

Aquatic genetic resources: Policies and regulatory mechanisms including lessons learnt from indigenous and ancient knowledge

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ABSTRACT

India possesses rich biodiversity of both terrestrial and aquatic flora and fauna along with ancient and traditional knowledge for its utilization as food, medicine, etc. The traditional knowledge along with its methods for conservation strategies is needed to be documented and brought forward to draw suitable policies and formulate regulatory mechanism to conserve the aquatic bioresources and to reproduce them in sustainable environment friendly manner. Stakeholders' participation is the key to achieve such goals since the local communities and tribes possess the key knowledge of the region's bioresources and environmental phenomenon.

Key words: Conservation, Genetic resources, Policies, Traditional knowledge

Aquatic genetic resources range from microbes, planktons to gigantic whales. There is a definite food chain present in the aquatic ecosystem. The famous "Trophic Prism" indicates the intimate and intricate relationships among the primary producers and secondary and tertiary level consumers. At the same time, different ecosystems are mostly inter-dependent but self-sufficient. Various biological, biochemical and reproductive processes of complex nature support numerous life forms across the aquatic system. The value of biodiversity is based in the functioning of these components supported by the interactions of organisms, populations and communities.

India, is blessed with several types of ecosystems ranging from coldwater—Himalayan rivers and lakes; tropical wetlands; brackish water lake—Chilka, which is largest in Asia; coastal wetlands; estuarine, coastal and oceanic systems. These various ecosystems are threatened as a result of pollution, degradation and several developmental activities like over-exploitation, reclamation, etc. The ecosystems contain a range of creatures like coral reefs, mangroves, marine algae and sea grasses, conventional fishery resources, the rare groups of faunal elements and various micro-organisms which are responsible for various interdependent functions.

Along with rich cultural heritage and natural resources, India harnesses tremendous traditional knowledge of utilization of the resources and their conservation. The only lacuna is to put these three together and make appropriate and precise policies and regulatory mechanisms for the conservation and sustainable utilization of the aquatic resources. Some of such policies have been drawn for the

terrestrial resources, the aquatic resources, however, are yet to receive proper attention.

AQUATIC ECOSYSTEM

Fresh water Ecosystem

The country is endowed with vast and varied resources possessing river ecological heritage and rich biodiversity. Freshwater fishery sites are varied like 45,000 km of rivers, 1, 26,334 km of canals, 2.36 million hectares of ponds and tanks and 2.05 million hectares of reservoirs (Ayyappan and Biradar, 2004). The biodiversity assessment of freshwater fishes is done mainly on the basis of 6 drainage systems in the country. These are Indus river system, Upland coldwater bodies, Gangetic river system, Brahmaputra river system, East flowing river system and West flowing river system. The Western Ghats is the richest region in India with respect to endemic freshwater fishes. Northeastern India, which has a very high diversity among freshwater fish, does not have many endemic species within India because of its jagged political boundary.

Brackish water and Marine Ecosystem

Tropical marine ecosystems of Indian subcontinent harbour a large number of species belonging to various habitats that include mangrove forests and swamps, estuaries, lagoons, muddy, sandy/rocky shores, and oceanic islands. In India, although the marine biological research has been going on for a long time, there are several groups of living, or endangered (some extinct) organisms, about which there is no proper scientific information available. This includes

algae, sea grass and mangrove as flora and zooplankton, echinoderm, molluscs, crustaceans and finfish as fauna.

Aquatic genetic resources of India

The aquatic resources include both flora and fauna. Among the floral species, microscopic algal forms are found to be more than 1,500. The marine macroscopic algae; that are commonly known as seaweeds are estimated to be about 844 along the Indian coast. Only 14 species of seagrasses are found, mainly in the Gulf of Mannar region. Mangrove

biodiversity of India, is very diversified with 65 species, most of which are reported from Sundarban, the biggest mangrove forest (Table 1). Among the faunal groups, molluscs are the most diversified followed by crustaceans and finfish species. Echinoderms and amphibians are less and most of the species appeared in the red data book as rare and endangered.

