Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in South Asia

Editors

Grinson George
Ganga Dutta Acharya
Md. Baktear Hossain

SAARC

SAARC Agriculture Centre (SAC)

A Regional Centre of *South Asian Association for Regional Cooperation (SAARC)*

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in South Asia

Edited by

Grinson George
Ganga Dutta Acharya
Md. Baktear Hossain

SAARC Agriculture Centre

A Regional Centre of *South Asian Association for Regional Cooperation (SAARC)*

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in South Asia

Edited by
Grinson George
Ganga Dutta Acharya
Md. Baktear Hossain

December, 2022

Published by The Director, SAARC Agriculture Centre, BARC Complex, Farmgate, New Airport Road, Dhaka 1215, Bangladesh (http//www.sca.org.bd).

ISBN: 978-984-35-2764-6

Citation:

Grinson George, Ganga D. Acharya, and Md. Baktear Hossain (Editors). 2022. Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in South Asia. SAARC Agriculture Centre, Dhaka, Bangladesh, 232p

*This book contains the country paper, invited paper and proceedings of the SAARC regional expert consultation meeting on "*Cross-learning for Thematic Regional/ Sub-regional Challenges in Aquaculture and Fisheries*" held virtually during 03-04 August, 2021 by SAARC Agriculture Centre, Dhaka, Bangladesh. The experts for the country paper presentations were the representatives of their respective government of SAARC Member States. Other experts invited for technical paper presentation delivered talks in their official capacity on personal invitation. The opinions expressed/ images used/ tables presented in this publication are those of the authors and do not imply any opinion whatsoever on the part of the SAARC Agriculture Centre, specifically regarding the legal status of any country, territory, city or area or its authorities. It is implied that necessary permissions are taken by the authors for reproducing any of their content and any legal queries may be addressed to the authors.*

Cover design: Ms. Sanjida Akhter, SAC, Dhaka

Printed by: Momin Offset Press, Dhaka, Bangladesh

Price
US$ 10 for SAARC Member States
US$ 15 for rest of the world

भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान भवन-II, नई दिल्ली-110 012
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAVAN-II, PUSA, NEW DELHI-110012
Ph.: 91-11-25846738 (O), Fax: 91-11-25841955
Email : ddgfs.icar@gov.in, jkjena2@gmail.com

डॉ. जे.के. जेना
उप महानिदेशक (मत्स्य विज्ञान)
Dr. J.K. Jena
Deputy Director General (Fisheries Science)

Foreword

Aquaculture and fisheries in South Asia are among the fastest-growing economic areas. Cross-learning is very relevant in such a growing field, where ideas are imbibed from related disciplines and adopted for resolving challenges faced by the sector. There are several thematic areas in aquaculture and fisheries which require a priority setting and should be part of the discussions as well as actions of the formal as well as informal networks involved in the sector. There is a need for strengthening the infrastructure available for augmenting fish production in South Asia. The status papers included in this book present a Strength Weakness Opportunity and Threat (SWOT) analysis based on the information received from the SAARC Member States. A resource paper discusses the scientific frameworks available and case studies on resolving specific challenges.

A first glance of the book unravels the efforts that different SAARC country representatives took to introduce the ongoing activities, and identify the existing thematic networks in the country for addressing regional and sub-regional challenges in aquaculture and fisheries. The various governance instruments and private sector interventions also form an integral part of these chapters with specific case studies highlighting some useful interventions. I am sure that an avid reader interested in the diversity existing in the aquaculture and fisheries domain of South Asia will find this compilation very interesting.

I take the privilege and opportunity to congratulate the editors from the SAARC Agriculture Centre - Dr. Grinson George, Senior Programme Specialist (Fisheries), Dr. Ganga Dutta Acharya, Senior Programme Specialist (Priority Setting), Dr. Md. Baktear Hossain, Director, and the entire team of experts of eight South Asian countries, eminent resource persons who contributed and deliberated on the topic, and all others who worked for the successful compilation and completion of this valuable book. I would also like to appreciate all authors for their enthusiastic contributions. I am confident enough that this book will encourage the policy planners and stakeholders in the fisheries and aquaculture sector to uphold the goals and targets as envisaged in the Sustainable Development Goals (SDGs) of the United Nations.

Long live the spirit of SAARC.

1/12/2022

(J.K. Jena)

Preface

The combined fish production from eight SAARC Member States is estimated to be around 18 million MT, while most of the undertakings are small-scale based on their nature of operation. South Asian countries have common constraints such as less utilization and low productivity of water bodies, and vulnerability to climate change. However, opportunities lie in utilization of seasonal water bodies, wetlands, lotic and lentic aquatic systems. As most of the fish farming activities remain traditional with low input resulting in low production, there is a need to enhance the productivity. Nutrition and feeding play an essential role in the sustained development of aquaculture and, therefore, fertilizers and feed resources continue to dominate aquaculture needs.

Coastal aquaculture and fisheries are practiced in five countries - Bangladesh, India, Maldives, Pakistan and Sri Lanka of South Asia, all of which have abundant coastal areas with Bay of Bengal in the east and Arabian Sea in the west. The average per capita fish consumption among these five countries is highest in Maldives (>200 kg/person/year), followed by Bangladesh (19.35 kg), Sri Lanka (15.8 kg), India (9.2 kg) and Pakistan (2 kg). Fish contributes high dietary protein to the extent of 70% in the Maldives, 57% in Bangladesh and 55% in Sri Lanka.

South Asia region is increasingly experiencing a soaring demand for fish and the probable expansion of fish production from wild capture related resources is minimal. A fruitful effort on improving aquaculture and fisheries in the SAARC platform will help us in achieving the SDG 3 (good health and well-being), 8 (decent work and economic growth) 10 (reduced inequalities),12 (responsible consumption and production), 13 (climate action), 14 (life below water) and 16 (peace, justice, and strong institutions). A major peril faced by the region is the increasing temperature in the northern Indian Ocean and resulting problems in the South Asian rim countries. There are increased frequencies of weather shocks such as droughts, floods, cyclones and many more. So, for improvement of the fish production in these situations, it is important to bring unutilized water bodies as a mechanism of horizontal expansion of aquaculture. Further, we have to start practicing seasonal aquaculture in water bodies as a climate change adaptation strategy. The discussions held during this consultation meeting came up with a compilation of the problems and recommendations which is spread over eight chapters in this book covering all Member States of the SAARC.

Lack of data, economic constraints, infrastructure lacunae, and non-availability of institutional support often act as stumbling blocks in rightly facilitating regulations which can have effective solutions for many of the challenges in aquaculture and fisheries in South Asia. With the inherent complexity in operations related to aquaculture and fisheries, there is often a serious demand

for multi-disciplinary/ multi-institutional support for resolving all these sectorial challenges. The possible avenues regarding cross-learning for thematic regional/ sub-regional challenges in aquaculture and fisheries remain diverse and different in the South Asia. Examples from the South Asia is quoted for better implementation of frameworks to be developed suiting to the country needs. Since all possible formal and informal networks in aquaculture and fisheries have been complied, we earnestly believe that the book will be useful for all general practitioners in the field.

We thank the support received from the SAARC Secretariat, lead planners of South Asia, resource persons and various associated organizations in effectively coordinating a discussion which resulted in this book with commendable contribution from all the nominated member state representatives.

Grinson George
Ganga Dutta Acharya
Dhaka, Bangladesh **Md. Baktear Hossain**

Contents

Chapter-1

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in South Asia - an Introduction

Grinson George

Senior Programme Specialist (Fisheries), SAARC Agriculture Centre, Bangladesh
E-mail: grinsongeorge@gmail.com

Abstract

South Asian agriculture is diverse with the inherent strengths and weaknesses which is evident in all sectors including aquaculture and fisheries. There can be large variations amongst different member countries depending upon the extent of activities in aquaculture and fisheries, there are certain issues that require a regional perspective for resolving it. Even for the strongest country in terms of the resources and technologies, sometimes may require the help of the weakest and vice-versa. A sudden outbreak of disease in the region, adulteration in the quality of inputs such as fish seed and fish feed, trans-boundary challenges and many more can be cited as examples for managing the aquatic resources at the right earnest. It is imperative to learn from each other and be familiar with the regional and sub-regional networks prevalent in each country in the region which will help us in sourcing the right information. Aquaculture and fisheries are emerging sectors in the region and leads the world in the production process. The prevalent infrastructure and situations make it challenging for the small-scale fishers and aqua-famers. There is a need to establish professional and stakeholder networks which can evolve to help the fishers and aquafarmers in the South Asia region. In this introductory chapter, we are discussing some of the opportunities and challenges in aquaculture and fisheries where cross-learning and net-working can bring in better solutions for improving the fish production from the region.

Keywords: inter-disciplinary, SAARC, fish-farming, capture-fisheries, networks

Introduction

Augmenting aquafarming is a firm solution for satiating the soaring demand for fish. South Asia region has been exemplary in promoting aquaculture and different member states have high proportion of fish production from aquafarms than wild capture (George and Hassan, 2020). Afghanistan, Nepal, Bangladesh and India are doing well in this area. Other countries are also equally prospective. But off late there is serious disruption in aquafarming activities with

the prevalence of lockdown or regulations related to COVID-19 pandemic. Therefore, there is a need to assess the dynamics of aquaculture in this context. The problems related to this sector are imminent and there have been contingent responses requested from various farming groups to resolve some of the issues which have been emanated purely in the wake of the pandemic. Marine and inland capture fisheries also faced serious challenges with fishing coming to a standstill and captured fish denied of proper marketing channels and issues related to seafood industry. All these challenges have to be assessed and issues have to be prioritized with possible recommendations in order to bring a stimulus into the sector. This book is a compilation of the regional consultation meeting which addressed cross-learning for South Asian challenges in aquaculture and fisheries. The deliberations helped us to understand the problems and vulnerability of fisheries and aquaculture in the wake of the pandemic and come up with pragmatic solutions. During the discussions the expert team tried to identify various challenges associated with fisheries and aquaculture in South Asia in the wake of COVID-19 and assessed, analysed and shared knowledge on the innovations, technologies and approaches in resolving the challenges in order to improve the efficiency and add stimulus to the pandemic affected sector for enhancing the quantity of fish production. As a part of the discussion process the SAARC Agriculture Centre could document the challenges and possible technological solutions for resolving COVID-19 related issues in fisheries and aquaculture and formulate guidelines on knowledge sharing, regional support and backup for the sector

Climate change – a major thematic area

During the meeting the SAARC countries sought regional cooperation to reduce impact of climate crisis in aquaculture and fisheries. Fishery experts from member countries identified issues in the sector and proposed suggestions to address them. In a major development in reducing the impact of climate crisis in aquaculture and fisheries in the region, SAARC member countries have sought for regional cooperation to implement strategies in battling the climate-induced fallouts in the sector. The consultative meeting of fishery experts representing Afghanistan, Bangladesh, Bhutan, India, Nepal, Maldives, Pakistan and Sri Lanka organized by the SAARC Agriculture Centre (SAC) has felt the urgent need for implementing strategies such as introduction of climate-friendly technologies in fisheries and aquaculture as well as measures for sustainable utilisation of the resources. The meeting came up with this suggestion after the experts identified climate crisis a major concern in aquaculture and fisheries sector of South Asian countries. The experts voiced concern over dwindling marine catch and aquaculture production, environmental disruption in aquatic

ecosystem and its rippling effect on livelihood of the stakeholders owing to climate change and associated developments.

They suggested that technologies such as seaweed farming and integrated multi-trophic aquaculture (IMTA), including cage fish farming could be adopted to reduce the impacts of the crisis to a certain extent. The sector could use 'green fishing vessels' with built-in design features for energy saving and fuel saving technologies to reduce carbon emission. Increase in frequency and intensity of cyclones, storms and extreme weather conditions causes drastic decrease in marine fishing days, habitat destruction, depletion of commercially important resources and other ecosystem changes in marine and inland aquatic system which ultimately affect the livelihood of those depending on the sector.The expert's group pointed out that increasing trend of floods, long-lasting droughts and salinity changes are posing severe threat to inland aquaculture.

