Vision 2030

National Bureau of Fish Genetic Resources

(Indian Council of Agricultural Research)

Lucknow

www.nbfgr.res.in

Vision 2030

National Bureau of Fish Genetic Resources
(Indian Council of Agricultural Research)
Lucknow

www.nbfgr.res.in

PRINTED : July 2011

Compilation : Dr. Kuldeep K.Lal and Dr J K Jena
Cover Page : Dr. Peyush Punia
Proof & Editing : Dr. Lalit K. Tyagi and Sh. Ravi Kumar

Published by: The Director, National Bureau of Fish Genetic Resources, Lucknow.
Printed in India at ARMY PRINTING PRESS, 33 Nehru Road, Sadar Cantt., Lucknow-226 002 Tel : 0522-2481164

सत्यमेव जयते

डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
DR. S. AYYAPPAN
SECRETARY & DIRECTOR-GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद्
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 114
Tel. 23382629, 23386711 Fax: 91-11-23384773
Email: dg.icar@nic.in

Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

The National Bureau of Fish Genetic Resources, Lucknow, established in 1983, has emerged as a Centre of Excellence in cataloguing and conservation research on aquatic bioresources of India. The recent achievements towards database development for more than 2500 fish species, population genetic structure analysis of several prioritized species, development of molecular markers to document intra-and inter-specific genetic divergence in fish species, development of functional genomic resources, development of *in situ* and *ex situ* gene banking of endangered

species and diagnostic capabilities for exotic pathogens in relation to the evaluation of exotic fish species are praiseworthy.

It is expected that the analytical approach and forward looking concepts presented in the 'Vision 2030' document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

Dated the 5th July, 2011
New Delhi

(S. Ayyappan)

Preface

Fisheries sector with a total production of over 8.0 million tonnes of finfishes has been an integral component for growth of Indian agriculture and an important source of income and livelihood for millions of people in the country. Increased attention on aquatic organisms for food and on bioprospecting of the unique genes that they contain; combined with rapid biotechnological development has raised global concern for conservation of aquatic genetic resources. The genetic resources have value in terms of economic, ecological and social uses. Therefore, they need to be characterized, managed and utilized judiciously on sustainable basis in the country. Hence, it is imperative to put in perspective research programmes to develop appropriate strategies for conservation and sustainable use of these organisms and actions to safeguard the aquatic biodiversity of the country for the benefit of the present and for posterity.

With a vision of assessment and conservation of fish genetic resources for sustainable utilization, posterity and intellectual property protection of the country, the National Bureau of Fish Genetic Resources (NBFGR) has taken up various research programmes to generate empirical information relevant to conservation strategies of prioritized and endangered fish species. The Bureau has built up a strong database on fish genetic resources of the country; generated information on population genetic structure and DNA barcodes of several aquatic species; developed techniques for *ex situ* gene banking of endangered species and diagnostic capabilities for exotic pathogens of aquatic organisms; and contributed significantly in bringing out several policy documents for the country

The Vision 2030 document envisages setting the goal, strategies and logistics to be implemented and achieved in fish

genetic resource conservation by the year 2030. The NBFGR has a major role to play in ensuring the growth and sustainability of fisheries and aquaculture of the country by adopting timely and appropriate strategies to catalogue, providing scholarly information on genomic resource structure for effective utilization and conserving the valuable aquatic genetic diversity for the future generations. The vision embodied in the document would ensure that the NBFGR continues to fulfill its mandate.

We are extremely grateful to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi for his continued guidance and encouragements for preparation of this vision document. Our thanks are also due to Dr. B. Meenakumari, DDG (Fisheries), ICAR, Dr. Madan Mohan, ADG (Marine Fisheries) and Dr. S. D. Singh, ADG (Inland Fisheries) for their cooperation and help in our endeavors. I sincerely thank all my colleague scientists for their inputs and Dr K.K. Lal, Head, Fish Conservation Division in particular for his effort in bringing out this important document.

6th July, 2011 **(J.K. Jena)**
Lucknow **Director**

Preamble

The vast aquatic resources of India are source of rich biological wealth and provide ample opportunities for development of fisheries. The major Inland aquatic resources include 1.2 million hectares of brackishwater area, 2.38 million ha of freshwater ponds and tanks, 3.15 million ha of reservoirs besides about 0.19 million kilometers of rivers and canals. In India, large and medium dams have created almost 250 million cubic meters of water storage intercepting 30% of the available surface flow. The long coastline of 8129 km with the exclusive economic zone (EEZ) encompasses 2.02 million km^2 of coastal and offshore areas in eastern, western and southern parts of India.

Fisheries and aquaculture play promising roles in social development by providing nutritional security for the burgeoning Indian population and contribute to economic upliftment of farmers and fisherfolks. The fish production in India has shown spectacular growth during the past six decades, from a meager 0.75 million tonnes in 1950-51 to 8.0 million tonnes at present (2009-10), which has placed the country as the second largest producer of fish in the world? The fisheries sector provides livelihood to 14.5 million fishermen and fish farmers and contributes nearly 1.1% of the national gross domestic product (GDP) and 5.3% to agricultural GDP. Fisheries sector has been one of the major contributors to foreign exchange earnings of the country, with present export being Rs. 121 billion (2010-11).

Aquatic germplasm resources are turning out to be an important source of genomic resources and products of pharmaceutical and commercial value. During the recent times, aquatic germplasm resources are exposed to contrasting trend *viz.* (i) Need for conservation, management and enhance utilization, (ii) Depletion of resources due to manmade and

natural threats and (iii) Biopiracy for the genomic values of such diverse resources.

