Best Management Practices in Aquaculture

Capacity Building and Policy Development

Edited by
Shiba Shankar Giri

SAARC AGRICULTURE CENTRE (SAC)
South Asian Association for Regional Cooperation

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Foreword

Aquaculture has been responsible for supply of fish for human consumption. At present the global supply of fish for human consumption has surpassed the population growth, resulting in increasing average per capita availability of fish. Almost 90 percent of the global fish production takes place in Asia and the South Asian countries mainly India and Bangladesh, respectively ranked 2nd and 5th in aquaculture production in the world. However, at present the major concerns of South Asian seafood export market are the strict enforcement of quality standards by the US and the EU, implementation of Codex Standards, HACCP regulations, social and economic issues.

As aquaculture is growing rapidly in South Asian Region conflicts with other resource users are also increasing. The conflicts mostly involve environmental and social issues, poor planning and bad management which have negatively impacted aquaculture. The governance of fisheries and aquaculture should coincide the Sustainable Development, the Sustainable Development Goals (SDGs), and the Paris Agreement of the Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change. Prospects of increasing aquaculture production can be achieved by developing Best Management Practices (BMPs) for voluntary adoption by the aquaculture industry in the South Asian region.

Much activity has been initiated globally on BMPs for improving environmental and social responsibility in aquaculture, but even more remains to be done if BMPs are to be effective for the intended purpose. **Best Management Practices in Aquaculture: Capacity Building and Policy Development** is published to share information on present practices in aquaculture in SAARC member countries, aiming to support capacity building and policy development for BMP in aquaculture by the member countries.

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Chapter 1

Best Management Practices in Aquaculture: Capacity Building and Policy Development- A Regional Overview

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World Aquaculture Scenario

Fisheries and aquaculture have become the sources of food and nutrition security and livelihoods earnings of millions of the world. At present the aquaculture and fisheries products are the most traded food commodity in the world with exports rising from US$8 billion in 1976 to US$148 billion in 2014, at an annual growth rate of 8.0 percent in nominal terms and 4.6 percent in real terms. These sectors possess tremendous potential to contribute significantly to food security and adequate nutrition for a global population expected to reach 9.7 billion by 2050. The capture fishery production is relatively static since the late 1980s and aquaculture has been responsible for the growth in the supply of fish for human consumption. The growth in the global supply of fish for human consumption is double (3.2%) than that of population growth (1.11%) in the past five decades, resulting in increasing average per capita availability of fish beyond 20 kg (FAO, 2016) of which aquaculture supplied 10.42 kg of food fish for human consumption. Fish accounts for about 17 % of the global population's intake of animal protein (FAO, 2016), and as high as 72 % in some of the South Asian countries (WorldFish, 2017). With annual 167.2 million tonnes fish production fisheries and aquaculture became the potential contributors to food and nutrition security and livelihoods at global level (FAO, 2016). The world total aquaculture production in 2015 was 106 million tonnes with an estimated farmgate price of US$ 163 billion. This total comprised of farmed aquatic animals 76.6 million tonnes (US$ 157.9 billion), aquatic plants 29.4 million tonnes (US$ 4.8 billion) and non-food products 41.1 thousand tonnes (US$ 208.2 billion) (FAO, 2017). Aquaculture currently provides about 44 % of the world's fisheries products (calculated from FAO, 2016 Report) and it is expected to share 50 % of world fisheries to keep up with the greater demand for fisheries products 189.1 million tonnes by the year 2030 (World Bank Report, 2014). It is estimated that by the year 2020 an additional 23 million tonnes fish will be required to meet the demand of the growing

population to maintain at least current level of per-capita fish consumption of 19.7kg in 2013 (FAO,2016).

Trade in fish and fishery products is largely demand driven and the developed world dominates world fishery imports. The fish and products trades are very often linked to technical regulations and standards that set out specific characteristics of a product. Lacking of adequate infrastructure, services, regulatory frameworks, institutional capacity, limited access to credit and a lack of accurate and reliable market information affect the quality and safety of fishery products, leading to their loss or difficult y in marketing.

Table: Top 15 Aquaculture producers in the World in 2014 (*production in thousand tonnes*)

Major Aquaculture Producers in the World	Total Aquaculture animals production (World position in parenthesis)	Total Aquaculture plants production	Total aquaculture production (World position in parenthesis)
China	45469.0 (1)	13362.3	58795.3 (1)
Indonesia	4253.9 (3)	10077.0	14330.9 (2)
India	4881.0 (2)	3.0	4884.0 (3)
Viet Nam	3397.1 (4)	14.3	3411.4 (4)
Philippines	788.8 (11)	1549.6	2337.6 (5)
Bangladesh	1956.9 (5)	…	1956.9 (6)
Republic of Korea	480.4 (14)	1087.0	1567.4 (7)
Norway	1332.5 (6)	…	1332.5 (8)
Chile	1214.5 (7)	12.8	1227.4 (9)
Egypt	1137.1 (8)	…	1137.1 (10)
Japan	657.0 (12)	363.4	1020.4 (11)
Myanmar	962.2 (9)	2.1	964.3 (12)
Thailand	934.8 (10)	…	934.8 (13)
Brazil	561.8 (13)	0.7	562.5 (14)
Malaysia	275.7 (15)	245.3	521.0 (15)

Source: FAO 2016

Scenario and Prospects of Aquaculture in the South Asia

Almost 90 percent of the global fish production takes place in Asia and the South Asian countries mainly India and Bangladesh, respectively ranked 2nd and 5th in aquaculture production in the world. Fisheries and aquaculture

remained as the second largest export earnings in Bangladesh, next to garments, and during 2013-14 the country earned 630.2 million US$. During 2015-16 the export earnings from fisheries and aquaculture was US $ 4.69 billion in India (DAHD, 2017), 253.1 million in Pakistan (during 2014-15), and 162.8 million US$ in Sri Lanka (in 2015). The transformation of the fisheries sector from traditional to commercial scale has led to an increase in fish production in South Asia. The historical scenario of Indian fisheries reveals a paradigm shift from marine dominated fisheries to a scenario where inland fisheries has emerged as a major contributor to the overall fish production in the country. At present inland fisheries has a share of 66.81% in total fish production of India and aquaculture shares over 63% of total fish production. In Bangladesh the contribution of Aquaculture is 55.15% of total fisheries production and is growing at 8.2% annually (APCAS, 2016). The last 10 years witnessed the tremendous aquaculture growth of 6-8% in the South Asian region. However, most forms of aquaculture are perceived to have adverse environmental effects (Tucker et al. 2008a, Klinger and Naylor 2012).

At present the major concerns of South Asian seafood export market are the strict enforcement of quality standards by the US and the EU, implementation of Codex Standards, HACCP regulations, social and economic issues. In South Asia aquaculture is a highly disorganized activity. Aquaculture, like other kinds of agriculture, is conducted on a variety of scales, and production methods vary greatly. As aquaculture is growing rapidly conflicts with other resource users are also increasing. The conflicts mostly involve environmental and social issues, poor planning and bad management which have negatively impacted aquaculture. Prospects for increasing fisheries production through aquaculture can be enhanced through efficient, environmentally responsible and standardized production techniques. In addition to improving performance, aquaculture would benefit from programs to improve its image with environmental advocacy groups, human rights organizations, and consumers (Boyd and Clay, 1998). Obviously, achievement of these objectives will require a great effort in research and development, extension, and public education and cooperation among many organizations with different and sometimes conflicting interests. Therefore, to improve the environmental and social performance of South Asian aquaculture the best short-term approach is to develop Best Management Practices (BMPs) for voluntary adoption by the aquaculture industry and to follow the FAO Code of Conduct for Responsible Fisheries (FAO, 1997). The governance of fisheries and aquaculture should be greatly influenced by the 2030 Agenda for Sustainable Development, the

Sustainable Development Goals (SDGs), and the Paris Agreement of the Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (FAO, 2016). Best management practices (BMPs) are increasingly regarded as meaningful goals in the overall reduction of cumulative impacts of agriculture (Clay, 2009). Much activity has been initiated globally on BMPs for improving environmental and social responsibility in aquaculture, but even more remains to be done if BMPs are to be effective for the intended purpose. BMP can encompass a wide variety of issues to include environmental impact assessment of various kinds of aquaculture in different countries, development of BMPs from existing data and from results of new studies, verification of BMPs, and efforts to enhance the implementation of BMPs.

Issues and Challenges in Aquaculture in South Asia

Environmental issues

- Conversion of important ecosystems like lakes, mangroves and agricultural lands to aquaculture farms
- Stalinization and pollution of land and water by effluents from aqua culture ponds
- Nutrient loading of coastal water bodies and estuaries
- Excessive use of ground water for filling ponds
- Transmission of diseases to the surroundings and neighboring ponds
- Introduction of exotic diseases which affects the native shrimp and fish species
- Excessive use of drugs, antibiotics, and other chemicals for aquatic animal disease control
- Inefficient utilization of fish meal and other natural resources for fish and shrimp production
- Negative effects on biodiversity caused by escape of non-native species introduced for aquaculture, and destruction of birds and other predators

Social issues

The social issues related to aquaculture are conflicts over use of land, water and

other natural resources. In South Asia many landless people live near the coast and depend upon fishing and harvest of other coastal resources for their living. Many times the big investors obtain the land through financial

or political influences. Local people sometimes are unable to develop small aquaculture projects in prime areas because the land is occupied by big companies. These people have sometimes been forced from coastal land by aquaculture developers.

Local people often develop small aquaculture farms in coastal areas without adequate technical knowledge and capital, and without proper permission from the government. Such projects sometimes lead to environmental damage, and they often are abandoned within a few years.

Construction of aquaculture farms sometimes interfere with use of traditional resources for local communities. Pollution by aquaculture farms also may result in a decline in fish and aquatic organisms important as a local food source.

The excessive use of surface or underground water by the large companies for aquaculture farming very often lead to controversy.

Pollution to the neighbouring agricultural farms due to conversion of fertile lands into farms is another issue in aquaculture. Drinking water gets contaminated due to pond effluents and salinization. This is the reason in 1996 the Indian Supreme Court banned the construction of shrimp culture ponds, other than traditional or improved traditional ponds, within the Coastal Regulation Zone (CRZ) and within a kilometer of Chilka Lake in Odisha and Pulicat Lake in Andhra Pradesh states. The court also directed to establish an authority for protecting the environment of the coastal area. Following to this the Government of India passed the Coastal Aquaculture Authority (CAA) Act in 2005. The Coastal Aquaculture Authority has been founded and resorts under the Ministry of Agriculture. The organization issues licenses to eligible farms, feed companies and hatchery owners.

Planning and management issues

Aquaculture Zoning: The main purpose of delimiting geographical areas within which aquaculture will be allowed is to address the issue of equity. This would seem to be particularly important for marine areas. The general notion in most countries is that the sea belongs to all. The issuance of aquaculture permits is contrary to this belief, and the very idea runs into opposition, and not only from direct users of the water areas concerned. When establishing a zone these issues must be addressed squarely.

Technology transfer: Transfer of technology in aquaculture among the SAARC member countries is an important aspect that needs to be given emphasis as th region possess two large global aquaculture players, India

and Bangladesh. Also, the technological advancements need to be transferred to small and marginal farmers with in a country to make aquaculture economically self-sufficient sector of food production.

Diversification of Aquaculture: So far only few candidate species are being aquacultured in the SAARC Region. Standardization of technologies for seed production for other many indigenous as well as exogenous finfish and shellfish and culture of sea weeds are other possibility of aquaculture diversification. Also, the diversification of aquaculture systems, cage culture, pen culture, raceway, flow-through, RAS can be new initiatives in aquaculture. Farm mechanization, pond automation, information and communication technology (ICT) through web service is identified as key areas to reduce the input cost, crop losses and to harvest healthy crops from the aquaculture ponds.

Genetically improved aquatic species: So far only a few genetically improved aquatic species have been brought into commercial aquaculture operations. But, the know-how to develop genetically modified fish is spreading. These genetically improved organisms (GMOs) should satisfy the desires of both the producers and the consumer. R&D efforts on Jayanthi Rohu have yielded fruitful results and introduction of GIFT Tilapia in India has opened up new vistas for genetically improved species.

Public-Private Partnerships: Another important aspect about the positive impact of aquaculture is the Public-Private Partnerships which can be seen in many areas of infrastructure development such as market facilities, cold storages, processing sector etc.

Aquaculture insurance: In view of the severe natural calamities and disease out breaks, aqua farmers are incurring huge losses. Introduction of Aquaculture insurance to all fish and shrimp ponds can encourage farmers for aquaculture.

Investments: Generally, there is low participation of private investors in the sub-sector due to various constraints in the procedures, lack of incentives, short term licenses with lengthy procedure for application dealing with several line agencies which cause he investigators discouraged.

De-silting and de-weeding of creeks, dredging of sea mouths: is yet another important aspect to allow free movement of water, and reduce the chances of pollution.

Seed Certification and accreditation programme is being implemented in few countries in the SAARC region, but it is necessary for developing BMPs.

Expansion of coastal aquaculture: Expansion has been given priority and the area near the coast which is hitherto lying fallow and assigned DKT lands are given Certificate of Cultivation in Andhra Pradesh state for a period of one year and which can be renewed. This will help many small and marginal farmers to take up shrimp/crab culture and teke out their livelihoods.

Infrastructure Development: Poor infrastructure development for post-harvest care and value chain maintenance in aquaculture hiders the huge demand of exports.

Issues related to export of aquaculture products

Fishery products are the most internationally-traded food commodities and they are subsequently at the forefront of food safety and quality improvement (Huss et al., 2004). Products from aquaculture are very often contaminated with harmful chemicals and biological agents. Consumers expect the best quality product in terms of appearance, freshness, nutritional value, size, price, safety and other characteristics. However, governmental regulations and inspections do not adequately assure the safety of the food supply in the SAARC region. The demand for improved quality and safety in the major markets of the European Union (EU), United States of America (USA), Canada and Japan have resulted in the renovation of fish inspection regulations for the implementation of HACCP-based systems, in conformity with the guidelines of the Codex Alimentarius Commission (CAC) (Neeliah et al. 2011). The USA seafood importing guidelines requires every seafood product imported to USA should have Country of Origin labeling (COOL) and Method of Production (MOP) labeling on the products, and the consumers are made aware since implementation of the guidelines in 2004 of where a seafood product originated and if it was the result of aquaculture or fishing. Therefore, the products exported to USA from South Asian countries very often face the pain of rejection, causing heavy loss to the exporters.

The indiscriminate use of antibiotics in shrimp cultivation emerged as a threat to the export of the seafood, which is a major revenue churner for the government exchequer. During 2017, 36 containers carrying shrimp shipped from Visakhapatnam and Nellore, India were returned by European Union countries as the consignment failed to match their safety standards because of its high antibiotics content. In the same year the European Union had rejected 10 shrimp consignments from India owing to the presence of banned antibiotics Furazolidone, Chloramphenicol and veterinary antibiotics residue in the Vannamei variety of shrimp (The

New Indian Express, October 25, 2017). Of the total fish exports of 11,34,948 MT from India in 2016-17 fiscal, 9,34,484 MT are shrimps and 60 per cent of it was from Andhra Pradesh, especially the Vannamei variety which is high in demand in the US, the EU and Japan. There is increasing Rapid Alert System for Food & Feed (RASFF) alerts from the European Union on the aquaculture exports from India and Andhra Pradesh. The recent spate of rejections has prompted the EU to increase their sampling percentage of farmed shrimp from India for border inspection from 10 to 50% since October 2016. The maximum permissible limits for antibiotic residues are different for different products in EU, USA, Japan and other countries. Therefore, there is need to process aqua products as per Standard Operating Procedures (SOPs) of importing countries to promote exports and also need for a mechanism for preventing usage of banned antibiotics in the aquaculture sector and strengthening the traceability in aqua products exports.

In the late 1970s the US Food and Drug Administration placed seafood imports from Bangladesh under automatic detention due to lack of sanitary facilities, technology adaptation and inadequate training to handle the products. In 1997, the fourth leading export item in Bangladesh was frozen shrimp and fish, with a 7.3 percent share of the total export market. The major importers at the time were the European Union (EU) accounting for 34–50 percent of Bangladesh's exports, the United States at 23–38 percent, and Japan at 15–26 percent. At that time the value per kilogram of Bangladesh's frozen shrimp was lower than average for the Asian region. Furthermore, Bangladesh had a reputation for producing seafood that sometimes did not meet minimum international standards as specified by the Codex Alimentarius Commission. With a low percentage of the world market, a lower-valued product, and a negative reputation in quality, Bangladesh had been a price taker, rather than a price-setter. Similarly, on July 30, 1997, the EU banned imports of fishery products from Bangladesh following to the EU inspections of Bangladesh's seafood processing plants. Inspections found serious deficiencies in the infrastructure and hygiene in processing establishments and insufficient guarantees of quality control by Bangladeshi government inspectors (Cato and Subasinge, 2003). The ban was estimated to cost the Bangladesh shrimp-processing sector nearly US$15 million in lost revenues from August to December 1997, the impact on both the industry and the economy of Bangladesh was substantial.

Pakistan's fisheries trade with European Commission (EC) came to a halt in April 2007 after the EU inspectors found systemic enforcement failure and serious deficiencies in the sanitary qualities of the fish, and the EU de-listed

11 seafood exporting companies. The ban cost Pakistan about US$ 50 million worth seafood products annually to the EU when the ban hit its trade. Pakistan's share of fisheries export to the EU markets was 26 percent of its global seafood trade in 2007 (Pak Tribune, 28 February 2013 report).

Sri Lanka's fish export to the EU was banned for 15 months, starting from February 2015, which the EU noted was due to a long standing failure to address serious shortcomings in the implementation of control measures, a lack of deterrent sanctions, as well as the failure to comply with international and regional fisheries rules. The ban was lifted in April, 2016 after the island nation changed its laws to fight against illegal, unreported and unregulated fishing. The ban weighed heavily on exports from Sri Lanka which used to be the second largest exporter of fresh and chilled swordfish and tuna to the EU with exports worth 74 million euros in 2013 (Asian Tribune, 22 April, 2016).

It is believed that the consumer would appreciate assurance about three major issues: (1) Is the product safe? (2) Is the product the result of environmentally-responsible production methods? (3) Is the producer socially aware? In addition, many consumers would be interested in the origin of the product, e.g., captured or fished by which nation.

Codes of Conduct and Management Practices in Aquaculture in South Asia

Practices thought to be the most effective practical methods of reducing environmental impact levels to those compatible with resource management goals are called BMPs (Hairston et al. 1995). The term practice refers to the structural, vegetative, or management activities needed to solve one aspect of a resource management problem. In some situations, a single practice may solve the problem, but usually a collection of practices or a "system of BMPs" is needed to provide effective environmental management (Boyd et al.2008).

India

Responsible aquaculture practices are being adopted in all the states of India with effective management for sustainable aquaculture development. The following management practices are being followed in the country:

Registration of Aquaculture

The states where aquaculture is in progress have stipulated strinngent measures to register the aquaculture ponds and regulate the activity. The

Departments of Fisheries in the states are responsible for registration of freshwater fish culture. The Coastal Aquaculture Authority, under the Ministry of Agriculture and Farmers Welfare, Government of India is responsible for regulating aqua-farming activities in coastal areas.

Establishment of National Freshwater Fish Brood Bank

A National Freshwater Fish Brood Bank (NFFBB) is established at Bhubaneswar, Odisha for production of quality and improved fish seeds Freshwater prawn (Scampi) brood bank is being established at College of Fisheries, Nellore, Andhra Pradesh. The brood bank for common carp (Amur) is being established at Karnataka Veterinary, Animal & Fisheries Sciences University, Bengaluru. Thestates like Andhra Pradesh has established databases and information networks to collect, share and disseminate data related to their aquaculture activities to facilitate cooperation on planning for aquaculture development.

Disease surveillance

Fish and shrimp diseases are constantly monitored by Disease Surveillance programme implemented under National Surveillance Programme on Aquatic Animal Diseases (NSPAAD) with the aegis of National Bureau of Fish Genetic Resources (NBFGR), Lucknow, Uttar Pradesh state. Some states have already established many aqua-labs for disease diagnosis and new aqua-labs are also being established in public sector in different states of India. There are also mobile aqua-labs are in operation in the country.

Chemicals and antibiotics use

Safe, effective and minimal use of therapeutants, hormones and drugs, antibiotics and other disease control chemicals are advocated. Several campaigns on banned antibiotics and usage of chemicals in a responsible way are conducted. Coastal Aquaculture Authority has listed and registered all the inputs used in aquaculture. Traceability system for antibiotic usage has been established. ELISA labs and Quality Control Labs are established by Marine Products Development Authority (MPEDA) in different states to test the sea foods export for antibiotic residues, Chloramphenicol and Nitrofurans. These quality control labs are upgraded to the standards of importing countries to avoid impediments in exports.

Quarantine measures

The introduction of exotic organisms for aquaculture carries a risk of introduction of exotic pathogens. Aquatic quarantine facilities established

for the purpose of the import of L. vannamei and operating at Rajiv Gandhi Centre for Aquaculture (RGCA) under the overall control of the Animal Quarantine Officer of the Department of Animal Quarantine and Certification Services, Ministry of Agriculture and Farmers Welfare. Based on guidelines developed by CAA only the registered shrimp hatcheries are permitted to import the exotic shrimp and to use the quarantine facility for obtaining import clearance.

Import risk assessment

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) stimulated global adoption of risk analysis to investigate disease risks associated with international trade. In 2003, India's Ministry of Agriculture and Farmers Welfare introduced IRA for evaluating risks associated with importing exotic species and developed guidelines for their culture. On that basis permissions are granted to import of the Pacific white leg shrimp, *L.vannamei* SPF broodstock, *P. hypophthalmus* and Tilapia.

Health certification of imported stocks

A detailed guidelines have been developed for the importers and the health certifications are issued to confirm the health status of imported stocks to prevent transboundary diseases. Importation of exotic shrimps and fishes is regulated by a high level committee under the chairmanship of the Joint Secretary (Fisheries), DAHDF, Ministry of Agriculture and Farmers Welfare, under the Union Government.

Environmental impact assessment (EIA)

Environmental impact assessment (EIA) is made as prerequisite prior to start of aquaculture operations in India. EIA is mandatory for farms larger than 40 ha. The Coastal Aquaculture Authority (CAA) regulates shrimp farms and prevents construction of farms on agricultural land, in mangrove or other sensitive areas. State Pollution Control Boards are responsible for implementation of EIAs by the freshwater aquaculture units. However, with more than 90 percent of Indian farmers are less than 2 ha land holders, and no new large farms currently under development, in practice the EIA is rarely applied (FAO-RAP PUBLICATION 2013/11).

Food safety standards

Food safety standards require control over the use of drugs and chemicals in aquaculture, traceability and record keeping, hygienic conditions of

aquaculture facilities and operations, monitoring, and worker training. The CAA, BIS and MPEDA are involved in setting guidelines and for implementation of seafood safety regulations. From 2003-2006 ICAR conducted an evaluation of seafood safety through its implementation of a 'National Risk Assessment Program for Fish and Fish Products for Domestic and International Markets'. In 2003, the Ministry of Health and Family Welfare issued Gazette notifications on permissible limits of chemicals and enteropathogenic microbes, which serve as benchmark in assessing seafood quality in the country. The Ministry of Commerce and Industry has also issued notifications, setting maximum residue limits for antibiotics, heavy metals and pesticides in fresh, frozen and processed fish and fishery products and issued a list of prohibited antimicrobials and chemicals in aquaculture in 2001. Moreover, MPEDA implements a national program on residue control planning, which includes monitoring and control of residues such as antibacterial substances, dyes, aflatoxins, pesticides, and heavy metals at all stages of seafood production (FAO-RAP PUBLICATION 2013/11).

Input quality assessment

Seed and feed are the primary inputs in aquaculture production. The CAA Act has standard setting provisions for all inputs used in brackish water aquaculture. A high-level committee chaired by the Fisheries Deputy Director General of ICAR has been constituted by the Ministry of Agriculture, charged with developing a comprehensive plan for regulation and use of 'aquaculture medicines. Fish and shrimp fish standards are developed by Bureau of Indian Standards (BIS) in collaboration with the ICAR institutions, CIFA, Bubaneswar and CIBA, Chennai.

Application of HACCP

In 1995 the Ministry of Commerce issued Gazette notifications adopting HACCP principles in order to maintain the highest quality standards for fish and fishery products as required by importing countries such as USA, EU member states and Japan. The Ministry of Health and Family Welfare, Government of India under the Prevention of Food Adulteration Rules in 2003 issued notifications on permissible levels of chemicals and microbes in fish and fishery products, which largely conform to EU standards.

Setting up of Farmer Producer Organisations (FPO)

Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India has identified farmer producer organisation registered under the

special provisions of the Companies Act, 1956 as the most appropriate institutional form around which to mobilize farmers and build their capacity to collectively leverage their production and marketing strength. FPO is created with a vision to build a prosperous and sustainable agriculture sector by promoting and supporting member-owned producer organisations, that enable farmers to enhance productivity through efficient, cost-effective and sustainable resource use and realize higher returns for their produce, through collective action supported by the government, and fruitful collaboration with academia, research agencies, civil society and the private sector.

Shrimp toilet and waste disposal system

As part of responsible aquaculture development in India and to see that aquaculture does not impose any harm to human health and the environment, certain provisions are being advocated to aqua farmers viz., establishment of 'shrimp toilets' and proper disposal of wastes, such as offal, sludge, dead or diseased fish, excess veterinary drugs and other unwanted chemical inputs into the environment.

Better management practices (BMPs)

In view of environmental and social concerns aquaculture management strategies are stated globally in the form of Codes of Conduct, Guidelines, and Better Management Practices (BMPs) in aquaculture. Though these codes are voluntary in nature, they can also be used as a basis for regulation or certification.

In India BMPs were collaborately formulated by MPEDA and the Network of Aquaculture Centres in Asia-Pacific (NACA) during 2000-2002 with a focus on control of shrimp diseases. This initiative led to the formation of the National Centre for Sustainable Aquaculture (NaCSA), a registered society under MPEDA with its headquarters at Kakinada, Andhra Pradesh and it is functioning as an extension arm of MPEDA and provides technical support to the primary aquaculture societies and build capacity among small farmers to produce quality shrimps in a sustainable manner.

a. BMPs in Shrimp Culture

The shrimp farmers are adopting better management practices which include bio-security, three stage water filtering mechanism is followed to prevent the entry of egg, larvae of predators and any other particulate matter into the farm, screening of seed for various pathogens through PCR,

introduction of nursery pond management, water treatment for reservoir, aerators, aerator pipeline at the bottom of nursery pond and effluent treatment of pond etc. The inlet water is filtered through 150 micron mesh before entering in to the reservoirs. The water in the reservoir is allowed to settle for 2-4 days. The suspended matter, silt etc. are settled at the reservoir bottom. There after water is treated with bleaching powder at 25 ppm followed by potassium permanganate treatment at 5 ppm to kill the animals and parasites which might carry virus and bacteria. After 3-4 days of treatments the water from reservoir is pumped into the Nursery pond through 60 and 40 microns mesh to prevent entry of finer particles into the Nursery ponds for the rearing of post larvae (PL). The culture ponds are fitted with a Central Drain System to let out the organic wastes accumulated at the centre of the pond (Shrimp Toilet) into ETP through underground pipe lines. The water quality of the nursery ponds are tested before stocking the PL. The stocking density varied from 25-40 PL per m^2. Farmers are using only pellet feeds to the growing shrimp as per the standard charts. Weekly sampling is done to check the health and growth of shrimp. Aqua farmers are maintaining the data recorded in the registers. The average Production is 8-10 MT/ha/crop. Two crops are being harvested per year. Total production from the farm per year is ranging from 16-20 MT/ha.

b. BMPs in Fish Culture

Fish farmers are also adopting best management practices which include nursery pond management, water quality management, stocking density and size of fish seed i.e.50-100 g size, and usage of pelleted feeds viz., sinking pellets and floating pellets for achieving higher production. The fingerlings (60-80 mm size) are reared in 1 Ac size ponds for 60-90 days to get advanced fingerlings of about 50 g body weight. The size of grow-out culture ponds vary from 1 ha to 40 ha. The pond preparations, such as drying, liming, manuring are done carefully and stocking density is maintained at 5,000-8,000 juveniles per ha. The production ranges from 5-8 MT fish/ha.

c. Capacity Building

With the rapid advancements in aquaculture technologies, the educational and knowledge status of most of the extension workers are inadequate and needs up gradation. Universities, colleges and training centres are playing important roles for developing a sustainable aquaculture and fisheries sector. A number of training programmes are organized in all the states to develop skills and competencies to foster sustainable aquaculture

development. Exposure visits, orientation courses, training programmes, refresher courses are already in existence. Several Fisheries Colleges, Polytechnic colleges are established in India for the development of skilled manpower for aquaculture.

Bangladesh

The Codes have been developed by the Bangladesh Shrimp and Fish Foundation (BSFF) reflects five key areas viz. social responsibility, human rights and labour rights, environmental sustainability, food and feed safety, and traceability.The Codes are intended to promote aquaculture production which meets international food safety standards, is sustainable, ecologically sound and socially responsible.

BSFF, in collaboration with DoF, has prepared Codes of Conduct for the various segments of the shrimp industry:

- Black tiger or Bagda shrimp (*Penaeus monodon*) hatchery
- Galda shrimp (*Macrobrachium*) hatchery
- Black tiger or Bagda shrimp (*Penaeus monodon*) farm
- Galda shrimp (*Macrobrachium*) farm
- Shrimp / Fish feed mill
- Shrimp collection and service centre or depot
- Ice plants
- Fishing boats
- Shrimp or fish carrier transport van / vessel

Recently, in February 2, 2015 Bangladesh has founded Bangladesh Food Safety Authority (BFSA) for tighter checks food safety and their marketing. Since its establishment BSFA has set up 71 safe food courts across the country, framed six rules including those on labeling, additives, sampling and testing, and formed 8 technical committees on various aspects of food safety (The Daily Star 2 February, 2018 Report).

Maldives

The following measures are already practiced in the Maldives' aquaculture development policy:

Aquaculture development focusing on locally available species: in order to manage biosecurity issues associated with transboundary movement of live aquatic animals, the aquaculture development shall focus mainly on locally available and sourced species.

Import allowed only for approved species: a pre-approval process is already in place for import of live organisms for aquaculture process. Only two species are included in the approved list at present. Although the sea cucumber, sandfish (*H. scabra*) is the only approved non-native aquaculture species as yet, this species has been introduced to the Maldives over two decades back and is now considered naturalized. The stringency in the conditions imposed for the import of live aquaculture organisms vary based on the results of a risk assessment.

Regular monitoring and reporting of effects on the natural environment will be made mandatory when the aquaculture regulation comes into effect.

Feeding and feed management: feeding practices and feed management measures shall be monitored to ensure adequate feeds are provided to the culture animals both in terms of quantity and quality of feed.

Further, new farmers need to be educated on best aquaculture practices for the sustainability of this new sector in the Maldives.

Bhutan

The NRDCA has produced best management practices for carp farming best suited for Bhutan's conditions and has been making efforts to disseminate them among fish farmers. In this regard, not much has been achieved due to, among other things, shortage of competent extension workers, lack of adequate funds, and inefficient institutional set up and stakeholders management mechanisms.

