting desired germplasm with specific trait(s) meticulously
- Threat to loss of diversity, which is an open-ended phenomenon, makes it imperative to collect the representative diversity for conservation lest it is lost forever, particularly in undisturbed areas facing anthropogenic pressures, more prone to vagaries of climate change and also the areas with significant genetic erosion
- Detailed documentation during collection is essential to use the germplasm at the full extent and to protect them through legal means

**Germplasm Conservation**

- CWRs will be important in the coming years owing to their potential scope in increasing agricultural productivity which the cultivated genetic pool will be unequipped to supply. The fast advancing molecular technologies, interspecific hybridization techniques and genetic knowledge should be harnessed for overcoming the barriers that prevail in their effective utilization




**On-farm Conservation**

- Institutional mechanisms to collaborate with community seed banks to effectively complement the national gene bank in conservation

and regeneration of landraces and traditional varieties which are potential sources of agriculturally important genes
- On farm conservation and clonal repositories need a big boost to complement *ex situ* conservation efforts
- Conservation strategies for genetic stocks (including chromosome substitution lines, alloplasmic lines, single chromosome recombinant lines, introgression lines, etc.), progenies of bi-parental crosses (doubled haploid lines, recombinant inbred lines, etc.) and panels for association mapping need to be developed and implemented. New and specific protocols need to be developed for long term conservation, multiplication, regeneration and supply of transgenic material

### Plant Quarantine

- Introduction of seeds and other planting material always carries an inherent risk of introducing exotic pests or their more virulent races into new areas as they are the most efficient means of long distance dissemination as evident from several examples of trans-boundary movement of pests in the past. Therefore, import of all commercial consignments of grains, plants and plant products as well as commercial imports of seeds/ plants for sowing or planting including PGR meant for research have to comply with Plant Quarantine (Regulation of Import into India) Order 2003 (PQ Order 2003). NBPGR has been empowered by Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India under PQ Order 2003 to undertake the quarantine processing of all germplasm including transgenic planting material under exchange for research purposes, both for public and private sector
- Plant quarantine methodologies require to adopt all the novel technologies to develop suitable tools that are environmental friendly, with greater salvaging capability, economical and with a high throughput

### Germplasm Evaluation

- Strenghtneing of germplasm evaluation programmes with modern technologies, trained manpower, institutional interfaces and organizational support through development of linkages and partnerships
- In order to discover the true potential of genotypes conserved over the years, there is a need to shift the evaluation strategy to more effective phenotyping with special focus on stress and subsequent

investigation for the presence of useful genes using molecular maps and QTL analysis. This would ensure the availability of validated trait- specific germplasm in all crops, which can be directly utilized by breeders

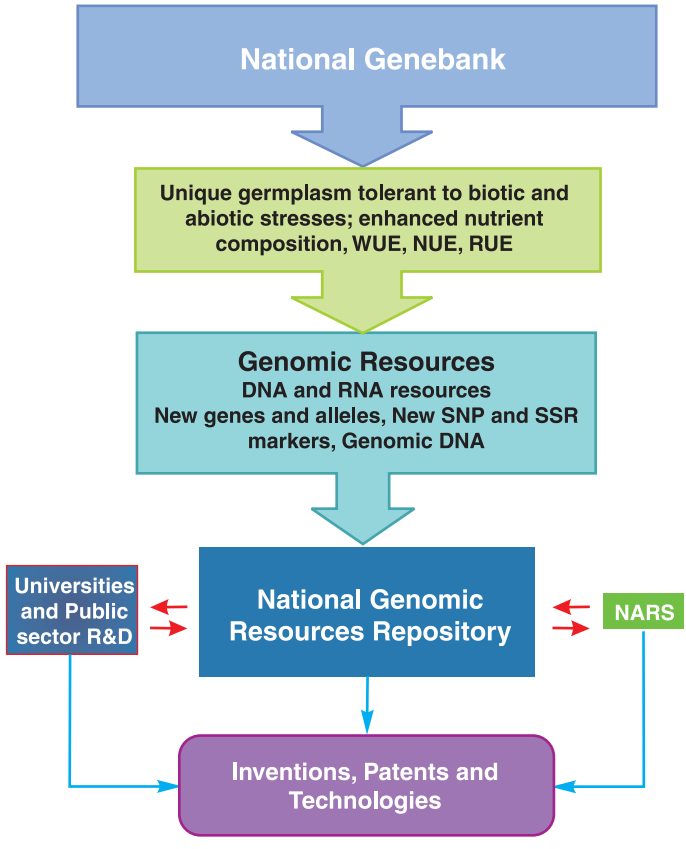
- Developing mechanisms to handle large number of accessions of diverse crop plants, including the wild and weedy relatives in terms of crop based networking backed by manpower, land and funds
- Modernization of the Issapur farm (saline soil, limited canal irrigation facility and poor underground water) to make its best utility
- Transforming germplasm characterization and evaluation activities from its current routine form to a more exciting and attractive activity for young scientists in terms of professional satisfaction and career advancement

### PGR and Genomics

Genomics based approaches have brought in a dramatic ability to characterize and utilize PGR. Basic studies using molecular profiling suggest that the diversity conserved in genebanks has only been marginally utilized.