Corals of the Indian coast are all declared as rare and endangered species and coral ecosystem, that harbours several flora and fauna and one of the most productive ecosystem of marine region is known to be a fragile one. Table 2 gives an account of existing coral reefs along the Indian coast and the biodiversity. Total 71 hermatypic coral genera represented by 200 species are reported. Most diversified are Andaman and Nicobar Islands followed by Palk Bay and Lakshadweep atolls.

Most of the fish species belong to the marine environment contributing to 64% (Table 3) followed by warm water and brackish water species.

Need for Conservation of Aquatic Genetic Resources

Since time immemorial, the human race is establishing itself on the bank of water bodies, where both terrestrial and aquatic resources are available in plenty. In the world, more than 80% of the population is settled along rivers/lakes banks or along the coast. This emphasizes the human dependency on the aquatic resources including both living and non-living resources. Rapid development due to urbanization and

Table 1. Biodiversity of aquatic resources

Aquatic resources	Species (No)
Flora	
Other Algae	>1500
Seaweeds	844
Sea grasses	14
Mangrove	65
Aquatic weeds	~150
Fauna	
Zooplankton	>1000
Crustacean	2430
Mollusca	5000
Echinoderms	765
Finfish species	2200
Amphibians	~250
Avian fauna	>1000

Table 2. Coral Diversity of the Indian coast

Area	Type	Hermatypes		Ahermatypes	
		Gen	Spp.	Gen	Spp.
Palk Bay and Gulf of Mannar	Fringing	28	84	9	10
Gulf of Kutchch	Fringing Patchy	20	34	4	3
Andaman and Nicobar Is.	Fringing	47	100	12	35
Lakshadweep Is.	Atolls	27	69	4	9
Submerged Banks	Patchy	5	5	—	—
Central West Coast	Patchy	8	8	—	—
Indian Reefs	—	51	156	21	44

Total Genera: 71, Total Species: 200 (Pillai 1971, 1977, Pillai 1983, 1986, Patel 1988, Pillai & Jasmine 1989)

Table 3. Fish biodiversity of different ecosystems

Ecosystem	Fish Species (No.)	Composition (%)
Cold water	154 (34 fishes are common to cold and warm water)	7.27
Warm water	433 (67 fishes are common to warm and brackish water)	20.45
Brackish water	171 (16 fishes are found only in brackish water, 73 are common to warm, brackish and marine water and 82 are found in both brackish and marine water.	8.07
Marine	1360	64.21
Total	2118	100

Source: NBFGR Annual Report (2005)

industrialization has resulted in the destruction of habitats, resulting in extinction of several aquatic organisms. Only a fraction of these species is known to science. On the advent of the industrial revolution, the coastal regions are threatened by industrial and pesticide pollution, habitat destruction, reclamation and rapid urbanization.

Efforts to meet growing demands for food, fiber, fuel and fresh water are ever-increasing due to population explosion. Introduction of alien species, destruction of wetlands, removal of riparian vegetation are adding to the ever-increasing threats to the aquatic resources all over the world (World Wide Fund for Nature, 2004; World Conservation Union, 2006) with freshwater species having declined more rapidly between 1970 and 2000 than their terrestrial and marine counterparts (Abell, 2002). In addition to this, climatic changes are playing a great role towards the loss of aquatic bioresources. Increasingly, we see the potential value of aquatic genetic resources for all kinds of social purposes including food, medicines or novel industrial applications, but they are disappearing before we have had a chance to understand how they might be used – and in some cases before we have even discovered that a species exists in the first place. In the late 1980s, the UN's Brundtland Commission issued a wake-up call by drawing attention to the interdependence of economic, environmental and community long-term well-being. 'Sustainable development' has been a common phrase ever since.