Platform for cross-learning

The member countries have demanded for regional cooperation among the nations and a platform for cross-learning and knowledge sharing to check the fallouts in the best possible way in the time of climate change. In marine fisheries, need for capacity building for exploitation of deep-sea resources was raised by Bangladesh, India, Maldives and Sri Lanka. Scarcity of quality seeds and shortage of other input materials were the major gaps faced by the member countries in inland aquaculture. Based on the discussions in the meeting, the SAC came up with a set of recommendations to address such issues. Technical collaboration for knowledge sharing and capacity building among the SAARC countries and setting up of regional network for seed bank and germplasm transfer are some of the important suggestions. The entire list of recommendations emanated out of the discussion is also provided separately. There are scientific gaps inhibiting the implementation of rules and regulations for sustainable management of fisheries and aquaculture. Some possible solutions can be looked upon in satellite remote sensing, numerical modelling, stakeholders' perception, prioritization of spatial sensitiveness to ecosystems and many more with right interference from the stakeholders.

Socio-economic security

Referring to the existing disparity in socio-economic standards of the stakeholders, the SAARC body recommended for promoting discussions and cross-learning on strengthening 'social-safety-nets' with emphasis on ensuring socio-economic security of the stakeholders, and policies, laws and regulations harmonising between environment conservation and livelihood development. Establishment of referral laboratories for aquatic animal health management, a

centre of excellence in aquaculture and fisheries in the region and e-repository for information sharing were also listed in the recommendations. Marine pollution, increased fuel prices, illegal, unreported and unregulated fishing, increasing length of value chain, resource crunch and lack of adequate infrastructure are some of the other major issues raised in the meeting by representatives of member countries.

The meeting stressed the need for applying artificial intelligence, bio-informatics, genetic and biotechnological tools, etc. in frontier areas of research to improve aquaculture and fisheries sector. Mariculture sector (cage farming, seaweed farming, mussel culture) needed comprehensive development in the areas of leasing policies and hatchery development.

Inadequate infrastructure especially in fishing harbours, cold chain and distribution system; limited scope for expansion due to overcapacities in territorial waters; deficiencies in processing and value addition; depleted stocks in inland water bodies; low adoption of technologies; and shortage of skilled manpower are some of the gaps in the sector in the South Asian region.

Conclusion

The meeting came up with some salient observations and identified key networks to be developed in the South Asian context. The delegates suggested that aquatic animal health surveillance should be promoted in all countries and there is a need for interlinking the networks across the region. A SAARC regional network on fish seed bank should be in place, which can facilitate germplasm transfer, harmonized-certification process, technical know-how and infrastructure establishment. South Asian collaboration is required for exploring knowledge sharing and capacity building by establishing Tuna and Hilsa fisheries network. Technical collaboration for transfer of technology from production to consumption value chain in aquatic products by enabling SAAF Conference or exhibition was proposed as an innovative step forward. There can be various webinar series and guided study tours for improving capacity building and knowledge sharing which can include co-farming studies. There is a need for promoting discussions and cross-learning on policies, laws and regulations on aquaculture and fisheries harmonizing between environment conservation and livelihood development and for strengthening social-safety-nets in SAARC countries. An initiative to facilitate cross-country demonstration trials for flagged regional issues in aquaculture and capture fisheries which can culminate in the establishment of a regional centre of excellence in fisheries and aquaculture in the South Asian University can enable the researchers and academic professionals in the region to perform better. Enhanced human resource development for fisheries professionals in South Asia can be enabled

by facilitating the SAARC UG, PG, PhD fellowships and facilitating student exchange, short and medium-term training opportunities. The E-repository at SAARC Agriculture Centre should have SAARC country's aquaculture and fisheries laws and regulations and access sharing of South Asian institutional repositories for aquaculture and fisheries professionals. The most important thematic area should be on promoting climate resilient aquaculture and fisheries technologies using SAARC network.

References

George and Hassan, 2020. Guidelines for ensuring sustainability of fisheries and aquaculture in South Asia. SAC Policy Brief 12/Fisheries 09.

Grinson George, Md. Baktear Hossain (Eds.), 2021. Promoting Innovations in the Fisheries Value Chain for Improving Human Nutrition in South Asia. SAARC Agriculture Centre (SAC), Dhaka, Bangladesh. ISBN: 978-984-35-0861-4

Chapter-2

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in Afghanistan

Khalilullah Frough and **Rahmatullah Akbari**

Ministry of Agriculture, Irrigation and Livestock, Afghanistan
E-mails: khalilullah.frough@gmail.com; rahmat60akbari@gmail.com

Abstract

Afghanistan has plenty of water resources which are considered suitable for cold-water and sub-tropical fish farming. Being a landlocked country, wild capture fisheries takes place in the lakes and rivers, particularly in the different lacustrine and riverine resources of the country. As per the earlier estimates by the government, on average basis, up to 57 billion cubic meters of water resources were available in Afghanistan. Different factors including global warming have reduced the extent of these resources significantly. The recent challenges resulted in serious depletion of the water resources and the present water resource status has now reduced to approximately 49 billion cubic meters of water. The capture fishing methods remains rudimentary due to less attention to the sector, poor infrastructure and lack of expertise. Most of the fish and related commodities are imported from neighbouring countries such as Pakistan, Iran, Uzbekistan and others. Afghanistan currently requires an estimated 1,20,000 metric tons of fish, but poor fish production is forcing the fishing industry players to import most of their supplies from neighbouring nations. Fisheries and related aquatic resources are important to national and regional economic development, and often fish production and trade represents an important sector of the economy. Proposed development initiatives of the fisheries have documented feasibility of cold-water and sub-tropical aquaculture in Afghanistan. In general, fish production relies on a variety of factors, which are essential in some quantity to enable the activity to be pursued successfully. This includes essential supplies in the form of seed, feed and others. In this chapter, we are looking into the various organized and informal networks to address cross-learning as a multi-disciplinary approach to address the imminent challenges and explore potential opportunities to augment fish production to support various other efforts to ensure food and nutritional security in the country.

Keywords: Food Security, Fish, Afghan, Multi-disciplinary, Production

1. Introduction

1.1 Location and background

Afghanistan is located centrally to Asia (Figure 1) and one of the 48 least developed countries in the world. Majority of the population, which approximately estimated as 85% depend on agriculture and livestock for their livelihood. Afghanistan is a net food importing nation. The area of the country is 652 thousand square kilometers and 75% of its territory is mountainous. Its population is estimated to be close to 35 million (2019) with a literacy rate of 80 percent. Afghanistan has a young population, with 45% falling below 15 years of age (2018). Nearly 75% of the population live in rural areas. Different forms of agriculture and allied sectors are their main source of income and employment. A general profile of the different sectors in agriculture is compiled in Tables 1 and 2.

Table 1: General geographic and economic indicators

Area	652,000 square kilometers
Shelf area	None (country is landlocked)
Population (2019)	35 million
Urban population as % of total population (2018)	24%
Literacy rate (2018)	80
GDP at current prices (2018)	US$ 20.4 billion
GDP per head 2018)	US$ 680
Fisheries as percent of agricultural GDP (2012)	Less than one percent
Unemployment (2018)	40% (estimated)
Percent of population below poverty line (2018)	30%
Exports of fish	0
Fish products /year	12000 Metric ton
Share of agricultural products in total imports	13.8%
Imports of fish /year	130000 Metric ton

Table 2: Afghanistan livestock population limit

No	Name	Amount	Meat percentage
1	Cattle	6 million	25%
2	Sheep	15 million	14%
3	Goat	8 million	8%
4	Chicken	8345 farms	20%
5	fish	3855 farms	10%
6	Camel	45000	3%

Figure 1: Location of Afghanistan in Asia

1.2 Diversification of aquaculture species

As a land-locked country with seasonable water flows and diversion of water for irrigation purposes, fisheries are not a large contributor to the national economy, although from a biodiversity perspective, fisheries may be considered in the context of water use and water withdrawals (Allison, 2011). Afghanistan have minimal aquaculture feasibility but with changing economic conditions there are some aquaculture operations slowly developing as niche markets around large towns and among the northern border where water supplies are more regular, noting that cold water environments may offer reasonable potential for cold water high value species (FAO, 2004).. However, Afghanistan has adequate water reserves and suitable climate for fish farming (both cold and warm species). The construction of medium size and small dams on a number of rivers also provides opportunities for fish stocking (Edwards, 1990). Areas that have reasonable potential for fish production (including aquaculture):

- Perennial rivers in northeast Afghanistan (Amu Draya, Kokcha, Balkh, Kunduz and Murghab Rivers) for cold water species.
- Perennial rivers in eastern Afghanistan (Laghman, Kunar, Pech and Panjshir Rivers) for cold and warm species.
- Perennial rivers in southern Afghanistan (Helmand and Arghandab Rivers) for warm species.
- The Hamoun wetland for warm species.

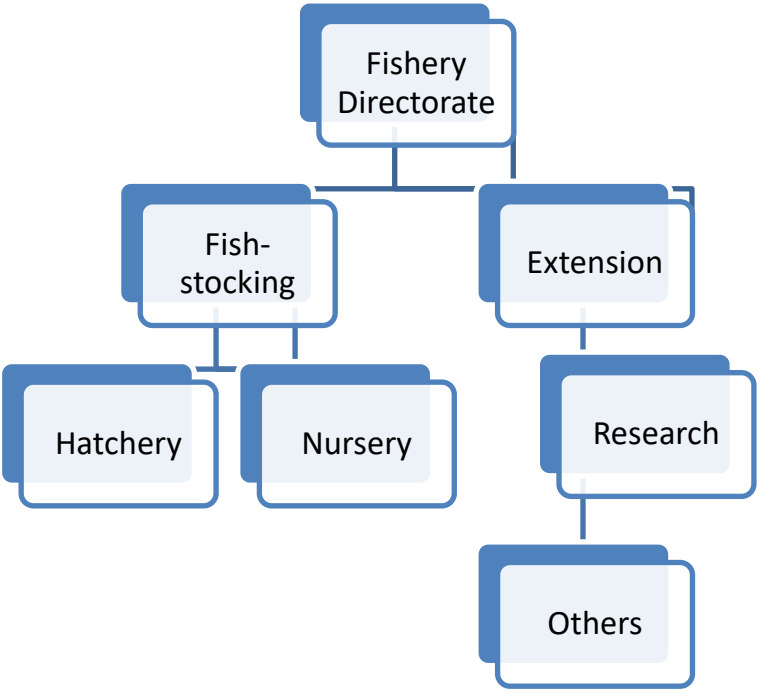
Hamoun is an inland water delta created by spring floods from the Helmand River. The Hamoun is shared by Afghanistan and Iran. Its waters contain nearly 140 species of fish and receive a variety of migrating birds. Once a fertile land, the productivity of this wetland of approximately 2,000 square kilometers has deteriorated severely due to mismanagement.

Investment for fish production in these areas can only be undertaken on the basis of appropriate feasibility studies for each potential river basin. The major types of fishes produced in the country are compiled in Table 3.

Table 3: Major types of fishes produced in Afghanistan

No	Type	Production ton/years
1	Carp	7300 m
2	Trout	354 m
3	Royal	2000 m
4	Miscellaneous	1500 m

2. Chart of human resource networks engaged in aquaculture and fisheries in Afghanistan



3. Current challenges in Afghanistan

The major challenges identified for the aquaculture and fisheries sector in the country are as follows:

- Droughts
- Diseases
- Lack of human resources in aquaculture and fisheries
- Not enough infrastructure such as hatcheries
- Internal war and security problems
- Lack of aquacultures education centres

4. Governance instruments and private sector interventions

4.1 Government's e responsibility

- Establishment of fish breeding and production farms.
- Establishment of feed production factories
- Establishing laboratory for diagnosis of fish diseases
- Formulation of guidelines for farmers involved in fisheries

4.2 Private sector's involvement

Majority of capture and aquaculture fisheries production belong to private sector. As a scientific discipline, aquaculture is not taught and there is a need for specific fisheries faculty in the universities (Kabul University, 2022). Therefore, there is lack of capacity building and huge demand for manpower in fisheries sector. Staff of the respective fisheries department or those who work in fishery related areas technically are trained by foreign specialists who provide long and short-term courses. International organizations are cooperating in different sections of fisheries for example scholarships, fellowships for staff of fisheries and for capacity building on fish nutrition, disease, reproduction and even game fishery (FAO, 2016).

5. Need assessment

The priority areas based on the need assessment in the country are as follows:

- Establishment of fisheries department in the Faculty of Agriculture in Afghanistan Universities. Lack of fisheries education centers are identified as a major challenge.
- Establishment of fishery research farm.
- Establish feed production factories.
- Compiling technical course for fisheries staff, introducing new methods.