With respect to aquatic biological diversity of India, certain issues of utmost significance requiring urgent attention include; explorations to define species diversity, validated systematic as well as phylogeny, abundance status, intraspecific genetic divergence for important species, documenting such information on interactive and analytical formats for aiding decision making process, risk assessment of potential threats, *ex situ* conservation of tools and packaging the available information to develop real time *in situ* conservation strategies. Documentation and conservation of resources need to go beyond species and genetic stocks, but upto the level of genomic resources. In view of the vast and diverse nature of the resources, prioritization of exploratory areas and species hold the key to success of such endeavors. The prioritization necessarily need not to be based on only economic importance but also should take into account the threatened status.

The National Bureau of Fish Genetic Resources has taken up various research programmes to generate information, relevant to conservation strategies of prioritized and endangered fish species. The envisioning process drawn on the directions of the Council with Vision 2020, followed by Perspective Plan 2025 and the present document Vision 2030 reflects the emphasis to keep pace with technological advancements with respect to infrastructure as well as human resources.

The document 'Vision 2030' is presented in the perspective that conservation needs a holistic approach. A multidisciplinary team spirit and networking are the driving forces that would integrate information from biology, genetics, molecular biology and biotechnology techniques besides habitat, inventory, remote sensing and GIS applications.

Contents

Scenario: Aquatic Genetic Resources

Genetic resources are receiving considerable attention world over from the perspective of sustainable utilization to alleviate the fear of food shortage looming large over mankind. Without exception, the aquatic genetic resources understandably have shown importance for their role in direct consumption, providing new species for aquaculture diversification, genetic diversity to improve domesticated species, utilization for ornamental trade and also the products of commercial value. The availability of genetic diversity, within and between species, is of utmost significance in mitigating the impacts of environmental changes, including climate change. Therefore, the role of genetic resources for sustainable livelihood and nutrition to growing populations is considered unambiguous. The protection of natural biological wealth for posterity and appropriate conservation efforts are need of the hour. Conservation efforts can not be derived to fulfil the desired objectives unless appropriate policy framework is in place to support such efforts.

Recent times have witnessed focus of international and national authorities to establish such frameworks. Convention of biological diversity (CBD) is such an instrument which not only addresses the biodiversity but sovereign rights of nations and communities on this wealth. Some of the global efforts apart from CBD are Bonn guidelines on access to genetic resources for fair and equitable sharing (Secretariat of the Convention on Biological Diversity, 2002) and World Intellectual Property Organization (WIPO) Track Treaties. Benefit sharing out of resource utilization with native communities is an important aspect of all these guidelines and is likely to influence the concerns of preserving the resources at grassroot level. Though legally binding laws on benefit sharing hardly exists at present, but some countries like Guyana, Uganda, Brazil, Queensland, Ethiopia, India etc. are in the process of their preparation. India has responded to such needs by implementing Biological Diversity Act 2002 and rules 2004. The act provides guidelines for judicious utilization and also laws for conserving the biodiversity in India. To implement the various provisions of the act, National Biodiversity Authority and State Biodiversity Boards are already in place. Another

important issue that the Act deals with is the access of foreign nationals on Indian biodiversity. This is very important from the view that biodiversity rich countries such as India are attractive to the researchers in developed countries. Such developed countries are technologically rich but generally poor with respect to biodiversity. In contrast, most of the biodiversity rich countries are developing and not adequately equipped with technology. Therefore, regulated access to biodiversity can lead to collaborative programmes, which could be beneficial to both.

As a part of National Agricultural Research System, NBFGR is concerned to agrodiversity or genetic resources for food and agriculture. As per FAO (FAO, 2004), agrodiversity is a component of biodiversity and also covers the resources that are utilized through hunting from natural resources, besides their use through cultivation. Therefore, from fisheries perspective the wild resources, that are economically important, are essential component of researchable material for NBFGR. In this context, the genetic variability, both at inter- and intra-specific levels is of paramount importance.

Threats

The aquatic biodiversity has been facing severe threats through wide-ranging factors including overexploitation, habitat alterations, reduced environmental flow of rivers, introduction of non-native species, etc. Alteration in environmental parameters is leading to more species becoming threatened day by day. It is envisaged that such species will be restricted only to sanctuaries and protected areas. Many of the threatened species or their genetic stocks may become extinct unless species/stock-specific recovery programmes are initiated.

Wild populations of cultivable species face the danger of loosing their genetic diversity in their native distribution range due to escapes or stocking in rivers/reservoirs with conspecific fishes of non-native origin. Taking examples from salmon programme, cautious approach for Indian major carps is, therefore, necessary. The growing aquaculture and ornamental industry is likely to introduce more exotic species (at present 291), leading to unintentional introduction of exotic pathogens and also adverse ecological impacts from invasive species. Besides live organisms, import of unprocessed fishery products will be a source of exotic pathogens. Looking at aquatic resource scenario from food and agriculture perspective in India, introduction of exotic or alien fish species, per se, should not always to be considered as concern but a forward looking activity for enhanced returns

from aquaculture. It can provide economic returns without many investments on technology development, as it happened in case of superior plant and cattle germplasm introduction. However, its non-judicious introduction as well as use is a threat to resource conservation. Though some procedures for regulating introductions and quarantine mechanism have been laid for India, however, stringent measures to regulate fish introductions, cultivation areas and protocols, diagnostic capabilities and quarantine are of utmost importance.