The codes of conducts and recommended management practices for carp farming in Bhutan basically:

- Discourages the release of farmed fishes into natural waters
- Provides guidelines to prevent outbreak of diseases on fish farms
- Manipulation of such aspects as feed types and feeding regimes, stocking densities and rates, etc. to enhance productivity
- Management activities to keep rearing loss at a minimum
- Discourages the use of chemicals and drugs for fish production
- Discourages the culture of fish species not approved for farming by the government
- Specifies the quality of fish seeds (size at stocking, etc)
- Provides guidelines to prevent harvested fish from spoiling prematurely (enhance shelf-life)

Sri Lanka

After the disease outbreak of white spot syndrome condition in the shrimp culture, many management practices came out. BMPs have been introduced in shrimp culture practice by NAQDA. Various activities were implemented during last few years and the main activities undertaken were dredging of Dutch canal; introduction of a crop calendar and zoning; formation of relevant rules and regulations and implementation; regulation of shrimp hatcheries and screening of post larvae of shrimp and broodstock. In addition, services are being provided at the shrimp disease diagnosis and health management laboratory at Battuluoya for shrimp farmers to detect shrimp diseases. Moreover, inter-calibration of PCR laboratories which engage in WSSV which is the main virus detected in Sri Lanka carried out by initiation of NARA with the expert consultation under the FAO.

With regard to ornamental sector, health certifications such as bacterial types and counts, especially for *Vibrio cholerae*, is requested by certain buyers prior to export of ornamental fish. This is to prevent the spread of disease through trans-boundary movements of live aquatic animals. The health certification for export of live fish is issued by the Department of Animal Health and Production in compliance with the infectious pathogens and diseases listed by the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Office International des Epizooties (OIE)

Institutional Setup and Stakeholder Involvement for Code of Conducts in Aquaculture in South Asia

The phenomenal growth of aquaculture in the South Asia is attributed to the institutes that are set up for aquaculture sustainability. The Indian Council of Agricultural Research (ICAR) has eight fisheries research institutes of which three focus on aquaculture: The Central Institute of Freshwater Aquaculture (CIFA) in Bhubaneswar focuses on freshwater aquaculture, the Central Institute of Brackish Water Aquaculture (CIBA) in Chennai deals with brackish water aquaculture and the Central Marine Fisheries Research Institute (CMFRI) in Kochi researches marine fisheries. Additionally, the National Research Center for Coldwater Fisheries in Bhimtal focuses on cold water fisheries and aquaculture, Central Institute of Fisheries Education (CIFE), Mumbai engaged in Fisheries and aquaculture education. The State Agriculture Universities having Fisheries Colleges, the state Departments of Fisheries and having inter-departmental tie-ups, and State Pollution Control Boards work for the development of aquaculture in India. Marine Products Export Development Authority (MPEDA) with head

quarters at Kochi, under Ministry of Commerce and Industry, Export Inspection Council for India, Coastal Aquaculture Authority of India, Bureau of Indian Standards and NFDB are competent authorities to prescribe codes and standards for aquaculture and products.

The Ministry of Fisheries and Aquatic Resources Development (MFARD) the Central government, Sri Lanka is entrusted with the responsibility of development and management of the fisheries sector. National Aquatic Resources Research and Development Agency (NAQDA) and National Aquatic Resources Research and Development Agency (NARA) are the two main institutions functioning under the MFARD, Sri Lanka pertaining to aquaculture research and development, and Department of Fisheries involved in issuing permits.

In Nepal nine Fish Research Stations under the Nepal Agriculture Research Council (NARC), Fish Development Centers of Department of Agriculture, Tribhuwan University, and Agriculture and Forestry University are working for the development of aquaculture in the country.

In Pakistan 13 Federal Government Institutes, 10 provincial fisheries departments, 11 fisheries education departments and 6 others fisheries organizations/association are involved in the aquaculture development. Marine Fisheries Department (MFD) is the competent authority for sea food safety in Pakistan.

In Bangladesh, Department of Fisheries (DoF), Agricultual universities, BFRI and BARC are working for the fisheries and aquaculture development in the country. Bangladesh Standards and Testing Institution (BSTI) and Bangladesh Food Safety Authority (BFSA) are the competent authorities to handle food safety and quality control issues.

The Ministry of Fisheries and Agriculture (MoFA), Maldives is the main regulator of aquaculture activities in the country. MoFA is mandated with the responsibility to formulate and implement all legislatures related to aquaculture, and planning out its development in the country. The Marine Research Centre (MRC) of MoFA is responsible for research and development efforts as well as awareness building, information dissemination and demonstration of successful aquaculture models. All environmental issues are regulated by the Environmental Protection Agency (EPA), the national environmental regulatory body. Maldives Food and Drug Authority (MFDA) is responsible for ensuring the all public health and food safety criteria for aquacultured products. Maldives Customs Services is mandated with the responsibility of regulating all imports and exports to and from the country.

There is no national standards organization in Afghanistan to handle the aquaculture food safety and quality measures.

The National Research and Development Center for Aquaculture (NRDCA), Bhutan has produced best management practices for carp farming best suited for Bhutan's conditions and has been making efforts to disseminate them among fish farmers.

Conclusion

Aquaculture affects different stakeholders viz., producers, input suppliers, fish processors, seafood buyers, consumers, government agencies, members of affected communities, and environmental, social, and consumer advocates. The Aquaculture BMPs consist of general and specific instructions and guidance that address construction, operation, management, species selection and product sales for commercial aquaculture facilities. Farm owners and managers adopt BMPs that are appropriate for the size, production system design, location and species for their farm. BMPs are promoted as a way to reduce costs and waste, increase income, reduce pollution, produce higher quality products, gain or maintain access to new markets, and obtain regulatory relief. Therefore, representatives of all the stakeholders must be involved in formulating BMPs. South Asian countries can very well compete with the developed countries in world food commodity markets because of the lower production cost of export commodities. However, the products from developing countries must meet minimum safety and quality standards. Being the pioneers in aquaculture production the South Asian countries can achieve this goal through adapting latest technology, trained workers to use technology and conform to world food-handling, sanitation, and personal hygiene standards. The SAARC Regional consultation on 'Best Management Practices in Aquaculture: capacity building and policy development' is the unique and first SAARC initiative to bring all the member countries to a discussion forum for initiating policy framing and capacity development in BMP for the region.

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Chapter 2

Best Management Practices in Aquaculture in India

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Aquaculture Scenario

The burgeoning human population has an adverse impact on the standard of living for many people particularly in developing and under developed countries. This begets a major challenge to meet nutritional security to increased population. To meet this challenge, great improvement in food security is needed. Aquaculture has provided this not only as food for local consumption but also for export to other countries and year-round availability in the market. Aquaculture is the chief source for production of relatively cheap protein food, livelihood for rural folk and foreign currency earner. In India more than 70-75% of Aquaculture is owned by small and marginal farmers.

Aquaculture is the fastest growing food-producing sector in the world. It is developing, expanding and intensifying in almost all regions of the world (Subasighe et al, 2009). Aquaculture, on a global scale and in comparison to animal husbandry, became a significant contributor to the human food basket relatively recently. The aquaculture sector has experienced very strong growth over the last two decades, making it the fastest growing primary production industry (FAO, 2007). There is tremendous potential for aquaculture development in India, as it is endowed with highly diversified and potential water resources. The country has a coastline of 8,118 km, continental shelf area of 0.53 million sq.kms, Exclusive Economic Zone of 2.02 million sq. kms. India's inland water resources consist of rivers and canals (197,024 kms), reservoirs (3.15 million ha), ponds and tanks (235 million ha), oxbow lakes and derelict waters (1.3 million ha), brackish waters (1.24 million ha) and estuaries (0.29 million ha). According to CMFRI Census 2010, there are 3,288 marine fishing villages and 1511 marine fish landing centres in 9 maritime states and 2 union territories. Global total capture fishery production in 2014 was 93.4 million tonnes, of which 81.5 million tonnes from marine waters and 11.9 million tonnes from inland waters whereas aquaculture amounted to 73.8 million tones with 44% share in the total global production of 167.20 million tones (FAO 2016). In India, the annual fisheries and aquaculture production increased from 0.75 million tonnes in 1950-51 to 10.79 million tonnes in 2013-2014 (DAHDF, 2016-17).

Though cultured fish has no export market, shrimp has a huge international market demand. This sector contributes to domestic food security and self-sufficiency. The infrastructure development in the rural areas can be attributed to the large scale expansion of coastal aquaculture. More important is the contribution of aquaculture sector towards employment generation. Aquaculture has shown immense opportunities to many unemployed youth to take up their livelihoods. Further aquaculture offered excellent economic growth, opportunities and entrepreneur development with ample investments. The dwindling production from agriculture sector has paved the way towards investments in aquaculture as this sector has generated more income, reduced poverty and thereby improved human health as well. The Indian shrimp aquaculture industry has rapidly transitioned from giant tiger shrimp to white leg shrimp because of increased production efficiency and huge profits.

Prospects of Aquaculture

The development of aquaculture mainly depends on the availability of brood stock of fish and shrimp. Indian Major Carp brooders are available in different rivers in the country whereas in terms of shrimp brood stock, Tiger shrimp brood stock is sourced entirely from wild (sea) and White legged shrimp is entirely outsourced from different countries. Government has recently started a domestication program for giant tiger shrimp and also establishing Aquatic Quarantine Facility (AQF) and Brooder Multiplication Centres (BMC) for vannamei. The phenomenal growth in aquaculture occurred in the country because of the rapid expansion, substantial investment in capacity, improved production techniques and the ability of the industry to compete in international markets where demand has also grown substantially. Aquaculture contributes over 47% of world fish supplies for human consumption and over 500 million people in developing countries depend directly or indirectly on fisheries and aquaculture for their livelihoods (FAO, 2009). The pace of development of aquaculture from 1980s to 2017 is phenomenal from traditional farming to intensive culture and new technologies like cage culture, Recirculation Aquaculture Systems (RAS), nursery and grow-out systems in shrimp farming, Biosecurity measures with latest aspects viz., pond lining, shrimp toilets, pond automation, aqua mimicry and biofloc technology. There has been a gradual shift in tilapia culture from traditional, semi-intensive to intensive farm systems. Farmed tilapia production increased dramatically in recent years, increasing from 383,654 MT in 1990 to 2,326,413 MT in 2006 (Chakraborty and Banerjee, 2009).

Aquaculture Production Scenario

India has quickly become a major player in the global shrimp industry since the country initiated culture of white leg shrimp in 2009, with production rising from 1,700 to over 250,000 metric tons in a span of five years. Of India's 36 states and territories, eight account for 98% of national shrimp production: Andhra, Tamilnadu, Kerala, Karnataka, Maharastra, Gujarat, Odisha, and West Bengal. Of those eight, Andhra is, by far, the leading farmed shrimp producer, accounting for 64% of Indian farmed shrimp production. (Nicole Portley, 2016). In the coastal state of Kerala, fish is consumed the most, with 22.7 kg/per capita and in the mountainous state of Himachal Pradesh consumption is with 0.03 kg/capita relatively low (FAO, 2014).

As per FAO report the estimate Indian fish production during the year 2015-16 was 10.79 million tonnes and has nearly 65% contribution from the Inland sector and nearly 65 to 70% from the culture fisheries. It constitutes about 6.38% of the global fish production, contributes to 1.1% of the GDP and 5.15% of the agricultural GDP. The annual carp seed production from the country is 25 billion and shrimp is about 12 billion. Along with food fish culture, ornamental fish culture and high value fish farming are gaining importance in the recent past. Presently India is the second largest fish producing and second largest aquaculture nation in the world after China. The total fish production during 2015-16 (provisional) is at 10.79 million metric tonne (MMT) with a contribution of 7.21 MMT from inland sector and 3.58 MMT from marine sector. The sector contributed about 0.9% to the National Gross Value Added (GVA) and 5.43% to the agricultural GVP (2015-16). The historical scenario of Indian fisheries reveals a paradigm shift from marine dominated fisheries to a scenario where inland fisheries has emerged as a major contributor to the overall fish production in the country.

Issues and Challenges in Aquaculture

Aquaculture in India, as in other countries, is facing a plethora of challenges albeit its huge dividends. These issues and challenges can be broadly classified as following:

Environmental Issues

Aquaculture development brought significant environmental issues and management problems to share access to the coastal resources. The following are some of the environmental issues results due to aquaculture activities:

- Conversion of important ecosystems like lakes, mangroves and agricultural lands to aquaculture farms
- Salinisation of land and water by effluents from aqua culture ponds
- Nutrient loading of coastal water bodies and estuaries (eutrophication):
- Excessive use of ground water for filling ponds
- Transmission of diseases to the surroundings and neighboring ponds
- Health issues: Introduction of exotic viruses which affects the native shrimp species

Social Issues

Many social issues arise due to aquaculture activity as detailed below:

- Land owner ship disputes
- Multi-user conflicts: Social unrest is bound to result if high investors enter in the field and disturb the traditional and improved traditional system of farming that are being practiced by the small farmers
- Land, water and associated conflicts
- Pollution to the neighbouring agricultural farms due to conversion of fertile lands into farms
- Drinking water pollution due to pond effluents and salinization.
- Farm regularization issues

Planning and Management Issues

Regularization of farms: Government has framed certain guidelines according to which aqua farmers have to register their ponds with Coastal Aquaculture Authority in case of brackish waters and with Department of Fisheries of respective states in case of fresh water aquaculture.

Aquaculture zoning: The main purpose of delimiting geographical areas within which aquaculture will be allowed is to address the issue of equity. This would seem to be particularly important for marine areas. The general notion in most countries is that the sea belongs to all. The issuance of aquaculture permits is contrary to this belief, and the very idea runs into opposition, and not only from direct users of the water areas concerned. When establishing a zone these issues must be addressed squarely.

Technology transfer: Transfer of technology is an important aspect that needs to be given emphasis in aquaculture. Technological advancements need to be transferred particularly to small and marginal farmers. Then only aquaculture will be economically self-sufficient aquaculture. For this capacity building programmes for skill development by way of awareness campaigns, training programmes and refresher courses, orientation courses are being organized in all aquaculture potential states.

Diversification of Aquaculture: So far only few candidate species are being cultured in the country and there is urgent need to develop and streamline new species like Cobia, Grouper, Silver Pampano, Mud Crab, *Penaeus indicus*, Sea Weed etc. Standardization of technologies for seed production and farming for commercial production is major task for ICAR institutions and Researchers. Domestication of new species for aquaculture is also important and plans are afoot to take up this activity. Murrel culture is still in the nascent stage and hatchery technology needs to be streamlined and it has great potency in future in India. Researches on all male culture of scampi are in progress.

Genetically improved aquatic species: So far only a few genetically improved aquatic species have been brought into commercial aquaculture operations. But, the know-how to develop genetically modified fish is spreading. These genetically improved organisms (GMOs) should satisfy the desires of both the producers and the consumer. R&D efforts on Jayanthi Rohu have yielded fruitful results and introduction of GIFT Tilapia in India has opened up new vistas for genetically improved species. Cage culture of Tilapia has been practiced in many states and remains to be seen how far this species gets popularized as the present market demand is fragmentary.

Public-Private Partnerships: Another important aspect about the positive impact of aquaculture is the Public-Private Partnerships which can be seen in many areas of infrastructure development such as market facilities, cold storages, processing sector etc.

Aquaculture insurance: In view of the severe natural calamities and disease out breaks, aqua farmers are incurring huge losses. In India, introduction of Aquaculture insurance to all fish and shrimp ponds is being considered and this insurance cover will at least ensure that finance is available to recommence culture operations. Government is now considering insurance as mandatory for aquaculture farmers to reduce long term losses in production.

Promoting aquaculture by providing subsidies: Government is centivizing aquaculture by providing subsidies and under "Blue Revolution", several schemes have been implemented in all the states.

De-silting and de-weeding of creeks, dredging of sea mouths: is yet another important aspects to allow free movement of water, and reduce the chances of pollution.

Seed certification and accreditation programme: is being implemented in the country based on the guidelines issued by the Government of India in all states and this will provide quality seed to the aqua farmers who are facing severe problems with survival due to disease outbreaks. However, in states like Andhra Pradesh, "Andhra Pradesh Aquaculture Seed (Quality Control) Act 2006" is under enforcement to monitor the quality of the aquaculture seed.

Extension activities: As part of Corporate Social Responsibility, Text and Voice messages are sent to aqua famers on Best Management Practices in some states like Andhra Pradesh with the support of Reliance Foundation as part of "Digital India Programme".

Expansion of coastal aquaculture: Expansion has been given priority and the area near the coast which is hitherto lying fallow and assigned DKT lands are given Certificate of Cultivation in Andhra Pradesh state for a period of one year and which can be renewed. This will help many small and marginal farmers to take up shrimp/crab culture and teke out their livelihoods.

Incentives: Fisheries policy in Andhra Pradesh has been announced and several incentives were announced viz., Power subsidy, subsidy for establishment of feed mills, processing plants and cold storages to promote aquaculture sector.

Infrastructure: Infrastructure development of the post harvest care in aquaculture is being given priority in view of the huge demand for exports.

Farm mechanization: Farm mechanization, pond automation, information and communication technology (ICT) through web service is identified as key areas to reduce the input cost, crop losses and to harvest healthy crops from the aquaculture ponds.

Issues related to Exports of aquaculture products

There is a serious concern on continued presence of banned substances in the aquaculture based export consignments. Due to presence of various types of residues 36 shrimp consignments were rejected by major markets

such as USA, European Union and Japan in 2016 with USA being the major rejecting market with 28 rejected consignments. There is increasing Rapid Alert System for Food & Feed (RASFF) alerts from the European Union on the aquaculture exports from India and Andhra Pradesh. The recent spate of rejections has prompted the EU to increase their sampling percentage of farmed shrimp from India for border inspection from 10 to 50% since October 2016. The maximum permissible limits for antibiotic residues are different for different products in EU, USA, Japan and other countries. Therefore, there is need to process aqua products as per Standard Operating Procedures (SOPs) of importing countries and promote our exports and also need for a mechanism for preventing usage of banned antibiotics in the aquaculture sector and strengthening the traceability in shrimp exports. The concept of Hazard Analysis and Critical Control Points (HACCP) is already in vogue in most of the processing units and in future it is being practiced in hatcheries and culture systems. Once this HACCP concept is implemented, there is greater consciousness in the quality of the shrimp production and India will continue its dominance in international market. To regulate the usage of banned antibiotics in aquaculture, the Governments has constituted task force teams to create awareness among the farmers and to penalize the violators.

Codes of Conduct and Management Practices in Aquaculture

Responsible aquaculture practices are being adopted in all the states of India with effective management for sustainable aquaculture development. The following management practices are being followed in the country:

Registration of Aquaculture - The states where aquaculture is in progress have stipulated strinngent measures to register the aquaculture ponds and regulate the activity. The Departments of Fisheries in the states are responsible for registration of freshwater fish culture. The Coastal Aquaculture Authority under the Ministry of Agriculture is responsible for regulating aqua-farming activities in coastal areas. Government is making all out efforts to make aquaculture sustainable.

National Freshwater Fish Brood Bank – A National Freshwater Fish Brood Bank (NFFBB) at Bhubaneswar is established for production of quality and improved fish seed in substantial quantity using latest technologies. R & D efforts are in progress for genetically improved stock brood stock development, production of quality brood, rearing of quality fish seed to fingerlings and to distribute these fingerlings to hatcheries in different parts of the country. Apart from this assistance is given in

setting up of fresh water prawn (Scampi) brood bank at College of Fisheries, Nellore, Andhra Pradesh. One more unit is setting up of brood bank for common carp (Amur) at Karnataka Veterinary, Animal & Fisheries Sciences University, Bengaluru.

States like Andhra Pradesh have established databases and information networks to collect, share and disseminate data related to their aquaculture activities to facilitate cooperation on planning for aquaculture development.

Diseases are constantly monitored by Disease Surveillance programme implemented under National Surveillance Programme on Aquatic Animal Diseases (NSPAAD) with the aegis of National Bureau of Fish Genetic Resources (NBFGR), Lucknow. Some states have already established many aqua labs for disease diagnosis and new aqua labs are also being established in public sector in different states of India and Andhra Pradesh is the leading example. There are not only stationary aqua labs but also mobile labs are in operation.

Safe, effective and minimal use of therapeutants, hormones and drugs, antibiotics and other disease control chemicals are advocated. Several campaigns on banned antibiotics and usage of chemicals in a responsible way are conducted. Coastal Aquaculture Authority is registering all the aquaculture inputs used in aquaculture. Traceability system for antibiotic usage has been established. ELISA labs, Quality Control Labs were established by Marine Products Development Authority (MPEDA) in different states to test the sea food exports for antibiotic residues like Chloramphenicol and Nitrofurans. These quality control labs will be upgraded to the standards of importing countries to avoid impediments in exports.

Setting up of Farmer Producer Organisations- Government is promoting active participation of aqua farmers and their communities in the development of responsible aquaculture. As part of this Farmer Producer Organizations (FPO) are being formed. FPO can be a producer company, a cooperative society or any other legal form which provides for sharing of profits/benefits among the members.

As part of responsible aquaculture development in India and to see that aquaculture does not impose any harm to human health and the environment, certain provisions are being advocated to aqua farmers viz., establishment of 'shrimp toilets' and proper disposal of wastes

such as offal, sludge, dead or diseased fish, excess veterinary drugs and other unwanted chemical inputs into the environment.

BMPs in shrimp culture: The shrimp farmers are adopting better management practices which include biosecurity, three stage water filtering mechanism is followed to prevent the entry of egg, larvae of predators and any other particulate matter into the farm, screening of seed for various pathogens through PCR, introduction of nursery pond management, water treatment for reservoir, aerators, aerator pipeline at the bottom of nursery pond and effluent treatment pond etc. The inlet water is filtered through 150 micron mesh before entering in to the reservoirs. The water in the reservoir is allowed to settle for 2-4 days. The suspended matter, silt etc. are settle at the reservoir bottom. Then water is treated with bleaching powder at 25 ppm followed by potassium permanganate at 5 ppm to kill the animals and parasites which might carry virus and bacteria.

After 3-4 days, the water from reservoir is pumped into the Nursery Pond through 60 and 40 microns mesh to prevent entry of finer particles into the Nursery where the shrimp post-larvae (PLs) will be reared. The Culture pond is fitted with a Central Drain System to let out the organic wastes accumulated at the Centre of the Pond (Shrimp Toilet) into ETP through underground pipe line system. The water quality is tested before stocking the juveniles from the Nursery pond. The stocking density varied from 25-40 pieces per m^2 area. Farmers are using only pellet feeds to the growing shrimp as per the standard charts. Weekly sampling is done to check the health and growth of shrimp. Aqua farmers are maintaining the data recorded in the registers. The average production is 8-10 MT/ha/crop. Two crops are being harvested per year. Total Production from the farm per year is ranging from 16-20 MT/ha.

BMPs in Fish Culture: Fish Farmers are also adopting best management practices which include nursery pond management, water quality management, stocking of quality fish seed of 50-100 gm size and usage of pelletised feed viz., sinking pellets and floating pellets for achieving higher production of fish. The fingerlings (60-80 mm size) are transferred into another pond (1 Ac) for rearing into advanced fingerlings to attain 50 g body weight in 60-90 days. The size of culture ponds ranges from 1 ha to 40 ha. Proper pond preparation is done carefully such as drying, liming, manuring and stocking density ranges from 5,000-8,000 per ha. The production ranges from 5-8 MT/ha.

Capacity Building: With the rapid advancements in aquaculture technologies, the educational and knowledge status of most extension staff is inadequate and needs to be upgraded. All the extension workers are to be trained properly in all relevant fields in view of the current trends in development. Universities, Colleges and training centres are playing an important role in support of developing a sustainable aquaculture and fisheries sector. A host of training programmes are organized in all states where aquaculture potential is there to develop the skills and competencies of the technicians to foster sustainable aquaculture development. Exposure visits, orientation courses, training programmes, refresher courses are already in existence. Several Fisheries colleges, Polytechnic colleges were established in India as part of Manpower Development.

Institutional Setup and Stakeholders Involvement

The phenomenal growth of aquaculture in India can be attributed to many institutes that are set up for its sustainability. The Indian Council of Agricultural Research (ICAR) has eight fisheries research institutes of which three focus on aquaculture: The Central Institute of Freshwater Aquaculture (CIFA) in Bhubaneswar focuses on freshwater aquaculture, the Central Institute of Brackish Water Aquaculture (CIBA) in Chennai deals with brackish water aquaculture and the Central Marine Fisheries Research Institute (CMFRI) in Kochi researches marine fisheries. Additionally, the National Research Center for Coldwater Fisheries in Bhimtal focuses on cold water fisheries and aquaculture, Central Institute of Fisheries Education (CIFE), Mumbai and several other universities have separate fisheries colleges that undertake aquaculture research. (Jelte de Jong, 2017). Apart from this there is Marine Products Export Development Authority (MPEDA) with head quarters at Kochi under Ministry of Commerce and Industry, State Agriculture Universities having Fisheries Colleges, different states with Department of Fisheries and having inter-departmental tie-ups. These institutes work in tandem for the development of aquaculture.

It is high time that all stakeholders viz., Government Officials, Aqua farmers, Hatchery Operators, Feed Mill owners, Scientists, Technicians, Input suppliers should come to a common platform and need to focus on how the aquaculture sector is to be managed for the improvement in the quality of the produce as well as doubling the production from the sector without environmental damage.

Recommendations

- Carrying Capacity measurement i.e., the number of fish/shrimp that can be supported in a pond within natural resource limit or the number of ponds that can be dug abutting a creek/drain is an important aspect that has to be taken up as it provides a more practical approach to determine the sustainability of aquaculture.
- Policy development for proper approaches on minimizing water pollution, fish/shrimp diseases and escapees into the natural environment.
- Policy making regarding regulation and setting standards, zoning, fiscal incentives and capacity building of extension staff and technicians.
- Harmonization and simplification of existing policies in order to enable better coordination with aqua farmers.
- R&D efforts for diversification of new aquaculture species as well as streamlining of seed production and culture technologies of new species with proper policy frame work.
- Educating extension workers, aqua farmers and other relevant stakeholders on food safety and the rational use of antibiotics and chemicals under skill development program.
- Preparation of extension material on best practice guidelines and associated regulations for fish/shrimp seed production, culture operations with particular focus upon proper water and soil management, as well as disease prevention.
- Encourage formation of aqua clusters and thorough monitoring of the clusters with proper extension and financial assistance wherever possible.
- Framing implementable guidelines, rules, and regulations and enforce them so as to reduce the hazards of chemical abuse.
- Strict implementation of HACCP concept as part of food safety management system will fillip quality shrimp production.
- More Disease diagnostic laboratories should be established in strategic areas to assist farmers in the identification, prevention and cure of diseases. Supply of drugs and chemicals should be affected with proper prescription from such laboratories.
- Education and training on the use of chemicals, their dosages and side effects should be imparted to the farmers and state government extension officers.

- Implementation of Aquatic Animal Health Programmes.
- Feed Technology and Post Harvest Technology need to be strengthened in view of the large-scale development of aquaculture. More over domestic market development is of important concern and supply of quality product to the consumers of abroad as well as in India is the need of the hour

Conclusion

Indeed aquaculture will continue to be an increasingly important food production sector in India and sustainable aquaculture will ensure many dividends to the aqua farmers. Aqua industry is the only industry which can complete and surpass IT industry. Focused attention on aquaculture at stocking densities that suit the carrying capacity of the ponds, minimising the risk of disease outbreaks and thereby minimizing the usage of therapeutic drugs and chemicals is the need of the hour. What is more required for sustainable aquaculture production is the gaining confidence of the consumers who take immaculate care of their health and choose their food item. Awareness creation and promotion of better farm management practices are essential and state governments are geared up to tap the domestic market access to make aquaculture more sustainable. Implementation of Best Management Practices, Capacity building of extension officers and other stakeholders, domestic market development and research-extension linkage programmes are the priority items. Time is ripe to conduct frequent stake holder's meetings to prepare a roadmap to make India a sustainable shrimp production country in the world. All support is needed from stakeholders and research institutes in order to extend cooperation in a coordinated way to the Blue Revolution in the country.

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Chapter 3

Best Management Practices in Aquaculture in Sri Lanka

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Aquaculture Scenario

With stagnating global capture fishery production and an increasing population, aquaculture is perceived as having the greatest potential to produce more fish in the future to meet the growing demand for safe and quality aquatic food. According to FAO (2004-2017), Asian region have the highest average food fish consumption rate - estimated at 29 kg per person per year and the highest contribution (80%) to global aquaculture. In order to maintain at least the current level of consumption, and taking into consideration the growing world population, Asia will require an additional 20 million tons of fish per year by 2030 (FAO,2004-2017), which will have to come from aquaculture This is a major task for the region and there will be hurdles on the road to success It is acknowledged that, with growth in volume and value of aquaculture production in the past decade, aquaculture has made a positive contribution to national, regional and global economies, poverty reduction and food security.

In the Sri Lankan context aquaculture is not a traditional farming system, despite the large freshwater and brackish water resources available in the country. There was virtually no aquaculture carried until the year 1979 in Sri Lanka. Freshwater fish culture in seasonal village tanks was initiated in 1979 by the Inland Fisheries Division of the Ministry of Fisheries with 23 tanks in the country's dry zone and since 1979 onwards the poly-culture of tilapia and carp has started. In the early 1980s a number of small-scale entrepreneurs and a few multinational companies, responding to the incentives offered by the government including duty free imports of inputs, embarked on the culture of giant tiger prawn (*Penaeus monodon*) in coastal ponds. In the late 1990s the commercial growing of the Indo-Pacific swamp crab (*Scylla serrata*) in plasticised wire mesh cages began in coastal lagoons. In contrast, the ornamental fish industry in Sri Lanka has a long history and was started with household based small-scale outlets in cities. In the early 1930s, there were several small-scale importers, breeders and hobbyists in Sri Lanka; a commercial aquarium was started in 1952 in Colombo. This

industry was commercialised by a few entrepreneurs about 50 years ago and it has now developed into a thriving industry affording profits and employment for many. Ornamental fish culture is carried out mainly in cement tanks (FAO 2004-2017).

The main Sri Lankan export market for farmed shrimps is Japan followed by the United States of America and the European Union countries. The European Union market takes mainly small shrimps in both head-on and tail only products. The Fish Product (Export) Regulations of 1998 and Aquaculture (Monitoring of Residues) Regulations of 2000 require inspection and certification of compliance to these regulations by the licensee for each export consignment. A special emphasis has been placed on monitoring to ensure there are no residues of antibiotics as per European Union's guidelines and requirements. The competent authority for issuing residue free certificates is the Director General of the Department of Aquatic Resources.

With the discontinuation of government support for inland fisheries and aquaculture in 1990, inland fish and freshwater aquaculture production 39,720 Mt in 1989 dropped to 12,000 Mt by the year 1994. With the reinstatement of government patronage to inland fisheries in 1995, the former activities recommenced. In 1998, the National Aquaculture Development Authority (NAQDA) was established under an Act No.53 of 1998 to continue with the programs implemented by the former Inland Fisheries Division of the Ministry of Fisheries and Aquatic Resources (MFARD). According to the past statistics aquaculture contributed by less than 3% to the total fish production of Sri Lanka (MFARD 2016).