Each step in the food chain of the aquatic ecosystem is important as one type of organism depends on the other. Hence, it is necessary to conserve not only the economically important species, but also the insignificant ones, as well.

Strategies for conservation of aquatic bioresources

A coherent strategy includes an appropriate combination of *in-situ*, *ex-situ*, *in-vivo* and *in-vitro* conservation methods. In determining the precise combination of conservation methods to use, the following factors should be considered:

- *In situ* community-based, management and conservation strategy deserves priority attention where maintenance of the aquatic genetic resources is in the best interest of local communities for their available livelihood options.
- *Ex-situ* or *in-vivo* conservation in institutional or communally owned water bodies to support conservation of aquatic genetic resources that have current value.
- *In-vitro* conservation provides a secure back-up for the developing world's aquatic genetic resources in the face of natural and human disasters that could drive the aquatic genetic resources to extinction faster than *in-situ* or *in-vivo* approaches can respond.

Indicative priority actions

For effective conservation of an aquatic ecosystem, it

requires prudent management of the entire catchment to achieve sustainable social, economic and ecological objectives (Davies and Wishart, 2000; Gilman *et al.* 2004; Chan *et al.* 2006). This should be based on integrative assessment and planning approaches that incorporate terrestrial and aquatic issues, including the reconciliation of conservation and water use goals both inside and outside of protected areas, into a single decision-making framework (Nel *et al.* 2007). Systematic conservation assessment and planning methodologies have become well-advanced for terrestrial ecosystems, but the aquatic ecosystems have often been poorly dealt with (Abell *et al.* 2007). In such a situation, the conservation issues should be prioritized before formulation of the management policies. Priority actions should address the following:

General

Priority should be given for development of policy that promotes and support appropriate use of aquatic genetic resources and conservation. Further, development of policies and guidelines for biosecurity, exchange, ownership, access and benefit-sharing of aquatic genetic resources is another prioritized area. Benefits and costs of conservation should also be evaluated and demonstrated to raise awareness of the issues. Establishment of funding mechanisms, legal frameworks and advocacy to support the actions of developing countries to conserve aquatic genetic resources should also be given priority consideration.

Conservation

Conservation priorities mainly include development of capacity for cryopreservation, including the development of human and technical resources; determine the most appropriate system for regional and international cryopreservation programmes as a back-up for *in-situ* and *ex-situ* methods; Identify hotspots of diversity and identify the most threatened aquatic genetic resources within those hotspots and taking action to conserve them.

Research and information

Proper cataloguing and collection of all existing information on aquatic genetic resources in an internationally accessible information system along with tools for analysis and interpretation of information and for decision-making is one of the most important area which deserves priority attention. Complete global surveys of the molecular genetic diversity of major aquatic species are equally necessary. The economies of various conservation actions and interventions should be critically analyzed. Improvement in the technologies and reduction in the cost of cryopreservation of gametes, embryos and somatic cells of most species of aquatic genetic resources are other research priorities.

Since aquatic resources are origin of civilization, the distribution of the same along different countries or sharing

of the resources has been an issue of debate. There is strong need to unite and take a solution on the prioritization of the resource management policies.

Knowledge Gap

- Lack of high quality information about the status, characteristics, and current and future values of most aquatic genetic resources, due to scanty knowledge and inadequately developed information systems and low intensity of information gathering mechanism.
- A lack of inventory, analysis and design of policy and regulatory frameworks and how they affect conservation efforts.
- Lack of knowledge about how to prioritize, design and operate conservation and utilization programs that will be sustainable in the medium to long term.
- Limited understanding of methods suitable for valuing aquatic genetic resources and limited information on the costs and the benefits of different conservation methods are hampering the development of conservation on the scale required.

Lessons Learnt from Indigenous Knowledge and Practices

Local communities, their traditional knowledge and practices are critically important for the commoditization of genetic resources. Both men and women's key role as food producers link them directly to the management of genetic resources. They are in possession of unique knowledge of local species, ecosystems and their use acquired through generations of experience. In fisheries sector or aquatic resources, the availability of quality seed to a poor farmer is out of reach most of the time. Though the farmer is aware of breeding practices, the constant supply of healthy germplasm, subsidy on the electricity, disease control, etc. are difficult to manage as majority small holder farmers are not aware.