Biopiracy is another negative aspect associated with natural aquatic germplasm resources. An increased threat to the biodiversity rich countries such as India is expected from the countries that are technologically rich but poor in genetic diversity. Such genetic diversity and/or information therein is relevant to technologically rich countries to decipher conserved level of genome resources across evolutionary scale, especially related to commercially important cultivable traits with concurrent studies on phylogeography and evolutionary relatedness besides direct products produced through biotechnological applications. It is worth mentioning that such aquatic organisms or their genetic stocks have evolved after genetic selection through different climate changes over million of years and therefore are huge mine of genes and alleles. The concern is the Indian fish germplasm becomes available to researchers outside India through ornamental and fishery trade, freelance researchers or NGO's. Tradeable commodity that could include live ornamental fish and frozen and dried fish products, which can be source of DNA, can be used to circumvent preview of BDA-2002. Some advanced countries are already undertaking the research on evolutionary and phylogenetic description of fish species from biodiversity rich and other regions of the country. In order to cite some examples, All Planet Catfish Inventory at US (Sabaj, et.al. 2003-2006) or international barcoding initiatives such as C-BOL etc. where stakeholder countries, which are origin of germplasm or even analysed information, may not have adequate appraisals about ultimate outcome of such studies. There is a need for uniform and stringent implementation of BDA to promote regulated collaborative research and discourage clandestine sourcing of germplasm.

Climate changes occurring across the globe are likely to impact the aquatic resources which could be adverse like loss of populations or even species, while other side could be the evolution of new species over course of time adapted to changed environment. However, such changes have

been happening since the time immemorial. The mitigation of likely adverse impacts is important along with global efforts to reduce pace of climate changes. From food and agriculture point of view, prospecting the pattern of climate changes and simultaneous bioprospecting, the tolerant species, strains or even their genomic resources will hold the key in preparedness to mitigate changes and plan cropping profiles.

Documentation and Explorations

Out of known fish species of the world, India harbours approximately 10% of them. NBFGR has prepared a database that validates 2649 finfishes including 291 exotic fishes found in India and also contains available information on such species (NBFGR, 2011). Out of 2358 indigenous species, 877 fishes are found in freshwaters, 113 in brackishwaters and 1368 fishes are found in marine waters, belonging to 39 orders, 225 families and 852 genera. The biodiversity rich areas such as North East India and Western Ghats have been explored through various network programmes. Discovery of more than 39 new species in recent years make us to believe that still many of the unknown resources could be there and need intensification of exploration activities. More explorations would be necessary for discovery of new species from deep seas of EEZ, cold deserts, other upland regions and aquatic bodies in Western Ghats and NE region. There is also a need for developing databases on other important macro fauna including crustaceans, molluscs, echinoderms, etc. Aquatic ecosystems have not also been adequately looked for other resources such as microbes and zooplankton. With the advent of molecular markers in use, to aid taxonomic validation, there is a need for developing complementary approach that uses conventional and appropriate molecular taxonomic tools. This will bring in precise description of the new species. NBFGR is working in this direction and a programme on DNA barcoding is in place. Mahseer, a group of important game fish of India, has been addressed in depth using molecular markers. The study indicated for relook into the systematics of the Indian mahseers. Similar work has been carried out on Indian catfish species.

Exploration and documentation has another niche that is intra-specific genetic variability, which has been addressed at limited level yet. Inadequate knowledge on genetic stocks of fish species of cultivable and conservation value is a major constraint. This is in contrast to the scenario in domesticated animals and plants where breeds/varieties etc. are well documented. Hence, bridging this knowledge disparity between fisheries

and other agriculture sectors is necessary for formulating common guidelines on issues related to biodiversity, IPR protection and technological advancements. Total seventeen fish and shellfish species have been studied for their population genetic structure using molecular markers across the natural range of distribution in Indian waters. Some of the new species researched recently are *Labeo calbasu, Pangasius pangasius, Panulirus homarus* and *Harpodon nehereus*. Already an outreach programme is in progress to address ten cultivable fish species such as *Labeo rohita, Catla catla, Cirrhinus mrigala, Labeo fimbriatus, Clarias batrachus, Tor putitora, Macrobrachium rosenbergii, Penaeas monodon, Pinctada fucata* and *Crassostrea madrasensis* in their native range of distribution, from freshwater, brackishwater and marine ecosystems. The project combines molecular and biological approaches and is expected to bring the information on genetic stocks of these species and also their biological descriptors.

India's rich aquatic genetic diversity is a huge mine of genes that are responsible for imparting unique physiological adaptation to organisms inhabiting different aquatic ecosystems, potential products with high commercial applications etc. This not only pose challenge to harness the potential of vast available genetic resource diversity but also to maintain sovereign claim on the benefits arising out of it. There is a need to develop capability and infrastructure that is equipped for large-scale genomic exploration of Indian fishery resources. Therefore, development of genomic resources and their preservation becomes necessary to meet the challenges holistically, in addition to the *in situ* and *ex situ* conservation of genetic resources. For the purpose a national repository of genomic resources is also being pursued.

Conservation of Germplasm Resources

Global and national developments following biodiversity regulations and Intellectual property regimes will enhance the need of germplasm conservation. Out of 27800 fish species reported globally, 2649 species occur in the Indian sub-continent. India with 2.4% of the world's land area has been supporting 16% of the human population, therefore, required to increase its productivity from aquaculture while sustaining its natural resources. Therefore, balancing efforts that enhance conservation, while allowing effective utilization of biodiversity, are important. Conservation of natural resources inhabiting aquatic ecosystems is important from the fact that majority of the genetic resources

for food still comes from the wild due to low domestication level in fisheries sector. This is in contrast to the animal farming and agriculture where domesticated varieties only contribute to food security. Therefore, while it is true that certain aspects of biodiversity and genetic resources policy can apply equally to plants or animals or fish, significantly different approaches is necessary for fisheries resources. It is unambiguous to state that conservation and management of these resources, therefore, will need to be based on precise scientific information.