6. Policies, laws and regulatory mechnisms

Afghanistan is currently having a significant opportunity in the aquaculture sector and relevant policies may be established for the development. Equipping the farmers with workshop and training for modernization with adequate methods on practical and theory in fisheries and extension and the new technical developments based on advents in the science and technology will help farmers to augment production and create awareness on conversation with themes about their challenges in the sector (MAIL, 2022). Encouraging farmers to improve the quantity of production and generate additional and alternate employment opportunities in fisheries and ancillary industries may contribute to alleviate widespread poverty. Increased fish production can be achieved by using new production systems and by resolving the problems of the farmers.

7. Production cycle and Infrastructure

In Afghanistan, hatchery, nursery and other aqua-farming related facilities belong to the government and are producing the best outputs for farmers by researching in accordance with science and technology. The notable supply chain is as follows:

Hatchery - fingerling product - Farm- fish production -process centres- market –customers

7.1 Systems of production

- Rural Subsistence Small Holdings
- Rural Market Oriented Small Holdings
- Rural Commercial Farming
- Open system Orbit Farming.
- Soil fish (warm species) Farming
- Corporate reproduction Farming

Project planning for five years		
1	Estimated quantity	Establishment of 10000 aquaculture farms
2	Activity	Creation of Warm/cool water fish farms for breeding and fish production
3	Project owner	Ministry of agriculture /fishery and poultry Directorate
4	Project users	Private sector especially disabled farmers
5	Project area	(4000) Hectares
6	Budget	(200) Million $

8. Conclusion

Serious study is needed to assess the potential of inland fish production (both capture and culture fish) in Afghanistan and to explore the means by which the potential can be exploited. After 4 decades of war/fighting Afghanistan's agriculture and livestock sector is twice borne. Afghanistan livestock especially fishery production is in a situation where dire promotion, awareness and opportunities to be created. Increasing Afghanistan's internal fish production will reduce the relevance of import of fish from foreign countries.

9. Recommendations

The following recommendations are put forth for fisheries development in the country:

- Operational training for fishery department staff especially for preventing fish disease.
- Making seminar, workshops for capacity building (fishery production process and marketing)
- Establishment of fish breeding farms.
- Establishment of fish production farms
- Establishing feed production factories
- Establishing laboratory for diagnosis fish disease

References

Allison E.H., 2011. Aquaculture, fisheries, poverty and food security. Penang: WorldFish Center; 2011.

Edwards D., 1990. Final technical report on rainbow Trout Culture in Qargha Fish Farm, Kabul, Afghanistan, Rome (Italy), 7p. Project: FAO-FI-DP/AFG/86/013.

FAO, 2016. The State of World Fisheries and Aquaculture 2016: Contributing to food security and nutrition for all. Rome. 200 pp.

FAO, 2004. https://www.fao.org/3/bm091e/bm091e.pdf (last accessed on 8th July 2022)

Kabul University, 2022 –agriculture faculty-livestock department. https://www.ku.edu.af/ (last accessed on 8th July 2022)

MAIL, 2022. Site of agriculture irrigation and livestock. (https://mail.gov.af/en/ categories/mail) (last accessed on 8th July 2022)

Chapter- 3

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in Bangladesh

Md. Mukhlesur Rahman[1] and **Md. Nowsher Ali**[2]

[1] District Fisheries Officer and [2]Assistant Director
Department of Fisheries Bangladesh, Matshya Bhaban, Ramna, Dhaka 1000

Abstract

The fisheries and aquaculture sector play a significant role in socio-economic development of Bangladesh in terms of maintaining livelihood of fishermen, supplying nutrition to the people, creating employment, and earning foreign exchange. The country with diversified fisheries resources and aquatic fish species is fortunate enough in contributing the sturdy growth rate of capture and culture fish production. During the country's independence in 1971, the basement of aquaculture was in the conventional mode. In the decades after 1980, the country started fish seed production by the government, along with the innovations on new farming technologies and transfer it to the farmers following a unique extension approach. The enthusiasm of non-government organizations in seed production along with adoption of fish culture applying aqua-inputs further triggered fish production in this country. Thus, the contribution of the government, and non-government partners both in the national and international academia, and researchers were instrumental for the development of fisheries sector in Bangladesh.

Keywords: Socio-economic, Aquatic Species, Seed production, Bangladesh, coordinated networks, SAARC

1. Introduction

From the time immemorial, fish has been a popular complement to rice in the national diet of Bangladeshi people. The favorable geographical position of the country comes with crisscrossed rivers, canals, beels (natural depression), harbour, pond, lake, ditch, floodplains and vast marine areas which earned the name 'Bangladesh' meaning 'land of rivers'; which are further blessed with fisheries resources. In this regard, the father of the nation and a visionary leader-Bangabandhu Sheikh Mujibur Rahman mentioned that fish would be the second major foreign currency earning source of Bangladesh (DoF 2020).

The abundance of water resources has driven Bangladesh as one of the leading fish producing countries in the world. In 2020-2021, total fish production of

Bangladesh was 4.621 M MT. The fisheries sector contributes 3.57 percent to the national GDP and more than one-fourth (26.5%) to the total agricultural GDP (DoF, 2022). Now, per capita fish consumption attains 62.58 grams/day against the set target of 60 g/day. This sector provides employment to about 195 lakh people that is 12% of the total population directly or indirectly (DoF 2020).

This contribution of fisheries sector comes from three broad areas: inland capture fisheries (38,60,466 ha), inland aquaculture (8,43,729 ha) and marine fisheries. The inland aquaculture sub-sector is contributing more than 57.1%, followed by the capture (28.16%) and marine (14.74%) of the total fish-production. Shrimp industry is one of the most important contributors to economic development of Bangladesh where the main cultured shrimp is Tiger shrimp (locally known as "Bangda Shrimp"). It is a marine shrimp species. There are two production zones for shrimp in Bangladesh, the southern region and the Chattogram region. Shrimp farming is having a positive impact on the livelihood of many people especially in the coastal region.

Now, Bangladesh acquires 3rd position in inland open water capture fish production, and 5th position in inland aquaculture fish production in the world (FAO, 2020). Similarly, the country ranks at 4th position around the globe and 3rd position within Asia in tilapia production, and 1st in Hilsa fish production.

Hilsa is our national fish and it has GI (Geographical Indication) certificate for Bangladesh. Hilsa is our own national pride and Bangladesh produces over two-thirds of total production of hilsa. Hilsa fish production increased from 1.99 lakh MT in 2003-04 to 5.65 lakh MT in 2020-21.

Fish and fishery products are one of the major export commodities of Bangladesh. Mainly Galda (*M. rosenberggi*), Bagda (*P. monodon*) and other species of shrimp and different marine fishes such as sea bass, Datina, pomfret, cuttle fish, crab and eel fish are exported from Bangladesh. Besides these, dry fish, shark, finfish scale and shrimp shell are also exported. Bangladeshi fish and fishery products are exported to more than 50 countries including European Union (EU), USA, Japan, Russia, and China. EU countries are the major importers. In the fiscal year 2020-21, Bangladesh earned 4088.96 crore taka by exporting 76591.69 MT of fish and fishery products. During last two decades, the export trends and corresponding foreign earnings (in crore) are shown in the following graph (Fig. 1).

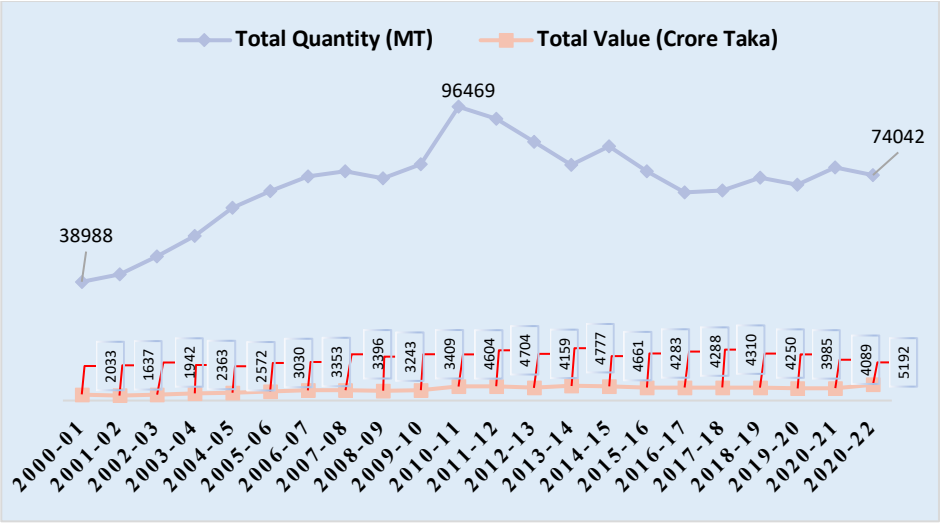


Fig.1: Last two decades export trends of fish and fishery products and corresponding foreign earnings

The strategies and policies adopted and amended by the Department of Fisheries (DoF) are envisaged in the targets of 'Vision 2041'. Hence, it is DoF initiatives to reach the targets which are encrypted in the 'Sustainable Development Goals (SDGs)' and 'Vision 2041' to become an upper middle-income country by 2031 and a prosperous country by 2041 in the platinum jubilee of its birth having per capita income of $12,500 (more than $16,000 in 2041 prices).

2. Existing thematic networks in aquaculture and fisheries

DoF motivates and facilitates fish farmers and fishers for adopting eco-friendly management regimes in aquaculture and fisheries resource management to enhance production and productivity. It provides updated research findings and better farming techniques to farmers/growers for increasing production through establishing effective linkage between the various research institutes and the fish farmers. DoF also serves as liaison agency between farmers and other organizations, both public and private.

2.1 Public sector networks

Department of Fisheries (DoF) Bangladesh acts as a key agency under the Ministry of Fisheries and Livestock and its mandate is to support sustainable growth in fish and shrimp production with other aquatic resources for domestic consumption, exports and management of open-water fisheries resources through community participation leading to equitable distribution of the benefits for optimal economic and social growth in Bangladesh. Bangladesh Fisheries Research Institute (BFRI) developed economically viable,

environmentally sustainable and socially acceptable fisheries and aquaculture technologies to optimize fisheries production in the country. On the other hand, Bangladesh Fisheries Development Corporation (BFDC) is a national corporation that constructs fish landing centres, runs cold storage, processing centres, and transportation centres for fishes and to reduce post-harvest losses of fish and fish products in Bangladesh. Marine Fisheries Academy (MFA) under the same ministry is shouldering the responsibilities of exploring and pooling the seafaring talents of the country and training them in well planned and well-organized manner as Navigator, Engineer and Fish Processing Technologist. Fisheries and Livestock Information Department (FLID) is dedicated to the collection, storage, evaluation, analysis and thus the support activities for poverty alleviation through the extension of information technology and ensuring the display and supply services of dissemination/extension materials containing information on fisheries and livestock development.

2.2 Fisheries and Aquaculture Human Resource Development in Bangladesh

There are 49 public Universities in Bangladesh, among which 17 Universities imparts academic programs related to fisheries and aquaculture, contributing to research, education, training, and consultancy in a shared network. Graduates and post-graduates from this country and those completing their degree from abroad form the man-power to increase fish production in the country and some of them perform in a global setting too.

2.3 Non-Government Organizations (NGOs) and International Organizations

There are various national and international NGOs such as SOLIDARID Network Asia, Winrock International, DANIDA, USAID and many others that are working in aquaculture and fisheries sector of Bangladesh. They work in areas related to aquaculture, fish conservation, community mobilization, fish processing and trading, microfinancing, coastal aquaculture etc. under the legal frameworks of Department of Fisheries, Bangladesh integrating with other stakeholders.

2.4 Other international Organizations

Food and Agricultural Organization (FAO) of the United Nations, World Bank, WorldFish, International Union for Conservation of Nature (IUCN), Wildlife Conservation Society (WCS), The World Fish Centre, Malaysia is working with Bangladesh in specific areas of fisheries research, aquaculture and livelihood improvement projects in Bangladesh. The fisheries and aquaculture in South Asian countries has a coordinated network enabled as part of the South Asian Association for Regional Cooperation (SAARC)and the SAARC Agricultural Centre (SAC), Dhaka is facilitating it. The International Fund for Agricultural

Development (IFAD), Indian Ocean Tuna Commission (IOTC), Asia-Pacific Fishery Commission (APFIC); Network of Aquaculture Centres in Asia and the Pacific (NACA); World Organization for Animal Health (OIE), Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region (INFOFISH); Commission for International Trade on Endangered Species (CITES) are also working in fisheries and aquaculture sector in Bangladesh.

