Past, present and future of stakeholders in marine fisheries and mariculture: the role and support extended by CMFRI

Gopalakrishnan A.
Director, Central Marine Fisheries Research Institute
E-mail: director@cmfri.org.in

Introduction

India is the second largest producer of fish in the world, contributing to 5.68% of global fish production. India accounts for 2.5% of the global fish market and the fisheries sector is a source of livelihood for over 1.44 crore people. During the 11th five year plan, the fisheries sector contributed 1.1% to the GDP. Contribution to agricultural GDP in the year 2014-15 was 5.3%.Total production during 2013-14 was 9.58 Million Metric Tonnes (MMT), (Marine- 3.44 MMT and Inland- 6.14 MMT).Overall growth in fish production in 2013-14 was 5.9%(Marine- 3.7% and Inland- 7.3%). Fisheries is one of the major forex earners with revenue reaching Rs.18,856 crore in 2012-13, accounting for about 18% of agricultural exports. During 2013-14 the volume of fish and fish products exported was 9.8 lakh tonnes, worth Rs. 30213.26 crores. The sector plays a vital role in the Indian economy through its consistent contributions to the GDP, besides becoming a vital source of livelihood for about four million people including 1.6 million active fishermen. The stakeholders include fishermen; mariculturists; seafood exporters, wholesalers, retailers and vendors in domestic markets; self-help groups; developmental department for fisheries in 9 maritime states and 4 UT's; Department of Animal Husbandry Dairying and Fisheries; financial institutions; researchers and academicians; policy planners; conservationists and all associated fraternities contributing to the cause of marine fisheries in the country. The Central Marine Fisheries Research Institute (CMFRI) established in 1947 conducts research and development activities in marine fisheries sector supporting all these stakeholders in different capacities directly or indirectly. This article looks into sector wise needs, future plans and research support for these stakeholders.

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Marine capture fisheries vis-à-vis mariculture

The marine fisheries sector of the country has changed tremendously over time.The fishing fleet has became larger and more energy-intensive, and the catch and trade of marine fishes has increased substantially. Concerned by the increasing fishing effort and the potential for overexploitation and depletion of several fish stocks in the country, the status of several fish stocks were assessed scientifically. Consequently, attempts were made to shift from open to regulated access fisheries through Marine Fishing Regulation Acts (MFRAs). However, conflicts in sharing the limited resources intensified within and with other sectors and this, in turn, had high economic, social and environmental costs. Thus, in recent years, the sector has recognised the need for effective management for sustainable fisheries and a healthy marine environment through ecosystem

Fig.1: Fishing occurs on market demands not driven by regulations unless implemented strongly

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approach and habitat restoration. These changes are encouraging, but across the country, unsustainable fishing is still practiced, causing major concern (Fig.1). Meanwhile attempts were also made to develop hatchery and farming technologies of marine species to augment production, but these did not meet with success initially except for large scale farming of brackish-water shrimps. In recent years, however, success has been achieved in mariculture, raising hopes of producing plentiful fish in future from farming marine fish.

Knowledge of the direction, pace and type of progress in marine capture fisheries and mariculture in the last forty years provides a clue to future progress of the sector. Over time, the fisheries sector is expected to be different from what it is now, but we do not know by how much and what differences there would be. One factor we are sure of, is the rise in human population and India emerging as the most populous country in the world. Coupled with the awareness of fish as a health-food, the demand for seafood would increase substantially. We are also sure that climate change will intensify and though climate outcomes cannot be precisely predicted, the probability of greater impacts due to climate challenge is rising. The distribution, abundance and phenology of fish stocks would have changed and there would be a novel mix of organisms, impacting the structure and functions

Fig.2: Cage culture is coming up well in the coastal States as an alternative to capture fisheries

of ecosystems and ocean productivity. While the compulsion to make available plentiful fish will continue, production will have to come from marine systems undergoing intensified climate change.