Aquaculture is growing at a fast pace of over 8% globally since 1970 and is diversified to over 300 fish species. Even some of the endangered species have been successfully conserved and are also part of aquaculture such as White Sturgeon. Therefore, it offers a possibility that aquaculture and conservation efforts can be planned to achieve harmonization of the two aspects. Development of region-specific aquaculture and conservation practices could yield multiple benefits for aquaculture diversification and livelihood security, besides conserving genetic resources. Approach for development of live gene banks could also be modulated to reap such benefits.

Fishing communities though convinced for conservation but are not willing to make the necessary sacrifices as restrictions directly affect their livelihoods. This problem is compounded by lack of alternate sources of earning/employment. For sustainability of all such endeavors of conservation, utilization and management of resources, communities and stakeholder's can play significant role, therefore, deserve to be acknowledged. Cooperative bodies do exist in some states that function well, however, majority of states are not sensitive. There is need to study factors that could improve functioning of such grassroot level bodies and improve community participation for conservation.

There has been some effort to develop germplasm repositories for fisheries sector. However, vast and diverse canvass of the sector with taxonomic conflicts need highly integrated type of repository structure where the voucher specimens remain a reference point for any type of repository material. Live gene banks are another form, however, need prioritization in terms of species with the perspective role in supporting *in situ* conservation efforts.

The major policy legislations such as CBD or BDA 2002, adequately recognize and make it obligatory to plan and implement by the government authorities both *in situ* and *ex situ* conservation strategies. Here research

organization such as NBFGR has critical role to play to act as source of critical scientific inputs and to develop conservation tools and models, repository of information and germplasm, disease diagnostics and quarantine techniques and other relevant issues. Under such scenario, it is evident that there should be complete harmonization between implementing agencies and research organizations concerning prioritization of researchable issues. Possibly, such critical gap need to be looked into and committees such as that on agrobiodiversity empowered by NBA could play an essential role for prioritization of research areas.

From national perspective, though protecting the sovereignty and conservation over the germplasm resources is important, however, only adhering to protectionism could prove counter productive to the developing and biodiversity rich countries like India. Therefore, collaborative forms of research between the technologically developed countries and India, with mutual benefit sharing could be encouraged. Biodiversity rich countries could also develop capacity to complement such efforts for long-term benefits. One such successful example is 'Shrimp Genomics', operated in consortium mode between developed countries like USA and Australia with developing country like Thailand. In addition, to considerable advancement in knowledge of shrimp genome, the capacity of Thailand in this field of research has been built manifold, as evident from the creation of Center of Excellence for Shrimp Molecular Biology and Biotechnology (CENTEX SHRIMP). In India also such process has taken shape, as those of Indo-US Knowledge Initiative in diverse field like biotechnology, water resource management, agriculture education etc.

In this context, collaborative role of SAARC and other neighboring countries is also important. It is a fact that India has four mega biodiversity rich hotspots; however, genepools are also shared with other neighboring countries. India by virtue of its strength and expertise in conservation and management of fish germplasm resources can play a leading role in the conservation research in South and South-East Asian countries. Therefore, the germplasm lost by such neighboring countries through piracy, lack of adequate policy or through their own bilateral agreement will affect stake of India also. Moreover, conservation efforts and exotic introduction policies are not harmonized between such countries which can adversely affect conservation efforts of India. Linkage with SAARC countries in areas such as common germplasm repositories, characterization and documentation of important genetic resources, therefore, is of paramount importance.

The Institute: National Bureau of Fish Genetic Resources

The National Bureau of Fish Genetic Resources (NBFGR) was established during 6th five year plan to carry out research related to conservation of India's fish germplasm resources. The Bureau's main campus has been developed at Lucknow, which comprises administrative building, laboratories, farm complex with hatcheries, aquarium house and residential blocks. The Institute has developed expertise for research in the area of fish taxonomy and database, conservation genetics and genomics, induced breeding of important endemic species, *ex situ* conservation, and diagnostics tools for pathogens and other areas of biodiversity conservation. The XIth Plan budget of the institute under plan was Rs. 3378 lakh. The sanctioned staff strength of the institute is Scientific-40, Technical-36, Administrative-19 and Supporting-20.

Mandate

- Collection, classification and cataloguing of fish genetic resources of the country.
- Maintenance and preservation of genetic material for conservation of endangered species.
- Evaluation and valuations of indigenous and exotic fish species.

The institute possesses a Research Unit at Kochi, Kerala for carrying out research activities with regard to characterization and conservation of marine and brackishwater fish germplasm, besides the endemic species of Western Ghats. Another Research Unit came into the possession of NBFGR, consequent to the formal merger of erstwhile CIFE Centre, Chinhat, Lucknow with NBFGR. The Centre subsequently recognized as the 'Aquaculture Research and Training Unit', with the focus given to impart training to the farmers and the line department personnel on sustainable fish production and conservation.

The thrust of the institute has been to keep pace with technological advancements and development of in-house expertise and infrastructure to fulfill its chartered commitments. Development of knowledge is a dynamic

process at the institute, which is accomplished through team work and network programmes. To facilitate the research, the major facilities created are Automated DNA sequencing and genotyping system, DNA and protein electrophoresis facility, thermal cyclers, gel image analysis and documentation systems, programmable bio-freezers and cryo-preservation facility are some worth mentioning. An international Centre for Fish taxonomy and DNA Barcoding has been established since 2006. Cell culture facilities have been established, both at Headquarters at Lucknow and at the Research Unit at Cochin. For disease diagnostics, a microbiology lab has been developed with facilities for detection of bacterial and viral pathogens using molecular techniques. The Research Unit at Kochi has also been equipped with thermal cycler, gel documentation system, ultra-low freezers, etc. Library at NBFGR has specialized books and journals and managed through fully automated system.

