

Sustainable aquaculture

to ensure food security

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During the period of past four decades, there is a rapid progress in aquaculture development all over the world particularly in the South-East Asian countries. Owing to new innovations and technological advancement in aquaculture, production has increased. Though aquaculture is a small-scale enterprise, in recent past it has emerged as a major growth sector in fishery industries. Now it is speculated that while there is a little scope for increase in fish production through intensifying capture fisheries, only alternate way of increasing fish production is by means of sustainable system of aquaculture. It is now most essential to maintain and if possible, increase the rate of growth of aquaculture to ensure food security for burgeoning population all over the world particularly in developing nations.

Key words: Aquaculture, Sustainable fish farming, Shrimp farming

IN order to accomplish adequate fish protein to rapidly growing population, raising fish through aquaculture practices have become more promising than any other method.

A number of problems and issues, which will be of complex nature, may come up while dealing with aquaculture as a large-scale activity. The most important issue is supply Vs demand. But behind this, there are economic issues, which are critical, and then we have social, biological, environmental and ethical ones, which must be sorted out and resolved with the minimum of conflict and waste of resources or to state it positively, to be resolved in the spirit of social harmony and environment sustainability.

South East Asia, having aquaculture as an important activity, continues to be the dominant region in the world in terms of production. According to South-East Asia State Fisheries and Aquaculture report, there is an increase in the world's human population from 6.1 billion in

2000 to 7.3 billion in 2014 and further in 2018 it has become 7.7 billion which has led to the world's increasing demand for fish to sustain food security requirements. From 2000 to 2018, the aquaculture production at global level has continued to grow at an average rate of more than 7% annually. But according to FAO, the annual growth rate of aquaculture has been reported to the tune of 5.8% during the period 2001–2016, however, aquaculture continues to grow faster than other major food production sectors, but it no longer enjoys the high annual growth rates experienced in the 1980s and 1990s. Also, the disparity in the level of sectoral development and uneven production distribution remain great among the countries within the regions and across the world. Today the world aquaculture production has reached to the tune of 80.0 million tonnes. Asia is the biggest aquaculture producer with production that accounted for more than 90% of the world's total aquaculture production, out of which

aquaculture production from the Southeast Asian countries accounted for around 22%. India is also an important country that produces fish through aquaculture in the world. India is home to more than 10% of the global fish diversity. Presently, the country ranks second in the world in total fish production with an annual fish production of about 9.06 million metric tonnes.

All over the world, fish production from capture fisheries is continuously declining and in 2018 according to SEASOFIA's report, the production from capture fisheries was 79.30 million tonnes. In the Southeast Asian region also, capture fisheries continued to show declining trend, particularly for marine capture fisheries whereas aquaculture has shown steady increase in the production. Besides aquaculture's contribution to food security, it also plays very important role in terms of enhancing people's livelihood and generating income. Further, it also helps in reforming the practice of using low-value fish as feed to





Farmed shrimps (*Penaeus vannamei*)



Sustainable fish farming system

produce higher value aquaculture products, thus, enhancing the economic growth of all developing nations.

Indian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about 14 million people in different activities. Constituting about 6.3% of the global fish production, the sector contributes 1.1% to the GDP and 5.15% to the agricultural GDP. The total fish production of 10.07 million metric tonnes presently has nearly 65% contribution from the inland sector and culture fisheries.

Aquaculture production has been broadly classified into mariculture, brackishwater culture, and freshwater culture. Aquaculture in coastal areas is normally considered part of brackishwater aquaculture while aquaculture activities in cages or pens set in bays and lagoons are considered part of mariculture activity. In terms of aquaculture production in quantity during the year 2016, China ranks first with the production of 49.244 million tonnes and India occupies second position with the production of 7.3 million tonnes.

Mariculture

Mariculture in India, although limited to the farming of mussels and edible oysters undertaken in some coastal region of Kerala over the years, has successfully produced sea cage farming in recent years, initially

with seabass and most recently cobia, which has shown the prospects of commercial mariculture in the country. Mariculture, with technologies developed in the recent years, is an option for supplementing the marine capture fisheries and also gainful employment for the fisher folk in the coastal areas. Mussels, oysters and seaweeds have been the main component of mariculture, with some possibilities of crab and lobster fattening. Green mussel, *Perma viridis* and Indian brown mussel, *P. indica* are the two important mussel species viable in the country, the culture technologies of which have been standardized.