Knowledge is generated through exposure, education and experience. Indigenous knowledge (IK) refers to the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area. Indigenous knowledge is stored in peoples' memories and activities and is expressed in the form of stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local language and taxonomy, practices, equipment, materials, aquatic species, and their distribution and behavior.

Within the fisheries sector, many fishers have a profoundly detailed knowledge of their environment, the species of fish they target, and changes in the waters they fish, navigation, the seasons which influence their fishing and the techniques which preserve fish. Women often have detailed knowledge of the various systems, for instance processing and preservation of fish under different circumstances, and of markets. Fishers also have considerable knowledge about the social, cultural and institutional arrangements which

operate within their communities, how resources are allocated and how conflicts are avoided or resolved. This information can be useful for designing development interventions or designing effective resource management systems

The traditional knowledge and ancient culture has experienced both positive and sometimes negative impact on the resources. Some of the case studies are mentioned here to understand the lessons to be learnt:

Positive lessons of the tradition

Sacred Groves: In several parts of India, the temples or shrine is located in the forest and the adjacent area belongs to the shrine. The local people preserve this as sacred grove and, thus, the biodiversity is preserved. *Achara*, in Maharashtra is thus preserving about 150 ha of mangrove forest that belongs to the temple. Local community does not cut the mangrove for their use, no aquaculture clearing or settlement is allowed. Another example is *Sravan Kavadia* in Gujarat. Here it was believed that according to mythology, Sravan had rested his parents in the mangroves of Sindhu where he was killed by King Dashratha. Today some 100 inland mangrove trees are being taken care of the Kachchi people of the region (Untawale Pers. Comm).

Idol worshipping: Some wild animals of the aquatic origin are worshipped and thus saved from being extinct. A place called Kumberjua in Goa has a festival called *Mangethapni*. In this festival a mud replica of crocodile is prepared and worshipped. It is considered as sacred and thus the hunting is prevented. Turtles are also considered as incarnation of God and thus not hunted.

Fish is incarnation: Fish is known to be a first incarnation of Lord Vishnu to save mother earth and since then it has been worshipped and some are protected. There are many marine faunal species like corals, Shankh (gastropod) used for prayer and considered as good omen. The areas are conserved as sacred areas.

Fishing ban: Several ban on fishing in common property resources such as lakes, rivers, coastal waters and creeks is a common phenomenon observed among the traditional fishing communities of Eastern India and Bangladesh. During the rainy season which coincides with breeding season, they stop fishing till Durga Puja. This practice is of immense value for restoring fisheries and fish biodiversity. By law, Emperor Ashoka had banned fishing during breeding season.

Negative lessons of the tradition

Polluting the sacred locations: Since the ancient time, the holy places, rivers are being used for bathing and place offerings. This in recent times has actually been damaging the ecosystems and the biodiversity, in turn (Jain *et al.* 1999).

Overexploitation: Mollusc like *Conus* is kept in shrines and home that fetches reasonable value. This has lead into over-exploitation of the shell fisheries at coastal worshipping sites like Rameshwaram, Somnath, Puri, etc. Over-tourism

has resulted into destruction of nesting sites for marine turtles.

Biodiversity get protected when the community sees a use for it. The different livelihood strategies and interests, water tenure and organizational structures of different user groups (by gender, age, class, ethnicity and occupation) as well as uneven power relations in access to, use and control over land, animal and plant resources directly influence their capacities and incentives to conserve agro-biodiversity.