In a 'business-as-usual' scenario, fish catches in the tropics are expected to decline, and since most of the seafood comes from wild capture, such a situation will be detrimental to our food security. We have to change this situation by reducing our dependence on wild capture and instead, promote mariculture. Mariculture, the farming and husbandry of marine plants and animals in the marine environment, is the fastest growing subsector of aquaculture. Globally, mariculture produces many high value finfish, crustaceans, and molluscs. In India, the potential of mariculture production remains largely untapped. It has been realised that the vast coastal areas of our country are suitable for mariculture where high value finfish, shellfish and sea plants could be farmed. Presently, standardised hatchery and farming

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technologies are available only for a limited number of marine fmfish and shellfish species. Hence there is a need to enhance mariculture production from a large number of marine species, extend areas of marine farming, and introduce new production systems (Fig.2). The increased application of biotechnological tools such as transgenesis, chromosome manipulation, cryopreservation, gene banking and marker-assisted genetic improvement can revolutionise production of farmed marine fish. Over a period of time, the proportion of production from coastal and marine aquaculture should be aimed at 40% and in terms of value, at 70% of the total output.

Any planned development needs appropriate policies, legislations and acts. As the existing policies are inadequate to meet the anticipated challenges in the sector, it is important to develop effective new policies. In mariculture, there is a need for developing leasing policies and other regulations.

By following state-of-the-art practices and effective planning, it is possible to achieve blue revolution. The government's role is to manage the fisheries assets on behalf of societies and to derive maximum benefits for future generations. The role of research institutions such as the Central Marine Fisheries Research Institute (CMFRI) is to provide scientific support and suggestions to the governments, and do reality checks while undertaking the journey. A sustainable fisheries sector is essential for ensuring seafood for all and forever (Fig. 3).

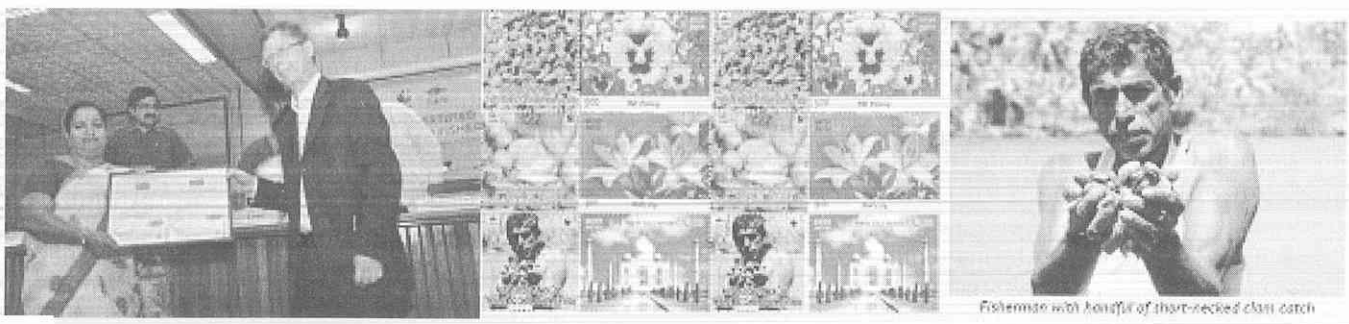

Fig.3: Marine Stewardship Council certification to Ashtamudi short neck clam is an example of effective community based management in marine fisheries

Way forward: Technologies envisaged for our marine environment and associated stakeholders

It is being increasingly recognised that marine ecosystems have manifold services, much beyond what we have been using so far. Aquatic resources are now regarded as major contributors to provisioning services that include health-food supply and pharmaceutical products. There are tremendous opportunities to advantageously make use of the rich biodiversity and supporting services of our seas to meet the emerging demands of humankind. Since biodiversity and ecosystem functioning are inextricably linked to human societies, we have to value the services of marine biodiversity and ecosystems, considering the growing costs of biodiversity loss and ecosystem degradation. A greener environment with enhanced ecosystem services will be beneficial to the ecological and human well-being.

However, the current operating environment in marine fisheries is focused on short-term profits and livelihood instead of long-term sustainability and profitability. This 'business' environment is harmful to the oceans, fishermen, traders, consumers, and the coastal communities. Fishermen need predictable and stable access to fisheries and a flexible management regime that allows them to improve their financial security while safeguarding the invaluable marine ecosystems.

India's marine fisheries sector is poised for greater opportunities as well as challenges in the years to come. On the benefit side, India is contemplating extension of EEZ up to 350 nautical miles from the present 200 nm which will result in a physical operating environment much larger than the land mass of India. This will increase our resource base tremendously which needs to be quantified scientifically by way of exploratory surveys and remote sensing for sustainable utilisation and management of the resources. This necessitates upgrades in infrastructure and introduction of innovative technologies for fishing and mariculture. These enhanced capabilities will also enable India to explore and harness the immense

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resources of the Southern Ocean. These opportunities are likely to revolutionise the operating environment of the Indian fisheries sector and compensate for the likely scarcity of animal protein from terrestrial systems.