2.5 Fishermen/ Fish Farmers' /Traders' Associations

There are many fishermen/ fish farmers' / traders' associations such as Bangladesh *Matshyajibi Sommiti* dealing with fishermen's right; Bangladesh Shrimp and Fish Foundation (BSFF), Bangladesh Frozen Food Exporters Association (BFFEA) involved with shrimp production and trading; Bangladesh Aqua Product Company Association (BAPCA) linked with aqua product manufacture, import and distribution, Animal Health Companies Association Bangladesh (AHCAB) having the members producing aquatic animal heath related products manufacture, import and distribution; Feed Industry Association of Bangladesh (FIAB) dealing with fish feed manufacturing and distribution; Fish Farmers Owners Association dealing with the farmers welfare, Shrimp Hatchery Association (SHAB) etc. taking members with fish seed producers and so on. These associations are supporting DoF Bangladesh in augmenting fish production, fisheries management and policy formulation and reform.

3. Government regulatory activities

3.1 Fish Feed and Animal Feed Act 2010 and Fish Feed Rules 2011

Fish feed is one of the most important factors for commercial aquaculture. There were no rules and regulations to maintain the quality of the feed and feed ingredients for the farmers before 2010. But government took initiative and enacted Fish Feed and Animal Feed Act 2010 and Fish Feed Rules 2011. These rules are under effective enforcement all over the country since enactment.

3.2 Fish Hatchery Act 2010 and Rules 2011

Aquaculture of Bangladesh is flourishing with the rapid expansion of public and private hatcheries providing support for good quality fish seed. But with the expansion of private hatcheries the quality issues of fish seeds have raised over the years. There are many reasons for the low quality, for instance, inbreeding, inter-specific hybridization, negative selection, improper brood-stock management. Furthermore, hybridization and cross breeding are threatening the genetic diversity of indigenous wild stocks of Indian Major Carps. The quality

standards and their compliance is critical in private hatcheries and to prevent these undesirable practices, Bangladesh government promulgated the Fish Hatchery Act and Rules to ensure the quality of fish seed produced from public and private hatcheries. Under the act and rules, every hatchery must be registered with the DoF.

3.3 Protection and Conservation of Fish Act 1950 and Rules 1985

The provisions of Fish Act-1950 is to safeguard breeding and growth of carp and other important fish species contributing to increase in fish production in the country. Appropriate measures are taken to implement the Fish Act-1950 with assistance from local administration as well as law and enforcement agencies such as Police, Rapid Action Battalion (RAB), Coast guard, Border Guards Bangladesh (BGB), and Navy. Mobile courts are conducted throughout the country.

Public awareness programs are chalked out and implemented by the Upazila Fisheries Officers through meetings, general campaigns round the year and during observance of National Fish Week to create mass awareness about Fish Acts. Different awareness materials such as posters, leaflets, booklets etc. are printed and distributed. In addition, TV spot are prepared and broadcasted, street drama is staged and workshops/seminars are organized to create mass awareness.

3.4 Fish Inspection and Quality Control (FIQC)

Fish and fishery products have been exported since the independence of the country. At present, these products are one of the major export commodities of Bangladesh. One of the other important agenda for the department is to facilitate and maintain fish and fishery products' quality and safety to enhance export. The Fish Inspection and Quality Control (FIQC) authority deals with this job. Envisaging this context, Government implemented the National Fish Inspection and Quality Control Project in 1976 establishing two regional offices located at Chattogram and Khulna. The office of Dhaka zone was established in 1980 under 'Establishment of National Fish Inspection and Quality Control Service' project at Matshya Bhaban.

Besides inspection and certification of exported fish and fish products throughout the year, renewal of licenses is carried out by each FIQC offices covering the establishments under jurisdiction, such as fish processing plants, depots, ice factories, landing centres, packing centers, non-packer exporters etc. each year. Requests for enlistment of the names of fish processing establishments and exporters intended to export to EU countries, China and Russia are facilitated as case to case basis. Competent authorities of other countries are communicated and their requirements are met to continue and enhance export

of fish and fish products. In this regard, Bangladesh has updated Health certificate for exporting shrimp to Australia and fish and fishery products to the Republic of Korea. Residue monitoring of fish and fish products as well as fish feed is monitored throughout the year for ensuring safe and quality fish and fish products for consumers. Routine inspection of fish processing establishments and ice plants and testing of swab, ice, water etc. are also carried out round the year for ensuring food safety.

In 2020, signatures of authorized officers of each FIQC offices involved with certification of fish and fish products has been sent to China for updating into the website of AQSIQ (Certification and Accreditation Administration of the People's Republic of China). This year two Crab processing plants (Japan Fast Trade Ltd; SAT-134 and Farid Nine Stars Agro Foods (BD) Ltd.; SAT-141) have been enlisted by Directorate General of Health and Food Safety (DG(SANTE)) of EU for exporting fish and fish products to EU countries. The new Fish and Fisheries Products (Inspection and Quality Control), Act 2020 is approved by the national parliament and the formulation of rules is under process.

3.5 Marine Fisheries Regulations

Marine fisheries sector is governed by "Marine Fisheries Act, 2020" (Previous the Marine Fisheries Ordinance, 1983). "Marine Fisheries Act, 2020" has been passed on 16 November 2020 in the 11th session of National Parliament and published in gazette on 26 November 2020. The DoF prepared a draft of "Marine Fisheries Rules 2021" after discussions with the relevant stakeholders and after incorporating their comments the draft of "Marine Fisheries Rules 2021" has been submitted to the Ministry of Fisheries and Livestock.

Similarly, along with a series of policy dialogues with the concerned stakeholders, a revised "National Marine Fisheries policy 2020" has been drafted and submitted to the Ministry of Fisheries and Livestock on 06 February 2020. All industrial fishing trawlers and mechanized fishing boats are required to have license for fishing. Industrial fishing trawlers are mandatory to take sailing permission (SP) from Marine Fisheries Office under the Department of Fisheries (DoF). Trawlers are allowed to operate in an area not shallower than 40 m depth zone. Mechanized fishing boats are allowed fishing below 40 m depth zone.

4. Interventions to improve fisheries and aquaculture in the country

4.1 Fish seed and post larvae production

During 1961-62 to 1974-75, the government established Fish Seed Multiplication Farms (FSMFs) to supply required quantity of quality seeds to the fish farmers. During that period, mostly wild fish seeds collected from the rivers were reared in the FSMFs and supplied to the fish farmers. In the mid-60s, due to reduction

in the availability of wild carp seeds in the rivers and as the natural fish seeds were not able to meet the growing demand of the fish farmers, the government established fish hatcheries to produce quality fish seed and at the same time the induced breeding technology was disseminated to the private sectors. At present the country is self-sufficient in carp seeds production, though quality fish seeds are produced in a limited scale. As a result of introduction and extension of breeding technology of Galda and Bagda, many private entrepreneurs have established shrimp hatcheries for the production of shrimp post larvae (PL).

4.1.1 Brood stock management

The DoF Bangladesh imported original stock of Chinese carp (Grass carp, Bighead and Silver carp) fry (3-4 g) from China in 2019 and distributed to 38 government fish seed farms to have quality brood fish after proper rearing. These fishes were taken under breeding from 2021 to produce quality brood and seed. Regular Brood Development program continue by collecting spawn from natural sources to produce brood fishes following brood schematic flow chart stated in Fish hatchery rules 2011 in the government and non-government fish seed multiplication farms. Cryopreservation programs have been undertaken in 14 farms to produce quality seeds of carps.

4.2 Fresh water aquaculture

The country has immense natural potential for developing the fisheries sector. Aquaculture production contributes 57.38% of the total fish production. Through this remarkable achievement, aquaculture is prioritized and focused area during the recent past decades. Because of continuous deterioration of open water fisheries due to natural and man-induced changes in the fish habitats and fish populations, the government has endeavored to increase fish production through aquaculture. The expansion of fish production is largely due to improvement in the use of aquaculture technologies by farmers. Extension and training support have aided the adoption of technologies by farmers. The development of long-term efficient and effective aquaculture training and extension support has contributed to the growth in aquaculture production in Bangladesh.

4.2.1 Freshwater fish culture in ponds/burrow-pit, and khal/ditch

Currently pond aquaculture has been practiced in a total area of about 4.07 lakh ha producing about 20.46 lakh mt fish which is contributing 45.24% of total inland production in 2020-2021. Different types of water bodies improved under Enhancement of Fish Production through Restoration of Waterbodies Project (EFRWP)

4.2.2. Fish culture in baor (Ox-bow Lake)

A total of 600 baors having an area of 5,671 ha are located in the southwest part of the country. Different development projects are being implemented to increase the fish production in these baors by adopting improved aquaculture including fingerling stocking and management practices that play a vital role to uplift socio-economic condition of the concerned fisher folk community.

4.2.3. Cage culture

Case fish culture in Bangladesh was introduced and promoted several decades ago, under different development projects run by several institutions/ organizations of the country. Nowadays, cage culture is popular, and attracting means of livelihood as more people are engaging themselves in this farming practice with fish species such as monosex tilapia, pangas, koi, singh, magur, thai and swarpunti. Cage culture of monosex-tilapia is being practiced in Chandpur, Laxmipur, Faridpur, Barishal, Mymensingh, Dhaka, Munsigonj, Gopalganj, Norsingdi, Pabna and other regions of the country.

4.2.4. Pen culture

Pen culture is also one of the potential means of producing fish from vast water body or canal. In recent years, pens are made with different materials such as bamboo, net, iron-meshed, wooden pillar etc. The area of a pen also varies in size from half to a few hectare. The fish species reared in the pen are carp, tilapia, pangas etc. Feeds are also applied in pen culture system but not regularly. Both single and multi-owner are found in pen management. Culture period also varies from June to December depending on availability of water. Pen culture is becoming popular in and around Dhaka and Narayanganj and expanding every year.

4.2.5. Fresh water mud eel culture

Monopterus cuchia is an important freshwater air breathing, swamp mud eel fish. It commonly occurs in the freshwater of Bangladesh, Pakistan, Northern and Northeastern India and Nepal. Once upon a time, indigenous cuchia was abundant throughout Bangladesh and it was found in large quantities in mud holes in shallow beels and 'boro' paddy field particularly in old Sylhet, Mymensingh and Tangail Districts. But nowadays this fish is hardly found in the open water area. The biodiversity and ecosystem of natural water bodies are being decreased due to global warming and climate change. *M. cuchia* is exported to many countries of South East Asia and Europe.

4.3 Coastal aquaculture

4.3.1 Shrimp (bagda) culture

Black tiger shrimp (*Penaeus monodon*) in Bangladesh is known as Bagda. Bagda grows faster and bigger in size, the species is very popular for coastal aquaculture among shrimp species available in Bangladesh. Bagda culture has been starting in the south-west region of the country using agricultural land since early 1970s. The larvae of shrimp and other fish are trapped into the crop fields during high tide and reared for several months. With the increasing demand of shrimp and prawn in the international market expansion of shrimp farming was observed in dyke elevated rice fields (traditionally known as gher).

In 1994 government declared the coastal region as ` Open for brackish water shrimp farming` through a government order. From then, brackish water shrimp farming has been expanded rapidly. In 2020-21 bagda production in Bangladesh was 68704 mt.

4.3.2 Prawn (galda) culture

The Giant freshwater prawn (*Macrobrachium rosenbergii*), called as Galda in Bangla, were being trapped and reared with other fishes in the tidal pond and low lands. Generally, the species were harvested from the river/canals, floodplains and beel areas which have connectivity with rivers. At present *Macrobrachium sp*. is being cultured in Gher in organized way along with other aquaculture, agriculture and horticulture crops. Different culture systems such as monoculture, poly-culture along with other fishes and aquaculture in paddy fields along with paddy are being practiced.

4.3.3 Cluster based shrimp farming

In the country, 300 clusters with 25 shrimp/prawn farmer and 7500 total farmers taking 50 decimal pond area each with a view to adopting improved traditional farming with Good Aquaculture Farming, water supply canal excavation, development with post-harvest centre and incorporating E-traceability system are being established by the Sustainable and Marine Fisheries Capacity building projects under DoF Bangladesh.