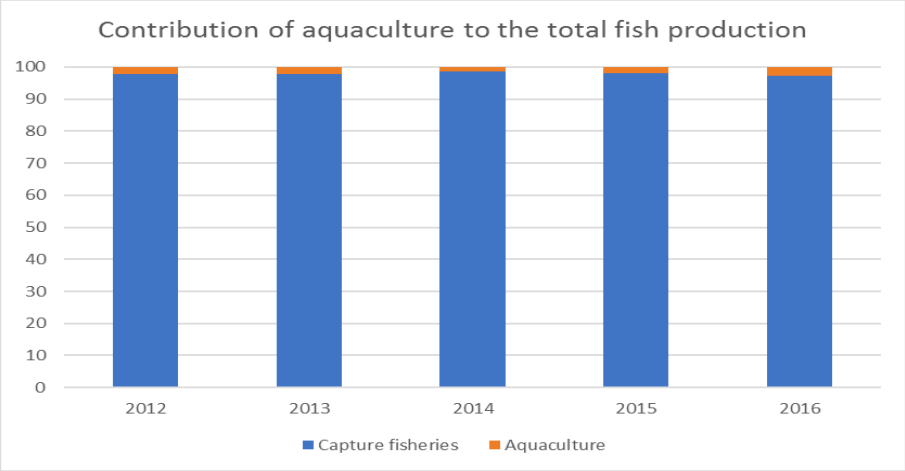

Figure 1. Contribution of aquaculture to the total fish production
(Source: MFARD, 2016)

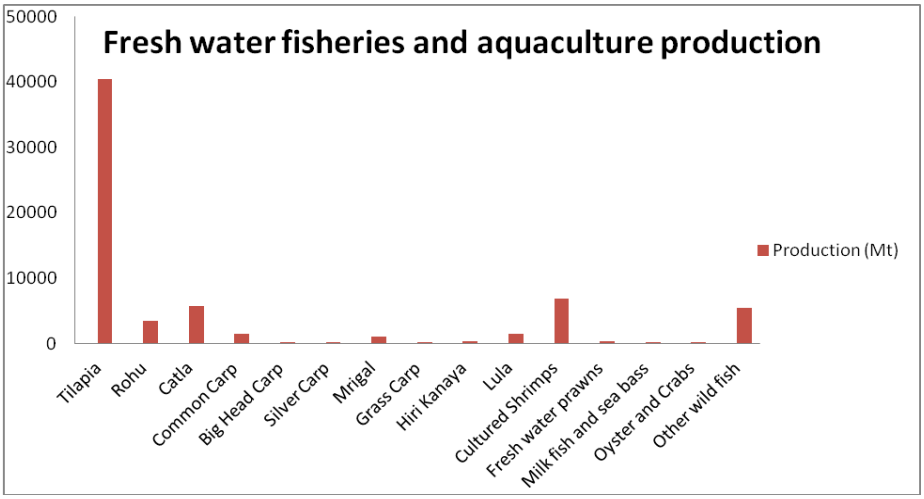

Figure 2. Fresh water fisheries and aquaculture production
Source: MFARD 2016, Note: Other wild fish includes wild fish, oyster and crabs

Although the demand in freshwater fish is continuously increasing current fresh water fish production is not adequate to meet the demand. The production is just sufficient for the consumption of the villagers living around the fish catching sites, therefore, it is difficult to get the fresh water fish for the consumption of the urban population. Apart from that there is a huge demand for tilapia from the export markets. Hence, there is big scope for establishing commercial level intensive fish farms in Sri lanka.

Brackish water shrimp aquaculture was the first ever well-developed aquaculture industry in Sri Lanka in the early 1980s. A number of local entrepreneurs and a few multinational companies embarked on aquaculture of *Peneaus monodon* (black tiger shrimp) in ponds along the North-western coastal belt of Madampe to Puttalam responding to the initiatives of the government to develop shrimp farming for the export trade. The industry established in the North-western coastal belt covering a farm area of more than 4,500 ha. In the eastern coast, Batticaloa District has recommenced the industry and over 60 small scale farms with an average pond holdings of 1-2 ha were in operation at present covering total pond area of 155 ha. The concept of culture shrimp farming has been established at the eastern coast, Vakerai with the intervention of NAQDA. Since 2014 the project has created a lucrative profit of up to Sl Rs. 2,00,000 for each members. Seaweed, sea cucumber, oyster and other marine fish culture is practiced in different scales in Sri Lanka. The introduced species *Kappaphycus alvarezii* is the species commercially thrived while species diversification has been identified as a need for the seaweed sector development.

Seacucumber trade was mainly based on the wild caught juveniles while the first seacucumber breeding was conducted in Regional Research Centre, NARA and the technology was transferred to the private sector. Consequently, one private sector hatchery has been established under the Vietnam expertise under a MOU signed by National Aquaculture Development Authority (NAQDA).

Seabass industry is another developing aquaculture industry in Sri Lanka and cage culture has been practised in lagoons and Bay areas while some pond culture of seabass also exists. Private sector entrepreneur has started Sri Lanka's first ever commercial scale oceanic farm for seabass at the eastern province.

Few decades ago Sri Lanka entered the World ornamental fish trade as a supplier of wild caught varieties, mainly marine fish. By 2015, Sri Lanka has earned, total export revenue (marine and fresh water) of Sl Rs. 2392 million through export of ornamental fish for 18 destinations, of which main contributor is cultured / reared freshwater ornamental fish varieties. The ornamental fish culture industry is wide spread in the island, while the breeders and exporters are mainly confined to Colombo and suburbs. Grow-out systems in the ornamental fish culture industry are wide spread throughout the country. Rapid growth of the industry started since 2012 (fig 3).

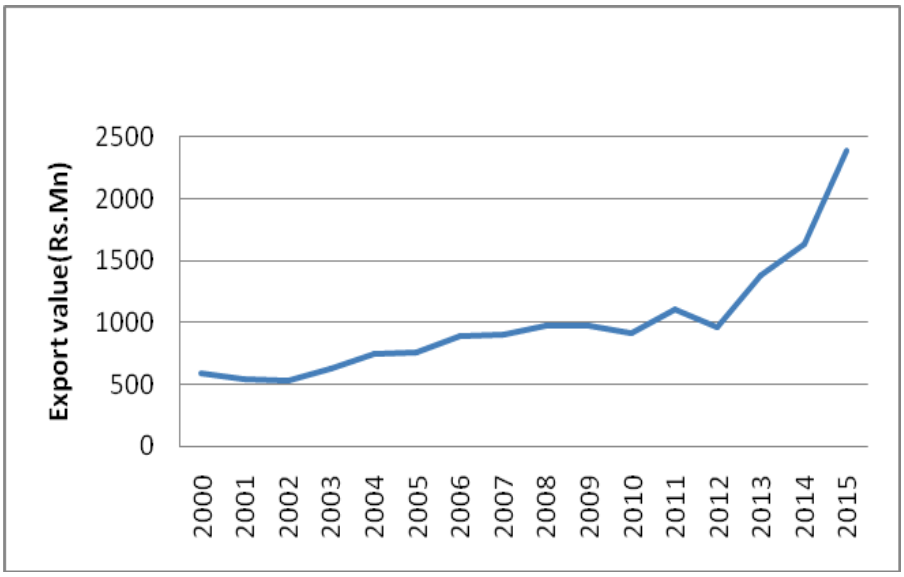

Figure 3. Export value of ornamental fish

(Source: MFARD, 2016)

Development of new ornamental fish strains, development of technology for induced breeding; providing brood fish, fish disease diagnosis, providing training and technical assistance are mainly conducted by the government sector in order to support development of ornamental fish and aquatic plant culture and exports. Aquaculture Development Centres at Rambodagalla and Ginigathena under NAQDA and the Panapitiya centre and the Inland Aquatic Resources and Aquaculture division at NARA are dedicating for development of ornamental fish and plant industries. Aquatic ornamental plant production is lower compared to the fish production. Very few entrepreneurs are engaged in aquatic plant production activities while few tissue culture laboratories work on micro propagation development and research.

There are more than 18 destinations where ornamental fish are exported while countries viz. Germany, France, United Kingdom, Belgium, Netherlands, Spain, Switzerland, Japan, United States of America and Italy are the 10 main export markets. According to the statistics of the Customs department of Sri Lanka, there are 66 large and small-scale ornamental fish exporters in the country, of which 10 exporters export ornamental fish, valued over SLR 10 million per annum.

Freshwater prawn production has shown a gradual increase in the country and the recorded freshwater prawn production was in 2015, about 374 t. Freshwater prawn created a new fishery in the inland waters and export of freshwater prawn is at emerging trend. Today, there are mainly two companies engaged in exporting the freshwater prawn and 21.36 Mt, 20.68 Mt, 141 Mt and 144 Mt were exported in the year 2012, 2013, 2014 and 2015, respectively.

Crab, *Scylla serrata* farming is confined to fattening and breeding has been initiated recently. Oyster farming is also in developing stage and the community based farming has been stated in Puttalam lagoon in the North-Western province of Sri Lanka.

Prospects of Aquaculture

As an island nation Sri Lanka is endowed with rich fisheries and aquatic resources in the seas around the country, including 200 nautical miles Exclusive Economic Zone consisting 517,000. The country is also blessed with inland water bodies and brackish water ecosystems that are favourable for fisheries and aquaculture. The lagoons and estuaries cover about 158,000 hectares and mangrove zones, mudflats and salt marshes cover more than 71,000 hectares of the coastal zone. In addition, there is more than 260,000

hectares fresh water bodies. These ecosystems provide excellent opportunities for aquaculture development.

The aquaculture species with high export potentials are shrimp, seaweed, sea cucumber and freshwater prawn (*Macrobrachium*).

Sea cumber and bivalve species have a good potential for industrialization with increasing farming practises with suitable techniques and suitable sites. Promfret, sea bream and milk fish are the other prospective species for aquaculture.

Production of farmed shrimp is tiger prawns (*P.monodon*) which are mainly exported in various forms of frozen products. The important export markets include the US, Japan and EU.

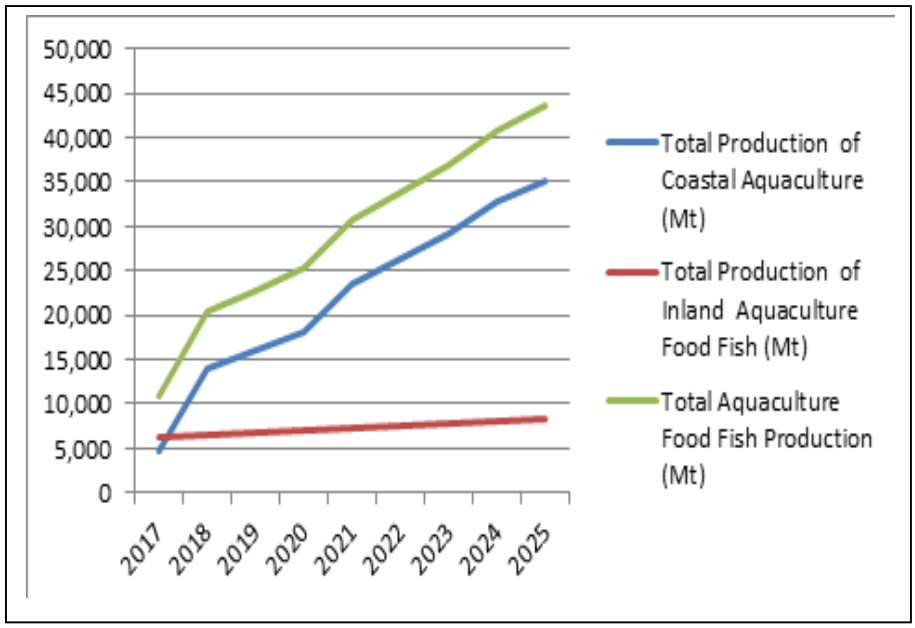

Figure 4. Aquaculture Food Fish Production Target (2017-2025, Communications with NAQDA)

High rate of expansion and enhance of production is anticipated in coastal aquaculture while inland aquaculture will be increased gradually

Guppy is the dominant species contributing around 70% to the freshwater ornamental fish exports and Sri Lanka produced only 3.3% of the ornamental fish world demand. Hence there is a big requirement in expand the industry through introduction of new varieties.

The marine ornamental fish export sector is totally dependent on the wild stocks hence there is much scope in breeding and culture of marine ornamental fish.

The seaweed, *K.alvarezii* is not of adequate demand for exporting. Species diversification also has become a current need for expansion of seaweed culture in sustainable manner. Also, the country is repository of more than 400 seaweed species along its coastal line. At present all the primary processing seaweed products are exported in the form of dried seaweed in bales. The major export markets are the Philippines, China, Hong Kong and France. Sri Lanka has a huge potential for seaweed culture.

Wild collected 13 species of sea cucumber has the export potential but only *Holothuria scabra* is cultured in the country. There is a high demand for freshwater prawn *Macrobrachium rosenbergii in the international markets* and the whole prawn is exported in chilled form. The production of freshwater prawn is not adequate to meet the market demand. Thailand is the major importer of Sri Lankan freshwater prawn.

Aquaculture Production Scales and Methods

Shrimp farming

Shrimp farming is the most lucrative commercial aquaculture activity in Sri Lanka. The industry recorded its peak economic performances in the year 2000, earning Sl Rs. 5041 million worth of foreign exchange. The quantity of processed (headless) shrimp exported in the year 2004 was 2462 MT earning a total export value of Sl Rs. 2359 million (MFARD, 2005). The variations in the export value are mainly due to the variations of the production as a result of the advent of 'White Spot' viral disease, which sprang up intermittently from 1996 onwards.

Semi intensive pond culture method is the most common method used in shrimp farming.

Export volume of shrimp products from Sri Lanka in the last 10 years (the years 2006-2015) tend to be uncertain and volatile between 854 - 2,023 tonnes per year depending on the yield both from capture (Wild catch) and from culture. However, the proportion of exports of aquaculture products is likely to fall compared with the wild-caught. Figure 5 shows the shrimp production from Aquaculture and wild catch and export during 2000- 2014.

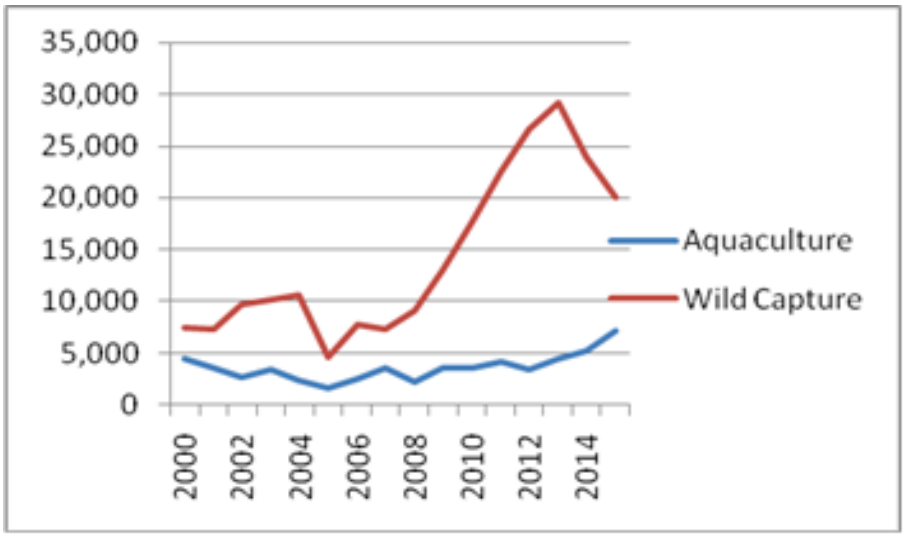

Figure 5. Shrimp production statistics (source: MFARD 2016)

Pond culture of Tilapia species has been rapidly developed after introduction of fingerlings and financial corporation be National Aquaculture Development Agency, Sri Lanka. The production in 2015 was 250 MT while the rate of yield was of 10 MT per ha density with the stock density of 2-3 fish per square meter. Also in the late seventies culture based fisheries at seasonal 23 tanks were initiated by the Inland Fisheries Division of the Ministry of Fisheries on a pilot scale, with in the dry zone resulting a production of 2370 MT in 2015.

Ornamental fish farming

Guppy is the dominant species contributing around 70% to the freshwater ornamental fish exports from Sri Lanka while exporting of ornamental endemic fish is 0.001% of the total trade and it was negligible comparing with whole trade. There are 66 large-scale and small-scale ornamental fish exporters in Sri Lanka. Table 4 shows the ornamental export value during 2000-2015. The breeders adopt simple natural spawning techniques to breed freshwater ornamental fish.

Enhance in ornamental fish exports has been observed due to technological developments in the breeding and rearing of more than 46 species of freshwater ornamental fish. The endeavours of induced breeding technology for economically important species which are not able to breed using conventional methods also have been succeeded. The export of marine ornamental fish is totally dependent on the capture of wild stocks

yet and currently over 200 marine species belonging to 40 families are exported. Increasing pressure on marine ornamental wild fish stocks has consequently led to the depletion of several wild fish populations; as a result government has prohibited or restricted export of certain marine and freshwater fish. As such it is recognized the need of research and development in marine fish breeding and rearing.

Seaweed farming

Seaweed farming concept was developed in 2008. The industry has picked up with the public - private partnership. 1.25, 22.5, 25, 70 and 165 of MT of sea weed are exported during 2011, 2012, 2013, 2014 and2015, respectively. Initiatives for the species diversification and upgrade seed stock maintenance have been taken in place which is much needed for the sustainability of the industry. Expansion of the industry is under consideration to North and South coastal areas with introduction of suitable methods. While Raft culture and monoline culture practised in the shallow sheltered coastal areas special structures to be maintained in the areas where exposed to rough sea conditions.

Other commodities

Live rock export is a new addition to our product range and as at November 2015 live rocks to the values of Rs. 13.5Mn has been exported.

Commercial scale seacucumber fattening is being conduction at Thewanpitti, Mannar south bay, Ambupuram, Kilinochchi, Valaipadu, Kilinochchi, and Nachchikuda, Kilinochchi and the production recorded 53 MT. (wet weight) were harvested in 2015 (NAQDA report). Pilot scale farming with hatchery produced larvae has been stated in Puttalam and Mannar districts.

The marine ornamental fish export sector is totally dependent on the wild stocks and currently over 200 marine species belonging to 40 families are being exported. Several species of wild marine fish populations have declined due to increased harvesting pressure on marine ornamental fish. As a result, the government of Sri Lanka has prohibited or restricted export of certain marine as well as wild caught freshwater fish species.

Other export commodities in smaller quantities are comprised with some bivalve species, oysters, mussels and sea cucumber,

Eighty farmers are engaged in seabass cage/pond culture and the production was36.5MT in 2015. During 2015 total 250,000 fingerlings were produced in a hatchery, established through private-public partnership.

Issues and Challenges in Aquaculture

Environmental issues

The National Environmental Act 1980 and amended in 1988 makes provision for the protection, management and enhancement of the environment, for the regulation, maintenance and control of the quality of the environment, and for the prevention and control of pollution. Through this act the Central Environmental Authority was established. Part IV C of the Act states that for "prescribed projects" approval of "project approving agencies" is required, followed byan Initial Environmental Examination (IEE) or EIA. According to the National Environmental (Impact Assessment) Regulations (1992), the Ministry of Fisheries and Aquatic Resources is considered a "project approving agency" for fisheries projects and programs.

The "prescribed projects" that require an IEE or EIA are further defined by an Order, issued in 1993 under section 23Z of the National Environmental Act. They include the following aquaculture projects:

- Aquaculture development projects over 4 ha, if located wholly or partly outside the coastal zone as defined by the Coast Conservation Act.
- Projects that involve conversion of forests covering an area exceeding 1 ha into non-forest use, if located wholly or partly outside the coastal zone as defined by the Coast Conservation Act.
- Aquaculture projects irrespective of their size and irrespective whether or not they are located within the coastal zone, if located within environmentally sensitive areas.

Environmental management

The most advanced level of environmental management is the development and enforcement of rules and regulations regarding how activities should be conducted in order to provide environmental protection.

In pond aquaculture, contamination of natural waters with nutrients, organic matter, and suspended solids in effluents usually are the major environmental concerns. Pond aquaculture normally cannot be conducted without effluents. So the most advanced regulation requires aquaculture

operations to reduce the concentrations and loads of pollutants in effluents to levels that would not cause deterioration of water quality in receiving waters. Although Central Environmental Authority has laid down the safe limits of substances in discharges. However, many farmers do not follow environmental regulations in aquaculture. Thus, it is necessary to encourage the farmers to adapt environmentally and socially responsible practices in aquaculture.

There has been some effort to develop systems approaches to aquacultural production to improve efficiency and enhance environmental and social performance. The systems would vary depending upon location, species, type of grow-out (ponds, cages, raceways, etc.), intensity of production, and other factors. For shrimp culture Code of Best Management practices have been introduces for shrimp culture to promote efficient, environmentally and socially responsible farming.

Destruction of Natural Ecosystems such as mangrove areas which provide valuable ecosystem services that benefit coastal communities, including coastal land stabilization and storm protection was recorded in the North-Western Province for shrimp culture development

It is regulatory to keep a buffer zone when construction of aquaculture ponds. Mangrove management policy has been documented by the Environmental Ministry to be implemented.

Alteration of soil conditions

Aquaculture farms specially shrimp farms are abandoned mainly due to the disease problem and increased soil salinity, acidity and erosion. In addition, the application of lime and other chemicals used in aquaculture modify the soil physicochemical characteristics and remains unfit for agriculture.

Eutrophication

The eutrophication or organic enrichment of water column has been reported in some areas of open waters which is mainly due to unconsumed feeds,, decomposition of died organisms and overfertilization causing phytoplankton blooms, burring, and death of benthic organisms. This leads to undesirable odors and the presence of pathogens in the discharges. It is proposed to discharge water in shrimp farms through sedimentation tanks which will help to remove excess nutrients. Moreover, it has to be met the effluent standards recommended by the Central Environmental Organization.

Introduction of invasive alien species

The negative impacts of the "biological contamination" through introduction of exotic species in to the native populations. The main problems anticipated are the displacement of native species, competition for space and food, and disease spread. Introduction of tank cleaner species has been become invasive and highly impacted the inland fisheries in Sri Lanka.

Social issues

Social factors are affecting the brackish water shrimp farming and mariculture, sea cucumber, seaweed and seabass farming, which include;

- Natural character, landscape, and amenity values
- Loss of access/alienation of public space
- Navigational/anchorage interference
- Interference with recreational use

visual pollution Conflicts with other development activities and user conflicts of different fishing activities are caused when social carrying capacity is not considered when designating areas for aquaculture,

Planning and management issues

Land allocation and design

The main constraint to attract private sector is lack of land for aquaculture development. It is experienced that investors very often face difficulties to acquired land permit due to restrictions imposed by the line ministries on various matters. Several limitations are in the land allocations due to lengthy procedure in approving for aquaculture. If the responsible agencies have clear zonal plans with identified areas it will be much easier for the land allocation procedure. There is a need for permitting new aquaculture ventures in inshore and offshore areas within the EEZ, so that the clear procedure should be there to allocate the areas based on prior identified designated area. Most of the lands suitable for aquaculture practices are paddy lands. However, even uncultivated paddy lands for longer periods is difficult to convert into fish ponds because of some policy issues of several government institutions. Since many of the immediate potential mariculture areas are lagoon types there would clearly be some potential overlapping interests or threatening conflicts, future mariculture activities should be carefully planned.

A legal constraint for using some of the lagoons may exist if they already are part of national parks and wild life sanctuaries or protected wetland (Marine Protected Areas, RAMSAR convention) areas.

Lack of aquaculture planning and understanding of carrying capacities of each species also are the major drawbacks in development of aquaculture

Issues in management of value chain

Fish feed

As feed shares the highest costs input in aquaculture, policy regulations should be available for feed production, management of quality standards. There is no commercial feed producers yet in Sri Lanka, but a medium scale fish feed machine is being installed at Central Fish market, Colombo in order to develop fish feeds. The fish feed production is conducted through research and development of National Aquatic resources Research and Development Agency with private sector participation and with patronage of food and agriculture organization. Although the feed development for shrimp culture is not yet succeeded in Sri Lanka it is prudent to regularly monitor the utilization of imported feed, different types of probiotics and other chemicals in the sector. In addition, the Animal Feed Act (1986), which regulates, supervises and controls the manufacture, sale and distribution of animal feed, may be applicable to aquaculture. The Act makes provisions relating to the particulars that must be stated on the print or label and prohibits manufacturing, preparing or storing any animal feed for sale, or sell or distribute and animal feed, which has been adulterated.

Seed certification

Lack or inadequacy of quality seeds in aquaculture is another problem of aquaculture growth. At present apart from the government no other private sector involved with the fresh water fish fingerling production. Although adequate and regulated seed production is prevailed in the shrimp farming sector all other brackish water and marine sectors face the problem of inadequate seed supply. Deterioration of quality of the seeds with long term usage can be observed in some commodities eg. Seaweed farming hence needs to have proper programmes to have high standard certified seeds.

The use of non-native species and improved strains of native species may provide better seed for farming, but policies are necessary to ensure protection of native biodiversity.

Investments

Generally, there is low participation of private investors in the sub-sector due to various constraints in the procedures, lack of incentives, short term licences with lengthy procedure for application dealing with several line agencies which cause he investigators discouraged.

Market

The main problem seen in the marketing is that the producer is getting very low price while middle men get higher profits in the export commodities. The low selling prices are not able to give profit margin to the producers resulting less enthusiasm for farming. Priority should be given to make a more detailed analysis of the value chain to see if it would be possible to make interventions which could bring about higher profit margin at the producer level.

Freshwater fish raised in rural areas are sold at the local fairs by the farmers themselves or sold to an intermediate to sell at local markets. This vital for house hold level for food security, improving nutrition and income. On the contrary more than 90 percent of the farmed shrimps are exported and sold directly from the producer to the processor / exporter, the balance of production is sold at the local market outlets.

Issues related to export of aquaculture products

- Less quantity does not meet the demand and lacks of continued supply
- Because no commercial aquaculture for some commodities which have more demand
- Export certificates- some commodity needs safety certification. Ex for bivalves
- More line departments involved in issuing licences which is not a simple procedure.

Codes of Conducts and Management Practices in Aquaculture

The statements in Codes of Practice usually are fulfilled with practising Best Management Practices (BMPs). In environmental management practices considered to be the most practical and effective means of achieving a particular resource management goal, or to prevent one or more negative environmental impacts are called BMP. After the disease outbreak of white spot syndrome condition in the shrimp culture, many management practices came out. BMPs have been introduced in shrimp culture practice

by NAQDA. Various activities were implemented during last few years and the main activities undertaken were dredging of Dutch canal; introduction of a crop calendar and zoning; formation of relevant rules and regulations and implementation; regulation of shrimp hatcheries and screening of post larvae of shrimp and broodstock. In addition, services are being provided at the shrimp disease diagnosis and health management laboratory at Battuluoya for shrimp farmers to detect shrimp diseases.Moreover, inter-calibration of PCR laboratories which engage in WSSV which is the main virus detected in Sri Lanka carried out by initiation of NARA with the expert consultation under the FAO.

With regard to ornamental sector, health certifications such as bacterial types and counts, especially for *Vibrio cholerae*, is requested by certain buyers prior to export of ornamental fish, this is to prevent the spread of disease through trans-boundary movements of live aquatic animals. The health certification for export of live fish is issued by the Department of Animal Health and Production in compliance with the infectious pathogens and diseases listed by the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Office International des Epizooties (OIE)

Institutional Setup and Stakeholders Involvement

The Ministry of Fisheries and Aquatic Resources Development (MFARD) is the ministry of the central government entrusted with the responsibility of development and management of the fisheries sector. MFARD formulates the national fisheries development strategy and the implementation plan generally for a period of six years or the duration of the respective government. MFARD also directly implements programs and projects for enhancing the country's fishing capacity, welfare of fisher communities, provision of social infrastructure for fishing villages, promotion of private sector investments, promotion of fishery product exports, and externally funded special projects for development of fisheries. The processes of enactment of new acts, amendment of existing acts, and promulgation of regulations are also initiated and serviced by MFARD. To undertake different activities concerning management and development of fisheries the following government institutions have been established.

National Aquatic Resources Research and Development Agency (NAQDA) and National Aquatic Resources Research and Development Agency (NARA) are the two main institutions functioning under the Ministry of Fisheries and Aquatic Resources in Sri Lanka pertaining to aquaculture

research and development while Department of Fisheries involved in issuing permits.

National Aquatic Resources Research and Development Agency (NARA) was established in 1982 under the National Aquatic Resources Research and Development Agency Act, No. 54 of 1981 for the purpose of conducting research and providing advisory and consultancy services on scientific, technological and legal matters relating to exploitation, management, conservation and development of aquatic resources. Its scope covers marine biological resources, inland aquatic resources and aquaculture, fishing technology, post-harvest technology, environmental studies, oceanography, information technology and hydrography. Apart from its main research centre located in Colombo, it runs three regional research centres at Kadolkele (Negombo), Kalpitiya, and Rekawa.

National Aquatic Resources Research and Development Agency (NAQDA) was established in 1998 under the National Aquaculture Development Authority of Sri Lanka Act, No. 53 of 1998. NAQDA's functions include development and management of the aquaculture industry, and inland fisheries, which are generally culture-based. It operates nine regional aquaculture development centres that provide seed-fish and extension services required for culture-based inland fisheries and aquaculture, a shrimp-farm monitoring unit, and a central aquaculture training facility located at Kalawewa.

Currently there are several associations active in the aquaculture sector in Sri Lanka:

- Prawn Farmers and Exporters Association.
- Shrimp Breeders Association.
- Local small-scale shrimp farmers associations.
- Ornamental Fish Breeders and Exporters Association.

Recommendations

On the other hand, stringent regulatory measures have been imposed by the authority to obtain permission for operation of shrimp farm industry throughout the country. In this regard shrimp farm operation is allowed only within the zonal plan prepared by National Aquatic Resources Research and Development Agency.

Capacity building

Capacity building is a cross-cutting theme which is one of the major elements for sustainable development. The trainings for aquaculture are getting from many Asian and South Asian countries. The FAO Fisheries and Aquaculture Department undertakes capacity building activities for marine and inland fisheries as well as aquaculture. These include provision of training courses within Technical Cooperation Projects (TCPs), preparation of training materials (e.g. simple methods in aquaculture series, disease diagnostic guides, surveillance methods, extension manuals, technical manuals, etc.), awareness raising through training/workshops, financial and technical support to existing training programs carried out by partner institutions and custom training courses on specific topics.

Community is trained for various aquaculture practices under NARA and NAQDA. Ornamental sector trainings are carried out regularly in breeding and rearing of ornamental fish, disease management, feed production and management and aquatic plant culture.

Government sector provides technical information, advice and training to stakeholders. Outputs are then used by fishers and fish farmers, resource managers and policy-makers to improve production, conservation and policy-making in the fisheries and aquaculture sector. The results obtained through these programs are improved food supply and rural livelihoods through responsible production, better management practices and improved environmental sustainability.

Policy recommendations (adopted from draft National Policy document)

Aquaculture production enhancement

- Expand aquaculture horizontally and vertically in a sustainable manner without causing adverse environmental, social, cultural or other impacts.
- Identify new areas suitable for development of aquaculture, both inland and marine in consultation with central level, provincial level, divisional secretariat level land, environment, forest, wildlife and other relevant authorities, and local communities.
- Ensure that development of aquaculture in identified areas will not result in conflicts with other land-use and water-use patterns such as agriculture, plantation, livestock farming, fisheries, etc.
- Design aquaculture systems in the identified areas with where relevant common water supply, common drainage, location of different culture

facilities including, hatcheries, access roads, internal roads, etc. and conduct environmental impact assessments.