Brackishwater aquaculture

Brackishwater aquaculture in India is concentrated around the giant tiger prawn (*Penaeus monodon*) as the single most important species. The culture of exotic, white leg shrimp, *Penaeus vannamei*, however, has attracted the farmers' attention because of its fast growth, low incidence of native diseases, availability of Specific Pathogen Free (SPF) domesticated strains and culture feasibility in wide salinity range. With the production levels of 10–12 tonnes/ha/crop of 3–4 months duration the production of this species has reached to a level of 10,470,516 tonnes during 2012–13.

Freshwater aquaculture

Aquaculture in India has evolved as a viable commercial farming practice from the level of traditionally backyard activity over last three

decades with considerable diversification in terms of species and systems, and has been showing an impressive annual growth rate of 6–7%. While the carp-based freshwater aquaculture, mainly constituted by the Indian major carps, such as, catla, rohu and mrigala, has been contributing over 90% of the aquaculture production satisfying the domestic need, the shrimp-based coastal aquaculture contributes to only about 5% of the export earnings. By modernization of aquaculture practices and adopting innovative technologies aquaculture production has achieved new heights and in recent years the production has gone up to 6.577 million tones. In terms of export value also aquaculture is contributing more than 60–65% of the total Indian seafood export (more than ₹ 30,000 crores).

Aquaculture as a scientific farming activity in India started only in 1980's. Today India has emerged as the third top producer in the world. Only China and Japan are ahead of India (FAO, 2016). SEASOFIA report in 2017 stated region wise requirement of fisheries products, considering the growth of the population by the year 2030. Taking into account the population trends, Asian countries need to increase their fish production in the range of about 15 to 20 million metric tones depending on the annual growth rate of population (2.5 to 4%).

So far, the world as a whole made a significant progress in fishery production over the last three



decades. Total production increased from 39.1 million tonnes in 1961 to 170.9 million tonnes in 2016. Its fastest growth was seen in the last five years with an average annual rate of more than 5.0%. From the analysis made above by 2030 we may require to increase our fish production additionally to the tune of 30.0 million tones to meet the minimum demand vs. supply.

Aquaculture development

Recognizing that over capitalization and increased fishing efforts are problems facing the fishing industry; many national governments have accorded high priority to aquaculture development, especially in order to reduce fishing pressure on exportable species. Therefore to augment the aquaculture development there is an urgent need to evolve proper strategic plans so that sustainability of the system and nutritional and food security could be ensured in future. To achieve this target the key elements involved in this sector which may we may have to look into are discussed here.

Investing in mass education and training: Investments in education and training are most essential to build awareness, knowledge, skill and attitude of all the people involved in aquaculture activity. Participatory approaches to curriculum development, cooperation between agencies and institutions, multidisciplinary and problem solving approach to learning, use of modern trends in training, education and communication tools are some of the important aspects, which are essential to be included while investment.

Investing in R and D: This target can be achieved through the mechanism of collaborative multi-disciplinary research, participation of industries for prioritization of research areas, efficient linkages between research, extension and producers, and continued effort to build the skills of researchers involved in aquaculture development.

Improving information flow and alleviating poverty: Improved information flow and communication system at national, regional and inter-regional levels. This will help in

avoiding duplication of efforts and save costs, while encouraging consistency in areas such as education and training, policy making, planning and the application of rules and procedures. This kind of system will increase institutional capacities for dealing with emerging issues and can be achieved by sharing data and information, strengthening national capacity to determine data requirements and data selections and management, providing effective mechanism for access to relevant and reliable information to all the stake holders, effective use of new technologies to improve information flow and management policies and practices within aquaculture. The collection and dissemination of accurate and verifiable information on aquaculture may help to improve public image.

Improving environment sustainability: Climate change is another important global issue that has created impacts on aquaculture development. The variability of weather conditions, prolonged hot conditions and draught, intense/stronger storm surges are just but a few factors that would most likely influence options for aquaculture. A rising water temperature and adverse rainfall patterns will affect the physical, chemical and biological quality of the water such as the dissolved oxygen, salinity, pH, nutrients and plankton dynamics. As such, greater impact will be experienced for those activities in the open environment like floating net cages in lakes and estuaries as well as in the open sea. In addition, the frequent change in water parameter is likely to create increased turbulence hence higher cost to install or maintain infrastructures to hold the fish. There is an urgent need to develop and adopt policies and practices that ensure environment sustainability and also rural development through eco-friendly sound technologies and resource efficient farming systems related to carrying capacity of the area and integration of aqua farms into coastal areas development and inland watershed management plans.