4.3.4 Crab culture and crab fattening

Recently traditional mud crab (*Scylla serrata)* culture has been practiced in Bangladesh based on capture and fattening of juvenile from the wild. Now mud crab is recognized as a valuable export commodity. After shrimp, mud crabs have become the second-most exported crustacean from Bangladesh. Because of high prices in international markets, mud crab farming is gaining popularity in

the coastal districts of Bangladesh. It has been harvested in greater Khulna, Barisal and Chittagong regions. Mud crabs are less susceptible to disease and more resistant to adverse environment conditions and climate change. Many shrimp farmers are switching to mud crab farming. Two species of crab are available in the coastal region of Bangladesh-*Scylla serrata* and *Scylla olivacea.* From this only mud crab (*Scylla serrata)* is culturable in Bangladesh.

Based on the increasing demand of gravid female in the south-east Asian countries, a sustainable aquaculture technology has been developed. Culture of juvenile crab in pen and cage is now being practiced in some selected areas of Bangladesh. This culture technology and production performance changed the socio-economic condition of the adopted communities and the fellow farmers also become interested to practice this kind of crab fattening.

4.4 Inland Open- water fisheries resource management

4.4.1 Community based fisheries management (CBFM)

Bangladesh has achieved recognition for its inclusive fisheries management through local community engagement. Community based management of resources is a time-driven and successful activity initiated by DoF. Bangladesh is emerging as a country of having positive lessons from community-based management of open water Establishment of Community Based Organizations (CBOs) and village level sub committees have been recognized as the first and fundamental step in creating sustainable co-management of fisheries resources in the decision-making process by user's group. Initial work on networking by community-based organizations has been started at regional level. More emphasis has been given to work with community-based fisheries management in the inland capture fisheries sub-strategy.

4.4.2 Fingerling stocking

Natural recruitment of carp spawn and fingerling declining due to human interferences and environmental degradation hampered the productivity of open water capture fisheries resources. To improve the productivity of open water the Ministry of Fisheries and Livestock through the Department of Fisheries initiated regular program from revenue and development budget to release fingerlings of major carp in open water bodies, floodplains and closed water bodies throughout the country. Stocking of fish fingerling into beels and floodplains is a temporary measure to address the quick declination of fish production in open water.

4.4.3 Beel nursery

Beel nursery has been proved to be a significant tool for increasing fish production in natural waterbodies. DoF has continued the program as regular

activity under revenue and development budget in various low lying rice field, floodplain, beel, haor, canal, river and government/non-government water bodies from 2009-10 fiscal year to increase natural production in these areas along with surrounding linked water bodies.

4.4.4 Establishment and Management of fish sanctuary

Introduction of sanctuary approach for fisheries resource conservation opened up a new horizon for sustainable use of valuable fish species. To stop the degradation of aquatic biodiversity specially species diversity of fish and other aquatic species in open water, a set of technical interventions such as establishment of fish sanctuaries, fish habitat restoration has been undertaken during the past years. Establishment of aquatic sanctuary is one of the effective tools for conserving fish stock, protecting biodiversity and increasing fish production. During the last five years, total numbers of 432 fish sanctuaries were established by DoF in different selected water bodies.

4.5 Marine Fisheries Resource Management

4.5.1 Marine Fisheries Resource Conservation and Management

Bangladesh is blessed with her vast coastal and marine resources. By the virtue of solemnity and sincere leadership of Honorable Prime Minister Sheikh Hasina, Bangladesh established her legitimate right in 1,18,813 sq km area of the Bay of Bangle resolving dispute over maritime boundary with neighboring countries Myanmar and India during 2012 and 2014 respectively settled by International Tribunal on the Law of the Sea (ITLOS) and International Court of Arbitration. This verdict ensures the sovereign right to explore, exploit, use, preserve, develop and manage the living and non-living resources in the EEZ of the Nation. Moreover, it also opens the opportunity for Bangladesh to attain fulfillment of animal protein, employment, poverty alleviation, export earnings, growth around sectors such as fisheries, aquaculture, tourism, explore of natural resources, trade as being to promote and strengthen her blue economy for well-being of the nation. It is now very significant to take effective initiatives for promotion and strength of her blue economy keeping the Marine Bio-bank sustain through proper conservation, management and scientific yield from the vast Marine ecosystem. Discussion on blue economy started in Bangladesh after the settlement of maritime boundary. In 2014 by the guidance of the Ministry of Fisheries and Livestock, Department of Fisheries has taken short term, midterm and long term "National Plan of Action (NPOA)" to address sustainable catch and conservation of marine fisheries resources to rise up Bangladesh as a middle-income country. The "National Plan of Action" updated in 2018 according to the SDG (2018-2030) of FAO.

4.5.2 Stock Assessment Marine Fisheries Resources (Updated)

Bangladesh has acquired a high-tech multipurpose fisheries survey and research vessel "R V Meen Shandhani" with the aid of Islamic Development Bank and Malaysian Government under the previous project "Marine Fisheries Capacity Building (BMFCB)" under DoF. Honourable Prime Minister has launched it on 19 November 2016. A TCP Project on "Technical Support for Stock Assessment of Marine Fisheries Resources in Bangladesh" funded by FAO has been implemented for skill develop, formulate survey design and plan, operating survey cruises by "R V Meen Shandhani". The project has been completed in June 2019. The Fisheries Research and Survey vessel "R V Mean Shandhani" has already conducted 31 survey cruises till May 2021 in the Bay of Bengal. All the collected data by the survey vessel have been preserved for further biological analysis. The first Survey Report for 2016-17 to 2018-19 has been published. The report now being used for the development of Marine Fisheries Management Plan. In accordance with the report, from 31 survey cruises, 457 fish and others species has been identified among which 373 species of fish, 21 species of sharks and rays, 24 species of shrimps, 21 species of crabs, 03 species of lobsters, 01 species of mantis, 04 species of octopus, 05 species of squids and 05 species of cuttle fish have been recorded.

With the assistance of Food and Agriculture Organization (FAO) of the United Nations and Institute of Marine Research (IMR) under the program of EAF_ Nansen, an Acoustic Survey has been conducted in the Bay of Bengal with the Research Vessel R.V. Dr. Fridtjof Nansen during 02- 17 August 2018. A database has been established which is accessible via DoF website. Data on crafts and gears have been collected and incorporated into the project Database (192.168.2.102/bmfcb). Updated data from the land based survey have been incorporated.

4.5.3 IUU Catch Monitoring

The Government has enacted the "Marine Fisheries Act, 2020" to incorporate FAO-CCRF to control, deter and eliminate Illegal, Unreported and Unregulated (IUU) fishing to conserve marine life. The European Union through its Council Regulation EC 1005/2008 has laid down Catch Certificate Scheme (CCS) to combat IUU Fishing. Under this Scheme any company wanting to export marine fishes to European Union countries must have IUU-Catch Certificate (CC) approved by the flag state's Competent Authority. The Marine Fisheries Ordinance 1983 was amended in 2010 to facilitate issuing IUU-Catch Certificates by the Director, Marine Fisheries Office as Competent Authority. Every month five industrial fishing trawlers are inspected to monitor IUU catches in the Bay of Bengal. The "National Plan of Action" (NPOA)- IUU Fishing has been developed with the assistance of Food and Agriculture Organization (FAO) of

the United Nations through a regional Technical Cooperation Project (TCP) on "Support to countries to address Illegal, Unreported and Unregulated (IUU) fishing" with joint collaboration of Bangladesh, Cambodia, Myanmar, Thailand and Vietnam. The project completed its tenure in December 2019. The draft "National Plan of Action" (NPOA)- IUU Fishing has been approved by the Ministry of Fisheries and Livestock. Bangladesh has signed the FAO Agreement on Port State Measures (PSMA) 2009 in 2019 to prevent, deter and eliminate Illegal, Unreported and Unregulated (IUU) fishing.

4.5.4 Marine Reserve/Protected Area (MR/MPA)

As a protective management measure, in the year 2000 the Government has declared 698 sq. km Marine Reserves (MR) area in the Bay of Bengal to protect and conserve marine fisheries resources. Marine Reserves area is protected from fishing. In 2019, the Government has declared 3,188 sq. km area at Nijhum Dewip and its adjacent area of Hatia, Noakhali coastal zone as "Nijhum Dewip Marine reserves" to formulate a management plan of reserves which is under processing.

4.5.5 Licensing activities of mechanized fishing boats and Industrial Fishing Vessel/Trawler

Marine Fisheries Office (MFO) under DoF provides license for mechanized fishing vessels but the licensing required prior Certificate of Inspection (COI) from MFO and vessel registration from the Mercantile Marine Office (MMO). At present combined camps are being operated by MFO and MMO at different fishing sites to provide the same through one stop service. During 2019-20, a total number of 257 industrial trawlers were engaged in fishing into the EEZ. The fleet comprised of 37 shrimp trawlers, 59 demersal trawlers and 122 mid-water trawlers. 39 trawlers are permitted to fish on trial trip basis. Fishing license for industrial fishing vessels also require prior registration and COI from MMO. They also require fishing license from MFO or from coastal DFO's offices. All fishing licenses are subject to be renewed every year.

4.5.6 Deep Sea Fishing

The Government has taken Initiatives to exploit tuna and tuna like fishes and other large pelagic fishes from the deep sea area beyond National Jurisdiction (ABJN). The Ministry of Fisheries and Livestock has issued permission against 10 long liner and 07 purse seiner vessels. The awarded companies are in the effort to collect appropriate vessel and equipment. Ministry of Fisheries and Livestock have been permitted to import/bring 01 long liner type and 01 purse seiner type fishing boat by joint venture to exploit tuna and tuna like fishes and other large pelagic fishes from the deep sea area of international waters. Bangladesh has

achieved her full membership that is the Contracting Party Status of Indian Ocean Tuna Commission (IOTC) on 24.04.2018 that would help us to build up tuna industry in near future. A pilot Project is implementing on "Tuna and Tuna like Fishing and other Pelagic Fishing at the Deep Sea" with various interventions.

4.6 Hilsa Fishery Conservation, exploitation and management

Hilsa is the most popular food for its taste and flavor to the southern people of Asia. It is indissolubly linked with our tradition and culture. Hilsa is also our national fish. Not only that, Hilsa has a great economic contribution to our national economy. In 2020-21 the production of Hilsa is 5.65 lakh mt which contributes 12.23% of total fish production which is the highest as a single species and more than 1% of total GDP. About 6 lakh people are directly involved with Hilsa catch and about 25 lakh people are indirectly involved with the trade of Hilsa. Hilsa production is increased about 78.24% in previous 11 years, that means the average growth rate of Hilsa production is 7.11% per year and in previous 17 years Hilsa production has been increased about more than 2.5 times.

Government took different initiatives to increase and sustain the Hilsa production. The major activities are

- Formulating and implementing "Hilsa Fisheries Management Action Plan";
- Identifying 7000 sq. km. major Hilsa breeding area in Bay of Bengal;
- Establishing 6 Hilsa sanctuaries;
- Declaring 3188 sq. km. Marine Reserve area adjacent to Nijhum deep;
- Imposing 22 days ban on Hilsa fishing at the peak spawning period of Hilsa;
- Imposing 8 months (November-June) ban on Jatka fishing;
- Imposing 65 days ban on all kind of fishing in Bay of Bengal;
- Developing the livelihood of Hilsa fishermen by giving VGF (vulnerable group feeding) and AIG (alternative income generation).

4.6.1 Brood Hilsa Conservation Activities

In 2002, Department of Fisheries prepared the Hisha Fisheries Management action plan and Ministry of Fisheries and Livestock approved that, after giving approval according to the rule 13 (b) of the Protection and Conservation of Fish Rules, 1985, brood Hilsa conservation activities had been started from 2006 in

7000 sq. km. of Bay of Bengal for 10 days. In 2011, government amended the rule 13 of the Protection and Conservation of Fish Rules, 1985 by a gazette notification. After that from 2011 to 2014 brood Hilsa conservation activities substantiated for 11 days. In 2015 government further amended the rule with the consultation of the Hilsa researchers and other stakeholders, in that amendment the ban period on Hilsa fishing was increased from 11 days to 15 days. Then finally the Hilsa ban period was ordained 22 days during the peak spawning season of Hilsa by a gazette notification in 2017. By the direct guidance of Ministry of Fisheries and Livestock Department of Fisheries substantiate the brood Hilsa conservation operation and the civil administration, Bangladesh Navy, Bangladesh Air force, Bangladesh Police, River Police, RAB (Rapid Action Battalion), Coastguard, BGB (Border Guard Bangladesh) etc cooperate to implement the operation during 22days ban period on Hilsa fishing.