- Advances in genomic platforms and availability of resources have enhanced capacity of researchers to investigate PGR and harness their full potential for improving crop productivity and quality
- Exploring the complexity in PGR, largely inaccessible until recently, employing tools, platforms and resources currently available (and likely to evolve) to investigate the structural and functional diversity present in both the coding and non-coding regions of the plant genome
- Exploiting the new paradigm set by next generation sequencing (NGS) and bioinformatics to deliver an exhaustive, accurate characterization of DNA variation at high throughput and at a low cost (cost of sequencing has already fallen dramatically and keeps dropping, thus allowing for the direct analysis of large sets of accessions at a fraction of the cost of such an operation just a few short years ago)
- Molecular profiling greatly improves the accuracy of germplasm characterization and help in cost-efficient management of germplasm collections (both *in situ* and *ex situ*) and the assembly of core collections suitable for association mapping studies. DNA profiling of all released varieties and genetic stocks would enhance scientific and legal validity of the existing data

**Generation and Utilization of Genomic Resources**




**WUE:** Water use efficiency; **NUE:** Nutrient use efficiency; **RUE:** Radiation use efficiency; **SNP:** Single nucleotide polymorphism; **SSR:** Simple sequence repeat marker

# New Opportunities

CLIMATE change and incessant demand for improved cultivars pose serious challenge to agricultural research and new opportunities for exploitation of genetic variability. Breakthroughs in the fields like remote sensing, molecular biology, ICT, etc. may facilitate efficient management of PGR.

- Hyper spectral remote sensing (through spectro-radiometer) techniques for identification of Crop Wild Relatives in field and locating their populations and DNA barcoding in species delineation
- New platforms and technologies to automate genebank activities (label barcoding system for effective tracking and retrieval of samples) and minimize discrepancies linking all stages of germplasm handling including multiplication, regeneration, evaluation and supply
- Fool proof techniques based on molecular marker technologies for identification of duplicates in the gene bank
- Increased realization of PGR exchange has opened enormous opportunities for undertaking basic and strategic research in the field of molecular detection and diagnosis of pests associated with germplasm
- Digitization of mapping and distribution of pests including insects, fungi, bacteria, viruses, nematodes and weeds of quarantine significance associated with PGR in all agro-ecological zones of India
- The conserved germplasm wealth in National Genebank provides enormous opportunities for the development of core set in various crops which will help in crop improvement programmes including genomic research
- The emerging regime of international treaties and national legislations demand a suitable policy backup and hence opens up ample scope for NBPGR to facilitate the process
- Large ICAR-KVK network to be exploited for working with farmers/farming communities in PGR management and utilization activities
- Using web-based systems to expedite and popularize registration of trait-specific germplasm to protect the ownership rights of breeders/researchers/farmers

- Joining the loose ends of phenotyping and genotyping with the help of high throughput systems provides opportunities for the efficient use of multi-disciplinary expertise available at NBPGR
- New regimes of open access to information to help disseminate documented information among breeders, crop curators, researchers, research managers and policy makers
- Valuation and impact assessment of PGR to understand the economics of conservation in terms of returns to investment
- Creating new infrastructure and strengthening the existing ones especially with regard to the National Genebank.


NBPGR houses the world's second largest genebank. Modernization of the genebank envisaged for efficient and cost-effective ex situ conservation

# Goals and Targets

### Strategic and Comprehensive Management of Plant Genetic Resources

- Strengthening NBPGR network especially regional stations by prioritizing activities and equipping them with modern facilities
- Rationalize *ex situ* collections and implement low cost conservation (e.g. room temperature) and zero energy conservation (e.g. permafrost)