With the growing importance on ecosystem services, lot of importance will be given to biodiversity conservation and biotechnological interventions. India being very rich in marine biodiversity, has many opportunities for providing monetary benefits to the coastal communities through benefit sharing from biodiversity conservation. The profit should motivate the community to conserve biodiversity. A consortium of biodiversity conservationists, biotechnologists and communities will change the operating environment of the sector from solely fishery dependent activities to "earning from biodiversity conservation".

With the anticipated addition of Marine Protected Areas, marine sanctuaries and no-fishing zones, a large number of fishing communities are likely to be displaced. As a result, we are likely to see an outflow of skilled human labour (fishing communities) seeking a non-risky and sustainable livelihood option and inflow of un-skilled migrant labourers from non-coastal States into marine fisheries.

On the down side, increasing marginalisation or even complete disappearance of traditional fishing communities and small-scale fishermen is likely. The changes in species composition, distribution and abundance of fish stocks due to climate change impacts are likely to alter the fishing types, costs and benefits. As these changes will be beneficial to larger boats with greater mobility, small-scale fishermen may find fishing unviable. With the anticipated addition of Marine Protected Areas, marine sanctuaries and no-fishing zones, a large number of fishing communities are likely to be displaced. As a result, we are likely to see an outflow of skilled human labour (fishing

Fig.4: Diversifying the species in marine ornamental fish trade by promoting hatchery techniques.

communities) seeking a non-risky and sustainable livelihood option and inflow of un-skilled migrant labourers from non-coastal States into marine fisheries. Increased mechanisation and correspondingly increased dependence on fossil fuels will occur. Thus the operating environment in the capture fisheries sector would see an increasing cost of fishing coupled with scarcity of skilled manpower. Consequently, the government agencies will have to either increase financial flow or attract funds in to the sector to meet the requirements (labour, capital and infrastructure) of the transformed industrialised marine fishing sector.

Along with all the changes in the capture fisheries sector, a progressive shift towards fish farming is also anticipated to change the operating environment. Development of an entirely new set of technological interventions and infrastructure like state-of-the-art hatcheries, feed mills and ancillary facilities will be seen with changes in the entrepreneurship, trade and societal responses.

For sustainable mariculture in the country, the mariculture practices should aim at optimum production and maintain a 'green environment'. The lessons learnt from shrimp farming are an eye opener as intensive shrimp farming resulted in environmental deterioration and consequent disease problems which called for a need for 'Better Management Practices' and species diversification. A green environment necessitates the need to adopt Ecosystem Approach to Aquaculture (EAA) by taking into account the knowledge and uncertainties of biotic, abiotic and human components of the ecosystem including their interactions within the ecologically and operationally meaningful boundaries. In many areas, there is lack of diagnostic support for mariculture. The farmers should be educated on the negative environmental impacts that will in turn affect their production. In this regard, establishment of SPR and SPF brood facilities can go a long way to avoid the environmental health hazards to farmed fish species. An SPF certification is therefore important. Finally, carrying capacity assessments are essential before any species is farmed either in the sea or land. This is particularly relevant while expanding sea cage farming in the country. The total number of cages in a given area, stocking density of fish per cage, and feeding intensities should be taken into consideration.

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All the changes envisaged in the operating environment will result in a broader scale of operation with changes in the composition of stakeholders. The anticipated open trade of fish and fish products will add another dimension to the sector which warrants an increase in India's competitiveness and bargaining power in international trade.

The changes in the operating environment of the marine fisheries sector will have to be transformed into opportunities. This, along with technological advances in other sectors such as remote sensing and biotechnology, provides an environment for holistic development of the marine fishing sector which benefits the fishermen and the environment.

Globally, marine finfish seed production and farming has expanded very fast in recent years. In India, research on seed production has gained momentum; however, we are far behind not only on a global level but also in the Asia-Pacific Region. The urgent need is to develop and standardise seed production and farming techniques for at least two dozen species of high value marine finfish within the

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next ten years so that the farmers will have a choice for selection of species. India, being rich in marine biodiversity, can offer a plethora of species for mariculture for which suitability tests need to be carried out by the R&D sector. It is possible through concentrated R&D efforts to enable diversification of potential mariculture species. Until the time seed production techniques are standardised, Capture-based Aquaculture (CBA) or the practice of collecting seed material from the wild is an option to address seed scarcity for mariculture. Extensive surveys to assess the abundance of seed of high value marine fin and shellfishes at various locations in the country need to be undertaken. Large-scale collection and conditioning of wild collected seed and establishment of seed banks are urgently required. This will enable farmers and entrepreneurs to get the required seed.