- Prepare zonal plans for aquaculture development areas and block-out plans for different aquaculture systems and units in such areas, and declare them as areas designated for aquaculture by order published in the government gazette.

Promote investments in aquaculture

- Invite investors by media advertisements to lease blocks for development of aquaculture from the areas designated for aquaculture.
- Make the investors aware of the BOI incentive package and EDB facilities available for export oriented industries.
- Simplify the leasing process of lands from the areas designated for aquaculture in consultation with the relevant land authorities.
- Introduce electronic online procedures and simplify the process of application for approval and granting approval under the NAQDA act for the aquaculture projects designed by investors for the leased land.
- Allow developers to transfer the leased and developed aquaculture systems to other parties together with the approval granted under the NAQDA Act.
- Make annual licensing of aquaculture projects only a means of collecting if relevant lease rents and verifying the conformity to conditions attached to the approval of the respective projects.
- Promote establishment of public – private partnership aquaculture projects.

Diversify aquaculture systems

- Promote different types of aquaculture such as pond culture, backyard aquaculture, pen culture, cage culture, stake culture, freshwater aquaculture, brackish-water aquaculture, mariculture, etc. in suitable areas in different intensities as appropriate.
- Promote the culture of different species including exotic species particularly those have a good demand in the domestic and export markets.
- Promote mariculture at industrial scale targeting the export market.
- Involve communities in community-based aquaculture such as fish culture in seasonal reservoirs.

- Involve households in rural areas in fish culture in backyard ponds as a means of food security.

Improve the productivity of the aquaculture systems

- Provide extension services to small-scale aquaculture farmers.
- Develop improved brood stocks at Aquaculture Development Centres and introduce to aquaculture farmers.
- Develop good aquaculture feeds.
- Encourage private sector to produce good quality aquaculture feeds.
- Establish an aquaculture-animal healthcare scheme in association with the Department of Animal Production and Health.

Provide financial assistance to develop aquaculture

- Develop low-cost credit schemes through the National Budget for small-scale aquaculture developers.
- Develop insurance schemes for aquaculture project in consultation with the insurance companies

Conclusion

The future development of aquaculture is strongly linked to the possibility of providing sustainable aquafeed ingredients. If the aquaculture of carnivorous species is mooted to continue further growth and improvements must be achieved through feeding of these animals and alternative feed ingredients for aquafeeds must be found. As a matter of principle the production of aquafeeds should be a sustainable activity. The sourcing of these raw materials should be environmentally acceptable, and should not have negative impacts on the ecosystems. Thereby feed management, feed production technologies and feed quality should be improved. Farming of lowtrophic level species, as well as the integration of aquaculture with other agricultural farming activities should be promoted. Confirmation of social carrying capacity is a major factor and the expansion will depend on perceptions of how much marine farming interferes with or detract from social values.

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Chapter 4

Best Management Practices in Aquaculture in Nepal

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Aquaculture Scenario

Nepal is situated between latitudes of 26°22' to 30°27' north and between longitudes of 80°4' to 88°12' east. Within the 147,181 km² area of the country, physiographic regions range from tropical forests in the south to the snow and ice covered Himalayas in the north and in-between that there are three geographic zones from east to west - plane (terai), mountain (hills) and the Himalayas. According to the topographic zones, there are three major climatic zones- tropical , sub- tropical and temperate.

The fisheries and aquaculture have emerged as potentially an important sector of Nepalese agriculture. It is among the fastest growing sectors in agriculture. Started in the early 1950s with the introduction of exotic carps, the aquaculture developed to a potential enterprise in the country. The current fish production in the country has reached to 83,000 MT. The most common aquaculture practices in Nepal are carp polyculture in ponds and in lake enclosures. Over the years, carp polyculture has been developed as the most viable and popular aquaculture production system in Nepal. It is becoming popular among professionals and especially the farmers due to different feeding behaviour of different fish species which gives low cost efficient production and are cultured in semi intensively managed earthen ponds. Basically two types of aquaculture are practiced in the country- cold water aquaculture in hilly and himalayan areas and warm water aquaculture in plane areas. In warm water aquaculture, it mainly includes the fish species that could adapt the wide range of temperature and are practiced with different species in polyculture. The species that are used in carp polyculture are mostly common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), Silver carp (*Hypophthalmicthys molitrix*), bighead carp (*Aristhicthys nobilis*), as well as Rahu (*Labeo rohita*), Mrigala(*Cirrhinus mrigala*) and Bhakur (*Catla catla*). There are some exotic fish (eg. Pangas and Tilapia) also which are used in monoculture practice. Rainbow trout (*Oncorynchus mykiss*) is aquacultured in intensive coldwater monoculture system. in The mixed effect of complex geographic and edaphic factors with thermal variables, the fish production from upland region is still at very low

pace. Except some development in trout farming in recent years, the cold water aquaculture is still in infancy.

Table 1. Import and export status of table fish in Nepal

Year	Import (MT)	Export (MT)
2009/2010	4334.86	850
2010/2011	5370.2	0.36
2011/2012	7424.92	0.1
2012/2013	9963.06	0.2
2013/2014	12869.46	-
2014/2015	11176.87	0.4
2015/2016	7153.48	-

MT- million tonnes

Source: Annual book 2015-2016 by Directorate of Fisheries, Balaju Kathmandu

Prospects of Aquaculture

Nepal has huge diverse water resources in the form of rivers, rivulets, streams, streamlets, lakes, swamps, reservoirs and irrigated paddy fields which have a total area about 8,23,160 ha. Rivers are the most important fresh water resources of Nepaland constitute 48.57 % of the total water bodies in the country. Lakes and swamps (Ghole) also play the significant role of water resources availability and got potential of future aquaculture in Nepal.

Table 2. Aquaculture and fisheries resources

Resources	Area (ha)
Aquaculture pond	11,160
River	3,95,000
Lake	5,000
Ghole(swamps)	12,500
Reservoirs	1,500
Paddy field	39,8000
Total	8,23,160

Source: Progress Report 20162017 by Directorate of Fisheries, Balaju Kathmandu

There are four major river basins in the country, namely, River Sapta Koshi, River Sapta Gandaki, River Karnali and River Mahakali. These four river systems are located respectively from eastern to western Nepal. The first

three of the major river systems cover nearly 60 percent of the total area of the rivers in Nepal and some of their tributaries originate from Tibetan region while the River Mahakali originates from the Himalaya within Nepal and flows as the western bordering river between Nepal and India. There are also seven medium rivers, namely, Mechi, Kankai, Kamala, Bagmati, Tinau, Rapti-west and Babai, which originate from the high mountaineous regions of the Himalayan or Mahabharat. The third categories of rivers originate from the Churia (Siwalik) range. These rivers are rain fed, short in length and have little or no flow during dry season.

Figure 1. Major rivers of Nepal from east to west, Koshi or Saptakoshi, Gandak or Saptagandaki, Karnali, and Mahakali.

Aquaculture Production Scale and Methods

Agriculture sector has the important role in the Nepalese economy. Aquaculture contributes about 1.32 % to national gross domestic products (GDP) and 4.22 % in agriculture GDP of Nepal. It is one of the fastest growing economic and food producing sector with growth rate of 10.79 % per annum. Pond aquaculture is the major aquaculture system contributing more than 65% in total aquaculture of which 70% is contributed by exotic carps. The total fish production in the country is about 83,000 t, of which 62,500 t is shared by aquaculture and rest of 21,500 t is shared by the capture fisheries. The total domestic production meets nearly 90 % in the total fish requirement of the country and deficit is imported from neighbouring countries.

Table 3. Fish culture technologies and inputs recommended to farmers

Attributes	Pond	Ghole	Cage	Paddy field	Integrated fish farming
Fish seeds (number of fingerlings)/ha	12,000	7,000	10/m^3	5,000	10,000
Feed (% of body weight)	3	2			2
Lime (kg/ha)	500	500			
N (kg/ha)	220				
Phosphorous (kg/ha)	345				
Culture period (days)	300	300	300	90	300
Production (t/ha)	>4.0	2.0	6kg/m^3	0.5	5.0

Although Nepalese aquaculture is much focused on semi-intensive carp polyculture, there are various methods adopted in practices as availability of resources. However, the carp polyculture is well adapted among farmers. On the base of low feeding cost and natural food availability in different ecological zone of pond ecosystem, polyculture has been well established. Polyculture system is mainly used in pond fish culture where multiple stocking and multiple harvesting, aerator, pellet feeds are used in well managed way. The pond dikes are also used as integrated fish farming for good economic return. Integrated fish farming are generally combination of fish farming with vegetable on dike, fruits on dike or piggery or poultry with pond fish farming. Regular monitoring pond water quality parameter is done. Monoculture system in intensive way of Pangas culture is also raised now a days where water quality parameter is monitored on the same way.

Table 4. Fish production status of Nepal during 2015/2016

S. No.	Programs	Areas ha/ m^3	Production	Productivity
1	Pond	9934	48543	4.88
2	Paddy field	100	45	0.45
3	Pen	100	140	1.4
4	Gholes	3300	6100	1.84
5	Cage	70000	350	6
6	Raceway	3	300	100

Source: Annual book 2015/016 by Directorate of Fisheries, Balaju Kathmandu

Recommended technologies for carp polyculture in pond: For best management practices

- Pond: Rectangular, 1.5 m depth
- Soil: loam, clay loam
- Slope: 1:2
- Species: 7 (common carp 25%, Silver carp 35%, Bigheah carp 5%,Grass carp 5%, rohu 10%, Naini 15%, bhakur 5%)
- Stock time: February - March
- Stock rate: 12,000 fingerling/ha
- Stock size: Fingerling 10-25 gm
- Feed: 3% bw/day, contain 25-30% protein, normally use rice brain and oil seed cake, if possible pellet feeds are suitable.
- Manure: 3000kg/year
- Nitrogen: 220kg
- Phosphorus:345kg
- Culture period: 300 days
- Multiple stocking and multiple harvesting
- Regular water quality checking: pH 6.5-9, temp. 18- 32* c, turbidity 40 cm, DO above 5ppm,
- Lime: 500kg/ha
- Aerator
- Production: above 5mt/ha

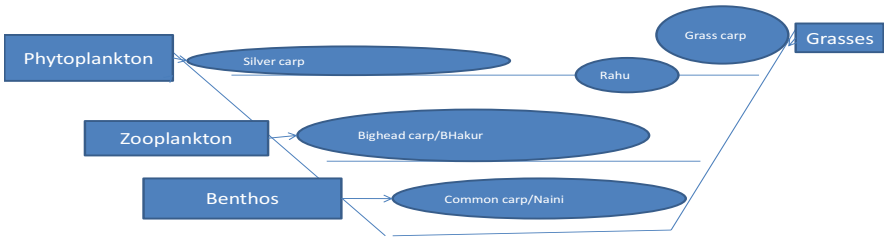

Figure 2. Natural food and feeding ground of cultivated fish

Recommended technologies for Integrated fish farming: For best management practices

- *Integration with Vegetable:* Brinjal, chilly & cucurbits:- In this type of fish farming grass carp is main species, where 40-50% grass carps are needed to stock for the proper utilization of vegetative part of vegetable.
- *Integration with Fruits:* Banana:- In this type of fish farming also grass carp is main species, where 40-50% grass carps are needed to stock for the proper utilization of leafy part of banana.
- *Integration with Piggery:* 30-40piglet /ha:- In this type of fish farming common carp is main species, where 40-50% common carps are needed to stock for the proper utilization of pig dung.
- *Integration with Poultry:* 700 poultry/ha:- In this type of fish farming carp polyculture system are recommended mainly focused in the production of planktons, which is natural foods of fish.
- *Integration with Duck:* 500 duck/ha.:- In this type of fish farming carp polyculture system are recommended mainly focused in the production of planktons, which is natural foods of fish. Ducks are suitable for increase the oxygen label in the pond.
- *Integration in Paddy field:* In the paddy field 8000 fingerling/ha are recommended for fish culture . Verities of paddy required tall and strong . 10% of total paddy field are required to make pit for the fish and fingerlings are release 15 days after paddy transplant. The pit size are varies according to soil type. Generally 1-2 m with, 60 cm depth and40-50m length is suitable. The fish cultured period of this integration is only 90 days and productivity near 500 kg/ha.
- *Integration with Livestock:* 4cows/ha:- In this type of fish farming, carp polyculture system are recommended mainly focused in the production of planktons, which is natural foods of fish.

Figure 3. Integrated fish farming with banana and poultry

Raceway Aquaculture

There is only one species of cold water aquaculture mainly Rainbow trout (*Oncorynchus mykiss*) is cultured in monoculture system with the practice of intensive farming.

The recommended technologies of Rainbow trout culture are as follows:

Pond: raceway 10 m length, 1.5 m with and 1 m depth

Stock time: March to February

Stock rate: 40-50 fingerlings/ m^3

Feed: 5% bw/day as 40-50% protein contain, pellet feed according to fish size

Culture period: 14-15 month

Water qualities: water color clear, temp.8-18^oC, water flow1 lit/se

Production: 100 MT/ha

Recommended technologies for carp polyculture in Gholes: For best management practices

- Species: 7 (common carp 25%, Silver carp 35%, Bigheah carp/ Bhakur 10%, Grass carp 10%, Rohu 10%, Naini 10%,)
- Stock time: February to March
- Stock rate: 7,000 fingerling/ha
- Stock size: Fingerling above 25 gm
- Feed: 2% bw/day, contain 25% protein, normally use rice brain and oil seed cake
- Culture period: 300 days
- Regular water quality checking: pH 6.5-9, temp. 18- 32* c, turbidity 60-80 cm, DO above 5ppm,
- Lime: 500kg/ha
- Production: above 2mt/ha

Figure 4. Ghole (Koilae ghole in Kailali)

Issues and Challengesin Aquaculture

Environmental issues

- Conservation of fish biodiversity: Most of the rivers and other natural water resources are having low catch per unit area of local indigenous species(eg. Sahar *Tor tor*, *Tor putitora*, Asala Schizothorax spp, katle *Neolissocheilus hexagonolepis* etc) year after year due to illegal and unmanaged way of fishing.
- Protection of natural habitat of fish from human activities: Construction of Dam and Hydro-power electricity station are also found the root cause of low catch of indigenous fish, as such construction destruct the natural habitat and not have the proper construction of fish ladder, fish sanctuary and breeding center.

Planning and management issues

- Introduction of new fish: Before introduction of a new species to the culture systems its' adaptability to the new system and affects on local species catch must be studied.
- Modification of fish culture system: To meet the total fish production of country there is very important uplift the productivity by modifying the culture system using mechanization and technology.

Social issues

- Use of natural water bodies in aquaculture/Ranching: Very few natural water bodies are stocked with fish seeds. Ranching of fish seeds to the natural water bodies increases production as well as natural stocks.
- Industrial as well as domestic pollution: Industrial as well as domestic wastes are directly released in to the rivers and water bodies which causes which pollute the water bodies and harm the fish and fish habitats.
- Aqua-Tourism and Live fish markets: Now a days people wants to spend their times in recreation that helps by fishing, boating in fish pond and fish restaurants. Similarly due to the health concern people wants to take fresh fish from the market, But there in mostly available of only dead table fish in the market. So there is a space for supply live fish in to the markets.

Figure 5. Aquatourism in Nepal

Code of Conduct and Management Practices

- Fish / aquaculture act and regulation: "Aquatic animal protection act 1960" should followed by the proper regulation for implementation of the act.
- Code of conduct and management practices: Still there is to follow "Animal health and livestock services act 2015" for health issue by aquaculture professionals as well as they should also have to follow "Animal slaughter house and meat inspection act 2015" at quarantine to address the quality of fish tissue.
- Working Procedure on special Fish production 2016 by MoAD
- Norms by MoAD

- Monitoring and Evaluation by FDC
- Technical discussion among Nursery man, District Agriculture Development Office and Fisheries Development Centre

Figure 6. Private hatchery monitoring

Supporting system to farmer/farmers groups from government side

Fish seed production as well as fish production technology

The new technologies are disseminated by government officials to the farmers under different program. These programs are arranged by time duration (1 day, 1 week, 1 month, 51days on the basis of farmer's need) under different modules.·

Figure 7. Farmer's training

Fish seed

There are 11 Government Fisheries Development Center all over the Nepal and they meet the fish seed requirement at different part of Nepal. These centres also coordinate with District Agriculture Development Offices for transfer of technology of seed production and fish rearing.

Figure 8. Fish seed converting

Figure 9. Fish seed distribution

Figure 10. Water quality checking

Subsidy for pond construction and management

The Government of Nepal provides subsidies to encourage farmers for aquaculture. Since 2 years government is providing Nrs.300,000/ha for fish pond construction. Similarly, 50% to 85% subsidy are provided other activities related to aquaculture viz., for buying aerator, drag net and vehicle used for fish seed transportation as well as marketing of table fish.

Figure 11. Pond constructed with government subsidy

Demonstration kits

The District Agriculture Development Office distribute the demonstration kits such as fingerlings, feed, fertilizer etc. and provide training to the farmer with the co-ordination of Fisheries Development Centres.

Figure 12. Fingerling distribution as demonstration kits

Institutional Setup

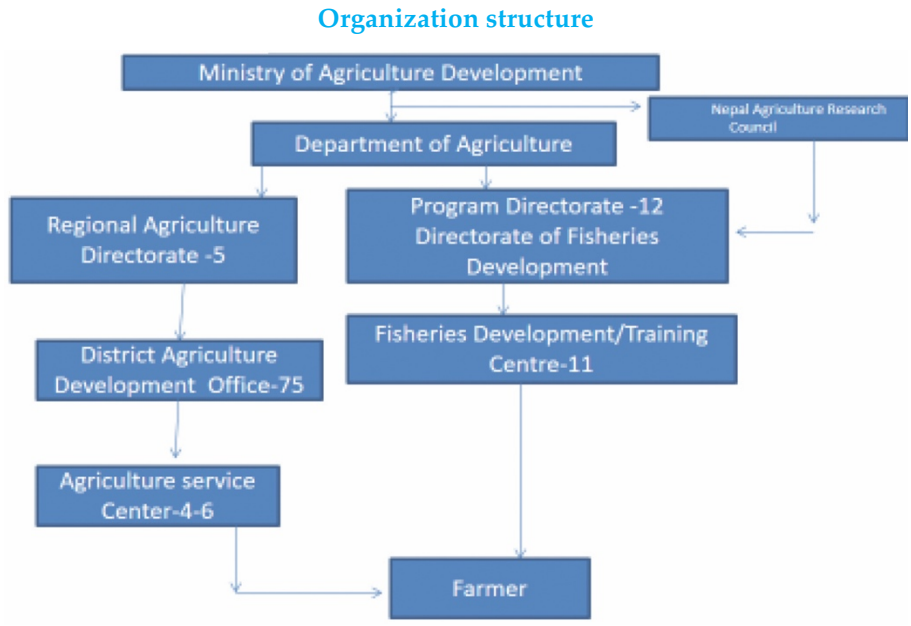

Figure 13. Organisational set up in Nepal

Governmental institutions are available at different levels as follows:

- Fish Research Station (Nepal Agriculture Research Council) – 9
- Fish Development Center (Department of Agriculture) – 11

Fisheries Extension Program (District Agriculture Development Office) – (Fisheries officers in 26 district and Fisheries Extension Workers in 33 districts)

- Tribhuwan University
- Agriculture and Forestry University

Figure 14. Fisheries Development Centre, Geta, Kailali Nepal

Recommendations

It is needed to make up one technical forum for technology transfer between member countries, which will help in capacity building of persons involved in aquaculture as well as in policies development within the SAARC countries.

Conclusion

Based on the scenario discussed above, Nepalese aquaculture product and productivity is found to be low. This program will help to share the ideas on best management practices of different member countries, which can be incorporated in the new policies that will ultimately help to increase productivity of aquaculture in the country.

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Chapter 5

Best Management Practices in Aquaculture in Pakistan

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Aquaculture Scenario

The population of the world is increasing at a fabulous rate. As a consequence of rapid population explosion, the problem of food shortage, particularly good quality protein is critical. Therefore without a corresponding increase in food production; this situation may lead to a risk of severe malnutrition in developing countries including Pakistan. It is unfortunate to mention that one or more nutrient is deficit in the food of a considerable population of the world (FAO, 2012) and this situation is adversely affecting the health and vitality of the people. Aquaculture provides aquatic animals including fish that are rich source of vitamins, minerals, protein, and essential fatty acids (FAO, 2012) and can play an important role in eliminating hunger and malnutrition.

Pakistan, despite of being an agricultural country and maintaining millions of people on its land, is facing an acute shortage of proteins. It is therefore, the need of the time to increase the animal protein production to solve the problem of protein shortage. Aquatic resources are among the major alternatives for the production of animal protein. With the declaration of an exclusive economic zone (EEZ) in 1976, Pakistan's fishing limits were extended to 200 nautical miles from the shore, providing the country with a fishing area of approximately 196,600 square kilometers, with shoreline areas of less than 200 m in depth estimated at around 50,000 square km. The entire coastline, of about 1,100 km bordering the Arabian Sea, lies within the subtropical zone and is divided into the coasts of Sindh and Makran in Balochistan. The continental shelf of the Makran coast is steep, rough and very narrow, i.e., between 12-32 km wide. The Sindh coast, on the other hand, has an extended 40-120 km shelf area. Mostly flat, it forms good trawlable ground. The coast protrudes into the sea in the form of capes and peninsulas and is, at a few sites, cut off into several small and large bays. There are only a few islands along the coast. The large estuarine delta of the river Indus provides good nurseries for fin-fish, shrimp and other marine life.

Pakistan possesses an extensive lake, river and canal system. Natural lakes cover an area of 109,780 ha. Some are high- altitude lakes suitable for cold water fish e.g., Saif-ul-Mulook in the Khyber Pakhtunkhwa (KPK), Satpara in the Gilgit Biltistan Areas and Hanna in Balochistan. Warm water lakes are mostly located in Sindh, and two such lakes are Manchar and Keenjhar. There are several small lakes also, mostly in the Thatta and Sanghar districts of Sindh. The Indus and its tributaries are the major freshwater fisheries of the country. The Indus flows from the GB Areas through the KPK and the Punjab, where it is joined by five large rivers; Kabul, Jhelum, Chenab, Ravi, and Sutlaj before passing through Sindh and finally draining into the Arabian Sea. Along the course of the Indus are a number of dams and reservoirs which provide water to an extensive irrigation network in the Punjab and upper Sindh regions, representing one of the world's largest canal systems. These running and still waters cover about 4.57 million hectares, while water logging covers about 2.225 million hectares. Of the reservoirs, six; Mangla, Tarbela, Chashma, Hab, Khanpur and Warsak cover an area of 80, 613 hectares and play an important role in freshwater fisheries. Besides these, more than a hundred small and minidams (in the baran (rain-fed) tract of the country, particularly in the Potwar Plateau) built for the storage of water, hold an immense potential for aquaculture. At present only a few of these water resources are being used to raise fish. Although aquaculture is a fairly new activity in the country, dug-out ponds for fish farming have been constructed in the private sector. There are approximately 120,000 hectare fish farming in the country. However, aquaculture is characterized by low production per unit area, mainly because of low inputs.

In Pakistan, according to the latest estimates, the total area covered by fish ponds across all provinces is about 60 470 ha, with Sindh having 49 170 ha, Punjab 10 500 ha, KP 560 ha and the other provinces (Balochistan, Azad Jammu Kashmir [AJK] and Northern Area [NA]) 240 ha. About 13 000 fish farms have so far been established across Pakistan, the size of these farms varies considerably; however, the average farm size ranges form 5-10 ha. No direct data on the number of fish farmers employed in this sector is available as fish farming in most parts of the country is carried out as an integral part of crop farming. According to a best estimates, about 50 000 people are either directly or indirectly employed in the sector (FAO, 2017). Pakistan has about 198 freshwater fish species, among those at least 31 species are economically important.

The aquaculture system in Pakistan mainly gyrates around carp fishes including both indigenous major carps and exotic Chinese carps

(Basavaraga *et al*., 1999). Indigenous major carps namely *Catla catla, Labeo rohita,* and *Cirrhinus mrigala* are the fish for culture. In order to improve aquaculture system Chinese carps i.e. *Hypophthalmichthys molitrix* (Silver carp), *Ctenopharyngodon idella* (Grass carp), *Aristichthys nobilis* (Bighead carp) and *Cyprinus carpio* (Common carp) were introduced to the culture system of Pakistan. These fishes have gained popularity in fish farming due to their number of traits, such as culture suitability in captive conditions and good growth in ponds (Mirza and Bhatti, 1999). Two species of trout namely brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) are cultured in KP, AJK and NA.

Carp are cultured in earthen ponds utilising extensive polyculture farming systems with very little inputs; in some farms semi-intensive culture has also been adopted. A combination of five or six of the three indigenous species of Indian major carps as well as 3 exotic species of Chinese carps are grown in the ponds. On a typical farm in Pakistan, the ratio of the warm water species stocked on the farm is as follows: catla (10-20 percent), rohu (30-35 percent), mrigal (15-20 percent), grass carp (15-20 percent) and silver carp (15-20 percent). The intensive culture of these species has not yet been adopted so far, the major impediment to this development being the non-availability of low cost feed and to some extent the non-availability of intensive fish farming technology.

The productivity of carp farms show marked differences across the provinces with Punjab having the highest per unit production followed by Sindh and KP. Presently two species, brown trout and rainbow trout are being produced and cultured successfully for use in sport fishing activities. The intensive rearing of trout is practiced in commercial raceways in Swat, Dir, Chitral and Hazara in KP and in AJK and NA. With the exception of trout culture in KP and the northern region, virtually all aquaculture currently carried out in Pakistan is pond culture of various carp species. Freshwater fish culture in earthen ponds, both small and large reservoirs as well as community ponds was initiated in late 1960s by the provincial fisheries departments. From 1980 onwards the polyculture of Indian major carps and Chinese carps has been carried out in Punjab, Sindh and to some extent in NWFP.

Prospects of Aquaculture

The potential for fish farming particularly in developing countries is great. It offers as economical source of protein rich food. It also offers that the land which is unsuitable for cultivation, can be used for fish farming. According

to the UN survey, that fish production from aquaculture in 1985 stood 10 million tons, closed behind beef, pork and poultry. According to the FAO estimates at present world aquaculture provides 12 per cent of global fish production, but it will be more than double by the end of the century. FAO figures suggest the demand for aquatic foods will reach 100 million MT annually by the year 2000 creating a 20 million MT gap between supply and demand. Aquaculture is the major hope for providing animal protein at a reasonable price to meet the nutritional requirements of Pakistani People for the year 2010 AD.

The fisheries sector plays an important role in the alleviation of poverty and the achievement of food security in many parts of the world. In many economies, fisheries exports generate more foreign exchange than the revenues earned from any other traded food commodity (FAO 2004). According to the Economic Survey of Pakistan 2006-2007 (ESP 2006-2007), fisheries are the principal source of livelihoods for many rural communities inhabiting the long coastline of Sindh and Balochistan, as well as inland along the major rivers, and in the vicinity of lakes and dams. The fisheries sector is estimated to provide direct employment to about 379,000 fishermen and 400,000 people in ancillary industries (State Bank of Pakistan).

With the exception of trout culture in KP and the northern region, virtually all aquaculture currently carried out in Pakistan is pond culture of various carp species. Pakistan has not yet begun any coastal aquaculture operations although there is good potential all along Pakistan's 1100 km coastline. Efforts have been made in the past to start shrimp farming along Sindh coast (Yaqoob, 1994) which did not succeed, the main constraints being the non-availability of hatchery produced seed and lack of expertise. Freshwater fish culture in earthen ponds, both small and large reservoirs as well as community ponds was initiated in late 1960s by the provincial fisheries departments. From 1980 onwards the polyculture of Indian major carps and Chinese carps has been carried out in Punjab, Sindh and to some extent in KP and Balochistan.

According to the old estimates, the total area covered by fish ponds across all provinces is about 60470 ha, with Sindh having 49170 ha, Punjab 10500 ha, KP 560 ha and the other provinces (Balochistan, Azad Jammu Kashmir and Northern Area [Gilgit-Biltistan or GB]) 240 ha (Akhter), current data of total number of fish farming is not available, however, a recent survey conducted by Fisheries Development Board reveals that in three Tehsil one each of Gujranwala, Hafizabad and Mandi Bahuddin, about 10000 ha of area

is under fish farming. Projecting based on this data, it could safely be said that total fish farming area of Pakistan is about 120,000 ha.

Marine fisheries exclusively depend upon capture fisheries. Some development work for shrimp farming was initiated under two development projects namely Aquaculture1 and Aquaculture 2 during 1980s and 90s, which established among other a big coastal aquaculture farm at Gharro area district Thatha. The farm consists of about 28hectare of pond area along with offices, labs and residential buildings. At the same time the Sindh government allocated 6800hectare of land in the area to about 80 prospective shrimp farmers. However, because there was no local production of seed in Pakistan, all those involved had to import seed from Sri Lanka and Malaysia resulting to high mortalities experienced. Due to the lack of expertise, none of the pilot farms managed to continue in operation and all shrimp farming activities ceased by 1990. The government, however, took note of the potential importance of shrimp farming and again initiated efforts to establish a shrimp hatchery complex at Hawks Bay which started operation in 2001. Successful rearing of post-larvae (PL) was achieved at this hatchery in 2002. A privately run enterprise has successfully cultured the seed from this hatchery and subsequently produced about 3.0 tons of shrimp that were later exported. Fisheries Development Board has supported to enhance the capacity of the said hatchery upto 32 million PL/year (Personal communications).

The federal government has also taken a number of additional steps aimed at supporting the development of commercial scale shrimp farming in Pakistan. In this context, the Marine Fisheries Department (MFD) conducted two stock assessment surveys of the coastal areas of Sindh and Balochistan provinces, established a hatchery for shrimp and fish species. Fisheries Development Board under aquaculture and shrimp farming project selected 11 potential sites along Balochistan Coast and established a shrimp hatchery at Jiwani. But all these efforts remained unsuccessful due to one reason or other (personal communications).

Pakistan has many marine and inland fishery resources. The potential was estimated at 1 million tonnes/year from the marine subsector alone. The commercially important resources include near 250 demersal fish species, 50 small pelagic fishspecies, 15 medium-sized pelagic species and 20 large pelagic fish species. In addition, there are also 15 commercial species of shrimp, 12 of cephalopods and 5 of lobster. The effect of the Indus River Delta on the marine resources of the coastline of Sindh is substantial, as this river system has been transporting enormous quantities of nutrients and

sediment to the continental shelf for centuries. Pakistan has an extensive inland water areas system, which is mainly dominated by the Indus River. These water bodies, depending on their type, possess varying potential for development of the inland and aquaculture subsectors.