Rationale for a Need of Policy and Management for Sustainable Aquatic Genetic Resources

The lack of effective policies is one of the constraints for the management of aquatic genetic resources for aquaculture and capture fisheries. Although there is a contribution from aquaculture to the world fish supply, overall management policies for implementation are lacking. The continued deterioration of a country's aquatic eco-systems will result in an inevitable decline in the provision of key ecosystem services that underpin social and economic development (Postel and Richter, 2003; Dudgeon *et al.* 2006 and Dasgupta, 2007). Due to the rapid expansion of aquaculture activities, irresponsible use of natural resources and the overexploitation of many capture fisheries have resulted in adverse environmental and social impacts, inter-sectoral conflicts and unsustainability. Further, non-availability of information on biological databases of fish genetic resources and lack of holistic approach towards management of genetic resources are taking a toll in the aquatic biodiversity. Territorial conflicts often drive the policymakers to shy away from the problems. The best example is seen in the river conflicts and commerce versus environment. The delineation and management of fish stocks as fish genetic resources, on the basis of their genetic differences is yet to be studied. Inadequate characterization and domestication of various resources and lack of resource inventories and adequate data on rate of over-exploitation are causing threat to the genetic resources. Hence, to stop such practices, management guidelines and policies are required for sustainable development of fish genetic resources.

International policy framework for management of aquatic genetic resources

The FAO Fisheries and Aquaculture Department produces a report on the State of World Fisheries and Aquaculture every two years and occasional other publications of a similar nature, though none of these addresses yet specifically the status of and issues pertaining to aquatic genetic resources. FAO also publishes useful *Species Fact Sheets* on farmed aquatic species; however, their coverage of fish genetic resources is irregular and sometimes lacking. The FAO Fishery and Aquaculture Information and Statistics Service compiles and publishes datasets on aquaculture and capture fisheries. The FAO Code of Conduct for Responsible Fisheries (CCRF) together with its Technical Guidelines and

Supplements are the main instruments through which the FAO provides advice and guidance and through which members are contributing to responsible aquaculture and fisheries. The Technical Guidelines cover a range of issues including policy formulation and, are not limited to technical or technological matters. The CCRF helps to catalyze and facilitate international, as well as, regional and national, aquaculture and fisheries regulations. The CCRF is "soft law" although it does have legally a binding section, the Compliance Agreement.

The movement of live aquatic animals is a necessity for development of aquaculture on both, subsistence and commercial level. However, such movements increases the probability of adverse ecological impacts and introducing new pathogens, which can have direct consequences on culture and capture fisheries that can affect the livelihoods which depend upon them for subsistence. To facilitate introductions with minimal risks, it is essential to develop and practice a strong, national quarantine system with stakeholder participation. The major challenges are to obtain adequate information, develop the diagnostic capacity for diseases and assess the ecological and disease risks, to implement disease surveillance and to implement effective legislations.

The CCRF emphasizes conservation of aquatic genetic diversity and of the integrity of aquatic communities and ecosystems, and responsible use of living aquatic resources at all levels including the genetic level. The above activities lead towards the formulation of an international framework for the management of aquatic genetic resources. Such a framework is necessary so that common strategies for improved assessment and management can be developed. Specific strategies will be required for *in-situ* conservation of fish genetic resources on farms and in natural ecosystems, and for *ex-situ* conservation of fish genetic resources, including *in-vitro* gene banking of cryopreserved sperm, embryos and tissues.

Regulatory mechanisms for introduction of exotic species

With the rapid development of the aquaculture sector, the demand for new candidate and diversification has increased. Several exotic species have been introduced in India intentionally or unintentionally. There have been divergent views regarding relative pros and cons of these introductions. The country is blessed with ample fish resources and the introduction of undesirable aquatic exotic species is an emerging threat to our native/endemic fish diversity. It adversely affects the aquaculture production systems. Thus, a scientific requirement analysis based on decision support systems and import risk assessment is essentially required for future introductions.