Integrating aquaculture into

rural development: Compared to agriculture and animal husbandry, aquaculture is a relatively recent and under developed sector but has huge unfulfilled potential in the country. Aquaculture could improve food security, provide employment opportunities and contribute to sustainable livelihoods for the poor through, enforcing rural development oriented aquaculture policies wherever appropriate, disseminating information about nutritional advantages of fish to vulnerable group of people and their families, greater use of holistic approaches to identify the poor and assess their needs and extend aquaculture technologies appropriate to the resources and capabilities of poor house holds, public support for the development of small scale aquaculture and empowering poor stakeholders to actively participate in policy decision making.

Strengthening institutional support: One of the important aspects of the growth of aquaculture is the requirement of a strong establishment of the institutional capacity to implement the policies and regulatory frame works, which should be transparent and enforceable. Economic aspects should be given more attention in planning and management of aquaculture development. Providing education and training, research and extension services involving government, public sector agencies, private sector and NGO's should be strengthened to support and improve aquaculture management, develop mechanism and protocol for timely collection and reporting of data, sharing information on policies, legislation, rules and procedures that encompass best practices in aquaculture.

Applying innovations in aquaculture: Aquaculture biotechnology and other technological innovations are showing a positive impact on aquaculture development. Improved exchange of information and discussion between scientists, researchers, and producers from different regions on their problems and achievements will undoubtedly



help this important sector in achieving sustainable productivity of aquatic animals globally. Many modern biotechnologies are based on rapidly evolving knowledge of molecular biology and genetics. The major biotechnology sectors involved in aquaculture are similar to those for agricultural sectors. Development of the knowledge required to optimize safe biotechnological innovation in aquaculture is of particular significance, and presents a unique set of challenges, due mainly to the diversity of species cultured and production systems used.

Investing in aquaculture development: Information on new innovations and technologies for sustainable aquaculture development should be developed and made available to the farmers/industries/users. The potential areas for further development should include technologies for sustainable stock enhancement and ranching programmes and open sea-farming, increased use of aquatic plants and animals as nutrient stripping, emphasis on integrated systems to improve environmental performance, development of newer technologies (recycling of waste, offshore cage culture, integrated water use, artificial upwelling and ecosystem food web management etc.)

Improving culture based fisheries and enhancement: One of the promising fields for increasing fish production is the culture based fisheries using both inland and coastal water resources. The full potential from culture based fisheries could be achieved by providing appropriate R & D inputs, managing environmental and other external impacts, promoting effective linkages to sustain investment in common pool resources.

Aquatic health management: Disease, a burning problem for the growth of aquaculture, require to be tackled to prevent disease attacks for a sustainable growth of this sector. This can be achieved through, effective policies and regulatory framework on introduction and movement of live aquatic animals and products to reduce the risk of spreading pathogens, developing and

implementing an effective national disease reporting system, mechanism of collection and analysis of disease information, developing modern scientific disease diagnostic methods which should be accurate and sensitive, safe therapeutants, and effective disease control methodologies, promoting holistic system approach to aquatic animal health management, developing alternate health management strategies such as use of disease resistant domesticated strains to reduce impact of disease. Since 2009, the emergence of a new disease, currently termed acute hepatopancreatic necrosis disease (AHPND), has stirred financial havocs among major shrimp producing countries in Southeast Asia, especially in Viet Nam, Malaysia, Thailand, and the Philippines. Aside from AHPND, farmers have been faced with urgent pressures ascribed to the emergence of newly emerging diseases like the hepatopancreatic microsporidiosis (HPM) and covert mortality disease (CMD), among others (SEASOFIA, 2017). AHPND, recently identified as the most serious disease of cultured penaeid shrimps in the tropics, has been mainly implicated in mass mortalities of the white leg shrimp (*P. vannamei*) but has also been reported in tiger prawn (*P. monodon*) and fleshy prawn (*P. chinensis*). Trans-boundary diseases, including AHPND, encompass concerns concomitant to economic, trade and food security for a considerable number of countries. The rapid spread of pathogens to other countries may inadvertently reach epidemic proportions thereby requiring pragmatic control strategies, including exclusion, through cooperation between and among several countries (SEASOFIA, 2017).