4.6.2 Hindrance of Jatka fishing

According to the Protection and Conservation of Fish Rule, 1985, 10 inches or less than 10 inches size Hilsa fish is called Jatka. In the 1985 rule, the size of Jatka was 9 inch and ban on Jatka fishing was during November to April. In 2014, to amend the existing rule, Jatka size was ordained 10 inches and the ban period on Jatka fishing had been increased from November to June. During the ban period on Jatka fishing DoF conducts operation in cooperation with the law enforcing agencies such as Bangladesh Police, River Police, Navy, coastguard etc.

4.7 Quality Control of fish and fish product

4.7.1 Quality Control Laboratory

Department of Fisheries (DoF) has ISO 17025 accredited three Quality Control (QC) laboratories (previously known as Fish Inspection and Quality Control (FIQC) laboratories) at Dhaka, Chattogram and Khulna for testing fish and fish products, ice, swabs, fish feed and feed ingredients. QC laboratory (formerly known as FIQC laboratory), Dhaka by reshaping construction design, on the 11th floor of Matsya Bhaban building in 1994 which has been shifted to new premises in 2014 at Savar, Dhaka. Two more modern laboratories have been established at Chattogram and Khulna under DoF with the financial assistance of UNIDO-SFIQC project during 2008-09. Since the creation of lab facilities, testing of microbial quality of exportable fish and fishery products has routinely been performed by the officials of three FIQC laboratories (presently Quality Control Laboratories). Moreover these laboratories started testing residues of harmful chemical residue analysis of fish and fishery products since 2007. From August, 2015, laboratory services were separated from Fish Inspection and Quality Control Services and since then `Fish Inspection and Quality Control Laboratory` have been designated as 'Quality Control (QC) Laboratory'.

To address requirements of EU and other importing countries, DoF has installed six LC-MS-MS machines at QC laboratory, Dhaka, Chattogram and Khulna for testing the contaminants and residues of prohibited antibiotics, dyes and anthelmintics in fishery product. Confirmatory test of the residues of chloramphenicol, nitrofuran metabolites (AMOZ, AOZ, AHD and SEM), metronidazole, malachite green, leuco- malachite green, crystal violet, leuco-crystal violet, anthelmintics (flubendazole, fenbendazole and mebendazole), Aflatoxin (B1, B2, G1 and G2) etc. in fishery product are being tested through LC-MS-MS machines at QC laboratory, Dhaka. Moreover, activities related to method validation of Amoxicillin and Tylosin is going on. Fish and fish products are tested for heavy metals by ICP-MS at the laboratory of Dhaka and Chattogram. Method development of testing different chemical residues through one LC-MS-MS machine at QC laboratory, Chattogram is under way. Furthermore, two ELISA systems have been added to each of QC laboratory, Chattogram and Khulna for screening tests of the residues of chloramphenicol, nitrofuran metabolites, oxy-tetracycline, tetracycline, chlor-tetracycline, metronidazole, malachite green, leuco-malachite green, crystal violet, leuco-crystal violet, histamine, methyl testosterone, diethyl stilbesterol etc. of fishery products. Method of testing of chloramphenicol, malachite green, leuco-malachite green, crystal violet and leuco-crystal violet has already been developed and validated through LC-MS-MS machine at QC laboratory, Khulna. Method validation of testing nitrofuran metabolites through LC-MS-MS machines is underway at this laboratory. Testing method of pesticide residues such as DDT, Aldrin, Heptachlor, Endrin and Dieldrin by GC-MS (TOF) machine has been developed at QC Laboratory, Dhaka in 2017. Method has been developed and validated for confirmatory test of tetracylines in shrimp matrix through UPLC at QC lab, Chattogram in 2018 and development and validation of same test in fish matrix has been completed in 2019 at the same laboratory.

Method has been developed and validated for screening test of Amoxicillin, Gentamycin, Sulfonamides and Tylosin through ELISA at QC lab, Chattogram and Khulna in 2018. Now, Method has been developed and validated for screening test of Gentamycin, Sulfonamides and Estradiol hormone through ELISA at QC lab, Dhaka in 2020.

Most of the test scopes of three QC laboratories are accredited according to ISO 17025: 2017 by Bangladesh Accreditation Board (BAB) except those very recently developed and validated. In 2018, BAB has carried out audit to the QC laboratories and accreditation of these three laboratories has been renewed upto 2021. Method of testing shrimp diseases specially those concerned with SPF shrimp has been developed and validated at QC lab at Chattogram and Khulna. These labs are already capable of detecting White Spot Syndrome Virus (WSSV), Yellow Head Virus (YHV), Acute Hepatopancreatic Necrosis Disease (AHPND),

Infectious Hypodermal and Hematopoetic Necrosis Virus (IHHNV), Taura Syndrome Virus (TSV), Infectious Myonecrosis Virus (IMNV), Macrobrachuium rosenbergii Nodavirus (MrNV) by using PCR technique. Furthermore, testing protocol for porcine and bovine test through PCR machine has been validated at the Quality Control laboratory of Chattogram.

Following parameters are tested by the QC laboratories-

Name of Lab	Test parameters	
	Fish and Fish Products	**Fish Feed and Feed Ingredients**
Quality Control Laboratory, Savar, Dhaka	**Microbiological Parameters:** Aerobic Plate Count, Total *Coliforms*, Presumptive *E.coli*, *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Salmonella* spp. **Chemical Parameters:** Antibiotics-Nitrofuran metabolites (AMOZ, AOZ, AHD and SEM), Chloramphenicol, Metronidazole; Dyes (Crystal violet, Leucocrystal violet, malachite green, Leuco- malachite green); Anthelmintics (Flubendazole, Febendazole, Mebendazole); Aflatoxin (B1, B2, G1 and G2), Pesticides (DDT, Aldrin, Heptachlor, Endrin, Dieldrin); Formalin; Moisture; pH; Gentamycin, Sulfonamides; Estradiol hormone; Oxalinic Acid	Antibiotics (Chloramphenicol); Proximate test of fish feed and feed ingredients (Crude Protein, Non-protein nitrogen, Fat, Fibre, Ash, Moisture; NIR Screening of fish feed
Quality Control Laboratory, 209 NM Khan Hill Road, Muradpur, Chattogram	**Microbiological Parameters:** Aerobic Plate Count, Total *Coliforms*, *E.coli*, *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Salmonella* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, *Shigella* spp., WSSV, YHV, AHPND, IHHNV, TSV, IMNV, MrNV **Chemical Parameters:** Antibiotics-Nitrofuran metabolites (AMOZ, AOZ, AHD and SEM), Chloramphenicol, Tetracycline, Oxy-tetracycline, Chlortetracycline, Metronidazole, Gentamycin, Tylosin, Sulfonamides, Amoxicillin; Dyes (Crystal violet, Leuco-crystal violet, malachite green, Leuco-malachite green); Heavy metals (As, Hg, Pb, Cd, Cr); Methyltestosterone (MTS); Di-ethyl stilbesterol (DES); Histamine; Total Volatile Basic Nitrogen (TVBN)/Tri-methyl Amine (TMA); Di-sodium di-phosphate/Total Phosphate; Filth; Formalin; Moisture; pH	Antibiotics-Nitrofuran metabolities (AMOZ, AOZ, AHD and SEM), Chloramphenicol, Tetracycline, Oxy-tetracycline, Chlortetracycline; Heavy Metals (Cr, Cd and Pb)

Name of Lab	Test parameters	
	Fish and Fish Products	Fish Feed and Feed Ingredients
Quality Control Laboratory, Boyra, Khulna	**Microbiological Parameters:** Aerobic Plate Count, Total *Coliforms*, Presumptive *E. coli*, *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Salmonella* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, *Shigella* spp., WSSV, YHV, TSV, IMNV, MrNV, AHPND, IHHNV, NHP-B **Chemical Parameters:** Antibiotics-Nitrofuran metabolites (AMOZ, AOZ, AHD and SEM), Chloramphenicol, Tetracyclines, Oxy-tetracycline, Chlortetracycline, Metronidazole, Tylosin, Gentamycin, Sulfonamides, Amoxilin; Dyes (Crystal violet, Leucocrystal violet, malachite green, Leuco- malachite green); Heavy metals (As, Hg, Pb, Cd, Cr); Histamine; Total Volatile Basic Nitrogen (TVBN)/Tri-methyl Amine (TMA); Di-sodium di-phosphate/Total Phosphate; Filth; Formalin; Moisture; pH	Heavy Metals (Cd, Cr, Pb, Hg)

It is worthy to mention that testing method of Chloramphenicol and Nitrofuran metabolites (AHD, AOZ, AMOZ and SEM) for poultry meat matrix has been validated at QC laboratory, Dhaka in 2017. With a view to ensuring external quality control, each QC Laboratory participated in international proficiency tests (PT) offered by world renowned PT provider organization on regular basis.

Analytical capacity of three QC laboratories was recognized through the overall comments in EU-FVO Audit Report-2015-"Significant improvements have also been noted in the performance of the laboratory network, accreditation of laboratories and validation of analytical methods and the competent authority can in general, have confidence in the reliability of analytical results".

4.7.2 Fish Inspection and Quality Control Services

Mandate of FIQC is to ensure quality and safe fish and fishery product to global consumers. In order to maintain safety and quality of fish and fish products, following activities are carried out by three Regional FIQC offices located in Dhaka, Chattogram and Khulna.

- Issuance of Licenses of fish processing establishments
- Annual evaluation of establishments (instrumental and operational conditions) and renew of licenses

- Regular monitoring of establishments' activities regarding HACCP, EU, USDA, Australia, GCC regulations etc. as per Fish and Fish Products (Inspection and Quality Control) Rules, 1997 (amended in 2008, 2014 and 2017) and Official Control Protocol.
- Monitor water, ice and swab quality of processing establishments and ice factories
- Plan and implementation of NRCP (National Residue Control Plan), FRCP (Factory Residue Control Plan) and MMP (Microbiological Monitoring Plan)
- Product inspection and issuance of certificates for exportable fish and fish products
- Surveillance and conducting mobile court to ensure safety of fish and fish products
- Implementation of activities under APA
- Conduct awareness meeting
- Training of stakeholders
- Inspect imported consignments of fish and fish products on request of Customs Department

4.7.3 Adoption Traceability

Traceability is the ability to track any food stuff through all stages of production, processing and distribution (including importation and at retail). When a potential food safety problem is identified, an effective traceability system can help isolate and prevent contaminated products from reaching consumers or recall if distributed into commerce and ensure corrective actions as well. Traceability should mean that movements can be traced one step backwards and one step forward at any point in the supply chain. To ensure traceability, about 207,000 shrimp and 9,651 fin fish farms of Bangladesh have been registered. Other establishments involved in supply chain of fish and fish products in the country are also registered or licensed to ensure traceability.

4.7.4 On-line Certification System, TRACES (Trade Control and Export System)

TRACES (Trade Control and Export System) is the European Commission's multilingual online tool for certification on sanitary requirements for intra-EU trade and importation of animals, semen and embryo, food, feed and plants. The network not only promotes a better cooperation between the competent authorities but also between the traders themselves and their competent authorities. TRACES allows the quick detection of fake certificates and therefore contributes to the enhancement of trust vis-à-vis its partners. In 2017, Bangladesh has introduced online certification through TRACES for consignments of fish

and fish products intended to export to the EU countries. On 14 December, 2019, DG-SANTE has introduced improvised format of TRACES which is called TRACES-NT, i.e., TRACES New Technology. Deputy Director of three FIQC offices have been already trained at Bangalore, India on TRACES-NT certification and Bangladesh has already started using TRACES-NT for ET certification in exporting fish and fish products to EU.