NBFGR, Lucknow is entrusted by the council to develop strategies for registering genetic stocks and elite germplasm of potentially cultivable fish species, both from natural populations and domesticated sources in line with plants and animals. To fill the knowledge gap due to the inadequate knowledge on genetic stocks of cultivable fish species, an Outreach Activity on "Fish Genetic Stocks" involving other ICAR Fisheries research institutes has been taken up during XIth Plan period. The project directs efforts to study the populations of prioritized cultivable species across their range of natural distribution in India. The resource specific institutes (CIFA, CIBA and DCFR) expected to use this information to develop breeding plans for genetic improvements. The conclusions drawn from the genetic variation data will be extended to determine the threatened status of natural populations of these species for use in decision making for their conservation.

The institute has made pioneering efforts to emerge as Centre of Excellence in cataloguing and conserving aquatic bioresources of India. The achievements towards database development for more than 2500 fish species, population genetic structure analysis of several prioritized species, development of molecular markers to document intra-and inter-specific genetic divergence in fish species, development of functional genomic resources, cell line development of several species, sperm cryopreservation protocols, methodologies for *in situ* and *ex situ* gene banks for important fish species, impact assessment of exotic fish species and diagnostic capabilities for exotic pathogens in relation to the evaluation of exotic fish

species have been noteworthy. The new descriptions of 39 fish species from explorations through network programmes have been widely acclaimed. The institute has been giving technical backstopping to Ministry of Agriculture, especially on the aspect related to introduction of exotic germplasm and quarantine issues.

The future thrust of the institute would prominently focus on development of new technologies pertaining to emerging needs of the Country in the context of IPR regime. The exploration and documentation of germplasm at species and genetic stock levels will be the mainstay. Further, capacity building will be taken up for exploration of germplasm at genomic levels. In addition to generation of knowledge, importance will be given for utilization of the generated knowledge for conservation efforts.

NBFGR 2030

The National Bureau of Fish Genetic Resources is spearheading for the cause of aquatic genetic resources of India with focus on genetic resources for food and agriculture. The bureau is fully conscious of the changes and opportunities associated with genetic resources. The research is geared to meet such challenges so as to not only safeguard the aquatic biological wealth of the nation but to work towards its sustainable utilization for nutritional security of the masses.

VISION

Assessment and conservation of fish genetic resources for intellectual property protection, sustainable utilization and posterity

MISSION

Collection, cataloguing and documentation of fish genetic resources using operational strategies of partnership and cutting edge technologies

FOCUS

- Explorations programmes for discovery of new germplasm resources
- Development of databases on genetic resources
- Population characterization for documenting intra-specific genetic variation
- *In situ* conservation and live gene banks
- Valuation of genetic resources
- Development and maintenance of germplasm repository
- Risk assessment system for decision making and management of exotics
- Development of molecular diagnostic techniques for important fish pathogens and their management.
- Research on prophylactic and curative measure for improved health management in aquaculture

- Genetic resources of Indian major carps and their management
- Sperm banking for *ex-situ* conservation and aquaculture applications
- Genome explorations of important cultivable species and assessment of genetic variability
- Capacity building for research programmes on cutting-edge areas
- Human resource development and technology dissemination

Harnessing Science : Strategy and Framework

Perspective of future research at NBFGR is drawn from the likely scenario emerging with importance of genetic resources and the need for their sustainable utilization. The Indian aquatic genetic resources are diverse and vast, and considerable efforts and resources are required for their documentation and conservation research. Therefore, prioritization of researchable areas and species is the key. The clients for the research outcome of the institute could be identified as policy makers, authorities implementing conservation activities and resource-specific research institutes or any other organization that is involved with transformation of genetic resource information into commodity. The major research perspectives of the institutes are as follows:

1. ***Explorations programmes for discovery of new germplasm resources***: Explorations are most essential component for these organizations involved in germplasm related aspects. The exploration of germplasm and documentation from NBFGR perspective is required at two levels.

    a. Description of organisms in the aquatic habitat, including validation using molecular tools is the first level of description of resources. This is a macro level process and could lead to identification of germplasm resources not described till now and novel microorganisms from aquatic environment. This can be done on wider scale of regions, however, will need prioritization of regions which are biodiversity rich or are underexplored or likely to harbor new species or any other strategic importance for the nation or even group of species that need systematic revision. The exploration and documentation process need taxonomic skills, which unfortunately are not that readily available now. The brighter side is advent of molecular tools which can give quick resolution with evolutionary and phylogenetic information also; however, still they can be complementary to conventional taxonomic tools. Use of metagenomics could

lead to discovery of new bacterial species from aquatic environment. There could be good opportunity to train the people in undertaking the combined use of both tools, even at the level of undergraduate students, to enhance taxonomic capabilities. Such macro-level explorations will need to be holistic with respect to information coverage including characterization of species, habitat and environment.

b. Another level of exploration is micro level exploration for documenting within species variation for population genetics data from native distribution of species, for neutral markers or genomic levels, bioprospecting of genes and alleles for specific traits. This will lead to identification of genetic stocks that need conservation or have specific utility for breeding programmes, document genomic resources from native aquatic biodiversity for utilization in improvement programmes using biotechnological applications. Bio-prospecting of genes from aquatic microbes is also an important area of research, which has numerous applications. This level of exploration is time, technology and resource intensive, and therefore, need prioritization of species, traits and targeted genomic resource. Under future programmes both the areas will be intensified and taken with holistic approach with respect to researchable issue, networking of expertise for work execution and imbibing newer technological advancement.