In the regime of WTO, exotics and quarantine issues have tremendous significance in aqua trade. It is essential for us to be prepared for evaluating such exotic species under the

WTO agreement. To facilitate international trade of live aquatic animals and products, WTO has framed SPS agreement. According to this agreement, scientific evidence of exotics causing damage to the native fauna is required for restricting introductions of exotic species on the basis of ecological or disease risks.

Presently, all new trade agreements also underline the necessity for responsible movement of aquatic animals. In such a situation, the following suggestions have been made for preventing such unwanted introduction of exotic species

1. The provisions of the Convention on Biological Diversity with respect to aquatic genetic resources should be well defined
2. For creating awareness among the students issues related to conservation of aquatic genetic resources in the course curriculum in all education level should be introduced.
3. Utilization of indigenous knowledge and belief, and involvement of local communities in all conservation related works should be there.
4. For prohibiting entry of exotic species, stringent measures should be carried out to prevent the possible gene pool contamination of the native stock.
5. For the conservation and sustainable use of aquatic genetic resources the ecosystem approach including the incorporation of transboundary and cross-sectoral elements should be operationalized.
6. Different institutions and agencies should be entrusted national responsibilities for conservation and sustainable use of aquatic genetic resources.
7. For transplanting Genetically Modified Organisms in the natural water body, proper guidelines should be formed
8. All exports must be made known to the customs authorities of the importing country in advance of shipment.
9. Formulation of proper guidelines for the classification and taxonomy of aquatic resources.
10. Establishment of a nodal referral centre for the taxonomy of aquatic resources and national museum for the aquatic resources for creating awareness for conservation.

Desired policy element

To achieve the effective management of the aquatic genetic resources, certain policies should be formulated to address the following aspects for sustainable development and conservation of the bioresources.

1. State and National Universities/Institutions along with NGOs to take up awareness programmes amongst the local communities about the values of indigenous biodiversity and the need for its conservation and restoration.

2. To undertake restoration or rehabilitation of degraded or modified areas of habitats of indigenous fauna.
3. Creation of proper liaison with territorial authorities, other agencies and resource users for the protection of aquatic resources or habitats from inappropriate subdivision, use or development and also the isolation or fragmentation of ecosystems
4. Facilitate proper linkage between Ministry of Environment & Forests, Ministry of Fisheries and the Ministry of Agriculture for conservation of aquatic resources in the forests, marine reserves and other reserves in the Region
5. To oversee impacts of any construction in waterways on aquatic habitats, and in particular on the migration of aquatic fauna.
6. Guide to develop and maintain a regional database and indicative map of sites to the regional database of threatened species
7. Heritage protection which is another way of conserving the bioresources.
8. The policy should assure that no individual, institution or corporation can claim ownership over species or varieties of living organisms.
9. The policy should have proper guidelines to resolve the issues related to the granting of patent claims over organs, cells, genes, proteins, and other living matter whether naturally occurring or genetically engineered.

CONCLUSION

As the earth's population continues to grow, more resources will be needed. Desire for material goods continues to be a main goal for people, and these two elements combined places an increased pressure on mother earth. It is understandable that an increase in population is demanding more commodities, but with careful management of our natural resources, a sustainable balance can be achieved. Biodiversity may be the basis of human well-being but human habits threaten to deplete it. The most important drivers of biodiversity loss are unsustainable production and consumption, inequalities in distribution of wealth and resources, demographic developments, international conflict, and international trade and agricultural policies. These result inland conversion, climate change, pollution, atmospheric nitrogen deposition and unsustainable harvesting of natural resources. As ecosystems falter, threats to food and water security, health care and economies grow. In such cases, care should be taken for maintenance and enhancement of the biodiversity in a region, including the distribution and abundance of indigenous species and ecosystems. A consistent approach should be there throughout the world for identifying the issues related to the aquatic biodiversity conservation for protecting it from the future extinction. In such context, there is a need of proper management policy to be formulated and implemented so that the genetic

resources can be protected for the future use. For this purpose a close network between the government, non government organizations and the local communities should be there for effective implementation of the policy and proper utilization of the bioresources.

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