The commercialization of fisheries in Pakistan is fairly a recent phenomenon. On Fisheries side, Pakistan has opened up its deep-sea waters to commercial fishing relatively recently when compare to regional countries. This practice (with no scientific data in hand) has resulted in over exploitation of natural stocks and hence considered a main reason in depletion of fish stocks in Pakistani waters. The local fishermen are harvesting fisheries resources mostly in traditional manners but some fishermen are also using destructive fishing gears in greed of more fish and they also has contributed in stock depletion. The fish handling practices on boats and at harbors are so poor that it spoils fish during transportation and handling at harbors and in processing plants. The fish and its product produced under this supply chain are not at par with international standards and hence largely considered unhygienic for the export markets. The gaps identified in the supply chain are in respect to food safety standards, and sustainability standards. Further future prospects of aquaculture in Pakistan may include:

- Further intensification of fishing pressure in the shelf and deep seas is possible in the next few decades, due to addition of fishing units and enhancement of fishing efficiency in terms of vessel capacities, fishing power of gear systems and acoustic and satellite based fish detection systems and electronic navigation systems. This may raise issues of long term sustainability and impact on biodiversity and may result in diminishing returns in terms of landings and catch per unit effort.
- There will be increasing demand for development and implementation of conservation technologies for minimising negative impacts of fishing on resources, biodiversity and environment. These may include technologies for bycatch reduction, protection of vulnerable species, minimising energy use in harvest and post-harvest operations and minimising environmental impacts and materials protection technologies.
- Problems of scarcity and cost of timber resources for boat building, biodegradation and corrosion may further aggravate and may require intensive work on alternate boat building materials.
- Climate change is likely to show its impacts causing regime shifts of certain commercial species which may affect their regional availability

and abundance, which in turn may impact on the fish harvesting and processing sectors, either negatively or positively.

- Requirement for the regionalisation and implementation of the FAO Code of Conduct for Responsible Fisheries, adoption and implementation of Ecosystem based Fisheries Management (EFM) and effective control of illegal, unreported and unregulated (IUU) fishing to management of fisheries may come to the forefront.
- Fishery certification, ecolabelling and traceability may become important issues influencing international seafood trade from India, in the next few years and expertise and infrastructure may have to be developed to address these issues on national and international level.
- Reservoir fisheries may get a boost, due to its high potential in enhancement of national fish production. Cluster based integration in harvest and post harvest operations, value addition and marketing, under value chain concept may have to be evolved.
- Factors affecting riverine fish production such as pollution, destructive fishing and overfishing may aggravate in the next few decades and may need management redressel.
- Unconventional resources such as oceanic cephalopods and myctophids may become significant sources of seafood supply in the next few decades, in the context of stagnation and shortfall in the availability of traditional fishery resources, and these developments may demand appropriate technology interventions for their sustainable harvesting, value addition and utilisation.
- Further enhancement in India-based tuna fishing effort may take place in Indian Ocean region and accompanying effort in improving harvesting and processing of high value tuna products may be required.
- Advanced techniques for seafood preservation such as non-thermal processing may become available and widely applied in seafood processing and preservation. Value addition will be the key principle in guiding product development. A zero-waste approach will be warranted with fishery waste also converted to economical products. Packaging will play an important role in determining consumer acceptability with respect to perceptions on safety as well as maintenance of quality.
- Newer products that have wide ranging applications may be available from the large aquatic resources, including microbes. These can be exploited for human good.

- There is need to mainstream fish in the food habits of the Indian population with better understanding of the role of fish in decreasing malnutrition and improving health and creation of awareness about its significance.
- Seafood safety issues may bring in newer challenges with the emergence of new forms and variants of pathogens. The issue will also come into focus with increasing stress on the domestic market for promotion of seafood products.
- Increased awareness of consumer regarding the usefulness of fish as a source of nutrition and the changing demands for newer and convenient products that are easy to cook or consume will call for intensified efforts in this area.
- The national and international policy regimes vis-à-vis trade, climate change, conservation and environment are changing rapidly and these will continue to have an impact on the fisheries sector of the country.
- The traditional systems of technology transfer will undergo changes and innovative models including public-private partnerships will evolve making the process of technology commercialization more dynamic and a truly two way process.Intellectual Property protection will see new challenges in the face of the need for judicious commercialization and responding to societal needs.

Aquaculture Production Scales and Methods

Fisheries and allied industrial activities are the most important economic activities along the coast of Sindh and Balochistan supporting livelihood of about 1.0 million fishermen and their families living in rural villages under difficult conditions (Nasim, 2010). A fishery also is an important sub sector of agriculture in Pakistan and its role in national economy cannot be underscored. The sector also contributes towards national food security. The GOP, has been working in past to promote fisheries, both marine and inland, but somehow the sector was unable to receive attention and matching resources thereof from the government side due to which the sector could not be developed on strong footings in Pakistan, although there has been increasing trend in total fish production (Nasim, 2010).

The existing fish farming practices comprises of extensive to semi intensive system with low input and low output farms. Except trout farming which is practiced in concrete raceways, all farming practices are based on earthen ponds have shallow water depth of below 5 feet. Input consists of organic farm waste, cow-dung, poultry waste, farm made fish feed using locally

available feed ingredients. Stocking density is very low from 1250 to 3000 fish babies per hectare. Use of aeration is very limited to cluster of Muzafargarh where semi intensive farming practices have become popular (NFS&R Yearbook, 2013-14). With the promotion of tilapia farming one tilapia hatchery has been established and two commercial feed plants. Tilapia farming has promoted the use of water aeration in some parts of Punjab. Cage farming is being conducted at experimental stages by Fisheries Development Board in Mangla dam and some other water bodies. The concept of hygienic methods of fish handling and marketing is yet to be popularized among various players of the sector (FDB, personal communication). Pakistan has not yet begun any coastal aquaculture operations although there is good potential all along Pakistan's 1 100 km coastline. Efforts have been made in the past to start shrimp farming along Sindh coast, (Yaqoob, 1994.) which did not succeed, the main constraints being the non-availability of hatchery produced seed and lack of expertise.

About 50 % of the total production is consumed locally, 22% is exported whereas 28% is converted into fish meal for poultry industry. There are more than 50 fish processing plants in Pakistan with the capacity to process 586 metric tons of fish and shrimp daily. Out of these, 27 plants are involved in production of frozen products, 2 in canning, and 8 for fishmeal processing. The export of sea food products increased from US$ 213 in year 2007-08 to US$ 317 in year 2012-13 thus registered a marked increase in term of values (MFD, 2014).

Despite a lack of formal training, fishers in Pakistan are experienced and accustomed to coastal and offshore operations, which has resulted in successful fishing techniques, based on simple technology and fishing gear (Khan and Khan, 2011). Thus, the small-scale fishing communities have maintained their traditional methods of fishing, production and marketing (Siddiqi, 1992). Fishers engage in traditional fishing practices within the 12 nm coastal zone (no deeper than 50 meters), from small wooden-vessels, using cast nets, gillnets, stake nets and line gears (Khan, 2006). Many of the local gears used are non selective and unsustainable, with trammel nest and fine mesh gillnets used widely in coastal areas.

These fishing activities are managed by the provincial fisheries departments of Sindh and Balochistan (FAO, 2003). Fishermen use nylon gillnet for this purpose. Benthic variety includes Jew fish, Croakers, Grunters, Shaper, Groupers, Ribbonfish, and Pomfret. Pelagic fishing is used in Sindh on small scale by special nets using wooden sailboats. Fishing by this method is done especially in Ibrahim Hydari and Chashma Goth villages. Two types of

vessels are used for fishing in Pakistan firstly, Mechanized Docked Boats which are 6000, and secondly Mechanized Sailboats made of wood which are 2000 in Pakistan (Sidiqui, 2012).

It is difficult to estimate the total artisanal and subsistence fishery production in Pakistan, as there is no routine registration required for village fishers. Still, it is estimated that artisanal fishing contributes approximately 40% to total annual marine catch (Siddiqi, 1992).

As with most trawl fisheries, Pakistan's shrimp fishery produces a large portion of by-catch and discards. Substantial quantities of non-target fish are caught, which consist of a mixture of fish species, including fish of commercial importance, and a significant portion of small, unmarketable fish. The trawl feet can be at sea for approximately 7-15 days and the by-catch can be retained each day depending on the capacity of the vessel and is usually caught in the last few hauls (Shakir and Bano, 1999). Approximately 60-90% of all by-catch is retained for the purpose of fish meal production. Discard rates have been estimated by region for the trawl fishery (Davies *et al.* 2009).

Tuna supports some of the more important fisheries in Pakistan. There are eight known species of tuna landed in Pakistan. However, only five species contribute significantly to commercial catches (Khan 2012b): longtail tuna (*Thunnus tonggol*), yellowfin (*Thunnus albacares*), skipjack (*Katsuwanus pelamis*), frigate tuna (*Auxis thazard*), and Kawakawa (*Euthynnus affinis*). The official reported data does not include any landings of bigeye tuna (*Thunnus obesus*). According to Fonteneau (2009), vessels of Pakistan and Iran's oceanic gill net fisheries operating in Central Western Indian Ocean waters may have greatly under reported catches of bigeye tuna. It has been predicted that in some cases, bigeye catches have been misclassified as yellowfin tuna catches, something that has also been documented in Iran and the Maldives. However, as bigeye tuna are rare in northern parts of the Western Indian Ocean, this does not apply to Pakistan's tuna catches in EEZ waters or near-EEZ high seas waters (i.e., northwest Indian Ocean). The fishery operates as both an artisanal and industrial activity, using locally made wooden-hulled gillnet vessels. It is estimated that more than 500 gillnet fishing vessels are engaged in the inshore and offshore fishery for tuna (Khan 2012c), with most vessels ranging from 10-20 m. Only about 30 vessels are between 20 to 30 m LOA and have on board freezing compartments and dual registration to fish in Pakistan and Iran's EEZ (Khan, 2012c).

The elasmobranch fisheries of Pakistan, which target sharks, sawfish, guitarfish and rays, are in declining state. Pakistan's landings, in the early 1990s, contributed 5% of the world's elasmobranch production (Bonfil, 1994), and Pakistan became one of the 30 top shark fin exporters to Hong Kong in 2008 (Maslam, 2010).

A sizable recreational fishery exists in Pakistan that targets fish in three different zones of the EEZ: billfish and tuna fishing out of Karachi, sport fishing in coastal waters, and hand-line (bottom) fishing in near-shore waters (FAO, 2009). The only available information on this sector evaluated the fishery at about 900 participants, catching approximately 130 MT in 2002 in all activities, and by 2009 it was estimated that 1000 participants were involved in the sector, operating approximately 120-150 non-licensed vessels (Khan, 2006; FAO, 2009). Despite this information the total contribution from this sector remains unknown and no official records of catch can be found.

Issues and Challenges in Aquaculture

Environmental issues

As in many other environments, those occupied by fish are not stable, but characterised by natural and anthropogenic change. Natural environmental variations present their own challenges to fishery managers. In freshwaters, flow regulation and obstruction by dams, fragmentation, catchment management, pollution, habitat alterations, exotic fish introductions and nursery reared fish are widespread issues. In marine systems key issues include the direct effects of exploitation on fish, habitats and other organisms, while habitat or water quality problems arise also from the atmospheric, terrestrial and coastal environments to which marine systems are linked.

As in many other environments, those occupied by fish are not stable, but characterized by natural and anthropogenic change. Natural environmental variations present their own challenges to fishery managers. Issues of environmental change cut across the whole field of fish exploitation, conservation, restoration and management, and are increasingly sources of policy concern (FAO, 2002). While climate change reflects pollution through complex indirect pathways, changes in water quality have effects on fish that are more direct. Traditionally, the effects of aquatic pollutants have been disproportionately larger in freshwaters than marine waters. Previously widespread problems from organic effluents and some industrial discharges have been largely controlled, at least in economically richer

countries, although some substances continue to cause concern (Hall, 2002; Mason, 2002). This includes pollutants whose ecological effects have been geographically extensive and long standing despite large management efforts. After first becoming apparent as a major problem in the 1960s, eutrophication continues to have major effects on some lake systems (Verschuren et al. 2002).

Water pollution from oil spills at the ports and harbours; household and industrial waste; and effluents and agricultural run-off. Karachi and the surrounding industrial estates (Korangi, Landhi and SITE) are the main source of household and industrial wastes and effluents. Untreated waste flows into the sea at Kemari and Minora in violation of regulations. Agricultural run-off, which used to spill into inland lakes (Manchar, Haleji, Dhabeji), is now being diverted to the lower Sindh coast through the donor-funded Left Bank Outfall Drain (LBOD), with a parallel drain on the right bank of the Indus on the anvil (Aftab et al. 2000). Industrial policy and environment in Pakistan, Islamabad, UNIDO has quantified the magnitude of the pollution and estimated that 70 per cent of Karachi's waste water flows into the marine environment.

Population of some of the species is declining due to habitat loss and degradation, water abstraction, drainage of wetlands, dam construction, pollution and eutrophication. These factors have caused substantial declines and/or changes in inland fish species. Consequently distributional ranges of some of the species have shrunk tremendously over the last three decades and are restricted to localised areas. The species *Danio rerio*, *Megarasbora elonga*, *Rita rita, Nandus nandus*, *Badis badis*, *Monopterus cuchia*, and *Macrognathus aral* have been severely affected by the environmental deterioration and habitat loss.

Although intensification of aquaculture can potentially generate high levels of environmental problems, capital-intensive production systems often give producers more control over problems like effluent pollution and the spread of disease. Technology may in fact present economies of scale in the control of environmental problems. Intensification can raise the risk of disease. Management techniques such as rotation of cultured species and lower-density stocking of organisms can partially address this risk, but antibiotics and water control technologies like aerators and water recirculation systems can also mitigate the stress caused by high concentrations of organisms. Technologies based on local knowledge systems and different political and cultural contexts can also help develop aquaculture in underexploited water bodies, such as rice paddies, irrigation canals, reservoirs, and seasonal or

perennial ponds in developing countries. Some technologies long employed in traditional aquaculture systems can also be useful in addressing concerns raised by water management, effluent control, disease control, and land use in intensified aquaculture. Most of the culture practices in Pakistan are still based on extensive culture, but with the establishment of few feed mills, the semi intensive farming practices have been started on limited scale, to boosts this process substantial investment is required in raising awareness and extending financing to fish farmers.

The Indus River with its tributaries is the lifeline of agriculture in Pakistan. The Indus delta ecosystem is degrading from a combination of salt-water intrusion up to 30 kilometers inland and reduced silt and nutrient flows due to upstream dam construction. The ravages to the ecosystem have been exceptionally severe to the mangroves and this is likely to be one of the major causes of the reduction in fish stock. International Union for the Conservation of Nature-Canadian International Development Agency-Ministry of Environment and Pakistan National Conservation strategy, Islamabad claim that the mangroves sustain fisheries through their role as breeding grounds. The National Commission on Agriculture observed that mangrove forests were more seriously threatened than any other forests in the country. Pakistan has lost 1,700 square km its mangrove forest area in the past 50 years. The report noted that the Indus delta originally had eight different species of mangroves, most of which are not found in Pakistan today.

Coastal development and tourism are other major torments to marine life caused by human activities as 80% of the world tourism occurs in coastal areas and world's 60% population lives within 60 km of coastal sphere. Mangrove forests and sea grasses, meadows and other marine ecosystem have been removed to create open beaches, hotels, airports, marinas, resorts, and golf courses. As the Mediterranean Sea, one of the world's leading tourist destinations has lost its ecological assets due to massive tourism so ecosystem or ecological assets of Gwadar will face the same jeopardy and the ecological assets may lose their jewellery due to coastal development and tourism.

Planning and management issues

Breeding technology in aquaculture is in its relative infancy. Breeders have significantly raised productivity for a few commercial species such as salmon, trout, and tilapia, but the successful cultivation and breeding of other species such as cod and bluefin tuna would be a tremendous boost to high-value aquaculture. Genetic modification and biotechnology also hold

tremendous potential to improve the quality and quantity of fish reared in aquaculture, although not without significant controversy and risk. Biotechnology has the potential to enhance reproduction and the early developmental success of cultured organisms. The possible environmental effects of genetically modified aquatic organisms are not well understood, however, and concerns exist over possible human health risks. The documented escapes of farmed salmon and their threat to native wild populations demonstrate that caution should be employed when considering the introduction of a new species into an ecosystem. Pakistan is successfully breeding freshwater carp and trout species, but for others investment and training is required.

The main managerial issues of the aquaculture sector further includes Lack of Brackish water aquaculture, lack of diversification in species and systems, only limited number of finfish species are under cultivation since very long time. High input cost is another issue which need policy and research support. Loss due to diseases is an emerging issue with the intensification of the farming system, but there is no strategy to address this issue. Potential for salinity and temperature increase over present levels during grow-out period are the most easily perceived climate changes in the future. Export markets are becoming more and more competitive due to introduction of quality standards. No research backup will lead us to no market for export of our seafood products. Growing domestic demand for fish and shell fish may support the production system of aquaculture.

No commercial fish feeds are currently being produced in Pakistan, however, some experimental feeds have been prepared and utilised very effectively. Small pelagics caught as a by-catch from shrimp trawlers as well as fish offal are used for the production of fish meal on an industrial scale. About 189134 MT of small pelagic were landed, yielding 42230 MT of fish meal according to the latest reports. Some progressive fish farmers are using fish meal and or trash fish in aquaculture operations but it is not a common practice.

Aquaculture began in Pakistan as a small-scale side line of crop farmers, however, with the emergence of fish hatcheries operated by the public sector, there is a movement towards larger fish farms particularly with the entry of business men into this sector. This effect, however, is area specific and confined to areas close to big cities such as Lahore and Multan as well as in Sindh where people have large land holdings, the management of large water bodies and the construction of large farms are now common here.

In Pakistan, the participation of women in fisheries is common among the fishing communities but among fish farmers women usually do not participate in the business when it is an independent company. However, women are engaged in aquaculture activities when it is part of a family enterprise and help is required in feeding, planting grasses in the ponds and guarding the ponds when the farm is close to the house.

Issues related to export of aquaculture products

The marketing chain for fish is more or less similar to those of other agricultural commodities. Products are sold into the market to wholesalers and then onto retailers and end consumers through agents working on commission basis. Farmed fish tend to be marketed either at the farm gate, through middle men or during open auction where ice-packed fish sent to fish markets after harvest were sold. Buyers can be members of the public, retailers, wholesalers, agents for processing plants or exporters. Fish markets are very common in Sindh, at selected locations in Punjab; all markets are under the control of the local administrations.

Most fish markets have inadequate facilities, usually they lack cold storage facilities, have poor hygienic conditions and inadequate communication links, etc. Most aquaculture product is consumed locally with only a small portion being exported. Rohu (*Labeo rohita*) has a substantial local market; good market size is usually 2 kg+ up to a maximum of 3 kg. Prices tend to decline when the fish is more than 3 kg in weight; other factors include freshness of the fish and the supply/demand situation in the market. Best prices are achieved during the winter months. Carp price ranges from US$ 1.5 - 2.0 per kg in local markets. Local consumers generally prefer freshwater fish over marine fish because of their familiarity with river and inland farmed fish as well as the fresh condition of the product. This difference is reflected in both wholesale and retail prices where freshwater fish sell at a higher price than marine fish.

The importance of the fishing in the economy of Pakistan has by no means diminished despite the rapid pace industrialization. Pakistan is still predominately an agricultural country. About 70 percent of the population comprises agriculturists, farmers and fishermen, who toil in producing maximum quantity of food supply for the export and domestic consumption. The territorial seawater off the coast of Sindh and Balochistan has the potential to provide seafood to a population many times the present population of Pakistan. Aquaculture is gaining momentum in inland areas of Pakistan and many high value fish species are becoming popular in

aquaculture system. Fishing is an important source of Foreign exchange earnings. The fish supply/production shows an increasing trend and supply improved from 645000 ton in 2007 to 745,000 ton in 2014.

The worldwide export in the fish and fisheries products was roughly US$129.2 billion during the year 2012. Despite having very rich natural resources, the share of Pakistan in the world export is very limited (Kumar, 2006). The main reason behind this is that our exporters are exporting raw fish and are not focusing on value added products. In addition, lackluster marketing, untimely exports and variable export quality have all contributed to poor global market share, despite the richness of natural resource available.

Fish and shrimp are processed in Pakistan as chilled, frozen, cured, and canned before they are exported. Fish was being exported in different forms such as dried, salted, brine, smoked, fresh, chilled, frozen and canned but export of some forms have been abandoned. In addition, fishmeal is also produced from small pelagic and also from by-catch. Shrimp is the main export item both by weight and value. It is exported mostly fresh; frozen either as shell on tails or as peeled and divined. The USA, Japan, and the EU are the main importer. Also, Pakistan exports fish meal, fish maws and shark fins, as well as growing quantities of chilled fish, for which the main markets are Singapore and the Gulf. Although shrimp has occupied a predominant position among the items of seafood exported from Pakistan, very little efforts have been made to harvest shrimp through aqua farming. Fresh/chilled fish exports from Pakistan have not recorded marked growth and expansion, despite the attractive markets with growing demand, available in the Gulf States. Internal demand for fresh fish and supply constraints are the main reasons for the decline in fresh/chilled fish exports from Pakistan. In addition, with global stocks of marine shrimp is declining, it is becoming more and more imperative to move towards aquaculture. The country has about 6.8 million hectares of freshwater bodies in the form of lakes, reservoirs, rivers and water logged areas, which is ideal for aquaculture, this resource is not utilized at present.

Pakistan has more than 50 fish processing plants, which mostly clean and freeze fish for international buyers out of these only 2 plants have permission to export their fish to EU countries. The certified Pakistani plants maintain HACCP standards, which are accepted by European countries. The certification process is thorough and the SociétéGénérale de Surveillance (SGS) is the sole accredited certifying agency for marine products in Pakistan. The processing plants have made large investments in

the requisite safety equipment and procedures, and have also installed in-house laboratories to check fish toxicity. The drivers of compliance at the processing stage are markets and the underlying unpredictability of the business. The first is self-evident; if exporters fail to comply with standards they lose export markets. Second, processing is both high-risk and costly. Contamination in a single container means the entire consignment has to be destroyed. Finally, catches fluctuate daily. The high risks, high capital and processing costs involve owners closely in plant management. The EU inspectors have noted high awareness levels with regard to HACCP among plant workers, comparing it with conditions in India and Thailand.

HACCP standards are both plant specific and apply to all stages of pre-processing. The three stages of pre-processing are: 1) on board fishing vessels; 2) docks/auction halls; and 3) transport to processing plants.

The EU requirements also include traceability which include first, fishing vessels are registered with a name and identification number. Second, the vessel owners are required to install radio systems so they can be monitored. Third, processors are required to test each batch and, if found contaminated, to backtrack through the vessel owners to the source of the catch. The processors are also required to prepare regular reports. The system in Pakistan has been found to have flaws and contamination levels on board the fishing vessels, landing docks and auction halls are high and have been pointed out by the EU inspectors. On-shore handling also falls below the basic sanitary and health standards, the auction halls are equally unsanitary. Storages constructed near the auction halls for storing unsold fish exhibit similar unsanitary conditions. The transportation of fish from the auction halls to the processing plants meets acceptable cleanliness criteria if the processors use their own mobile vans. Other forms of transport, including open mode, tend to be sub-standard.

Compliance failure has institutional roots. Three potential players in compliance are the Fishermen's Cooperative Society (FCS), the Marine Fisheries Department (MFD) and the Karachi Fish Harbor Authority (KFHA). Overlapping responsibilities are a source of tension among them and none of the three are technically, financially or administratively equipped to cope with the various aspects of compliance.

Codes of Conduct and Management Practices in Aquaculture

Fisheries, including aquaculture, provide a vital source of food, employment, recreation, trade and economic well-being for people throughout the world, both for present and future generations and should

therefore be conducted in a responsible manner. National and international fisheries policies and management practices that better reflect the principles of the Code of Conduct will lead to an improved and sustainable economic, social and environmental contribution of the fisheries sector. The optimization of the contribution of fisheries to achieving benefits in terms of food, employment, recreation and trade as well as ecosystem and socio-economic well-being will benefit populations throughout the world.

To promote long-term conservation and sustainable use of fisheries resources, following a call from the International Conference on Responsible Fishing (1992) to strengthen the international legal framework for more effective conservation, management and sustainable exploitation and production of living aquatic resources, the 1995 FAO Conference adopted the FAO Code of Conduct for Responsible Fisheries. The Code provides principles and standards applicable to the conservation, management and development of all fisheries. It also covers the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management.

- States and users of living aquatic resources should conserve aquatic ecosystems. The right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources. Fisheries management should promote the maintenance of the quality, diversity and availability of fishery resources in sufficient quantities for present and future generations in the context of food security, poverty alleviation and sustainable development. Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species.
- States should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization. States should take measures to rehabilitate populations as far as possible and when appropriate. Conservation and management decisions for fisheries should be based on the best scientific evidence available, also taking into account traditional knowledge of the resources and their habitat, as well as relevant environmental, economic and social factors. States should assign priority to undertake research and data collection in order to improve scientific and technical knowledge of fisheries including their interaction with the ecosystem. In recognizing the transboundary

nature of many aquatic ecosystems, States should encourage bilateral and multilateral cooperation in research, as appropriate.

- States and sub regional and regional fisheries management organizations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.
- Selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain biodiversity and to conserve the population structure and aquatic ecosystems and protect fish quality. Where proper selective and environmentally safe fishing gear and practices exist, they should be recognized and accorded a priority in establishing conservation and management measures for fisheries. States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species.
- The harvesting, handling, processing and distribution of fish and fishery products should be carried out in a manner which will maintain the nutritional value, quality and safety of the products, reduce waste and minimize negative impacts on the environment. All critical fisheries habitats in marine and fresh water ecosystems, such as wetlands, mangroves, reefs, lagoons, nursery and spawning areas, should be protected and rehabilitated as far as possible and where necessary. Particular effort should be made to protect such habitats from destruction, degradation, pollution and other significant impacts resulting from human activities that threaten the health and viability of the fishery resources.
- States should ensure that their fisheries interests, including the need for conservation of the resources, are taken into account in the multiple uses of the coastal zone and are integrated into coastal area management, planning and development. Within their respective competences and in accordance with international law, including within the framework of subregional or regional fisheries conservation and management organizations or arrangements, States should ensure compliance with and enforcement of conservation and management measures and establish effective mechanisms, as appropriate, to

monitor and control the activities of fishing vessels and fishing support vessels.

- States authorizing fishing and fishing support vessels to fly their flags should exercise effective control over those vessels so as to ensure the proper application of this Code. They should ensure that the activities of such vessels do not undermine the effectiveness of conservation and management measures taken in accordance with international law and adopted at the national, subregional, regional or global levels. States should also ensure that vessels flying their flags fulfill their obligations concerning the collection and provision of data relating to their fishing activities. States should, within their respective competences and in accordance with international law, cooperate at subregional, regional and global levels through fisheries management organizations, other international agreements or other arrangements to promote conservation and management, ensure responsible fishing and ensure effective conservation and protection of living aquatic resources throughout their range of distribution, taking into account the need for compatible measures in areas within and beyond national jurisdiction.
- States should, to the extent permitted by national laws and regulations, ensure that decision making processes are transparent and achieve timely solutions to urgent matters. States, in accordance with appropriate procedures, should facilitate consultation and the effective participation of industry, fish workers, environmental and other interested organizations in decision making with respect to the development of laws and policies related to fisheries management, development, international lending and aid. International trade in fish and fishery products should be conducted in accordance with the principles, rights and obligations established in the World Trade Organization (WTO) Agreement and other relevant international agreements. States should ensure that their policies, programmes and practices related to trade in fish and fishery products do not result in obstacles to this trade, environmental degradation or negative social, including nutritional, impacts.
- States should cooperate in order to prevent disputes. All disputes relating to fishing activities and practices should be resolved in a timely, peaceful and cooperative manner, in accordance with applicable international agreements or as may otherwise be agreed between the parties. Pending settlement of a dispute, the States concerned should make every effort to enter into provisional arrangements of a practical nature which should be without prejudice to the final outcome of any dispute settlement procedure. States,

recognizing the paramount importance to fishers and fish farmers of understanding the conservation and management of the fishery resources on which they depend, should promote awareness of responsible fisheries through education and training. They should ensure that fishers and fish farmers are involved in the policy formulation and implementation process, also with a view to facilitating the implementation of the Code.

- States should ensure that fishing facilities and equipment as well as all fisheries activities allow for safe, healthy and fair working and living conditions and meet internationally agreed standards adopted by relevant international organizations. Recognizing the important contributions of artisanal and small- scale fisheries to employment, income and food security, States should appropriately protect the rights of fishers and fish workers, particularly those engaged in subsistence, small-scale and artisanal fisheries, to a secure and just livelihood, as well as preferential access, where appropriate, to traditional fishing grounds and resources in the waters under their national jurisdiction. States should consider aquaculture, including culture-based fisheries, as a means to promote diversification of income and diet. In so doing, States should ensure that resources are used responsibly and adverse impacts on the environment and on local communities are minimized.
- States and all those engaged in fisheries management should, through an appropriate policy, legal and institutional framework, adopt measures for the long-term conservation and sustainable use of fisheries resources. Conservation and management measures, whether at local, national, subregional or regional levels, should be based on the best scientific evidence available and be designed to ensure the long-term sustainability of fishery resources at levels which promote the objective of their optimum utilization and maintain their availability for present and future generations; short term considerations should not compromise these objectives.
- Within areas under national jurisdiction, States should seek to identify relevant domestic parties having a legitimate interest in the use and management of fisheries resources and establish arrangements for consulting them to gain their collaboration in achieving responsible fisheries. For transboundary fish stocks, straddling fish stocks, highly migratory fish stocks and high seas fish stocks, where these are exploited by two or more States, the States concerned, including the relevant coastal States in the case of straddling and highly migratory stocks, should cooperate to ensure effective conservation and

management of the resources. This should be achieved, where appropriate, through the establishment of a bilateral, subregional or regional fisheries organization or arrangement.

- A subregional or regional fisheries management organization or arrangement should include representatives of States in whose jurisdictions the resources occur, as well as representatives from States which have a real interest in the fisheries on the resources outside national jurisdictions. Where a subregional or regional fisheries management organization or arrangement exists and has the competence to establish conservation and management measures, those States should cooperate by becoming a member of such organization or a participant in such arrangement, and actively participate in its work. A State which is not a member of a subregional or regional fisheries management organization or is not a participant in a subregional or regional fisheries management arrangement should nevertheless cooperate, in accordance with relevant international agreements and international law, in the conservation and management of the relevant fisheries resources by giving effect to any conservation and management measures adopted by such organization or arrangement.
- Representatives from relevant organizations, both governmental and non-governmental, concerned with fisheries should be afforded the opportunity to take part in meetings of subregional and regional fisheries management organizations and arrangements as observers or otherwise, as appropriate, in accordance with the procedures of the organization or arrangement concerned. Such representatives should be given timely access to the records and reports of such meetings, subject to the procedural rules on access to them. States should establish, within their respective competences and capacities, effective mechanisms for fisheries monitoring, surveillance, control and enforcement to ensure compliance with their conservation and management measures, as well as those adopted by subregional or regional organizations or arrangements.
- States should take measures to prevent or eliminate excess fishing capacity and should ensure that levels of fishing effort are commensurate with the sustainable use of fishery resources as a means of ensuring the effectiveness of conservation and management measures. States and subregional or regional fisheries management organizations and arrangements should ensure transparency in the mechanisms for fisheries management and in the related decision-making process.