### Germplasm for Varietal Development

- Multi-location evaluation in target environment for identification of trait specific (tolerant to biotic and abiotic stresses; biochemical profiling including quality parameters; NUE including N/P/K, water, carbon use efficiency, precision farming, macro and micro-nutrients, etc.) germplasm for use in crop improvement
- Unambiguous phenotyping of identified germplasm using existing and evolving methodologies including high-throughput transcriptomics and metabolomics
- Development of core, mini-core and reference sets for various traits in crops with substantial number of collections
- Widening genetic base of crop cultivars using wild spp. and crop wild relatives/landraces
- Large-scale genotyping of prioritized PGR in a high-throughput scale using advanced approach to facilitate genomic selection, comparative genomics, breeding and mining of novel alleles
- Integration of '-omics' resources and high-computing bioinformatic resources for understanding 'Plant systems biology' and their use in translational genomics to facilitate utilization of plant genetic resources

### Conservation of Crop Wild Relatives, Landraces and Farmers Varieties

- Exploration and collection of trait-specific germplasm from niche areas (including remote, interior, protected areas, areas under potential threat, etc.)
- Biosystematic studies in native crop genera for understanding crop-wild species relationship, crop domestication, centre of origin, etc.

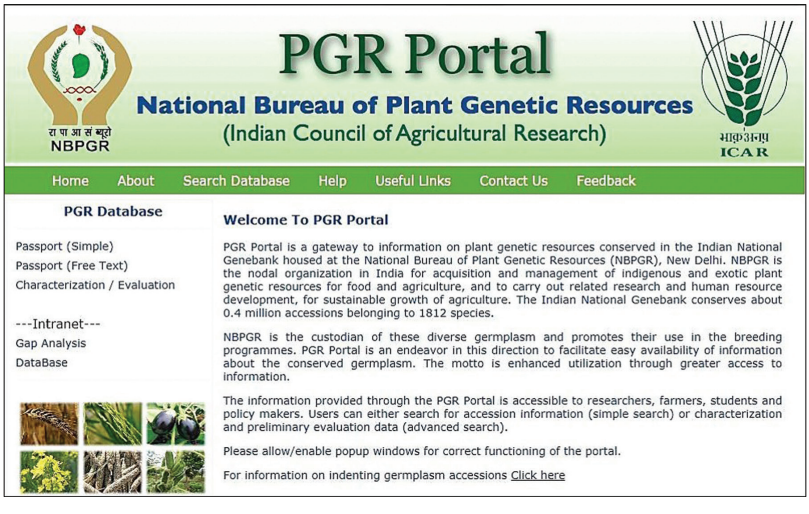
- Generation and conservation of genomic resources in priority species to promote utilization of PGR

### Compliance to National and International Treaties and Conventions

- Analyzing regulatory scenario and interpretation of national and international legal instruments related to PGR as well as formulation of proposals for PGR exchange with other countries
- Facilitate safe movement of exotic as well as indigenous PGR at national/ international level through stringent plant quarantine regulations
- ISO or better standard infrastructure, operating procedures, carbon credits and energy consumption
- Registration of the identified genetic material/stocks and benefit sharing with the stakeholders
- Seamless documentation of PGR information and its sharing with various stakeholders

### Developing Centres of Excellence at NBPGR in PGR Science and Management

- Commissioning state of art facilities for biotic/abiotic/biochemical/ molecular characterization. Capacity building of scientists in modern methodologies/technologies and developing advance facilities
- Development of deep sequencing-based, high-throughput, cost effective and rapid diagnostic tools for DNA fingerprinting and IPR protection, GM detection and plant taxonomic identification systems



# Way Forward

MANAGEMENT and utilization of PGR stands at a crucial juncture and strategic decisions on the way forward are imperative. Traditional methods of PGR management will continuously be challenged by changing needs, priorities, climate, technologies, and policies. One constant will be the perpetual dependency on PGR for food security. Envisaging the overwhelming pressure on the natural existence and evolution of PGR does not require clairvoyance. However, looking four decades through shows the promise of modern technologies in combating genetic erosion and enhancing utilization of PGR. It is in this context that adopting every forthcoming technology is the way forward.

In order to achieve envisioned goals/targets, following strategies/approaches/researchable issues shall be given priority:

1. Adoption of all the forthcoming technologies to:
    a. maximize accuracy, coverage and efficiency of germplasm collection
    b. economize and rationalize germplasm conservation
    c. Identify trait-specific germplasm and promote utilization
    d. Add value to germplasm based on genomic and geographical information
    e. Develop decision support system to manage PGR
2. Harmonizing multitude stakeholders including private seed sector, farming community, NGOs and international agriculture research centres to enhance conservation and utilization
3. Promoting the exchange of germplasm within the national framework and to get associated benefit sharing
4. Develop and implement strategies to comply with international and national legal requirements ensuring easy access and fair benefit sharing
5. Develop human resource in PGR and attract researchers to PGR science

❑

## NOTES

## NOTES

## NOTES

Laser typeset at M/s Print-O-World, 2568, Shadipur, New Delhi 110008 and printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028.