On a global level, marine ornamental fish trade has emerged as a multi-million dollar enterprise. There is scope to develop breeding and seed production technologies for a number of species which have high market demand, and develop trade for hatchery produced marine ornamentals in India. The techniques for breeding more than a dozen species of ornamental fishes have already been developed by CMFRI and research focus is needed to develop technologies for more species since the trade is based on diverse species (Fig.4). Parallel to this, establishment of small-scale ornamental fish hatcheries can lead to income generation for rural communities. By formulating appropriate policy regulations and guidelines for wild collection of species as exemplified by the international agencies like the Global Marine Aquarium Database (GMAD) and Marine Aquarium Council (MAC), and developing commercial production of selected species through available hatchery technologies, India has the capacity to emerge as one of the major source countries for marine ornamental fish trade.

Seaweed farming offers immense scope as livelihood opportunity and for developing a large number of byproducts with several applications. Seaweed farming has the advantage of low capital input as it is a primary producer requiring no feed inputs. Additionally in future years, seaweed farming can earn carbon credits to the farmers. In India, seaweed farming is at its infancy even though we have technologies for farming many species. The current industrial demand for raw material is not met by farmed and wild collected seaweeds. Hence, research and development thrust is needed to address the issues facing seaweed farmers and to popularise seaweed farming in India.

The production of algal biofuels is a novel area of research in India. Algae are known to produce more oil per unit area than conventional oil crops. Research on production of biofuels from microalgae is being carried out in many countries. India too needs to explore the opportunities of production of fuel from algae since we have a diverse and rich microalgal resource and suitable environmental conditions for large scale culture. Instead of land-based facilities, innovations that allow direct inoculation of microalgae into the sea, culture of microalgae in the sea and subsequent harvest should be developed.

On a global basis, breeding, seed production and farming technologies have been developed and commercialised for many marine species. A lot of innovative products and technologies are available in a few countries. In this context, instead of reinventing the wheel, it is worth collaborating with countries that have advanced in this field. It is also advisable to seek the support of national agencies in the country.

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Globally, a lot of advancements have taken place in the area of biotechnological interventions for mariculture, biodiversity conservation, environmental management and product development. In this context, collaboration with leading research organisations having cutting edge technologies such as DNA vaccines, transgenic fish, bioremediation, algal biofuels, bioprospecting, and omics- sciences is needed.

Improving the domestic markets and supporting the stakeholders involved in selling fish

An overhaul of the domestic fish marketing system is envisaged for better returns to the fishermen and continued economic viability of the sector. A Sophisticated Market intelligence and Information System using a combination of real time data and ICT needs to be established. Establishing a National Fish Marketing Council which will spearhead changes in the domestic fish marketing system is crucial. A domestic fish marketing grid will help fishers to receive the maximum share of consumer's rupee. This grid will enable the producers to sell their catch in a market where they get good net profit. The advanced market intelligence system ensured by the fish marketing grid will pave the way for profitable vertical and horizontal market integration.

Regulation of domestic fish market (price, inflow, outflow, unsustainable fishing practices) through market driven incentives, new marketing strategies (live fish market), online marketing and future trading in marine fish through well-developed market grids are some of the opportunities. All these developments should be bolstered by an increase in private capital formation in fisheries vis-à-vis public investment (upgradation of berthing facilities, development of onshore infrastructures like large-scale storage, etc.) in fishery infrastructure. Besides, investment in production of value added products will serve the needs of domestic consumers, who will be looking for ready to cook or eat items only due to their professional commitments.

The fisher's households do not get a sustained income throughout the year due to various factors such as closed seasons, natural calamities like cyclones and other related factors, which affect their livelihood seriously. Hence supplementing income through any alternate livelihood options (ALO's) is very much essential. Various ALO's are being studied, suitable to the location and their capability. Mariculture or sea cage farming including sea weed farming, repairing of crafts and gears are a few areas of ALO's which have proved successful. The ALO's will be successful only when it is linked with sustained market potential. Biodiversity conservation and the benefits arising out of that such as mariculture of non-conventional species (sponges, holothurians, gastropods etc.) could be developed as an alternate livelihood option for affected coastal communities. Bioprospecting from the marine ecosystems on a public-private partnership with active involvement of local communities is also another viable option. Carbon trading options for fishermen and fish farmers also must be explored. Developing successful rehabilitation models for launching any capital intensive labour displacement (alternate livelihood) is also essential.