2. ***Development of databases on genetic resources:*** Documentation and cataloguing process will be focused on information management and its utilization which can be in interactive mode and help in decision making process for conservation and management of resources. The databases that will arise out of primary information from explorations and also secondary information will be pursued with these objectives in view. In addition to the documentation, NBFGR will continue to support the Council's initiatives on information management such as National Agricultural Bioinformatics Grid.

3. ***Population characterization for documenting intra-specific genetic variation:*** The research on intra-specific genetic variation will be focused on prioritized species that are cultivable, potential cultivable

or important exploited stocks from freshwater, brackishwater and marine ecosystems. Such studies will be aimed to identify genetic status of natural populations, identify genetic stocks and stocks those need conservation. With the successful application in first outreach programme for application of both molecular and biological tools for generating individual specimen data, the future programmes will incorporate the same line of technical aspects. The species already accomplished will be further extended if some part of their native distribution is not covered or to answer specific questions regarding their phylogeography. Under similar programme new important species that has cultivable potential or high conservation value, *viz.*, *Tor tor, Labeo calbasu, Pangasius pangasius, Sperata seenghala, Channa marulius, C. striatus, Macrobrachium rosenbergii, Lates calcarifer, Mugil cephalus, Epinephelus meira, Rachycentron canadum,* etc will be taken up. Such programme will also incorporate the upcoming advancements to explore variation in functional genes or new markers such as single nucleotide polymorphism.

4. ***In situ conservation and live gene banks***: Under the future work, utilization of information will be given focus. There is need to integrate the population genetics data with breeding and cryopreservation technologies to work out real time model for species rehabilitation. Though NBFGR can play role of technical input provider, however, such aspects can be accomplished with the help of conservation implementing agencies. Here, the supportive role of live gene banks for *in situ* conservation efforts such as rehabilitation programmes, also needs to be explored. Therefore, to achieve this, a cohesive approach will be adopted towards on prioritization of species for live gene bank networks based on conservation as well as aquaculture and economic potential. Such species also will be targeted for the purpose of generating information such as genetic variation, life history traits in wild and captive conditions in addition to breeding protocols.

5. ***Valuation of genetic resources:*** Economic valuations of genetic resources are required to justify conservation research in quantifiable terms. Economic valuations must consider all kinds of benefits ranging from socio-economic, nutritional security and the products to possible source of important genes. The collaborative efforts between biologists, economists and social scientists will be

developed to first develop the much needed model for economic valuations of biodiversity.

6. ***Development and maintenance of germplasm repository:*** Repositories have an important role to play in future. The registered accessions can be useful for IPR protection. These provide avenues for access to germplasm resources for research and utilization. However, involvement at users, stakeholders and managing organization is necessary for enhancing richness of repositories within limited time. From fisheries perspective the repository need to integrate different components and referring to collection of voucher accessions. The different type of accession material could be cryobank, which has cryopreserved sperm, embryonic cells and other cells lines, tissue repository, DNA repository (total isolate/specific sequences like constructs) or other materials of similar nature and importance arising in future microbial repository including that of pathogenic significance under linkages with NBAIM and voucher specimen accessions. Such repository needs to have specialized infrastructure to house all components under one roof.

7. ***Risk assessment system for decision making and management of exotics:*** Under liberalized economy, the aquaculture industry may want to introduce a large number of exotic species. The increased introduction of exotic germplasm would lead to greater ecological and disease risks. This could be mitigated through scientific efforts on documentation of possible ecological risk and the assessment. NBFGR's role will be to develop scientific information and technical inputs for decision of exotic management by the concerned authorities Such information would be available through National Information Center for Aquatic Exotics and Quarantine and National Referral Laboratory to be established at NBFGR.

8. ***Development of molecular diagnostic techniques for important fish pathogens and their management:*** Pathogens of concern can find their entry into the country and existing pathogens can spread into newer areas. Development of diagnostic capability for detection of these pathogens could minimize the risks. This programme will help in monitoring the health status of fish and devising strategies for effective fish health management. Development of cell lines would help in virus isolation studies.

9. R*esearch on prophylactic and curative measure for improved health management in aquaculture*

   a) ***Engineering of disease resistant fish:*** Diseases like EUS, KHV etc. cause huge mortalities in cultured as well as wild fish. Identification and introduction of potential multi-gene constructs can be helpful to achieve disease resistance in fish. Other strategies possibly involving RNAi and gene targeting technology could be also worked out for imparting disease resistance in fish.

   b) ***Improved drug delivery system for treatment of fish diseases or improving the efficacy of vaccines:*** The benefits of nanotechnology enabled medicine and the promise of organ specific drug delivery in treatment of fish diseases shall be utilized. Application of synthetic, natural, or hybrid materials for innovative drug and gene delivery in fish will be undertaken.

10. ***International cooperation:*** India shares its water bodies and also biological resources with neighbors, especially SAARC countries. In this scenario, lack of coordinated efforts between these countries with respect to documentation, conservation of germplasm and exotic introductions pose critical gap and need to be bridged. Therefore, efforts are required to establish a platform to develop common Repositories/ Gene Banks and Genetic Characterization Programmes**.** The facilities need to expand for the purpose, if linkages with such countries can be established.

11. ***Genetic resources of Indian major carps and their management:*** Management of genetic resources of Indian major carps is an important area that institute proposes to focus its programme. IMC's from India contributes about 5% to world aquaculture. The three species have been core of the domestication scenario of Indian fisheries. There is concern to protect the natural and farmed genetic resources of these species. Concerns are similar to the worldwide erosion of cattle genetic resources, happening both at farm level and the native breeds. The management of IMC resources can be addressed at two levels as given below.

    a. National programme on genetic and health surveillance of Indian major carp hatcheries: The availability of quality seed

of Indian major carps is crucial for sustenance of Indian aquaculture and steps have already been initiated to evolve the process of accreditation of hatcheries. However, there is a need for assessment of hatcheries with respect to inbreeding levels, loss of genetic variation, genetic contamination and also pathological status. Moreover, there is likelihood of presence of elite germplasm in some farms.