Improving nutrition in aquaculture: Nutrition and feeding strategies are very important for sustainable development of aquaculture sector. While developing feed more emphasis is needed for efficient use of resources (conventional and non-conventional), nutritional requirement of the

cultivable species, acceptability of feed, food conversion efficiency, reduction in feed waste and nutrient discharge. More attention has to be paid on feed economics to avoid competition with users. This can be achieved by better understanding of dietary nutrient requirement of cultivable species, development of brood stock diet, potential nutrient load and losses in aquaculture system, use of agro-industries and fishery bio-products and non-food grade feed materials, use of renewable feed ingredient sources, better understanding of nutrient bio-availability and interactions of commonly used feed ingredients, mechanism of nutrient modulation of disease resistance, strategies to avoid toxicity of nutrient by promotion of good aquaculture feed manufacturing practices and on farm feed management and selection and trade of scientifically tested good quality of raw material.

Applying genetics and molecular tools in Aquaculture and other biotechnology aspects: Genetics and biotechnology play a vital role in increasing productivity and sustainability in aquaculture through high survival rate, increased turn over, better use of resources, reduced production costs and also environmental protection. Recognizing that aquaculture has not benefited as much as terrestrial animal husbandry from the adoption of best practices such as selective breeding and stock improvement programmes, high priority should be given to this area of science. The strategies should include, developing and utilizing improved domestication and brood stock management practices, efficient breeding plans to improve seed productions of aquatic animals, application of genetic tools and genetically improved organisms, public awareness on application of the use of genetic technologies, biodiversity conservation, bio-safety measures, biotechnological innovations in areas of nutrition, health and environment management, addressing the potential implication of biotechnology for aquaculture including GMO and other products,



IPR issues and patenting of products etc.

Improving food quality and safety: In order to improve profitability, quality of the aquaculture products is an important aspect. Product safety and nutritional value of the product are secrets of aquaculture trade. This can be achieved by adoption of international food safety standards, protocol and quality system in line with international requirements, international protocol for residue monitoring in aquaculture and fisheries products and strict implementation of food safety legislation.

Promoting market development and trade: Success of any industry always depends on market development and trade tactics of value added hygienic products. The same can be achieved by reducing trade barriers for aquatic products, assisting aqua-industries in

identifying market for aquaculture inputs, development of information technology about market systems, regular assessing of changing consumers pattern, market trends, and emergence of new products in the market, proper dissemination of information about the product to consumer level etc.

Supporting strong regional and inter-regional cooperation: In the past several years bilateral relationship between the countries has supported a lot to bring considerable benefits for development of aquaculture either through dissemination of knowledge or expertise. In this era of globalization, further strengthening of this kind of relationship and cooperation will ensure increased benefits for sectoral development and sustainability. This can be achieved by formulating the policies which should strengthen the existing regional organizations, improve inter-

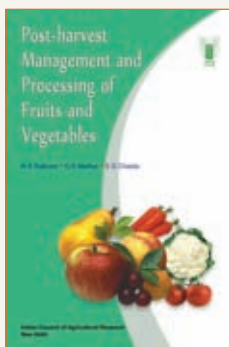
regional cooperation and net working between the nations and organizations for aquaculture developments, whenever it is needed and facilitate the country to support such activity.

Conclusion

Considering the importance of aquaculture development all over the world, now there is an urgent need that all the above mentioned issue should be addressed globally and for this there should be a strong establishment of a global inter-governmental forum within an appropriate existing international organizations, having sustainable aquaculture development as its primary focus and with a mandate for discussion, decision and agreement on technical and policy matters.

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Post-harvest Management and Processing of Fruits and Vegetables



Post-harvest management technology offers promising option for increasing production of vegetables and fruits quantity-wise and also in maintaining quality of the products. It involves all the activities that occur after production or harvesting of commodities, including procurement, removal of field heat, sorting, grading, packaging, storage, transportation, primary and secondary processing and marketing of agricultural products from farm-gate to distributors. This book is an effort to document vast available knowledge on the various aspects of post-harvest management and processing, and it will prove worthy for teachers, students and extension workers for understanding post-harvest management and processing of fruits and vegetables. It has 16 chapters covering storage, packaging, advanced preservation technology and value-addition of fruits and vegetables.

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