- States and subregional or regional fisheries management organizations and arrangements should give due publicity to conservation and management measures and ensure that laws, regulations and other legal rules governing their implementation are effectively disseminated. The bases and purposes of such measures should be explained to users of the resource in order to facilitate their application and thus gain increased support in the implementation of such measures.
- Recognizing that long-term sustainable use of fisheries resources is the overriding objective of conservation and management, States and subregional or regional fisheries management organizations and arrangements should, inter alia, adopt appropriate measures, based on the best scientific evidence available, which are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors, including the special requirements of developing countries.
- States should assess the impacts of environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks, and assess the relationship among the populations in the ecosystem.
- To be effective, fisheries management should be concerned with the whole stock unit over its entire area of distribution and take into account previously agreed management measures established and applied in the same region, all removals and the biological unity and other biological characteristics of the stock. The best scientific evidence available should be used to determine, inter alia, the area of distribution of the resource and the area through which it migrates during its life cycle. In order to conserve and manage transboundary fish stocks, straddling fish stocks, highly migratory fish stocks and high seas fish stocks throughout their range, conservation and management measures established for such stocks in accordance with the respective competences of relevant States or, where appropriate, through subregional and regional fisheries management organizations and arrangements, should be compatible. Compatibility should be achieved in a manner consistent with the rights, competences and interests of the States concerned.
- Long-term management objectives should be translated into management actions, formulated as a fishery management plan or other management framework. States and, where appropriate, subregional or regional fisheries management organizations and arrangements should foster and promote international cooperation and

coordination in all matters related to fisheries, including information gathering and exchange, fisheries research, management and development.

- States should ensure that the level of fishing permitted is commensurate with the state of fisheries resources. States should adopt measures to ensure that no vessel be allowed to fish unless so authorized, in a manner consistent with international law for the high seas or in conformity with national legislation within areas of national jurisdiction. Where excess fishing capacity exists, mechanisms should be established to reduce capacity to levels commensurate with the sustainable use of fisheries resources so as to ensure that fishers operate under economic conditions that promote responsible fisheries. Such mechanisms should include monitoring the capacity of fishing fleets.
- The performance of all existing fishing gear, methods and practices should be examined and measures taken to ensure that fishing gear, methods and practices which are not consistent with responsible fishing are phased out and replaced with more acceptable alternatives. In this process, particular attention should be given to the impact of such measures on fishing communities, including their ability to exploit the resource. States should require that fishing gear, methods and practices, to the extent practicable, are sufficiently selective so as to minimize waste, discards, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species and that the intent of related regulations is not circumvented by technical devices. In this regard, fishers should cooperate in the development of selective fishing gear and methods. States should ensure that information on new developments and requirements is made available to all fishers.
- States and fisheries management organizations and arrangements should regulate fishing in such a way as to avoid the risk of conflict among fishers using different vessels, gear and fishing methods. When deciding on the use, conservation and management of fisheries resources, due recognition should be given, as appropriate, in accordance with national laws and regulations, to the traditional practices, needs and interests of indigenous people and local fishing communities which are highly dependent on fishery resources for their livelihood.
- States and sub-regional and regional fisheries management organizations and arrangements, in the framework of their respective competences, should introduce measures for depleted resources and

those resources threatened with depletion that facilitate the sustained recovery of such stocks. They should make every effort to ensure that resources and habitats critical to the well-being of such resources which have been adversely affected by fishing or other human activities are restored. States, in conformity with their national laws, should implement effective fisheries monitoring, control, surveillance and law enforcement measures including, where appropriate, observer programmes, inspection schemes and vessel monitoring systems. Such measures should be promoted and, where appropriate, implemented by sub-regional or regional fisheries management organizations and arrangements in accordance with procedures agreed by such organizations or arrangements.

- States should ensure that fishing is conducted with due regard to the safety of human life and the International Maritime Organization International Regulations for Preventing Collisions at Sea, as well as International Maritime Organization requirements relating to the organization of marine traffic, protection of the marine environment and the prevention of damage to or loss of fishing gear. States should prohibit dynamiting, poisoning and other comparable destructive fishing practices.
- States should make every effort to ensure that documentation with regard to fishing operations, retained catch of fish and non-fish species and, as regards discards, the information required for stock assessment as decided by relevant management bodies, is collected and forwarded systematically to those bodies. States should, as far as possible, establish programmes, such as observer and inspection schemes, in order to promote compliance with applicable measures. States should promote the adoption of appropriate technology, taking into account economic conditions, for the best use and care of the retained catch.
- States, with relevant groups from industry, should encourage the development and implementation of technologies and operational methods that reduce discards. The use of fishing gear and practices that lead to the discarding of catch should be discouraged and the use of fishing gear and practices that increase survival rates of escaping fish should be promoted.
- States should cooperate to develop and apply technologies, materials and operational methods that minimize the loss of fishing gear and the ghost fishing effects of lost or abandoned fishing gear. States should ensure that assessments of the implications of habitat disturbance are carried out prior to the introduction on a commercial scale of new fishing gear, methods and operations to an area. Research on the

environmental and social impacts of fishing gear and, in particular, on the impact of such gear on biodiversity and coastal fishing communities should be promoted.

- States should promote the development of appropriate standards and guidelines which would lead to the more efficient use of energy in harvesting and post-harvest activities within the fisheries sector. States should promote the development and transfer of technology in relation to energy optimization within the fisheries sector and, in particular, encourage owners, charterers and managers of fishing vessels to fit energy optimization devices to their vessels.
- States should introduce and enforce laws and regulations based on the International Convention for the Prevention of Pollution from Ships States should adopt relevant standards and guidelines which would include provisions for the reduction of dangerous substances in exhaust gas emissions. Owners, charterers and managers of fishing vessels should ensure that their vessels are fitted with equipment to reduce emissions of ozone depleting substances.
- The responsible crew members of fishing vessels should be conversant with the proper running and maintenance of machinery on board. Owners, charterers and managers of fishing vessels should ensure that their vessels are fitted with appropriate equipment as required by MARPOL 73/78 and should consider fitting a shipboard compactor or incinerator to relevant classes of vessels in order to treat garbage and other shipboard wastes generated during the vessel's normal service. Owners, charterers and managers of fishing vessels should minimize the taking aboard of potential garbage through proper provisioning practices. The crew of fishing vessels should be conversant with proper shipboard procedures in order to ensure discharges do not exceed the levels set by MARPOL 73/78. Such procedures should, as a minimum, include the disposal of oily waste and the handling and storage of shipboard garbage.

Institutional Setup and Stakeholders Involvement

In Pakistan, aquaculture is a provincial responsibility; the Provincial Departments of Fisheries (DOF) in Punjab, KP and Sindh are working actively towards the conservation and management of inland waters and the development of aquaculture in their respective provinces. In Balochistan, the DOF is involved mainly in marine fisheries but also has a component responsible for inland fisheries. The fisheries departments in the

FATA, NA and AJK are relatively small and mainly aimed at the management of the trout fisheries.

At the central level, fisheries is overseen by the office of the Fisheries Development Commissioner (FDC) working under the Ministry of Food Security & Research. The office of the FDC is responsible for policy making, planning and coordination with the provincial fisheries departments as well as other national and international agencies. The Marine Fisheries Department (MFD), Karachi, an attached department of MnFS&R, is responsible for the implementation of Deep Sea Fishing Policy and the regulation of exports of fish and fishery products.

The Water and Power Development Authority (WAPDA) working under the Ministry of Water and Power also has a fisheries department responsible for the regulation and auction of fisheries rights in the large reservoirs found in Pakistan. There is a fisheries research unit at the National Agricultural Research Center (NARC) of PARC, the country's biggest research organizations established under the MnFS&R. Some universities in the country are also involved in basic fisheries research.

Freshwater carp farming which is by far the mainstay of aquaculture activity in the country is practiced widely in the two provinces of Punjab and Sindh and to a lesser extent in the province of NWFP. In Punjab, 74 fish hatcheries are operated by the private sector while 14 hatcheries and nurseries are operated by the public sector. There are 5 hatcheries in Sindh, located at Chilya (Thatta), Mirpur Sacro and Sukkar. In Balochistan, there are only a couple of hatcheries; 8 warm water fish hatcheries and about 30 trout farm cum hatcheries are operating in the NWFP. The DOFs provide technical guidance, juveniles at subsidized rates to farmers as well as other extension services which have resulted in the establishment of a number of trout hatcheries/farms under private ownership. The government has also successfully transferred the technology gained by the Provincial Fisheries Departments to the private sector and as a result the number of farms is increasing.

Efforts toward the establishment of shrimp farming in Pakistan begun in the early 1980s when the Government of Sindh began the establishment of a pilot scale farming at Garho in Mirpur Sakro District. At the same time the Sindh government allocated 17 000 acres of land in the area to about 80 prospective shrimp farmers. However, because there was no local production of seed in Pakistan, all those involved had to import seed from Sri Lanka and Malaysia resulting to high mortalities experienced. Due to the

lack of expertise, none of the pilot farms managed to continue in operation and all shrimp farming activities ceased by 1990.

The government, however, took note of the potential importance of shrimp farming and again initiated efforts to establish a shrimp hatchery complex at Hawks Bay which started operation in 2001. Successful rearing of post-larvae was achieved at this hatchery in 2002. A privately run enterprise has successfully cultured the seed from this hatchery and subsequently produced about 3.0 MT of shrimp that were later exported. The government of Sindh and the National Institute of Oceanography have since taken over operation of the hatcheries established at Hawks Bay and another at Clifton near Karachi and very recently seed has been produced which is now being reared at the Sindh government's facilities located in the Garho area. With the success in seed production using indigenous species, it is expected that commercial scale shrimp farming will begin in the near future.

The national government has also taken a number of additional steps aimed at supporting the development of commercial scale shrimp farming in Pakistan. In this context, the MFD conducted a survey of the coastal areas of Makran and identified potential areas where shrimp farming could be established. The Government of Sindh has also proposed potential areas for the development of shrimp farming.

Institutional framework of inland and marine fisheries

Federal Government Institutes

1. Ministry of National Food Security and Research
2. Ministry of Ports and Shipping
3. Fisheries Development Board (FDB)
4. Pakistan Agricultural Research Council
5. Marine Fisheries Department (MFD)
6. Korangi Fisheries Harbour Authority
7. Small & Medium Enterprise Development Authority(SMEDA)
8. Water and Power Development Authority (WAPDA)
9. Trade Development Authority of Pakistan (TDAP)
10. Enivormental Protection Agency (EPA)
11. Mercantile Marine Department (MMD)
12. Maritime Security Agency (MSA)
13. National Institute of Oceanography (NIO)

Provincial Fisheries Departments

1. Karachi Fisheries Harbour Authority (KFHA)

2. Fishermen Cooperative Society (FCS)
3. Pasni Fish Harbour
4. Gawadar Fish Harbour
5. Fisheries Department Government of Punjab
6. Fisheries Department Government of Sindh
7. Fisheries Department Government of Balochistan
8. Fisheries Department Government of KPK
9. Fisheries Department Government of GB
10. Fisheries Department Government of AJK
11. Coastal Development Authorities in Sindh and in Balochistan

Fisheries education departments

I. Universities having department of Zoology/Fisheries

1. Quaid Azam University, Islamabad
2. Arid Agriculture University, Rawalpondi
3. Punjab University, Lahore
4. Agriculture University Faisalabad
5. Bahuddin Zakariya University, Multan
6. University of Veterinary and Animal Sciences, Lahore
7. University of Karachi
8. Sindh University, Jamshoro
9. University of Balochistan, Quetta
10. University of Peshawar, Peshawar
11. Centre of Excellence in Marine Biology, Karachi.

II. Others Fisheries organizations/Association

1. Pakistan Sea Food Industries Association
2. Sindh Trawlers Owners & Fishermen Association
3. Karachi Fishing Boat and Trawler Owners Group
4. Mole Holder Association
5. Pakistan Seafood Exporter's Association
6. Karachi Fishing Boat and Trawler Owners Group

Fisheries laws were first enacted during the times of the British in the form of the Punjab Fisheries Act, 1914, Bahawalpur State Fisheries Act 1951 and the Fisheries Act, 1897. Post-independence, fisheries laws were promulgated through the *West Pakistan Fisheries Ordinance 1961 and Rules of 1965*; despite amendments/additions to these laws subsequently, all 4 provinces and

Northern Areas continue to retain most features of the 1961 and 1965 laws. The detail is given in table 1.

Table 1: Laws related to fisheries sector in Pakistan

Federal	
	The constitution of Pakistan, Fourth Schedule, Article 36
	The Territorial waters and Maritime Zone Act, 1976; Act No. LXXXII of 1976
	Exclusive Fishing Zone (Regulation of Fishing) Act, 1975 as amended 1993
	The Exclusive Fishing Zone (Regulation of Fishing) Rules 1976, promulgated under section 16 of the Exclusive Fishing Zone (Regulation of Fishing) Act 1975
	Exclusive Fishery Zone (Regulation of Fishing)(Amendment)Ordinance, 1983(Ordinance No. XXIX of 1983)
	Exclusive Fishery Zone (Regulation of Fishing) (Amendment) Act, 1993 (Act No. V of 1993)
	Conservation of fisheries resources S. R. O. 329(1)/79
	Notification No.DD-75/98/3342-48 dated 24-07-1999
	Port Qasim Authority Act, 1973 (Act No. XLIII of 1973)
	West Pakistan Fisheries Ordinance, 1961
	Fisheries Act (No. 4 of 1897)
	Deep Sea Fishing Policy.1995
	The Pakistan Fish Inspection & Quality Control Act, 1997
	Pakistan Fish Inspection and Quality Control (Amendment) Ordinance, 1998 (No. XI of 1998)
	The Pakistan Fish Inspection & Quality Control Rules, 1998
	The Pakistan Environmental Protection Act, 1997
	The Agriculture Produce (Grading & Marketing) Act 1937
	The Pakistan Animal Quarantine (Import and Exports of Animal and Animal Products) Ordinance, 1979
Punjab	
	Punjab Fisheries Ordinance, 1961 (W.P. Ordinance No. XXX of 1961
	Fisheries Ordinance 1961 (amended up to 2001)
	Fisheries Rules, 1965 (amended up to 2001)
	Punjab Fisheries (Amendment) Rules 1996
	Punjab Fisheries (Amendment) Act 1999
	Punjab Fisheries (Amendment) Ordinance 2001
	Punjab Fisheries (Amendment) Rules 2001
Sindh	
	Sind Fisheries Ordinance, 1980 (Sind Ordinance No. III of 1980)Part I.
	Sindh Fisheries (Amendment) Act, 2003 (Act No. VI of 2004)
	Karachi Fisheries Harbour Authority Ordinance, 1984 (No. II of 1984)

There is a need to formulate research programs with stakeholder participation and prioritization of research programs to be undertaken at organization levels including:

- Continued development of responsible fishing systems for inland and marine capture fisheries incorporating principles of bycatch reduction, protection of biodiversity, minimization of environmental impacts and energy conservation.
- Standardisation of craft-gear combinations in terms of fishing power and capacities.
- Development and standardisation of processing technologies for emerging species from aquaculture and less utilized species from inland and marine capture fisheries.
- Continued development of processes for utilization of processing waste and low value bycatch for isolation of novel potentially commercial products.
- Continued development of appropriate packaging technologies for improvement of consumer appeal and better storage.
- Developing food safety standards for the domestic market along the value chain and standards for processes and products.
- Rapid techniques for identification of hazards and surveillance of aquatic systems.
- Extraction and characterization of bio-molecules and genes for therapeutically and industrially significant biological activities, including anti-inflammatory, antiviral, anti-bacterial, anti-oxidant and anticoagulant activities.
- Use of bio-molecules for bioremediation of polluted aquatic ecosystems

There is a need to conduct focused research on green technologies

- Development of 'green fishing vessels' with built-in energy saving design features, fuel saving technologies and practices for existing fleet and alternate sources of energy for propulsion of fishing vessels and onboard fish processing.
- Development of green technologies and practices for the fish processing sector, including fuel saving, recycling and reuse of process water.

There shall be focus on efficient technology transfer and policy analysis for:

- Developing innovative models for technology transfer based on need evaluation and impact assessment.
- Technology incubation
- IP management
- Sectoral level analysis of impacts of policies

There shall be need for capacity building of stakeholders for:

- Responsible fishing.
- Fish processing, packaging and value addition
- Fishery waste utilisation.
- Energy conservation in fishing and fish processing
- Food safety and quality.

Recommendations

Focus areas of development for aquaculture sector are given below:

- Environment friendly and cost effective technologies
- Diversification of species and systems
- Comprehensive health management plans and infrastrucutre
- Faster growth and increased disease resistance
- Utilization of brackishwater resources
- Socio-economic analysis and support to policy and planning

Strategy for development is as below:

1. Increase aquaculture production through focused research on increasing productivit y, profitability, area under culture and diversification of species and systems while addressing environment, food safety and social equity issues through more on-farm research and extension.
    a) Improving existing culture practices by incorporating science behind best management practices, harnessing natural productivity, bioremediation and better feed management
    b) Provide research input to development agencies for reclaiming abandoned farms and for culture in open brackishwater bodies and diversification of species and systems

c) Increase awareness of farmers and aquaculture industry about environment, food safety and social equity issues and at the same time educate public about the positive aspects of aquaculture and fish as health food

2. Carry out strategic research to tackle emerging problems of brackish water aquaculture and to strengthen the capacity of key stakeholders to address the various issues that are likely to be confronted.
   a) Preparedness on emerging diseases and advice the development and regulatory departments to address risks
   b) Assess the climate change impacts and increase the capacity of farmers to adapt to climate change and develop policy initiatives which help in adaptation and mitigation of negative impacts
   c) Evaluate risks due to intensification of culture practices and develop an action plan to be implemented by the state
3. Invest in areas of research to utilize emerging opportunities and develop linkages for effective utilization of the research outputs.
   a) Carry out research on genomics of candidate species and ensure that these results are used in captive breeding, increased growth, enhanced disease resistance and better utilization of feed nutrients
   b) Enhance capacity to use biotechnology tools to address difficult to solve problems of captive maturation and disease threats
   c) Develop linkages with universities and industry partners for promoting work on basic and strategic aspects to fill knowledge gaps
4. Partnership with other institutions, large integrated brackishwater aquaculture projects in private and public sector, entrepreneurs and innovative farmers to augment the existing capacity for broodstock and farm testing facilities, scaling up and for commercialization of products.
   a) Carry out on-farm research under a project mode with other institutions, large integrated brackishwater aquaculture projects in private and public sector, entrepreneurs and innovative farmers
   b) Commercialize products in partnership with entrepreneurs
   c) Develop a consultative mechanism with stakeholders for tracking and responding to recent developments in hatcheries and farmer ponds
5. Ensure that stakeholder needs and impact assessment set the agenda for research and awareness building.

a) Strengthen Priority Setting Process, Evaluation and Monitoring process to undertake multi disciplinary and multi institutional research projects
b) Increase our capacity for carrying out risk and impact assessment
c) Increase awareness levels among stakeholders on research outputs.

Immediate and long-term requirements of fisheries sector include

- sustainability of the fishery resources – marine and inland,
- continued optimization of fishing gear for marine, inland and the aquaculture sector, in terms of selectivity and environmental footprint,
- conservation of biodiversity through optimization of fishing effort, prevention of capture of juveniles and non-targeted catches by suitable technical measures,
- development of harvest and postharvest technologies for the nonconventional deep sea resources,
- enhancement of shelf fishery resources,
- value addition along the value chain,
- utilization of fishery wastes
- ensuring environmental safety in harvest and post-harvest operations,
- energy conservation in fish production and post-harvest sectors,
- ensuring aquatic food safety and traceability,
- responsible utilization of landed fish,
- minimizing harvest and post-harvest losses,
- suitable inputs for policy formulation and effective transfer of technology.

Conclusion

- Pakistan is endowed with considerable quantity of resources i.e. 0.29 million sq km of marine with 1120 km long coastline and approximately 8.6 million ha of inland waters.
- Pakistan possesses seafood industry of worth about $1.2 billion of which exports alone are worth nearly $315 million per annum. About one million people are associated with the industry for their livelihood directly or indirectly.

- With the exception of trout culture in KPK and the northern region, virtually all aquaculture currently carried out in Pakistan is pond culture of various carp species. Carp are cultured in earthen ponds, using mostly extensive farming practices with very little inputs.
- Marine fisheries exclusively depend upon capture fisheries.
- About 50 % of the total production is consumed locally, 22% is exported whereas 28% is converted into fish meal for poultry industry.
- Human resource is single most critical area of concern in the fisheries sector of Pakistan. Only research program of PARC exists for aquaculture sector and that too is limited by human resources. The worst part of the scenario is that there is almost no research system either at the institutional level or at the enterprise level which could cater the needs of the fisheries industry.
- Global fish production was around 184 million tons of which 49% comes from Aquaculture (2012).
- Unrestricted access to fisheries resources has resulted in over exploitation of natural stocks. Fishermen are using destructive fishing gears in greed of more fish and they have contributed in stock depletion.
- Pakistan has more than 50 fish processing plants, which mostly clean and freeze fish for international buyers, out of these only 2 plants have permission to export their fish to EU countries.
- The maintenance of quality system in Pakistan has been found to have flaws and contamination levels are high on board the fishing vessels, landing docks and auction halls. On-shore handling also falls below the basic sanitary and health standards, the auction halls are equally unsanitary. Storages constructed near the auction halls for storing unsold fish exhibit similar unsanitary conditions.
- Technological advances that improve information and management methods are now required. Satellite remote sensing and other information technologies can help provide better information about wild fish stocks as well as help monitor fishing activity and improve consumer information about the condition and origin of fish products. Technology is also crucial to avoiding the environmental damage and waste caused by certain fishing practices.
- Genetic modification and biotechnology also hold tremendous potential to improve the quality and quantity of fish reared in aquaculture.

- Most of the culture practices in Pakistan are still based on extensive culture, but with the establishment of few feed mills, the semi intensive farming practices have been started on limited scale, to boosts this process substantial investment is required in raising awareness and extending financing to fish farmers.
- The main issues of the Fisheries sector includes Weak institutional management and capacities for strategic planning and implementation, unknown fisheries stock carrying capacity, high post-harvest losses, low quality of fish/fisheries products etc.
- The main issues of the aquaculture sector includes lack of diversification in species and systems, high input cost, low technology adoption, weak institutional support etc.
- Strategy to develop fisheries sector includes development of responsible fishing systems for inland and marine capture fisheries incorporating principles of bycatch reduction, protection of biodiversity, minimization of environmental impacts and energy conservation. Developing food safety standards for the domestic market along the value chain and standards for processes and products. Development of 'green fishing vessels' with built-in energy saving design features, fuel saving technologies and practices for existing fleet and alternate sources of energy for propulsion of fishing vessels and onboard fish processing. There shall be need for capacity building of stakeholders in public and private sector.
- Strategy to develop aquaculture sector includes environment friendly and cost effective technologies, ddiversification of species and systems, utilization of brackish-water resources. Increase awareness of farmers and aquaculture industry about environment, food safety and social equity issues and at the same time educate public about the positive aspects of aquaculture and fish as health food.

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Chapter 6

Best Management Practices in Aquaculture in Maldives

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Aquaculture Scenario

The Maldives' aquaculture industry is still in its infancy. At present, only one commercial aquaculture venture is in operation, with a total annual aquaculture production of approximately 144 MT of sandfish (*Holothuria scabra*) targeted at the export market. This amounts to approximately 7 MT of dried sandfish exported mainly to China, and an additional 250,000 pieces of live juveniles exported to Sri Lanka biannually (Barakathul Bakhr Pvt. Ltd., Pers. Comm).

The Government of Maldives recognizes potential for the country to develop a thriving aquaculture industry, mainly based on high-valued marine food fish targeting export markets. To this end, a 5-year mariculture enterprise development project, with financial assistance from the International Fund for Agriculture Development (IFAD), has been working with 150 beneficiaries selected from the south of Maldives in piloting commercial sandfish grow out businesses at the community level (Republic of Malives: Mariculture Enterprise Development Project (MEDeP) Design completion report, 2012). In addition, a World Bank funded project is underway, with a major mariculture component focusing on the establishment of a multi-species hatchery and the development of research and extension capacity within the Government of Maldives (The World Bank, 2017) Maldivian Government is also investing in establishing capacity to produce milkfish (*Chanos chanos*) as live bait for the Maldivian pole-and-line tuna fishery.

Prospects of Aquaculture

Maldives has immense potential for the development of marine aquaculture activities. The geographic expanse of the country provides marine areas with a variety of features upon which aquaculture of some high valued marine species could be developed.

While the development of land-based aquaculture facilities is possible, such development may be hindered by the limited availability of land. It is

expected that the establishment of land-based facilities will be limited, mainly, to hatcheries and nurseries, while the grow-out phases will be focused more on marine waters with desirable features for the species of interest.

The key species of aquaculture interest at the moment include the high-valued sea cucumber species, sandfish (*Holothuria scabra*), brown marbled grouper (*Epinephelus fuscoguttatus*) and milkfish (*Chanos chanos*). While locally fished groupers and sea cucumbers have an existing export market, milkfish is a new product of which the production is targeted at supplementing live bait for local pole-and-line tuna fishery. It is expected that most aquaculture development will be of export-market oriented, high-valued food fish species.

There is political support for the development of an aquaculture industry in the Maldives, both for the diversification of the fisheries sector as well as providing additional employment and income generating activities within the fisheries sector.

Aquaculture Production Scales and Methods

At present, only one commercial aquaculture venture is in operation in the Maldives, producing sandfish (*H. scabra* – a high-valued sea cucumber species) targeting export markets. The average annual aquaculture production from this venture is approximately 144 MT, of which some 7 MT of dried produce is exported mainly to China and other far eastern countries. And an additional 250,000 pieces of live juveniles exported to Sri Lanka biannually (Barakathul Bakhr Pvt. Ltd., Pers. Comm).

The brood sandfish are induced to spawn using thermal shock techniques, and the larvae produced are reared in in-land tank systems until they are ready to be transferred to ponds connected to the sea for on-growing. The sandfish are then reared in these ponds until they reach market size.

The Maldivian Government implemented Mariculture Enterprise Development Project (MEDeP) is currently working on the involvement of local communities in sandfish growout activities. The project currently works with 150 beneficiaries, where each individual farmer is provided with a loan in the form of construction material for sea pens and the initial seed stock. The sea pens are constructed in shallow, reasonably calm lagoons adjacent to the selected islands. It is estimated that each pen will produce some 3,000 market sized (approx. 500g) of sandfish.

Issues and Challenges in Aquaculture

As the aquaculture industry is still in its infancy in the Maldives, and not many commercial aquaculture ventures are in operation at present, the country is faced with investor reluctance to enter into this undemonstrated business. In addition, as a country that has relied extensively on wild fisheries for which the investment returns are very quick, a business such like aquaculture for which the return on investment is usually longer is not an attractive business option for the smaller scale operators. However, there is emerging interest among larger investors to enter into this business at present.

One other major challenge in aquaculture development in the Maldives is the lack of availability of seed stock for starting up an aquaculture venture. There is interest among local communities to engage in the grow out process of high-valued marine species, but to date, only one commercial hatchery is in operation. Recognising this gap, the Maldivian Government, with assistance from the World Bank is in the process of developing a multi-species hatchery, initially focusing on the brown marbled grouper and milkfish production. In addition, the Mariculture Enterprise Development Project is working on linking locals with the existing hatchery operation to source seed stock for their grow-out production.

Further, the lack of human capacity is also an issue with developing an aquaculture sector in the Maldives. Apart from a few, the Maldives lacks trained, technically capable individuals in this field. If responsible aquaculture was to develop in the Maldives, human resource development in this field is necessary.

Environmental issues

Maldives has a global reputation for its serene marine environments. The development of marine aquaculture in the country may result in negatively impacting this reputation, if not carried out in an environmentally responsible manner. Marine based aquaculture activities may contribute to increasing nutrient load in the waters as well as alteration of the cage-bottom diversity resulting from increased feed inputs. In addition, mariculture development will also carry the risk of disease spread within the cultured populations as well as transmitting those to wild populations.

In order to reduce the concerning environmental issues arising from mariculture development, the country chooses to adopt a precautionary approach to aquaculture development. Measures are taken to reduce impacts on the environment include but are not limited to restrictions in sourcing initial stock used and mandatory submission of environmental impact assessments for aquaculture operations.

Figure 1. Sandfish (*Holothuria scabra*) production facility in Maldives. A & B: Inland production systems. C: Pen within a saltwater pond for initial stocking in grow-out ponds

Figure 1. Market sized sandfish (*H. scabra*) produced at a private hatchery in Maldives. A: live market-sized sandfish; and B: sandfish being sundried

Social issues

It is likely that social issues will arise as a result of the geographic spread of the country, especially in relation to the distribution of seed stock from a single central hatchery. However, the magnitude of social issues arising from aquaculture development may be difficult to be estimated at this point.

As aquaculture development will result in the creation of new employment opportunities, this development is at present seen as a positive change.

Planning and management issues

The geographically widespread nature of the country makes planning and management of aquaculture challenging for Maldives in many ways. However, a set of procedures are already in place for the effective management of aquaculture in the Maldives.

Aquaculture in the Maldives is currently focused on developing techniques for breeding and rearing locally available marine species, especially those high-valued food fish species, and utilizing adequate marine environments in the atolls.

All aquaculture operations in the country are required to acquire a valid aquaculture license that is issued by the Ministry of Fisheries and Agriculture upon providing proof of land acquisition and a positive decision statement issued for an EIA submitted for the aquaculture activity of concern. Although the basic measures are in place, planning and management of aquaculture will need to be further strengthened as the industry is established and matures.

In order to manage biosecurity and aquatic animal health, the Government has taken a precautionary approach of restricting the import of marine species unless they are included in a positive list published by the Ministry of Fisheries and Agriculture. The terms and conditions for permitting the imports may vary in their levels of stringency based on the risks that may be associated with their import. At present, only two species – the sandfish (*H. scabra*) and fingerlings/juveniles of the brown marbled grouper (*E. fuscoguttatus*) are included in the positive list of species that can be imported for aquaculture purposes.

Training and extension in aquaculture management, best aquaculture practices, as well as aquatic animal health management is foreseen as a future requirement when more people are actively involved in aquaculture production.

Issues related to export of aquaculture products

It is expected that aquaculture, at least during the initial stages, will be developed exclusively targeting the high-value export markets. Thus, issues relating to export of aquaculture products are likely to arise, although the magnitude of these issues are difficult to estimate.

The grouper production will target the live reef fish trade in the Far Eastern countries, and as such, there will be a requirement for establishing basic testing capacity for aquacultured food organisms. The Ministry of Fisheries is in the process of establishing an Aquatic Animal Health Laboratory facility to address the requirement for diagnosis of aquatic animal diseases.

An unrelated issue, but one which is equally as important is the fact that operating an aquaculture venture in the Maldives will be more expensive than a similar operation in other countries within the region. As a result, Maldivian aquaculture production may be sensitive to price fluctuations and economic situations in the major importers of Maldivian products.

Codes of Conducts and Management Practices in Aquaculture

A matured aquaculture industry does not exist in the Maldives. Planning for the development of aquaculture shall consider the codes of conducts and best management practices that have been developed through experiences from other countries. The aquaculture regulation that is being prepared tries to incorporate measures to ensure good aquaculture practices are followed. Monitoring and reporting requirements need to be strengthened in the process of establishing an aquaculture industry in the country.

The following measures are already practiced in the Maldives' aquaculture development policy:

- Aquaculture development focusing on locally available species: in order to manage biosecurity issues associated with transboundary movement of live aquatic animals, the aquaculture development shall focus mainly on locally available and sourced species.
- Import allowed only for approved species: a pre-approval process is already in place for import of live organisms for aquaculture process. Only two species are included in the approved list at present. Although the sea cucumber, sandfish (*H. scabra*) is the only approved non-native aquaculture species as yet, this species has been introduced to the Maldives over two decades back and is now considered naturalized. The stringency in the conditions imposed for

the import of live aquaculture organisms vary based on the results of a risk assessment.

- Regular monitoring and reporting of effects on the natural environment will be made mandatory when the aquaculture regulation comes into effect.
- Feeding and feed management: feeding practices and feed management measures shall be monitored to ensure adequate feeds are provided to the culture animals both in terms of quantity and quality of feed.