A National Programme to quantify the status of hatcheries in India and the baseline data will not only help in seed certification process but also to develop guidelines for Indian major carp hatcheries. The identification of elite germplasm will help in further improvement of farmed population. This programme will need involvement of multiple organizations from ICAR and Ministry of Agriculture and NFDB.

b. National guidelines for stocking and restocking of reservoirs and rivers with Indian major carps with focus on Indo-Gangetic plains: There is danger of loosing the genetic diversity in wild stocks of Indian major carps, which could be essential for sustenance of natural resource as well as for genetic improvement programmes. These are most common species used for releasing in natural water bodies, most of the time seed is sourced form hatcheries and from non-native broodstock.The stocking of Indian major carps in rivers and reservoirs are considered favored means to augment production from capture fishery. Practice of stocking such seed is not appropriate as it can create genetic bottlenecks, homogenization and reduce the adaptive capability of species to changing environment leading to loss of species or populations. There is need for developing National Policy Guidelines on stocking of rivers and reservoirs with respect to source of stocking material, assessment of contribution of such stockings in enhancement of capture fishery. Population genetics structure of the Indian major carps has been studied through the molecular markers. At NBFGR level, the work to identify genetic stocks and development of molecular markers for these species will be further expanded to unearth more genetic variations. This genetic variation distribution data can be put to use for planning stocking programmes for

enhancing capture fishery or conservation of genetic stocks in wild.

12. ***Sperm banking* for *ex-situ conservation and aquaculture applications:*** Sperm cryopreservation protocol development will be expanded to new species of aquaculture and conservation importance. NBFGR has developed expertise to develop sperm cryopreservation protocol for varied taxonomic groups over twenty species. More species will be prioritized for the purpose which have cultivable potential, existence of milt related problems or scope to use as safeguard measures in live gene banks.

13. ***Genome explorations of important cultivable species:*** Developing complete genome sequence profiles for important fish and shellfish species such as *Labeo rohita, Clarias batrachus, Macrobrachium rosenbergii* and *Fenneropenaeus indicus* and *Penaeus monodon* etc. can be taken up under collaborative mode. The complete genome sequencing of the species will allow access to a completely annotated genome; identify the actions of regulatory elements and genes responsible for economically important traits and novel genes. Whole genome information will also be useful to derive SNP.s and repeat elements for use as markers to determine genetic variability.

14. ***Research programmes on cutting-edge areas:*** Further thrust will be given to research in some of the up-coming areas of stem cell research, cell line development, transgene research, functional genomics and physical mapping of genes etc. Expertise development in such areas have varied utilities such as *ex situ* conservation, tools for genomic expression assays and development of diagnostic capabilities, in addition to enriching repository of genomic resources for future use. Stem cell research will focus on stem cells of embryonic cells, primordial germ cells or spermatogonial cells. One of this possible potential could be to develop surrogate brood stock. Somatic cell line development is already being pursued and will be prioritized for species to be worked upon with potential application in viral isolation, *ex situ* preservation and for genomic expression assays. Transgenic technology need to be used in many of the *in vitro* genomic expression assays. Either it can be made available through in house expertise development or through outsourcing or collaborative work. Functional genomics is another important area where NBFGR has already pursued considerable progress.

Knowledge of transcriptome analysis (tissue specific) and associated type I markers have utility in finding responsible genes for specific traits and their linkage with markers. These can have application in marker based breeding programmes also. Such research can be undertaken in collaboration with culture-based institutes so that the genomic resources developed find the use in aquaculture programmes. Proteomic research can be used to identify the unknown genes coming out of the transcriptomic research. While Genomic information will be generated, it will be necessary to develop tools for localization of such genes on chromosomes. Research will also be oriented towards certain aspects of structural genomics like Fluorescence *in situ* hybridization (FISH) and (Bacterial artificial chromosome) BAC library construction.

15. ***Capacity building:*** Capacity building, both in terms of expertise and necessary infrastructure, in new areas such as transcriptome analysis, proteomics, phenomics, linkage studies, computational biology, stem cell research and other of similar kind that arise in future will be important aspect to be addressed in future programmes. From application perspective, information generation will be the first objective which will have commensurate technology or capacity build up. In other words, the capacity build up plan will have first hand view that what will be the road map to use the capacity in ultimate field level data generation. This is necessary to avoid limiting the efforts of capacity development only at the publication level.

16. ***Human resource development:*** Genetic resource research and handling is not going to be only a biologists job in future. It is adding multiple dimensions such as international policy, legal frameworks and trade, in addition to requirement of biologists' expertise. In other words, it is carving a separate niche as specialized fields. NBFGR will put across its view that post-graduate programme can be initiated with involvement of all the Bureaus in collaboration with law and policy institutes. The manpower so developed will be a bridge between law implementing agencies, policy makers both at national and international levels with the hardcore biologists. Such persons will be adequately equipped to present India on world forum that influence global policy on genetic resources.

17. **Technology dissemination:** NBFGR will continuously strive to put the knowledge and expertise gained for the use by stakeholders and perspective clients. This will be done through conducting training programmes, information exchange in seminars, using web as tool for dissemination and development of interactive databases. Research publications in International peer reviewed journals with high impact factors will also remain a priority.