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Targets and indicators for capture fisheries and mariculture will have to be identified for each approach. For example; annual production target of 6 million tonnes from coastal fisheries and offshore fisheries, and 1 million tonnes from mariculture may be fixed for the next 10-15 years.

Research institutions, governments and non-governmental organisations looking for achieving the vision of *Seafood for all and forever* should consider a suite of appropriate approaches that will rebuild fisheries and ecosystems that can create incentives for stakeholders and lead to environmentally and economically sustainable fisheries and mariculture. Clear communication and engagement with all stakeholders can contribute crucial information to the Vision and help overcome potential initial resistance to some of the approaches. Targets and indicators for capture fisheries and mariculture will have to be identified for each approach. For example; annual production target of 6 million tonnes from coastal fisheries and offshore fisheries, and 1 million tonnes from mariculture may be fixed for the next 10-15 years.

Strategies for a better tomorrow

Marine fisheries seeks to achieve improved

economic benefit through smarter use of our fisheries resources and ecosystem services, and provides for increased non-commercial benefits, while protecting the health of the fishery and the marine environment. To support and meet the goals, a strategic plan for each approach is needed. The strategic plan is to bring current and new works together in a comprehensive programme through consultations and engagement with institutions and stakeholders to provide direction for the sector.

The framework for the strategy of preparation and implementation of plans should be characterised by participation of a large number of national research and development organisations, consultations with regional and global organisations, and stakeholders such as fishermen associations, traders, processors, environmentalists, conservationists etc. The role of each participant should be clearly defined when developing the strategy documents. It is important to recognise that the envisaged goals can be achieved only by participation of several relevant non-fishery sectors working closely with the fisheries sector.

Several tropical countries in the region are adopting advanced regulations, legal and policy framework for effective management of fisheries sector. Learning from these countries will give valuable information to manage our fisheries

Collaboration with survey agencies for information and infrastructure support, fishing industry for skilled human resource for exploration and harnessing of offshore resources is important. For integration of remote sensing in fisheries and spatial management, collaboration with the space research agencies, oceanographic laboratories and numerical modelling groups are needed. To operationalise the domestic fish marketing grid, collaboration with regional fisheries research, education and developmental organisations is necessary. Policy formulation and implementation support from government agencies are essential to meet the goals.

The relevance of existing research institutions and their priorities may have to be revised. New institutions and centres of excellence may have to be established to address the need for state-of-the art technologies.

In the production process, the services of the ecosystem are often ignored mainly because they are not valued. To overcome this lacuna, valuation of ecosystem services (the valuation of biodiversity, recreation value, and occupational value) is very much essential. In this context, collaboration with environmental economics research institutions need to be sought with an aim to pave way for incorporating natural capital accounting / green auditing in our GDP estimates.

To address the challenges, it is necessary to have a strong scientific support. Research institutions such as CMFRI should devise and execute projects to meet the goals of the Vision. The relevance of existing research institutions and their priorities may have to be revised. New institutions and centres of excellence may have to be established to address the need for state-of-the art technologies.

With novel technologies to be integrated into the marine sector, we need to upgrade the skilled human pool in scientific research for seamless integration in areas such as remote sensing in fisheries management, valuation of ecosystem and biotechnological applications in mariculture and bioprospecting. This calls for inter-disciplinary trainings and repeated exposure to cutting edge research methods including training on use of latest research equipment and software. Human resource development should also be paralleled by upgrading research infrastructure. It is essential to train our scientists and technicians on the latest technologies in mariculture and biotechnology. Similar to research, the fishing industry will also be undergoing major changes with increasing industrialisation which would require skilled manpower and capital investment.

Resource management can succeed only with the involvement and participation of all the stakeholders in the sector as well those from relevant non-fishery sectors. This involves developing vital links with all stakeholders.

The contribution of fisheries to nutritional security, economic growth and livelihoods is often ignored. The priority is in convincing governments that the sector has an important role to play in the national development process by contributing to growth process in a substantive manner; and include fisheries and aquaculture in national development agenda. In this regard, it is essential to attract massive investments, and to increase the public and private capital formation in the fisheries sector, which will help achieving the goals envisaged.