Further, new farmers need to be educated on best aquaculture practices for the sustainability of this new sector in the Maldives.

Institutional Setup and Stakeholders Involvement

The Ministry of Fisheries and Agriculture (MoFA) is the main regulator of aquaculture activities in the Maldives. MoFA is mandated with the responsibility to formulate and implement all legislatures related to aquaculture, and planning out its development in the country. A stakeholder consultation process is in place for all regulations formulated by MoFA to ensure stakeholder feedback is obtained at various stages of development. In addition, the Marine Research Centre (MRC) of MoFA is responsible for research and development efforts as well as awareness building, information dissemination and demonstration of successful aquaculture models.

All environmental issues are regulated by the Environmental Protection Agency (EPA), the national environmental regulatory body. EPA is responsible for taking any necessary actions to ensure that all environmental requirements are fulfilled by the aquaculture operators.

The current aquaculture process involves the submission of an aquaculture proposal with details of culture species, methodologies that will be practiced, site plan and a layout of the aquaculture system to be used. A special committee reviews such proposals and issues no objection for the proposal, at which point the proponent is required to submit a thorough environmental impact assessment report. EPA reviews these documents and issues a decision statement based on the allowable levels of impacts, appropriateness of the mitigation measures proposed, and how well better alternatives have been explored. The proponent then submits an application to MoFA for the issuance of an aquaculture license.

MoFA is responsible for monitoring and evaluation of all licensed aquaculture projects, and decisions on the licenses issued based on the performance of the projects. Import of live organisms for aquaculture is also regulated by MoFA. MoFA is in the process of establishing an aquatic animal quarantine facility at the airport to provide quarantine services for importers of live aquatics. An aquatic animal disease diagnostics facility that will provide basic diagnostic services for farmers, is also to be established.

Maldives Food and Drug Authority (MFDA) is responsible for ensuring the all public health and food safety criteria for aquacultured products. MFDA also issues the necessary certification ensuring food safety and hygienic production, which is required for exportation of aquaculture products.

Maldives Customs Services is mandated with the responsibility of regulating all imports and exports to and from the country.

Recommendations

The major reasons, amongst others, for the lack of development of aquaculture are lack of demonstration of successful aquaculture businesses, investor reluctance to invest in aquaculture, lack of a reliable supply of seed and a general limitation in technical expertise in the field. In order for an aquaculture industry to be developed in the Maldives, it is recommended that the Government invests in a hatchery as well as human resources required for a sector at the initial phase of development. Financing options for aquaculture ventures is expected to increase as the investor confidence in the sector is increased through demonstration of viable aquaculture businesses and development of human resource capacity required for sector development. In addition, research and development followed by effective extension of technology is required for target aquaculture species.

Conclusion

Aquaculture development in the Maldives is still at its infancy, despite efforts to develop a striving aquaculture industry in the Maldives. To date, only one commercial aquaculture venture is in operation in the Maldives, producing approximately 7 MT of dried sea cucumbers annually, targeting export markets. In addition, the Government of Maldives is investing in developing aquaculture, particularly of high-valued food fish for export markets as well as live bait for the local pole-and-line tuna fishery. The major reasons, amongst others, for the lack of development of the sector are lack of demonstration of successful aquaculture businesses, investor

reluctance to invest in aquaculture, lack of a reliable supply of seed and a general limitation in technical expertise in the field. In order for an aquaculture industry to be developed in the Maldives, it is recommended that the Government invests in a hatchery as well as human resources required for a sector at the initial phase of development. Financing options for aquaculture ventures is expected to increase as the investor confidence in the sector is increased through demonstration of viable aquaculture businesses and development of human resource capacity required for sector development.

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Chapter 7

Best management practices in Aquaculture in Bangladesh

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Aquaculture and Fisheries Scenario

Bangladesh is a densely populated country of South East Asia where more than 168 million people lives in 147,570 sq. km (56,977 sq. miles) area. The average per capita accessible land resources are limited for agricultural production. A wide portion of land is covered by large international and cross boundary rivers such as Padma, Jamuna, Teesta, Meghna, Brahmaputra, and Surma. Besides, there are thousands of tributaries with a total length of about 24,140 km. These rivers follow in to the Bay of Bengal. In the past half a century, environmental degradation of land and aquatic habitats along with frequent natural disasters have affected the national economy. Fisheries are now considered as the most effective sector for employment generation and poverty eradication in Bangladesh. The tropical climate of Bangladesh is good for agriculture. The country has enormous potentials for fisheries and aquaculture growth to meet challenges of food as well as nutrition security and employment generation. Therefore, government and development partners have given prior attention to promote this sector.

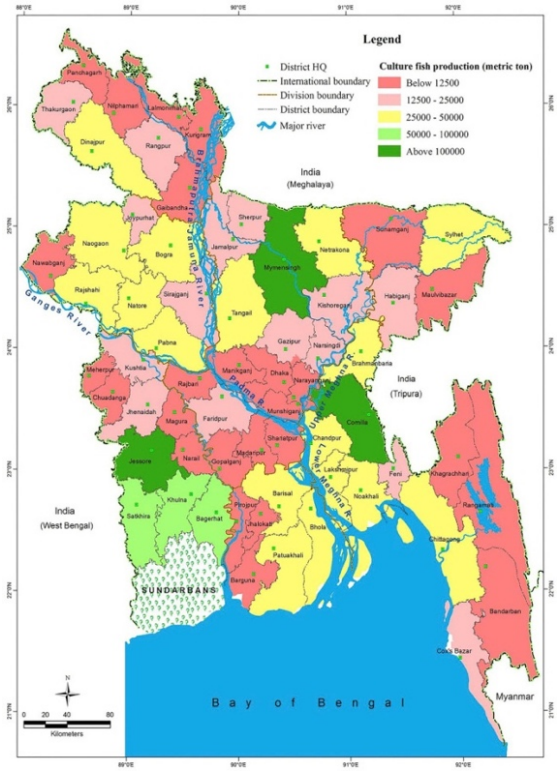

Figure 1: Zone wise fish production in inland water of Bangladesh (2015-16)

Figure 2: Government Fish farm ponds

Figure3: Fish harvest from river-commonly known as "*Maach ghat*"

Fisheries sector of Bangladesh is contributing 3.69% to the National GDP and 23.12% of Agricultural GDP. The total fish production of Bangladesh during 2015-16 is 3.878 m MT of which contribution of Inland closed water (culture) 2.203 m MT, Inland open water (capture) 1.048 m MT and Marine fisheries 0.627 m MT. Aquaculture production from inland closed water-bodies is 56% of the total production. Bangladesh is ranked as 5th in aquaculture in the world (FAO, 2015). During last decade average growth rate of fisheries was 5.4% and the aquaculture growth was 8.2%. Fisheries sector contributes 60% of the nation's animal protein supply. The current fish consumption in Bangladesh is 56 g/person/day which is projected to increase to 60 g/person/day in 2021. The sector employed 11% of the total population (17.80 million) in the country as full time and part time employment, and employed 1.40 million women (8.5% of fisheries sector employment). *(Source: Department of Fisheries, FRSS Report, 2015-16).*

Figure 4. Shrimp culture-locally known as "gher"

Figure 5. Fish harvest from Beel

Bangladesh has diversified fisheries resources with 0.794 million hector inland closed water body (Pond, Baor, Dighi etc.) and 3.92 million hector inland open water body (rivers, haor, beel, flood plain, kaptai lake etc.).

It has the vast 710 km long coast line with 12 nautical miles territorial marine water-body from the shore while 1,18,813 square kilometer maritime boundary and 710 kilometer coastline.

In the inland water bodies there are about 260 fresh water indigenous fish species, 12 exotic fish species and 24 species of fresh water shrimp species.

The country has diversified marine fisheries resources viz., finfish 475 species, sharks, rays/skates, dolphin 21 species, shrimp 36 species, lobster 6 species, crabs 16species, sea turtle 3 species, crocodiles 3 species, squid & others fish 7 species, shellfish (univalves & bivalves) 350species and seaweeds 165 species.

Since last two and half decades, significant growth rates in fisheries production have been achieved by expansion of closed water aquaculture through the intervention of production technologies and adoption of community based fisheries management for conservation and sustainable exploration of open water fisheries resources. During 1990s and 2000s along with National Fisheries Policy and Strategy framework, lots of efforts were made to increase the fish production for ensuring the nutritional security of ever increasing population. Recently, emphasis is also being given on food safety and quality standards of fish production in line with environmental sustainability in compliance to the national requirement and increase access to global market, addressing the traceability and health hazards related issues.

Aquaculture in Bangladesh is mainly confined to the freshwater closed water bodies viz., ponds, lakes, baor, creeks etc. Freshwater aquaculture involves pond aquaculture especially the poly-culture of native and exotic species. Intensification of aquaculture during last two decades has greatly contributed to the country's fish production. At the same time care was also taken for food safety and quality issues across the aquaculture fish value chain to comply the food safety standards giving priority of public health issues for the domestic as well as international consumers.

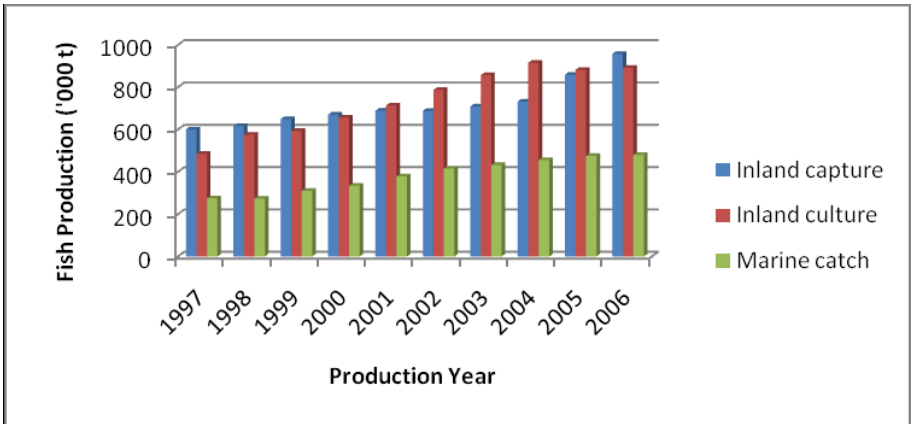

Figure 6. Resource wise fisheries production of Bangladesh from 1997-2006 (DoF 2006).

Attempts are also made to utilize the vast seasonal water bodies viz. flood plains, fellow rice fields, beels, canals and natural depressions for extensive aquaculture involving community based fisheries management by CBOs. To take care of biodiversity and natural resources conservations many biological management interventions are introduced in inland open water by habitat restoration, creating fish sanctuaries, beel nursery and continuing regular stocking of selected major and minor fish species (SIS) to ensure availability of small indigenous species along with increased productivity. Such improve/extensive aquaculture efforts ultimately compensated the gradual declining catch from the open water fisheries and also motivated peoples to switch over in to semi-intensive farm practices with attractive economic return and benefit-cost ratio than that of other agricultural sub-sectors.

Prospects of Aquaculture

Inland water resources

Inland fresh water fisheries resources include a number of rivers, estuaries, beels, haors, lakes, reservoirs and seasonal flood-plains covering over 3.918 million ha. Besides, about 8.0 million ha of inundated rice fields around the country where 3.0 million ha remain under water for 4-6 month having unique ecological suitability for fish and shrimp aquaculture with concurrent or rotational cropping (DoF 2016). These open, semi-closed or seasonal fresh water resources provide suitable natural habitats for numerous wild fish and shellfish species. Aquaculture is now practiced in more than 372405 ha freshwater ponds and 2,75,509 ha coastal shrimp farm

areas (DoF 2016). Aquaculture production has increased about 8 times during the last two decades. Large areas suitable for aquaculture still remain underutilized and have a good potential of increasing aquaculture production further in a cost effective way. Open fresh water resources also have potential for increasing fisheries production, employment generation, export promotion and maintaining biodiversity.

The Community Based Fisheries Management (CBFM) project was founded with an ambition to promote sustainable use of inland capture fisheries by empowering fisher's communities to manage their own aquatic resources. Most fishers in rural Bangladesh operate on a small-scale basis. Poor fishers suffer disadvantaged situations due policies that favor powerful players in the sector. The CBFM initiative has developed a series of fisheries management approaches for ensuring equitable access to fisheries resources for community-based organisations (CBOs). Founded in 1994, the project supported by Department for International Development (DFID) and implemented by Bangladesh's Department of Fisheries (DoF) in partnership with the WorldFish Center and 11 NGOs adopted a research-based approach to promote equitable access and sustainable management of inland fisheries resources and to be run by the CBOs. So far, a total of 164 fish sanctuaries have been established in over 80 water bodies under the CBFM approach. The project involved 14,000 CBO group members and a further 9,000 direct beneficiaries. The majority of CBOs reported increases in total production despite a 30 per cent increase in the number of fishers by then. Thus it appears that community-based fisheries management can offer significantly better utilization of the public water bodies covering over 4 million ha of floodplain wetlands in the country.

Marine water resources

Bangladesh has large marine resources including coastal plains, islands, tidal flats, estuaries and inshore and offshore waters extending to the Bay of Bengal beyond 714 km and an Exclusive Economic Zone (EEZ) of 164,000 km2 which is largely unexploited (DoF 2007). The coastal zone houses several natural and mangrove forest ecosystems (like the world famous Sundarbans mangrove) supporting rich aquatic biodiversity. There are more than 490 finfish species and 24 species of shrimps, 4 species of lobsters, several species of cephalopods, marine mammals and other wildlife. Among them, more than 100 species are commercially important. Finfishes include more than 70 pelagic species most of them still remain underexploited due to lack of resource information, skilled manpower, modern fishing vessels and gears, modern technology for resource management and utilisation policy (DoF 2007).

Bangladesh is considered one of the most suitable countries in the world for prawn and shrimp farming, Because of its vast resources of shallow water bodies which provide a unique opportunity for prawn and shrimp production. Prawn farming has brought about dramatic improvements in the livelihoods of the coastal poor, including women. During the 1990s, the rapid development of prawn farming in southwest Bangladesh has been likened to a "Blue revolution". The migration of poor communities form the coastal region to the urban areas has reduced thanks to improved livelihood opportunities brought about by prawn and shrimp culture.

Fisheries in Bangladesh are diverse and there are about 795 native species of fish and shrimp in the fresh and marine waters. Besides that, there are 10 species of pearl bearing bivalves, 12 species of edible tortoise and turtle, 15 species of crab and 3 species of lobster. Most of the prawn and shrimp farms (~75%) are located in southwest part of the country, mainly Bagerhat, Khulna and Satkhira districts, with the remainders in the southeast region including Cox's Bazar and Noakhali district. In 2003, more than 0.6 m people are engaged in shrimp farming activities.

Aquaculture Production Scales and Method

Aquaculture Systems/Methods

Most common aquaculture practices in Bangladesh are, (1) improved extensive culture for Indian majors Carps, Chinese Carps, Hungarian Carps and Shrimps and (2) semi-intensive aquaculture for Pangus, Tilapia, Koi (Perch), Shingh (Catfish),Gulsha (Catfish), Pabda (Catfish) etc.

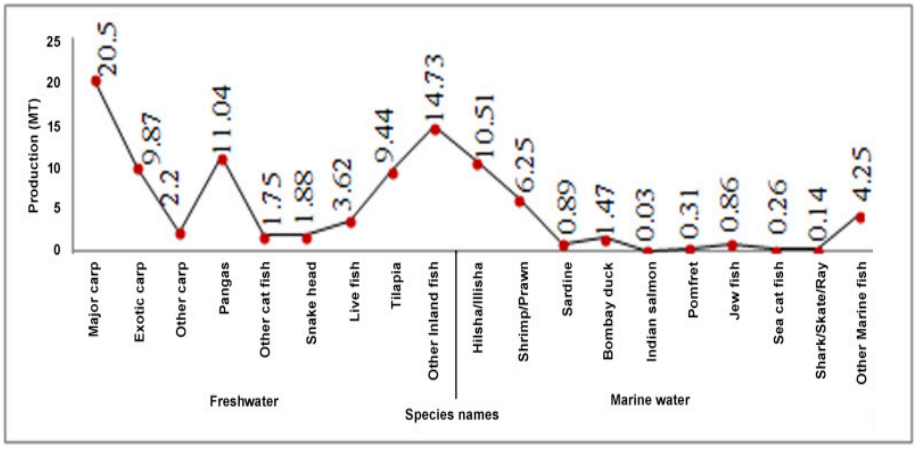

Figure 7. Species wise contribution in Aquaculture of Bangladesh

Scope of Marine Aquaculture and future intervention policy

There is enormous scope in Bangladesh for horizontal as well as vertical expansion of aquaculture at coastal belt. Extensive shrimp culture is traditionally practiced in the country and recently few shrimp hatcheries are established. Since last 3 decades very limited initiatives are taken on coastal aquaculture either by the private sector or by the government bodies like Department of Fisheries (DoF) and Bangladesh Fisheries Research Institute (BFRI). Recently Government in collaboration with development partners and private entrepreneurs planned to undertake larger programs introducing coastal aquaculture with selective finfishes, mollusks, seaweeds and some other important species to generate employment opportunity. The main objectives of the coastal aquaculture initiatives are,

- Research and demonstration project to develop breeding techniques, culture practice, safety and quality assurance of some selective species Vetki (sea bass), mullet, persa, tengara, tilapia etc)
- AIG for the coastal fisher community/other stakeholders to support/improve their livelihood, food security and social safety
- Generate investment and employment opportunity for private sector enterprises
- Reduce/control artisanal fishing particularly, over fishing pressure in the shoreline to protect/conserve important species to ensure sustainable yields
- Motivate, aware poor fishers and other stakeholders to involve in aquaculture value chain from harvest/catch to market/industry
- Prevent IUU, illegal shrimp seed collection and biodiversity destruction,
- increase per capita fish protein intake by the poor groups,
- promote aquaculture of commercially important species as raw materials for and feed export industry
- Organize environmentally sound, socially appreciated and cost effective aquaculture production for home and abroad.

Issues and challenges in aquaculture in Bangladesh

Fish is the second most valuable agricultural crop in Bangladesh and its production contributes to the livelihoods and employment of millions of people. The culture and consumption of fish therefore has important implications for national income and food security. Bangladeshi people are

popularly referred to as "Mache Bhate Bangali" or "fish and rice makes a Bengali".

The country also has a coastal area of 2.30 million ha and a coastline of 714 km along the Bay of Bengal, which supports a large artisanal and coastal fisheries. Bangladesh is considered one of the most suitable countries in the world for farming of freshwater prawn (*Macrobrachium rosenbergii*)

Bangladesh is one of the resourceful countries with its wide range of marine aquatic bio-diversities. There are about 1093 marine aquatic organisms where 44.35% are finfish, 32.23% shellfish, 15.10% seaweeds and only 8.32% are other organisms including shrimps. Bangladesh has so far realized only a fraction of its production potential.

Bangladesh has some 130 deep-sea fishing trawlers, 22000 mechanized fishing boats, and 25000 non mechanized fishing boats. Currently there are 133 fish processing plants in Bangladesh which are mostly located in port cities (Khulna and Chittagong) of which 74 processing plants are EU approved.

Though the country is endowed with enormous fishery resources which are vital to the livelihood of millions of people and national food and nutrition security, the sector is facing major constraints including climate change, poor fisheries infrastructure, resource mismanagement, water and environmental population, natural disasters such as recurrent flood and cyclones, and lack of knowledge among farmers. Bangladesh is working with close collaboration with World Bank, USAID, ADB, Department for International Development (DFID), World Fish Center and other international organization to develop the sector by building research partnerships and increasing investment.

Community based management of fisheries is proving its potential to avert the longstanding political challenges farmers have been facing. The country, however, faces urgent imperatives to strengthen environmental laws to curb pollution which is significantly compromising the performance of the fisheries sector.

Hilsha (Tenualosa ilisha) is one of the most favorite fish species in South Asian fish consumers and is recognized as the national fish of Bangladesh. Despite being a marine fish, the Padma-Meghna-Jamuna delta is the main site for hilsha capture where they migrate for laying eggs. Hilsha contributes to nearly 16.4% of the country's total fish production. Bangladesh produces about 3,95,000 tonnes of hilsha fish annually.

Role of fish in diet

Fish is the primary source of animal protein for Bangladeshi population, especially poor rural households. Fishes are the major source of animal protein providing 60% of the animal protein intake and 7% of total protein supplies. Rice and fish constitute such an important part of Bangladeshi food culture that it has become a popular proverb- "mache bhate bangali," which means "fish and rice make a Bengali. In terms of weight, fish is the third most widely consumed food nationwide. But consumption pattern tends to vary among urban and rural areas and is shown to be lower among female members. Per capita annual fish consumption in Bangladesh is about 14 kg against a recommended minimum requirement of 18 kg/year. From the last national survey in rural Bangladesh, the mean total protein intake was 48 g/person/d, of which fish contributed 3 g.

Prospects of integrated fish farming

Though rice monoculture is the main characteristic of Bangladeshi agriculture, rice-fish farming began to receive attention in the 1980s. Integrated rice-fish farming offers better resource utilization, diversity and food supply as well. In Mymensingh district, which is considered as one of the rice bowls of the country, has been identified as the most important region for integrated rice-fish culture due to its favorable climatic conditions and availability of low-lying agricultural land. Though currently a small number of farmers are practicing this method, it has been reported that the cultivation of fish in rice fields increases rice yields by 8 to 15% and thus the scope of rice cropping with integrated fish farm is remains considerably wide. Integrated fish farming can fully utilize the water body, the water surface, the land, and the pond silt to increase the food available for human consumption. Integrated farming reduces the need for pelleted grains, which is both economical and create less pressure on total grain supply for human consumption. Rice-fish farming is also being regarded as an important approach to integrated pest management (IPM). Integrated rice-fish farming is most technically and cost efficient, using the least inputs, in particular fertilizer and provides a sustainable alternative to rice monoculture. Researchers also suggest that integrated rice-fish farming system is better than rice monoculture in terms of a range of social, economic and environmental measures.

Green revolution (GR) worldwide has increased staple crop production and greatly contributed to combat global hunger. However, now when the long term repercussions of GR are understood such monoculture, soil

degradation, and extensive use of agrochemicals, all of which have had serious negative impacts on fisheries production, there is an imperative felt by agriculturists to find more sustainable strategies to reduce these negative impacts. Bangladesh has seen a dramatic rise in national rice production. Many watery areas have been brought under staple crop production to meet the demand of the huge population. Though fish production has also increased, but the its still far below the real potential of the country. Rice-fish farming can boost the production of both items which will help the country to improve food and nutrition security. The demand for rice and fish is constantly rising in Bangladesh with nearly three million people being added each year to its population. Integrated rice-fish farming can help Bangladesh keep pace with the current demand for food through rice and fish production.

Increasing population translates to increasing demand for food and more pressure on land and water. If sustainable policies are not taken, rice demand may continue to compromise fisheries output in Bangladesh. Although official figures show that the number of floodplain fisheries increased in the 1990s, after decreasing in the 1980s, it is widely held that floodplain catches have been falling. Agricultural intensification has been proposed by researchers to meet the rising food demand for the huge population in Bangladesh. While rice production is still likely to increase, its also possible that it'll come at the expense of diminishing resources for fish production.

Issues and challenges for fisheries sector in Bangladesh

The fisheries industry in Bangladesh is confronted with a range of economic, institutional and environmental concerns. According to a IUCN (International Union for Conservation of Nature) study, 54 floodplain fish species are in danger of extinction and the pressure of fishing is so heavy in the floodplains that less than 2% of produced fish survives the end of each year. Recurrent floods and natural disasters are believed to be main underlying causes behind this slump. Bangladesh is a low-lying land which makes it extremely vulnerable to sea-level rise, and is ranked first among countries to be affected by the adverse effects of climate change. Nearly 80% of total area in Bangladesh is regarded as floodplains, and its precarious geographical position makes it highly prone to natural disasters as well. Climate change have devastating impacts on fishery-based livelihoods and on domestic food supply. Vulnerability of fishery-based livelihoods may substantially increase in the coming decades due to climate change, and in

the absence of adaptation, increased frequency and intensity of cyclones and floods would result in greater damage to fishing materials and loss of fish.

Mariculture is also at risk of increasing salinity and over-fishing. According to FAO, globally, around a quarter of all fish stocks are overexploited and half of them are fully exploited. In Bangladesh, marine capture represents about 20% of total fish production. The floodplain and marine fisheries are under serious threat from overfishing. Overexploitation in the coastal region poses significant challenges on marine living resources and increases the dependency on distant water fishing in the long run.

Besides these natural and chemical events, inadequate financial capacities, poor resources management and lack of research facilities are also responsible for underperformance of the fisheries sector and environmental degradation. Researchers have shown that poor management of prawn and shrimp culture is having devastating effects on the Sundarbans (the largest mangrove forest in the world) where an estimated 9700 ha of the forest-mass has been lost as a result of intense shrimp farming. Conversion of many natural wetlands to prawn farms has resulted in impediment of water flows and also decreased the scope of migration for many fish species.

The fisheries sector of Bangladesh is vulnerable to numerous natural and anthropogenic causes such as,

Climate Change

It is an emerging issue for Bangladesh like other countries. Fish production and breeding season duration is decreasing gradually in inland open waters. To adapt to the climate change impacts different mitigation strategies are followed in aquaculture viz. stocking of fast growing fish, fishes which have market value even they are small in size, stocking of larger size fingerlings and lowering stocking density, supplying safe quality and cost-effctive supplementary feeds (floating feed) and adopting GAqP as much as possible.

Imbalanced Urbanization

Unplanned and imbalanced urbanization is going fast in Bangladesh. Huge area of water bodies are converted in to residential area, canals and others fish migratory routes are embarked and obstructed in many cases which ultimately affect fish production. Poor urban and industrial management and lack of enforcement of environmental laws are contributing to this pollution spree.

Industrialization versus environmental degradation causing fish habitat destructions

Water pollution is another growing threat for the future of fisheries sector in Bangladesh and is fast becoming a serious public health issue and a constraint for food production. Industrial (especially textile and tannery) effluent, fertilizer and pesticide run-off, poor sewerage infrastructure and improper disposal of household waste are the major causes of water pollution in Bangladesh. Rivers and canals near the urban areas are threatened by sedimentation and siltation due mainly to soil erosion, and compounded by industrial expansion, most of these water bodies have already become to polluted to support biological system. The Buriganga river that flows through the capital city is the most polluted river in the country, many parts of which have already turned coal black. Industrial wastes are directly discharged to the river and different open or semi closed water bodies without any pre-treatment. Waters bodies are getting heavily polluted which directly plays negative role on fish production.

Siltation of water bodies and re-excavation (Habitat restoration)

Due to regular flood and other natural calamity the open or semi-open water bodies are getting silted. They need re-excavation. The DoF has undertaken measures and implementing water body re-excavation policy since last 15 years through different GoB projects. The re-excavation activities are done through LCS (Landless/Labour Contracting Society) system. After re-excavation aquaculture activities is being initiated in these water bodies by constituting fish farming groups of local inhabitants.

Issues related to export of aquaculture products

In comparison to shrimp, the quantity and export value earnings from fish are very low. Although fish production increased more than double to 3.878 million ton in 2015-16, the export quantity of fish is less than 2% (75,338 t) of the total fish production. This is mostly due to the lack of diversification in export products along with quality and safety requirements to comply with the changing demands of consumers. Export processing industries in Bangladesh are mostly based on traditional knowledge on handling and processing of fresh and frozen shrimps (head on/off) collected from farmed or catch sources.

The processing factories personnel do not have good technical knowledge how to handle and process carps or catfish from fresh water and marine resources. Their workers lack skills and technical expertise and machinery

and technology is not advanced enough to produce good quality fish fillets or other diversified fish products for export in the competitive international market. Therefore, they could not able to utilize the available carp or catfish raw materials for producing quality export products. As fish handling and processing activities are quite limited in the industry, the workers could not increase their skills, efficiency and experience. On the other hand, the dependence of all processing plants on shrimp results in a shortage of raw materials and finally limits the utilisation of the processing factories. This situation also enhances competition for raw materials and to some extent the processing plant owners collect shrimp ignoring quality aspects and finally fail to get the expected price in the competitive market. Even such quality compromises may create future image problem in the strictly regulated export market for Bangladesh. About 50% of the leading processing industries have good technical, management capabilities and regulatory compliance to the export market but they are now not running well due to lack of raw materials (Pichler 2007). Out of 133 shrimp/fish processing plants 73 are maintaining International Food Standard (IFS) graded (>90% QM Score) and have EU licenses for the export of shrimp and fish (DoF 2007). To sustain the small and large factories, their economically feasible utilisation must be ensured. There are no other alternatives but for them to develop technological and management efficiency for handling and processing available carps, catfish and other fishes as raw materials to utilise the existing processing facilities. The supply of these fish to the factories can be easily increased in Bangladesh, which might not be equally possible for shrimps in a cost effective way.

Illegal Fishing

There are some illegal nets used for fishing in Bangladesh. Such nets are locally called Current net (monofilament nets) and behundi net (set bag net) etc. The mono-filamentous, transparent synthetic nets of different mesh size seriously destructive to the juvenile Hilsha (Jatka) and other important open water species directly by gilling during their movement. The set bag net is destroying the SIS species in flowing waters i.e. rivers and coastal areas. The uses of such nets are strictly prohibited by the laws and regulations. Government is giving maximum efforts to control the production, storage or uses of such nets. However, due to lack of implementation of rules, regulations and other associated socio political problems, still some illegal fishing happening in open water resources.

Open water management policy

In Bangladesh all the open water belong to the Ministry of Land but the beneficiaries or users of these water bodies belong to the Ministry of Fisheries and Livestock. Open water bodies are administratively controlled and leased by the Land Ministry and they are mostly emphasized on revenue earning rather than biological management system which is the mandate of DoF.

Innovations in shrimp Aquaculture

The modern techniques viz., cluster farming, increasing the water depth in *ghers* (at least 1 meter depth), nursery rising *with* PCR tested PL and use of *GAqP*/GHP/GMP are introduced in shrimp aquaculture recently.

Bangladesh Fisheries Sector Road Map 2015

Bangladesh Fisheries sector Road Map projects a total production of 4.55 million metric tons of fish by 2021 of which about 57 percent are now coming from aquaculture origin. Out of the total export earnings from the shrimp export, aquaculture products contribute at least 90 percent. Despite its significant contribution to the global food production and economy, aquaculture is not beyond criticism, often for valid reasons. The main points of concerns are, environmental stewardship; social, legal and community; food and feed safety; and traceability.

The environmental issues

- Mangrove and wetland destruction.
- Bio-diversity destruction by mass collection of shrimp post-larvae along with myriad of miscellaneous non-target aquatic organisms from the sea-shore and brackish water rivers; the latter are just wasted.
- Effluent discharge often with heavy loads of silt and organic matter offsetting the balance of the aquatic environment.
- Releasing prohibited or harmful chemicals used in the shrimp or fish farms.
- Salinization of agriculture land.
- Releasing diseased farm animals or exotic species from the farm into the open environment.

Social issues and resource use conflicts

- Obstruction of common property wetlands and flowing rivers and canals for aquaculture.
- Salt water intrusion in agricultural lands affecting agricultural crops.
- Unauthorized use of others' land.
- Using child labour.