Epilogue

In the changing scenario, the challenges and importance of natural genetic resources, including those from aquatic ecosystems, is undergoing paradigm shift. This shift stems from the basic fact that growing population of the world need to be not only fed but should also be nutritionally secured. The genetic resources are seen as basic ingredient for enhancing food production. Therefore, only protectionist attitude towards conservation of such resources can no more be sustained, but incorporation of strategies for enhancement and sustainable utilization for posterity, are inevitable. To achieve this, priorities of research at NBFGR, within its chartered mandate, must be in tandem with the commodity-specific institutes, both within and outside NARS. Therefore, collaboration with such institutes is necessary and should be initiated at the level of prioritization of species and researchable issues which in turn form the basis to identify capacity building at NBFGR. This could be a dynamic process where information generated by NBFGR contributes to transformation into product by respective institutes and taking the benefits to aquaculture communities and other fisher folks of the country. Undoubtedly, in overall perspective, the information and research tools generated at NBFGR will be also useful to the authorities responsible for management of biodiversity as a whole.

There will be continued thrust to keep pace with technological advancements, focused with in-house expertise development as well as taking advantages of outsourcing avenues available. Focused research on priorities and concurrent exit ways for the programmes that have outlived vis a vis the future needs, will be put forward to ensure judicious utilization of resources.

References

BDA (2002). Biological Diversity Act 2002. http://www.nbaindia.org/act/pdf/Biological_Diversity_Act_2002.pdf

C-BOL (2011). Consortium of Barcode of life. http://www.barcodeoflife.org/content/about/what-cbol

CENTEX-SHRIMP (2009). Center of Excellence for Shrimp Molecular Biology and Biotechnology. Faculty of Science, University of Mahidol. http://www.sc.mahidol.ac.th/research/shrimp.htm

FAO (2004). WHAT IS AGROBIODIVERSITY? Fact sheet. In: Training Manual "Building on Gender, Agrobiodiversity and Local Knowledge". http:// www.fao.org/sd/links

Greer, D and B. Harvey (2004). Blue Genes: Sharing and Conserving the World's Aquatic Genetic Resources. Earthscan Publishers, Canada

NBFGR (2011). Annual Report. National Bureau of Fish Genetic Resources, Lucknow

Sabaj, M. H., J. W. Armbruster, C. J. Ferraris, Jr., J. P. Friel, J. G. Lundberg and L. M. Page (2003-2006) (eds.). The All Catfish Species Inventory.

Secretariat of the Convention on Biological Diversity (2002).Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization. Montreal: Secretariat of the Convention on Biological Diversity.

Annexure 1: Strategic framework

Goal	Approach	Performance measure
Cataloguing of genetic resources	• Development of network for exploration across country. • Prioritization of areas of explorations. • Conducting explorations in holistic manner for genetic resources including abundance, environment, life history traits, tribal and indigenous knowledge etc. • Covering the issues on macro and micro fauna/flora including microbes, habitat information and life history traits. • Valuation and evaluation (where potential is discernible) of the resources for cataloguing the utility. • Documentation on a interactive web based database system along with the information	Catalogue and inventory on status of resources. Knowledge on new resources undiscovered till now.
Characterization of genetic resources for stock identification.	• Prioritization of species of cultivation, exploited resource or conservation value and native distribution of species. • Identification of molecular markers and biological descriptors. • Explorations for collection of accessions and data collection for genotypes and biological traits • Documentation of genetic variation pattern to identify genetic stocks with their biological descriptions of the target species. • Registration of genetic stocks with their descriptors	Knowledge of genetic stocks and natural genetic variability within species with population status, vulnerability with respect to breeding population and also paleogeographical information.
Development of genomic resources	• Prioritization of species and/or genomic information to be deciphered. • Capacity building for characterization of genome. • Documentation of genomic information and analysis.	Knowledge of genomic resources for future use for biotechnological, molecular breeding applications for aquaculture.
Conservation research for enhancement and utilization of resources.	• Prioritization of species or genetic stock of cultivation, exploited resource or conservation value. • Linkage with information generation to the genetic stock identification.	Procedures and models for conservation and utilization of genetic resources.

Goal	Approach	Performance measure
	• Development of live genetic resource centers through linkage for prioritized species or genetic stocks with breeding population and R&D for captive propagation and sperm banking. • Utilize the above protocols for enhancing aquaculture diversification and improvement and rehabilitation programmes through linkage with implementing agencies. • Research on embryonic stem cells procedures for long term storage and retrieval of diploid genome for *ex situ* conservation applications.	
Safeguarding measures for the health management of indigenous germplasm especially against exotic fauna.	• Evaluation of perspective/ introduced exotic germplasm for decision making on introductions and their management • Development of risk assessment, disease diagnostics and health management capabilities against exotic germplasm and fish pathogens.	Safe introduction of exotic germplasm. Capabilities to provide checks against pathogens and ecological risks to cut losses due to disease outbreaks and harm to native germplasm.
Repositories of genetic and genomic resources.	• Development of infrastructure for integrated repository and museum. • Linkage with exploration groups for enhancing voucher specimen accessions. • Protocol development and safe storage of different forms of accessions such as sperm, cell lines, primary cell cultures, tissues and DNA accessions including modified ones. • Reference of all types of accessions to voucher specimens to avoid taxonomic conflicts. • Procedures for deposition of material and benefit sharing.	Safe custody of germplasm for IPR protection, sharing for future research programmes.
Imbibing technological advancements for new areas of research	• Development of in-house expertise and infrastructure for undertaking research in new areas of research such as functional genomics, proteomics, phenomics and biosecurity etc.	Capability to undertake the research in these frontier areas of research.


हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agri search with a human touch