4.7.4 Aquaculture Residues monitoring through NRCP

Residue Monitoring Program of DoF enforced as National Residue Control Plan (NRCP), is a program to monitor status of residues and contaminant in farmed fish and shrimp to reveal the illegal use of banned or unauthorized substances as well as to determine the origin of residue contamination. For implementation of NRCP, 'NRCP Policy Guidelines 2011 (amended in 2012)' was formulated in line with the Fish and Fish Product (Inspection and Quality Control) Act-2020 and Fish and Fish Product (Inspection and Quality Control) Rules-1997 (amended in 2008, 2014 and 2017). The National Residue Control Plan is based on measures to monitor certain substances and residues thereof in live animals and animal products and fixing the levels and frequencies of sampling provided the control of certain substances and residues thereof in certain animal products.

NRCP: Test Parameters

Group name	Parameters tested
A1	Stilbenes (Diethylstilbestrol)
A3	Steroids (Methyl Testosterone)
A6	Banned Antibiotics: Chloramphenicol (CAP), Nitrofuran metabolites (AOZ, AMOZ, AHD, SEM), Metronidazole (MNZ)
B1	Antibacterial substances: Tetracycline, Oxytetracycline and Chlortetracycline (TC, OTC, CTC); Amoxicillin; Gentamycin; Sulfonamides; Tylosin
B2(a)	Anthelmintics: Mebendazole, Fenbendazole
B3(a)	Organochloride pesticides (DDT, Heptachlor, Endrin, Aldrin, Di-eldrin)
B3(c)	Chemical elements (Lead, Mercury, Cadmium, Chromium, Arsenic)
B3(d)	Mycotoxins (Aflatoxin B1, B2, G1, G2)
B3(e)	Dyes (Crystal Violet, Leuco Crystal Violet, Malachite Green, Leuco Malachite Green (CV, LCV, MG, LMG))

4.7.5 Activities towards production of value added fish and fish products

The exporters are investigating more to produce value added products instead of traditional block products to meet the demands of the global market. Now a days, exporters are focusing more on production and export of value-added

products of shrimp and fish. As for example, in order to cope with the requirements of competitive global seafood market two fin fish processing factories- Virgo Fish and Agro Process Ltd. and Seven Oceans Fish Processing Ltd., Trishal, Mymensingh have started production and export of fish fillet of pangas. Installation of the facilities for preparing fish ball, fish nugget etc. is underway at Seven Oceans Fish Processing Ltd. Setting of facilities for extracting fish oil and preparation of fish meal at Virgo Fish and Agro Process Ltd. is underway. Construction of two other fin fish processing factory named Earth Agro Farms Ltd. at Gazipur and Globe Fisheries Ltd. at Noakhali are underway. A company named Bangladesh-American Agro-process Ltd. located at Cumilla has already started production of fish fillets from pangas and tilapia and other ready to cook value added products such as fish finger, fish balls, fish nugget etc. of fish for local consumers. Construction of another fish processing plant named Alpha Accessories and Agro Export Ltd., Fakirhat, Bagerhat for production of 100% export oriented high value-added products is underway.

Besides ensuring production, distribution and export of quality and safe fish and fish products, Department of Fisheries has organized hands on training on value added product development with fin fish specially tilapia and pangas and other seafood items at Virgo Fish and Agro Process Ltd., Trishal, Mymensingh with the support of intergovernmental organization, INFOFISH during 02-06 May, 2017. Participants from other fish industries such as Seven Oceans Fish Processing Ltd. and Earth Agro Farms Ltd. also participated in the training. Initiatives have been taken to develop and commercial production of value-added products such as noodles, soup etc. of Hilsa with ECOFISH-BD Project support.

4.7.6 Rapid Alert System for Food and Feed (RASFF)

Shrimp of aquaculture origin of Bangladesh being contaminated by the NF metabolite evolved through repeated Rapid Alert System for food in the year 2009. Meanwhile substantial actions/ programs have been implemented for the total development of infra-structure, management and documentation. Motivational programs and training have been undertaken to increase the awareness about product quality and safety and to comply with HACCP and international obligations. Beside this, traceability system in aquaculture and processed products are being implemented and taskforce activities related to develop HACCP system in every stage from hatchery to processing of shrimp are also implemented according to EU requirements. Due to the repeated Rapid Alert System for Food and Feed (RASFF) from EU, National Working Committee was formed and that committee is working to mitigate the problem. With the continuous effort and progress achieved in residue analysis, the number of rapid

alert has been reduced to zero in 2013 from the highest number of 52 in the year 2009.

5. Potential Areas of Cooperation between Bangladesh and SAC

There are some potential areas that may be solved through coordinated network and these are as follow:

- Development of genetic resources of potential fish species - Fish Gene Bank regionally/sub-regionally;
- Initiating regional collaboration among neighboring countries for exploring the potentials of TUNA fisheries and development;
- Development of farming technology of both freshwater and brackish-water finfish, shrimp and other aquatic organisms and developed technologies transfer to member states;
- Collaborative efforts to develop value added fish and fishery products and production diversification;
- Development of business-friendly value chain, especially in commercial fish farming and strengthening cool chain development;
- Collaborative research and fish farm demonstration program among member countries; and
- Quality seed and brood fish supply among the member countries specially engineered for facilitating climate resilient adaptation interventions.

6. Conclusion and Recommendations

DOF Bangladesh acknowledges the contribution of all relevant stakeholders including academia, researchers, development partners, media for Bangladesh becoming a self-sufficient country in fish production. Fisheries of Bangladesh consistently contributing to the socio-economic development of the country, which eventually ensures nutrition and food security. To sustain this growth performance more collaborative efforts, institutional capacity and investments are needed.

Recommendations

1. Maintaining quality brood stocks, fish seed and feed, intensification and farm mechanization, vertical expansion of waterbody for aquaculture, innovating new feed sources (most feed raw materials imported), eenhancing cluster farming and promotion of GAP, HACCH and NRCP, promoting floodplain aquaculture, setting up pen and cage culture, adopting the smart aquaculture and supporting to Value Added Products- Ready To Cook and Ready To Eat may make sustainable inland aquaculture.

2. Production and fisher's friendly public waterbody management system, restoration of degraded habitats, establishment and maintenance of wetland sanctuaries, strengthening conservation measures and CBOs, dredging of the river channels, reducing discharge of pollutants and industrial effluents, fish pass or fish-friendly structures in open water; development of Fishers' community welfare centers, involvement of Women in Fisheries as Agents of Change in FLW in Fish Value Chains, ppromoting fish waste management/offal management and sstrengthening the cold chain development are to be ensured for open water fishery management.
3. Resource Mapping for sustainable exploitation and use, promoting zone-specific shrimp farming, up-scaling socio-eco-friendly shrimp farming through cluster approach, promoting Specific Pathogen Free (SPF) PL, introduction of e-traceability, farm mechanization, power supply, road communication; maintaining food safety compliances along the value chain and develop cool chain, developing Climate Information Services (CIS) for Aquaculture, promoting Smart Aquaculture Biosecurity (SAB), introduction to Ecosystem Aquaculture Approach (EAA), sustainable technology development for increase production and exploring the BLUE ECONOMY are prerequisite interventions for coastal and marine fisheries management.
4. Initiating regional collaboration among three neighboring countries - potentials of TUNA fisheries and deep sea fishing, implementation of an ecosystem approach to fisheries management, integrated data management or collection activities for Marine Fisheries and hilsa, institutional capacity building, rapid assessment of fisheries stocks by species, iimprove catch and effort statistics and the stock assessment, restrict and control pouching of resources, ccollaborative efforts for strengthening MCS, promote mariculture, including seaweed culture can bring a positive change in Marine Fisheries Management and to explore Blue Economy.
5. Member countries may strengthen surveillance of aquatic animal health including transboundary fish disease control as aquaculture will be very vulnerable with the intensification and species trading to combat aquatic diseases.

Acknowledgements

Appreciation with proper acknowledgement to the Director General for nomination of us to attend this workshop. Gratitude to Dr. Md. Baktear Hossain, Director, SAC and Dr. Grinson George Padinjakara, Senior Program specialist, SAC for advising us to prepare this country paper.

References

DoF (2022), Yearbook of Fisheries Statistics of Bangladesh 2020-21, Department of Fisheries Bangladesh, Ramna, Dhaka, 05 p

DoF (2020), Annual Report 2020, Department of Fisheries Bangladesh, Ramna, Dhaka, 01 p

FAO (2020). The State of World Fisheries and Aquaculture 2020: Sustainability in Action, Food and Agriculture Organization of the United Nations, Rome. 20, 33 pp,

Chapter- 4

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in Bhutan

Karma Wangchuk[1] and **Pema Thinley**[2]

[1] National Research and Development Centre for Riverine & Lake Fisheries, Department of Livestock, Ministry of Agriculture and Forests, Haa, Bhutan

[2]National Research and Development Centre for Aquaculture, Department of Livestock, Ministry of Agriculture and Forests, Gelephu, Bhutan

Abstract

Bhutan is landlocked mountainous country has areas suitable for cold-water and sub-tropical fish farming. Wild capture fisheries takes place in the lakes and rivers, generally with rudimentary techniques due to less attention to the sector, poor infrastructure and lack of expertise. For improving wild capture fisheries the government has introduced community-based management approach for sustainable utilization of fisheries resources from designated water bodies since 2010.

In this chapter, we are looking into the various organized and informal networks to address cross-learning as a multi-disciplinary approach to address the imminent challenges and explore potential opportunities to augment fish production to support various other efforts to ensure food and nutritional security in Bhutan.

Keywords: Food Security, Fish, Bhutan, Multi-disciplinary, Production

1. Introduction

Bhutan is a small kingdom in the eastern Himalayas, extending over an area of 38,394 km^2. The country is bordered by India and China. Despite being landlocked, with difficult terrain and a widely dispersed population, Bhutan has made appreciable socioeconomic progress in terms of aquaculture and fisheries. Warm-water carps form the backbone of the aquaculture which was introduced in the early 1980s. Bhutanese currently culture six species of carps: Common carp, Grass carp, Silver carp, Catla, Rohu and Mrigal. Bhutan is also making efforts to develop Rainbow trout farming. In terms of wild fisheries, Bhutan adopts a community-based management approach for sustainable utilization of fisheries resources from designated water bodies.

Institutionally, aquaculture and wild fisheries activities in Bhutan are implemented by two separate research centers under the Department of

Livestock (DoL), Ministry of Agriculture & Forests (MoAF). The National Research and Development Centre for Aquaculture (NRDCA) is mandated to undertake research and developmental activities on aquaculture, whereas the National Research and Development Centre for Riverine and Lake Fisheries (NRDCRLF) oversees development of wild fisheries including research and management aspects of all fisheries resources in the country. Forestry resources including fish in the rivers are regulated by the Department of Forests and Parks Services (DoFPS).

The fish production infrastructure is primarily made up of small backyard earthen ponds. Carps are farmed in these ponds in a 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. Fish farming activities are concentrated in the south where a majority of the country's available flatlands and a suitable climate (warm) exist, two of many conditions necessary for growing carp. As a result, very few warm water farms are located in the higher altitude hilly regions. Rainbow trout farming in that regard, is established to provide farming opportunities in the north. Currently, there are 509 active fish farmers (506: carp and 3: trout) with 687 fish ponds (667: carp and 18: trout), see table 1 and 2.

Table 1: Total number of active fish (Carp) farmers in Bhutan

Sl. No	Dzongkhag/District	No of Fish Ponds (Nos)	Total Farmers (Nos)
1	Chukha	41	25
2	Dagana	61	54
3	Mongar	14	13
4	Punakha	5	3
5	Pema Gatshel	19	4
6	Samdrup Jongkhar	125	89
7	Samtse	100	84
8	Sarpang	120	70
9	Trashigang	2	1
10	Tsirang	154	140
11	Wangdue Phodrang	16	17
12	Zhemgang	10	6
	Total	**667**	**506**

Table 2: Total number of active fish farmers (Rainbow trout) in Bhutan

Sl. No	Dzongkhag/District	No of Fish Ponds (Nos)	Total Farmers (Nos)
1	Haa	11	2
2	Paro	7	1
	Total	**18**	**3**

Even though fishing for consumption and commercial purpose is illegal in Bhutan, communities have customary rights over the use of fishery resources from designated water bodies, provided it is done within the provisions of a sound management plan. Thus, Community-based Capture Fisheries Management Programs (CCFMP) are legalized in Bhutan for sustainable utilization of fisheries resources from the wild. The first CCFMP was established in 2010 by the DoL in collaboration with DoFPS at Harachhu river in Wangdue. Five more CCFMPs have been developed ever since with 219 active fisher members (see table 3). Much as in aquaculture, fish produced from CCFMPs are consumed locally, with rarely any surplus making outside the community for sale.