Food safety issues

- Use of agricultural pesticides that may access to aquaculture areas
- Prohibited or restricted drugs and chemicals often used as preventive, curative or growth promoting agents in the farm feed or water, eventually gain access into the shrimp and fish and ultimately into human consumers.

Traceability

Lack of proper documentation of all aspects of the value chain.

In the context of Bangladesh, the *points that are more frequently raised in connection with coastal aquaculture of the shrimp* are the following:

- Legal ownership of the farm – Regulatory
- Social conflicts on the use of common properties viz., water usage conflicts and agricultural land use conflicts
- Conflicts between the rice farmers and shrimp farmers
- Environmental degradation
- Labour law violations
- Use of hazardous chemicals in aquaculture risking food and feed safety

Code of Conducts and Management Practices in Aquaculture

Codes of Conduct are standards or regulations defining minimal, internationally acceptable, operations and management practices pertaining to technical, environmental, and social standards.

The Codes have been developed by the Bangladesh Shrimp and Fish Foundation reflects five key areas:

- Social responsibility
- Human rights and labour rights
- Environmental sustainability
- Food and feed safety
- Traceability

The Codes are intended to promote aquaculture production which meets international food safety standards, is sustainable, ecologically sound and socially responsible.

BSFF, in collaboration with DoF, has prepared Codes of Conduct for the following segments of the shrimp industry:

- Black tiger or Bagda shrimp (*Penaeus monodon*) hatchery
- Galda shrimp (*Macrobrachium*) hatchery
- Black tiger or Bagda shrimp (*Penaeus monodon*) farm
- Galda shrimp (*Macrobrachium*) farm
- Shrimp / Fish feed mill
- Shrimp collection and service centre or depot
- Ice plants
- Fishing boats
- Shrimp or fish carrier transport van / vessel

Preparations of the above Codes have been based on the review of the following documents:

1. International Principles of Responsible Aquaculture UN/FAO/UNEP/World Bank- Netherland funded WWF- 2003

2. US Food and Drug Administration food safety regulations
   a) Federal Food, Drug, and Cosmetic Act (FDCA)
   b) The U.S. Code of Federal Regulations, Title 21 Food and Drugs
   c) Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

3. EU food and feed safety regulations
   a) Council Directive 2002/99/EC laying down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption
   b) Council Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with food
   c) Council Regulation (EC) No 852/2004 on the hygiene of foodstuffs
   d) Council Regulation (EC) No 853/2004 laying down specific hygiene rules for food of animal origin
   e) Regulation (EC) No 1332/2008 on food enzymes
   f) Council Regulation (EC) No 1333/2008 on food additives

g) Regulation (EC) No 1334/2008 on flavoring and certain food ingredients with flavoring properties

h) Regulation (EC) 854/2004 laying down specific rules for the organization of official controls on products of animal origin intended for human consumption

i) Commission Regulation (EC) 1251/2008 implementing Council Directive 2006/88/EC as regards conditions and certification requirements for the placing on the market and the import into the Community of aquaculture animals and products thereof and laying down a list of vector species

j) Commission Regulation (EC) 2074/2005 laying down implementing measures for certain products under Regulation (EC) 853/2004 of the European Parliament and of the Council and for the organisation of official controls under Regulation (EC) 854/2004 of the European Parliament and of the Council and Regulation (EC) 882/2004 of the European Parliament and of the Council, derogating from Regulation (EC) 852/2004 of the European Parliament and of the Council and amending Regulations (EC) 853/2004 and (EC) 854/2004

k) Council Directive 97/78/EC laying down the principles governing the organization of veterinary checks on products entering the Community from third countries

l) Council Regulation (EC) 1005/2008 establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing

m) Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals

4. Best Aquaculture Practices formulated by Global Aquaculture Alliance (GAA)
5. Code of Conduct: Seal of Quality Program of USAID/ATDP-II
6. Good Aquaculture Practices (GAqPs) – JIFSAN
7. Fish & Fish Products' Inspection and Quality Control Ordinance 1983
8. Fish & Fish Products' Inspection and Quality Control Rules 1997 and Rules Amended in 2008
9. Bangladesh Labour Law 2006
10. Fish and Shrimp Hatchery Law 2010
11. Fish and Animal Feed Law 2010

12. Thailand Department of Fisheries Code of Conduct (COC) and Good Aquaculture Practices (GAP) Program.

There are several Acts, rules, regulations, directives and Codes of Conducts (CoC) in Bangladesh for the development of Aquaculture. The summarize features of some important Fish Acts and Regulations are as follows:

1. *Fish Hatchery Act, 2010*

- Every hatchery must have registered and licensed from the authority (DoF) fulfilling all the terms and conditions as per regulations
- Every hatchery should have required technically skilled manpower
- All hatchery must collect and rear quality brood stocks from either natural sources or from Government suggested sources
- Without any prior permission of the competent authority hatchery owner could not go for any hybridization or genetic manipulation procedure that may affect genetic strain characters.

2. *Fish Feed and Animal Feed Act, 2010*

- Every Feed Industry owner should/ must have registered and licensed from the authority (DoF) fulfilling all the terms and conditions as per regulations
- Fish feed must be properly marketed in packet with all information as per directed in the rules (eg. proximate composition, safety and quality parameters, production and expiry date, quantity and quality index)
- Feed manufacturer should strictly follow the Government rules and CoC, and violation of CoC will be imposed with a penalty of Tk. 50,000.00 and/or one year imprisonment on to the offenders, as decided by the mobile court.

3. *Protection and Conservation of Fish Act (Amendment), 1995*

This act prohibits

The production, storage, transportation, marketing and any type of uses destructive to the fisheries resources as stated in the law.

- Any fixed structures/engine (current jal, behundi jal) prohibiting or stops the usual movement of fish stocks in the natural running water resources.
- Fish banned period: Hilsa: a. Juvenile - November to May, b. Brood - 22 days in October-November; depends on lunar activity

- Immediate after breeding season, during parental care period of natural species, it is strictly prohibited to catch any parents or spawn/juveniles.

4. *Codes of Conduct for Shrimp sector involved in the shrimp value chain*
   - For selected 10 segments of the shrimp Aquaculture industry in Bangladesh
   - Black Tiger or Bagda Shrimp (*Penaeusmonodon*) Hatchery
   - Galda Shrimp (*Macrobrachium*) Hatchery
   - Black Tiger or Bagda Shrimp (*Penaeusmonodon*) Farm
   - Galda Shrimp (*Macrobrachium*) Farms
   - Feed Mill
   - Shrimp Collection and Service Centre / Depot
   - Ice Plants
   - Fishing Boats and Vessels
   - Shrimp or Fish Carrier Transport Van
   - Code of Conduct for Fish / Shrimp Processing Plant

5. *Fish and Fish Product Inspection and Quality Control Act 1985, 2008 and proposed 2013*
   - Any fish and fish products which quality and safety parameters are not fulfilling the standard criteria settled in law and may affect public health should/ must not be produce, transport, storage, handling or marketing for human consumption or any intentional use that have risk of health hazards.
   - Input suppliers, producers, handlers and marketing stakeholders must follow the Codes of Conduct and implement GAqP, GHP and GMP through the fish value chain to ensure safe food production and consumption.
   - Violation of any instructed CoC, or legal procedure may impose punishment of any stakeholders in the Fish/Shrimp value chain

Institutional Setup and Stakeholders Involvement

Being government key agency, Department of Fisheries (DoF) playing the key role for the development of fisheries sector in Bangladesh. DoF along with its strong institutional set up actually driving the resource assessment, program planning, implementation, evaluation and expansion of the overall

fisheries sector in the country. Bangladesh is working in close collaboration with Department for International Development (DFID), FAO-UN, USAID, USFDA, EU, World Bank, OIC, JICA, World Fish, SAARC and other international organization to develop the sector by building research partnerships and increasing investment for resources utilization.

Mission Statement of DoF

To support sustainable growth in fish and shrimp production with other aquatic resources as well, for domestic consumption and exports, and management of open water fisheries resources through community participation leading to equitable distribution of the benefits generated, for optimal economic and social growth in Bangladesh.

Mandate of DoF

The Department of Fisheries serves through its following wings-

1. Inland Fisheries
2. Marine Fisheries
3. Fisheries Resource Survey System
4. Fish Inspection and Quality Control ,
5. and Training

Extension Service

- Provide technical know-how to the farmers through training and advice on aquaculture and management.
- Dissemination of modern technology on aquaculture, fisheries management, hatchery operation, etc.
- Render advisory services to provide credit on fisheries.
- Implementation of development projects to support farmers & fishers.

Conservation of Fisheries Resources

- Enhancement of fisheries through conservation and management of fisheries resources.
- Enforcement of Fisheries Acts, Regulations etc.

Quality Control of Fish and Fish Products

- Ensure quality of exportable fish and fishery products and issuance of health certificate

- Enforcement of Fish and Fish Products (Inspection and Quality Control) Rules

Policy Framework

- Advising the Government in formulating policies related to aquaculture and aquatic resource management.
- Collection of data on fisheries and its compilation, editing and publication.
- Planning, Formulation, Implementation, Monitoring and Evaluation of Development projects.

Health and Socio-economic Development

- Socioeconomic development of fisher-folk.
- To increase fisheries production to meet the increasing demand of fish and fishery products in-country and abroad.
- Poverty alleviation through aquaculture and aquatic resource management.

Human Resource Development

- Train the DoF official as to make them competent to cater the needs of the farmers/fishers and enable them to pursue sustainable management of aquatic resources.

Goals, Targets under 7th Five Year Plan:

- Increased 45% aquaculture production by 2020
- Introduction of Mari culture by 2020
- Diversified coastal aquaculture
- Participation of women in aquaculture production, fisheries CBOs and fish/ shrimp processing industries increase to 25%
- Good Aquaculture Practices (GAP) and Good Manufacturing Practices (GMP) at all stages of fish/shrimp supply chain to comply international market.

Recommendations

- Resource identification and utilization of blue Bangladesh.
- Minimization of Fish feed and seed cost.
- Collaborative research and management protocol on emerging issues, such as- marine fisheries resources management and

expansion of coastal aquaculture as well as on climate change impacts on fisheries resources.

- Infrastructure development to promote sustainable aquaculture practices (viz., Fish landing center, market development etc.)
- Hatchery development for potential coastal/marine finfish (for ex., *Lates calcarifer)*
- Dissemination of adaptive technologies (especially shrimp, prawn, tilapia and pangus) in ecologically constrained/ coastal areas.
- Popularization cage culture technology in coastal areas
- Stock assessment of marine resources
- Ensure adequate safety measures and early warning system for fishers
- Increase utilization of fisheries resources, development of diversified fisheries products for promotion of national and international market.
- Improvement of supply chain/marketing system
- Institutional Capacity Building through
  - community based fish culture;
  - stocking of fingerlings;
  - establishment of Sanctuaries,
  - beel nurseries,
  - creek development for hill area;
  - smart ID card for real fishers;
  - pen culture,
  - cage culture;
- Spillway construction etc.
- Recruitment of Field Staff at rural level (Field Assistant);
- Empowerment of DoF Officials towards different act implementation

Conclusion

Aquaculture and fisheries being the very fast growing sector in Bangladesh have high potential to contribute to the national economy. Bangladesh is blessed with water resources, good soil and water, cheap labor force and lots of culture-worthy fish species. Besides, as a lower middle income country, Bangladesh has good possibility of investing more resources on it.

Proper planning and implementation strategy, logistic support and also latest technology support from the neighboring countries can boost aquaculture development of Bangladesh.

Following the self-sufficiency in crop sector, country is hoping to be self-sufficient in fish very soon to reach the target of being a middle income country.

Development of Fisheries Sector of Bangladesh depends on a bottom-up process following on Vision-2021, 7th Five year Plan, SDG goals and targets and Annual Development Plan ADP. Bangladesh has published its National Fisheries Policy (1998), National Fisheries Strategy with eight sub-strategies (2002) to cover different fields.

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Chapter 8

Best management practices in Aquaculture in Bhutan

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Aquaculture Scenario

The mainstay of Bhutan's aquaculture is warm-water carps which were introduced into the country in the early 80s. Six species of carps are presently cultivated in Bhutan: Common carp, Grass carp, Silver carp, Catla, Rohu and Mrigal. Bhutan is also making efforts to develop rainbow trout farming. In connection to this, a government fisheries agency is presently conducting an adaptive rainbow trout production trial (Tshering, 2017).

Bhutan's annual output of farmed fish is less than 200 MT, with that in 2016 being 188 MT (Department of Livestock, 2017). In sharp contrast, the demand for fish in the country is massive, as indicated by an annual consumption of over 3000 MT: In 2015 alone Bhutan consumed 3752 MT of fish (wet weight equivalent). Since the domestic production of fish is meager, the huge demand for it has to be met through import. This causes huge amounts of foreign currencies to flow out of the country (as presented in the table below).

Table 1. Fish production and import in Bhutan during 2010-2016.

Year	Domestic output (MT)	Fresh fish import (MT)	Estimated Foreign Currency Outflow (Million Rupees)
2010	23.12	830	41.50
2011	49.49	915	54.90
2012	64.32	1325.18	92.76
2013	54.661	1412.5	113
2014	119.09	1457.69	131.19
2015	149.10	1346	121.14
2016	187.63	1261	114.3

MT- Million Tonnes

Fish production activities are concentrated in the south where a majority of the country's available flatlands are. The rest of the country is mostly sloped terrain, and so not readily amenable to excavating fish ponds. Also because the available cultivable species- warm water carps- require warm climate to

grow well, fish farming in the country has been literally forced to flourish in the south, as compared to the other regions, due to the suitable climate there. Very few warm water farms are located in the higher altitude hilly regions. These high altitude farmers do not generally cultivate the relatively slow-growing rohu, mrigal and catla.

Small landholdings and strong wetland conservation laws preclude the establishment of large commercial carp production systems on private lands. As a way to work around these limitations, the government encourages, and supports, the use of Government Reserve Forest (GRF) land through leasing by farmers for commercial fish production. However, state owned lands suitable for building large-scale commercial fish production systems are scanty. Therefore, the likelihood of large commercial-scale pond based fish production systems developing in Bhutan in the foreseeable future is low.

With an annual harvest of about 7.8 mt, exploitation of wild fisheries resources in Bhutan is virtually non-existent (Dorji, Impact of climate change on coastal fisheries and aquaculture in Bhutan, 2017). Though Bhutan is severely data deficient with regard to information on wild fisheries diversity and stock abundance, it is more or less understood these resources are limited and incapable of sustaining industrial scale exploitation. Therefore, the likelihood of capture fisheries programs contributing appreciably to the production of fish protein in the country is very low.

Except for the exotic carps, aquatic organisms such as crustaceans, mollusks and aquatic weeds are not cultured in Bhutan. Harvests of these organisms for food purpose from the wild, if any, are also not reported.

In summary, the following can be said about the aquaculture sector in Bhutan:

- The annual production of fish, including whatever little is harvested from the wild, is less than 200 mt;
- Limited flatlands preclude the development of commercial-scale fish production;
- Given the cultivable species available, short warm seasons preclude appreciable production of fish in the hilly regions;
- Aquatic organisms such as crustaceans, mollusks and aquatic weeds are not cultured;
- Farmers prefer to culture the relatively fast growing grass carp and common carp. Thus, the slower growing rohu, catla and mrigal are

effectively rendered redundant. This further limits the options of species that can be cultured;

- Aquaculture infrastructure is predominated by backyard production systems which are not "economically" amenable to being managed in a high-productive high-yielding commercial manner;
- Because of the backyard scale of production and short warm season, the average Bhutanese fish farmer engages in an "all-in & all-out" system of production wherein all the fish in a pond is completely harvested at the end of the warm season. Thereafter, the pond is dried and prepared to receive an all new stock of fingerlings to commend the next culture operation at the onset of the next warm season. This system is also often adopted for fish ponds which are fed with rainwater which all but dry up shortly after the rains stop. The all-in & all-out system sharply contrasts with the staggered-harvest system adopted for large commercial ponds that are fed water from permanent sources such as a river. Fish ponds in the commercial staggered-harvest system are rarely completely harvested. Such culture systems may only partially be harvested now and then for various reasons (for example, to fulfill an ad-hoc demand for fish), and the bio-mass gap in the pond created by the harvest is normally offset by an appropriate quantity of fingerlings restocked into it. In other words, commercial staggered-harvest type fish ponds retain water and fish all year round.

Figure 1. Typical subsistence-scale carp p

Prospects of Aquaculture

As has become amply clear by now, the demand for fish in Bhutan is massive and therefore the likelihood of the marketing of this commodity becoming difficult in the near future due to surplus production is rather very low. This prognosis, when coupled with the following few important facts about Bhutan, unmistakably indicates a successful future for aquaculture- specifically fish farming- in the country:

- Bhutan's topography and climate can support both warm water and cold water fish culture;
- The government of Bhutan strongly supports fish farming with financial incentives and other forms of support;
- Inputs of fish farming, including land and water, are readily available within the country;
- The system of governance of aquaculture in Bhutan is well established with clear mandates assigned to public, corporate and private stakeholders; and
- Technologies that are capable of sustaining both subsistence and commercial fish production activities are available in the country.

In the long run, Bhutan could also produce niche products, such as organic fish, for export. This is a real possibility because factors of fish production, especially water, in Bhutan are virtually uncontaminated.

Bhutan could also develop aquaponics to enhance domestic fish output in a climate resilient manner. This fish production technology has a high likelihood of becoming an attractive livelihood means for the Bhutanese youth and women.

Culture of other aquatic organisms, such as mollusks and crustaceans, however appears to have a bleak prospect in Bhutan. This is so for two important reasons. Firstly, being a landlocked country, Bhutan does not have saltwater/ marine/ brackishwater aquatic organisms and secondly, among the freshwater aquatic species available in the country, there is hardly any with the potential of becoming a commercially important cultivable species.

Aquaculture Production Scales and Methods

The fish production infrastructure in Bhutan is primarily made up of small backyard earthen ponds. Carps are farmed in these ponds in a most traditional manner, using as feed only farm residues such as rice bran and oil cakes. Fish thus produced are almost entirely consumed by the

households producing it. Only rarely are surplus available to sell off for cash.

More than 90 % of Bhutan's 500 odd fish producers are farmers who culture fish in backyard earthen ponds which are in some cases as small as 200 squared meters. These backyard farmers' primary motive for fish production is household consumption. Therefore, they hardly employ intensive husbandry techniques. For the Bhutanese backyard fish farmers, fish culture is, more or less, all about stocking their ponds with fingerlings and then leaving them on their own to grow to consumption-size. But for providing a supplementary feed comprised of farm stuffs such as rice bran, maize powder and other such things, Bhutanese backyard fish farmers invest virtually "zero" improved/ intensive inputs, such as nutritious commercial feed, in their fish production systems.

Only a handful of Bhutan's fish producers operate what may be termed as commercial fish production systems. These systems are usually a few numbers of decent-sized fish ponds built on Government Reserved Forest (GRF) land which the farmers take on lease from the government. Commercial fish ponds may each measure about 2500 squared meters, and a commercial fish farm may be comprised a few numbers of such ponds, often more than 5 ponds. In terms of production inputs, even the commercial farms do not use commercial feed, relying more on farm residues as fish feed. However, such farms invest relatively significantly in other inputs such as manure to enhance fish pond natural/ primary productivity.

In the north-west of Bhutan, a government fisheries organization named National Research and Development Centre for Lake and Riverine Fisheries (NRCLRF) is promoting intensive rainbow trout farming to exploit the country's potential to produce cold water fish. This technology however has a long way to go before it becomes a prominent producer of farmed fish. The main constraints to the development of rainbow trout farming are an under-developed capacity to produce fish seed and poor access to nutritious commercial fish feed (Tshering, 2017).

As Bhutan's waters are pre-dominantly fast flowing, often torrential, culture techniques such as cage culture have never been tried in Bhutan. Lately though, the government has been seriously considering conducting cage-fish culture in the country's hydropower reservoirs (Tshering, 2017). Bhutan is also considering harnessing the potential of Culture Based Capture Fisheries (CBCF) to contribute to national fish output.

Issues and Challenges in Aquaculture

Fish farming in Bhutan is significantly constrained by, among other things, unfavorable topography, climate, wetland conservation policies, smallholder farmers and inadequate resources such as flatlands. These factors effectively preclude the establishment of large-scale commercial farms by farmers. Of late, climate change induced extreme events have begun to impact fish farming adversely also.

Figure 2. Harvesting a fish pond in Bhutan

Figure 3. Harvesting carps and selling them on a typical Bhutanese fish

Figure 4. Establishment of a corporate-run commercial fish farm

Environmental issues

Being predominantly subsistent in scale, pond fish farming in Bhutan does not pose any serious threat to the environment. Farm effluents are not loaded with nutrients from fish feed, aqua-chemicals and drugs, and other inputs to the extent capable of causing adverse impacts on natural aquatic eco-systems due to eutrophication. Production systems such as cage-culture in natural waters are not yet existent. So environmental impacts associated with such systems are not encountered. Movement of farmed exotic species is strictly regulated, and under no circumstances are they permitted to be introduced into natural waters. Therefore, the likelihood of adverse impacts on natural aquatic biodiversity arising from the introduction of farmed exotic species in natural waters is kept to a minimum. Though establishment of large commercial scale fish farms by individual farmers is not possible due to reasons already explained, the government of Bhutan encourages establishment of such farms on Government Reserved Forests (GRF) land by groups of farmers and corporate entities. Activities pertaining to the construction and operation of such farms are strictly monitored to ensure that the environment is not seriously impacted by way of removal of large tracts of vegetation, dumping of materials in natural waters and other such activities. In the long run, however, these activities could become a significant threat to the environment. Environmental issues associated with mariculture are not applicable to Bhutan.

Social issue

The population of Bhutan is approximated at 700000 people. The official religion of Bhutan is Buddhism and approximately 75 % of the Bhutanese are Buddhist. The remaining 25 % mainly practise Hinduism. Buddhist Bhutanese on average are highly religious. This trait prevents a good number of Bhutanese from taking up livelihood activities that involve rearing and slaughter of animals including fish. Therefore, besides dairying for milk and milk products, other livestock husbandry activities such as poultry, piggery and aquaculture activities for production of chicken, pork and fish meat respectively are not intensifying commensurate with the support provided by the government. It is approximated that 657 Bhutanese people undertake fish (carp) production in earthen ponds. These activities are concentrated mainly in the south of the country and are undertaken mainly by people practicing Hinduism. The only social issue in Bhutan that that has a significant impact on aquaculture is the near-ostracization of people who undertake fish farming by those who do not. Bhutanese who are engaged in fish farming are more often than not looked down upon by those who are not engaged in fish farming. This has caused several farmers to discontinue their fish farming activities, and also the fear of being thus treated prevents a good number of Bhutanese from adopting fish farming despite their having interest to do so.

Planning and management issues

Since large commercial-scale fish farms are hardly ever established in Bhutan, because of reasons pertaining to landholding and topography as explained elsewhere, designing and constructing fish farms are relatively simple affairs that are overseen by government extension workers including extension personnel working at the NRDCA. Establishment of subsistence type fish ponds essentially involve excavating ponds each of which are size-wise often not more than a few hundred squared meters, less than 1.5 meters depth-wise and has simple dikes. However, establishment of large commercial-scale corporate fish farms are complex affairs involving detailed planning, designing and construction aspects. Establishment of such farms is almost always technically supervised by qualified civil engineers and aquaculture professionals.

Managing the typical subsistence-level fish farm in Bhutan is a rather simple affair. Bhutan's subsistence fish farmers hardly ever incorporate recommended and improved fish production principles in their husbandry practices. The average subsistence farmer pays very little or no attention to

the important details of pond fish production such as stocking density and stocking rate, feed type and feeding regime, water quality management, liming, manuring and ensuring optimal natural fish food production etc. This is thought to be the main reason why the average Bhutanese fish farm' productivity and output are not incommensurate with scientific expectations.

Large commercial-scale corporate fish farms however are managed in accordance with scientific recommendations.

Codes of Conducts and Management Practices in Aquaculture

The NRDCA has produced best management practices for carp farming best suited for Bhutan's conditions and has been making efforts to disseminate them among fish farmers. In this regard, not much has been achieved due to, among other things, shortage of competent extension workers, lack of adequate funds, and inefficient institutional set up and stakeholders management mechanisms.

The codes of conducts and recommended management practices for carp farming in Bhutan basically:

- Discourages the release of farmed fishes into natural waters;
- Provides guidelines to prevent outbreak of diseases on fish farms;
- Manipulation of such aspects as feed types and feeding regimes, stocking densities and rates, etc. to enhance productivity;
- Management activities to keep rearing loss at a minimum;
- Discourages the use of chemicals and drugs for fish production;
- Discourages the culture of fish species not approved for farming by the government;
- Specifies the quality of fish seeds (size at stocking, etc); and
- Provides guidelines to prevent harvested fish from spoiling prematurely (enhance shelf-life).

Institutional Setup and Stakeholders Involvement

The institutional set up for aquaculture development in Bhutan comprises the following key stakeholders, as would be the case elsewhere:

- The government;
- The fish producers;
- The corporate entities;
- The retailers; and
- The consumers.

Table 2. Aquaculture institutional set up and stakeholders' involvement in Bhutan.

Sl.No	Stakeholder	Main responsibilities
1	MoAF (Government)	i. Overall governance of aquaculture; ii. Promulgation of policies and rules and regulations; iii. Provision of support for aquaculture development;
2	DoL (Government)	i. Support the MoAF set aquaculture goals and objectives; ii. Enforcement of policies and rules and regulations; iii. Provide oversight and resource support to the NRDCA and the NCRLF; iv. Reports to the MoAF.
3	NRDCA (Government)	i. Produce carp seed; ii. Conduct research to develop/ improve aquaculture technologies; iii. Technically backstop fish farmers and corporate fish producers;
4	NCRLF (Government)	i. Customize Rainbow trout culture technology and produce rainbow trout seed; ii. Research other cold water aquaculture technologies.
5	RCA (Government)	i. Produce carp seed
6	RLDC (Government)	i. Technically backstop fish farmers and corporate fish producers; ii. Facilitate marketing.
7	Fish farmers (Fish producers)	i. Produce fish and other aqua-commodities
8	Corporate entities (Fish producers)	i. Produce fish and other aqua-commodities
9	The retailers	i. Market fish and other aqua-commodities

MoAF: Ministry of Agriculture and Forests

Recommendations

Aquaculture in Bhutan has a long way to go before it can be said that the country's aquaculture potential has been exploited to an appreciable extent. To enable Bhutan to realize its aquaculture potential, the following recommendations are made:

- Mainstream fisheries and aquaculture in its policies;
- Improve the efficiency of Bhutan's aquaculture institutional set up and stakeholders' involvement;
- Develop capacity in terms of quantity and quality of technical human resource;
- Strengthen infrastructure for aquaculture research and production;
- Diversify aquaculture technologies;

- Diversify cultured species;
- Improve brood-stock of existing cultured species;
- Strengthen networking with regional and global aquaculture entities;
- Disseminate existing aquaculture technologies aggressively among farmers; and
- Incentivize aquaculture activities

Conclusion

Despite having the potential to enhance its fish output through both backyard and commercial-scale production, Bhutan continues to remain unable to do so mainly because of an inability to back existing political will with appropriate efforts. This is why while massive quantities of fish are imported every year, domestic output is growing at a rate which is far below the rate at which it could grow if things are done correctly. Towards correcting this defect, among other things, the efficiency of Bhutan's aquaculture institutional set up and stakeholders' involvement to produce desired results must be improved, pro-aquaculture policies must be built, network must be forged, and infrastructure and capacity must be strengthened.

Bhutan today is at a critical juncture with the 11th Five Year Plan coming to an end and the 12th Five Year Plan (12 FYP) being formulated. Therefore, all in all, if the recommendations of this paper are acted upon in a non-negotiable manner, there is a high likelihood that Bhutan's aquaculture potential will be significantly realized and fish import will be reduced greatly by the end of the 12 FYP.

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REPORT OF THE SAC/NARA REGIONAL EXPERT CONSULTATION ON "BEST MANAGEMENT PRACTICES (BMP) IN AQUACULTURE: CAPACITY BUILDING AND POLICY DEVELOPMENT"

(19-21 September 2017, Goldi Sands Hotel, Negombo, Sri Lanka**)**

Opening of the session

The SAARC Agriculture Centre (SAC), Dhaka and National Aquatic Resources Research and Development Agency (NARA), Sri Lanka jointly organized the Regional Expert Consultation on "Best management practices in aquaculture: capacity building and policy development" at Goldi Sands Hotel, Negombo, Sri Lanka during 19-21 September 2017. The meeting was attended by the National Focal Point Experts of 6 SAARC member countries, experts from FAO, SAARC Agriculture Centre, Sri Lanka Council for Agricultural Research Policy, National Aquaculture Development Authority (NAQDA), Sri Lanka, and Ministry of Fisheries and Aquatic Resources Development, Sri Lanka.

Welcome addresses were delivered by Hon. Dilip Wedaarachi, State Minister for Fisheries and Aquatic Resources Development, Dr. Anil Premaratne, Chairman, National Aquatic Resources Research and Development Agency (NARA), Dr. Jerry Jayawardene, Chairman, Sri Lanka Council for Agricultural Research Policy, Sri Lanka and Dr. S. S. Giri, Senior Program Specialist (Fisheries), SAARC Agriculture Centre, Dkhaka, Bangladesh.

Papers presented

A total of 7 country papers on 'Best management practices (BMP) in aquaculture: capacity building and policy development' were present at the expert consultation, covering Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Another five technical papers covering crucial aspects of the management practices in aquaculture and policy development in the SAARC region were also presented by the acknowledged experts from the SAARC nations in these special fields.

Recommendations

1. Revisiting the existing codes in aquaculture in SAARC member states, and framing and harmonizing new codes to tap the global export market of aquaculture products
2. Establishment of brood banks, seed certification and health certification facilities

3. Development and harmonization of quality standards for fish, fish products and their handling
4. Development of disease surveillance, antimicrobial resistance (AMR), disease management and quarantine measures in aquaculture
5. Prevention of use of hormones, drugs, antibiotics and disease control chemicals in aquaculture and aquaculture products
6. Setting up of accredited fish feeds analytical laboratories in the region
7. Use of Information and Communications Technology (ICT) and smart technology in aquaculture
8. Proper disposal of wastes generated from aquaculture
9. Framing of policy to lease public water bodies, registration of Aquaculture, and setting up of Farmer Producer Organizations (FPOs)
10. Security to farmers in case of crop loses
11. Institutional linkages, capacity building and continuous awareness campaign at primary producer level for sustainable aquaculture
12. Creating more investment in aquaculture and creating market chain for the produce
13. Freshwater fish germplasm exchange among the member states
14. Creating mechanism for better information sharing among the SAARC countries on aquaculture development and conducting SAARC Aquaculture dialogue
15. Recognize nutritive value of small indigenous species and develop policy towards promoting nutrition sensitive aquaculture
16. Framing of biodiversity and environment compatible stringent Aquaculture Policy in the SAARC region.

Following this Expert Consultation which has recorded, for the first time, the importance of capacity building and suitable policy framing for the best management practices in aquaculture in the SAARC region should

- recognize that the Consultation has only made a first step in gathering information on the topic;
- collect and collate information on emerging issues and challenges in aquaculture, the management practices followed in aquaculture, legislations and framework available to manage aquaculture, institutional frame work and capacity available in SAARC member countries; and
- organize further meetings and finally drafting the best management practices to be followed in aquaculture in the SAARC region to tap the international export markets and domestic consumption of aquaculture products.

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