Table 3: Total number of CCFMPs in Bhutan

Sl. No	Dzongkhag/District	CCFMP Name	River	Total Members (Nos)
1	Wangdue Phodrang	Harachhu CCFMP	Harachhu	66
2	Zhemgang	Berti CCFMP	Mangdechhu	21
3	Lhuntse	Gangzur CCFMP	Kurichhu	42
4	Chukha	Drukdingsa CCFMP	Pachhu	25
5	Tsirang	Sergithang CCFMP	Lharichhu	42
6	Dagana	Peling CCFMP	Dagachhu	23
	Total			**219**

Bhutan's annual output of fish is 181.65 mt in 2020 (RNRSD, 2020). In sharp contrast, the demand for fish in the country is massive, as indicated by an annual consumption of over 1000 mt. This incongruence in demand-supply is due to low productivity per unit area resulting from limited use of external inputs, land terrain and lack of assured irrigation. Since the domestic production of fish is meager, the huge demand for it has to be met through import causing huge outflow of foreign currencies.

2. Existing thematic networks in the country for addressing regional and sub-regional challenges in aquaculture and fisheries

Despite the apparent scope for growth in Bhutan, aquaculture and fisheries sector continue to face challenges. In this regard, a number of key issues that

span multiple sectors and which are of primary policy, socio-economic and conservation importance have been identified and discussed under two broad headings: (I) Aquaculture; and (II) Wild Fisheries.

2.1 Aquaculture

2.1.1 Cultural issues

Bhutan is a Buddhist country and in Buddhism, any activity associated with causing harm to another living being is considered a sinful act. Aquaculture, as a result faces social backlash making it an ethnically impossible avenue to venture into. Furthermore, those already in fish farming are now abandoning the practice in pursuit of other alternative such as dairy, poultry and agriculture. This significantly impedes the growth of aquaculture and its ability to contribute to food security in Bhutan. Strategic community counselling and sensitization involving key personnel from different levels of the cultural and religious institutions could help mitigate these impacts.

2.1.2 Limited suitable landholding

In the mountainous landscape of Bhutan, limited flatlands preclude the development of commercial-scale fish production. Small landholdings and stringent wetland conservation laws on the other hand thwart plans for establishing commercial farms on private lands. Although, as a way to work around these limitations, there are provisions to use of Government Reserve Forest (GRF) land through a leasing scheme for commercial fish production. Another strategy that seems to be working is through the Land User Certification (LUC) involving youth to take up fish farming.

2.1.3 Climate change adverse impacts

Aquaculture is becoming more vulnerable to pest and diseases, posing threats of epidemics that can cause large-scale destructions. Climate change and escalating energy prices have started impacting aquaculture. Increase in temperature, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability are the main dimensions of climate change that affect aquaculture. Existing countermeasures are humanity's decreased use of fossil fuels for example through use of electric car, natural resources management to ensure minimum of 60% (The Constitution of Bhutan, 2008) of the total land maintained under forest cover in the country, and increasingly intensive biogas use to curb the greenhouse effect and limit the amount of harmful gases spread in the atmosphere.

2.1.4 Under-developed aquaculture support service delivery competence

Aquaculture and fisheries sector is currently managed by just seven fishery professional university graduates supported by an array of technical staff from Animal Science background. Newly recruited non-fishery staff are diploma graduates from the College of Natural Resources (CNR), with no formal training on aquaculture and fisheries. This often breed poor service delivery from the technical standpoint. Thus, to improve quality of technical staff, a training module on aquaculture and wild fisheries must be included as part of the CNR curriculum. Further, there is also a need to provide competency-based training for aquaculture and fisheries, capacity building through exposure visits, study tours, cross-learning programmes.

2.1.5 Existing stringent environment policy that prevent species diversity

Fish species diversity contributes directly to the food security, nutrition, and well-being by providing range of aquatic animals from either culture or capture based aquaculture or fisheries. However, there are only six cultivable exotic carp species along with a trout species in the country imported for aquaculture. Thus, there is limited species diversity to ensure optimum fish production. When the sector embarks on to realizing aquatic animals' species diversity it is profoundly impeded due to various standing environment policies. The mandates of the Aquaculture and the National Environment Commission (NEC) of the country contradict on introduction of additional species concerning the environment impact assessment risks.

2.1.6 COVID-19 pandemic and aquaculture

The generic impact of the ongoing pandemic includes disruption of fish restocking schedules, transportation of feeds & inputs and paralyzed marketing activities. As a result, all primary food producing sector has to run in a self-containment mode to sustain the food production chain. The pandemic has affected most vulnerable group such as women, children, smallholders, and indigenous groups.

2.2 Wild Fisheries

2.2.1 Contribution of wild fisheries to food security

Bhutan's annual output of farmed fish is 181.65 mt in 2020 (RNRSD, 2020). In sharp contrast, the demand for fish in the country is massive, as indicated by an annual consumption of over 1000 mt. However, this figure is not inclusive of fish consumed from the wild. In Bhutan, fish production is associated mostly with aquaculture and fishing for consumption or commercial is not legal, with the exception of a few regulated CCFMPs. Illegal fishing still exists in parts of the country, most of which go unreported. As a result, production from illegal

fishing, which by large support livelihood and nutrition never get reflected thus making it difficult to gauge the true potential of wild fisheries and its contribution to food security in Bhutan.

2.2.2 Lack of policy guide

As mentioned previously, fishing for consumption or commercial purposes is not legal, even though historically communities have relied on fisheries resources for their livelihood. This disparity in policy and socio-economic dependence of rural communities on fish is the cause of many illegal fishing practices, often using destructive methods. To reduce the perceived impact of illegal fishing on aquatic ecosystem and to sustain socio-economic growth of rural communities, controlled harvest of fisheries resources from designated water bodies is allowed. As a result, six CCFMPs have been established in the country since 2010. However, a proper policy framework for developing CCFMP is yet to be developed. Therefore, a strategic guideline is needed that includes a complete analysis of stakeholders, an accurate understanding of the resources and program impacts, and a deeper appreciation of the broader cross-sectoral and institutional linkages.

2.2.3 Institutional coordination

In Bhutan, wild fisheries development is implemented by the NRDCRLF, under the DoL. Unlike, many other countries, where wild fisheries (and all aspects of fisheries management) fall under forestry development, in Bhutan it lies within the ambit of DoL. However, water and aquatic resources fall under the jurisdiction of the DoFPS. So, while the laws governing the water and aquatic resources are enforced by the DoFPS, the technical capacity to manage fisheries resources lie within the DoL. As a result, planning and implementing any fisheries related developmental activities require collaboration between the DoL and DoFPS.

2.2.4 Strengthening reporting and data collection

In order to strengthen existing CCFMPs, managers/resource personnel need to ensure that decisions concerning management and long-term sustainability of fisheries resources are sound and more rationally based. In this regard, data collection and scientific assessment needs to be improved. Fisheries in general and CCFMP in particular is a new concept in Bhutan. Understandably so, long-term fisheries data does not exit. Furthermore, existing data collection practices are not successful in capturing true harvest potential of the resources. This in the long run can impact the operation of CCFMP.

2.2.5 Monitoring, control, and surveillance (MCS)

Currently, stakeholders comprising of government officials (such as resource managers, researchers, and forestry personnel) are responsible for monitoring CCFMP activities including management and conservation components. However, a system of MCS to monitor compliance within the CCFMP members is still lacking. Therefore, existing MCS needs to be strengthened to ensure that agreed ecological and socio-economic objectives are met and implemented in a manner that is in line with the provisional conservation and management measures. This could be achieved through provisions of effective consultation and training of fishers on concepts of maximum sustainable yield (MSY), input and output controls and their impact on long-term stock sustainability.

2.2.6 Promotion of traditional and indigenous fishing practices

Traditional fishing practices in Bhutan include using fish traps (*Do* and *Dang*) and line traps (*current jal*). These are passive gears and typically less efficient compared to some of the modern gears such as cast nets and drag nets. With the onset of modernization, access to diverse fishing gears improve, resulting in a gradual shift from traditional to modern fishing gears. Using modern fishing gears improve fishing efficiency (via improved CPUE[1]), but if un-regulated, can potentially lead to unintended over-exploitation. Promoting traditional and indigenous fishing gears helps ensure long-term sustainability of the fish stock.

2.2.7 Product diversification and marketing

Marketing fish and fishery products is one of the main issues facing the wild fisheries in Bhutan and there are several reasons for that. First, most CCFMPs are less than a decade old, and operate on a relatively small production scale. The lack of designated fish landing sites and marketing outlets mean most products are consumed locally with very little (surplus) making it outside the community. This affects the ability of fishers to sell their products and generate revenue.

3. Governance instruments and private sector interventions supporting fishers in the country using cross-learning in fisheries and aquaculture

Several interventions have been made (while some recommended) to address the issues/challenges in aquaculture and wild fisheries.

[1] Catch Per Unit Effort

3.1 Aquaculture

3.1.1 SOE and LUC for aquaculture

The government-initiated Land User Certificate(LUC) in 2015 as a new system of land allotment to promote sustainable management and productive use of land by the unemployed youth. This scheme greatly helped the aquaculture sector particularly those who did not own any land.

3.1.2 Loans and financial support

One of the essential support schemes in agriculture and livestock is the capital required for kick-starting the venture. Farmers typically do not have the principal amount required and rely on government and financial institutions for support. In this regard, two institutions, namely Cottage and Small Industry (CSI) bank and National Credit Guarantee Scheme (NCGS) currently provide subsidized loan to dedicated fish farmers. Recent establishment of commercial aquaculture farms at Tashithang in Umling and Sergithang in Tsirang are the testimony of such beneficiaries.

3.1.3 Government subsidy

The government strongly supports fish production with financial incentives and other forms of support through accelerated fish production programs. There is subsidy scheme called as cost sharing mechanisms that facilitates the development of aquaculture through supporting aspiring fish farmers. The government provides supports in terms of cash and kind to construct fishponds, water source to fish pond irrigation structures, fish seeds and feed. In addition to this, farmers are also provided with essential fishing gears and transportation equipment. The proportion of cost sharing currently ranges from 30% to 70% based on the scale of fish farming.

3.2 Wild fisheries

3.2.1 Government subsidy

The government also provides regular training on product diversification and marketing. Historically, most fish in CCFMP were consumed/sold fresh with very little to no processing. This has changed recently with subsidy support from the government both in kinds (supply of cool boxes) and services (facilitated transport of fish in refrigerated vans), which has allowed CCFMPs to sell their products outside the community. Further, CCFMPs have also been provided with fabricated smoking chambers as a way of diversifying fish products and improving shelf life.

3.2.2 Improving data collection

The NRDCRLF, under DOL in collaboration with DoFPS and other relevant stakeholder agencies will set up plans to strengthen data collection and scientific reporting using a multifaceted approach that include: (i) consultation and training of fishers and data users; (ii) identify and set up appropriate data collection mechanisms including data management system; and (iii) a national commitment to provide/generate data, to ensure data collection and subsequent decision making for strengthening CCFMP is achieved.

3.2.3 Developing policy guide for CCFMP

A national level strategic guideline for development of CCFMP is being developed by DOL in consultation with DoFPS and other relevant stakeholders. The document once approved, will provide a step-by-step guide to developing CCFMP in Bhutan and include all aspects of planning, research, collaboration, and sustainable management of fisheries resources.

4. Case studies on cross-learning application that improved fisheries and aquaculture in the country

4.1 Cultural issues

With regard to the challenges related to social stigmatization and political issues, State Owned Enterprise (SOE) provided a solution that seemingly grounded these issues revolving the aquaculture. As mentioned earlier, individual fish farming in Bhutan faces direct social and peer taboo that alters the progress of the activity at some point during the venture. Thus, State Owned Enterprise (SOE), LUC systems and Farmers Group (FG) made the aquaculture sector thrive well amid the prevailing criticism and perception on aquaculture by the Buddhist.

4.2 Inclusion of fish in school agriculture programmes

The School Agriculture Programme (SAP) is a joint initiative between the MoAF and Ministry of Education (MoE) involving school engagement in agriculture activities to improve kid's nutritional requirements and also to inculcate farming as an alternative livelihood option. Fish is a vital source of high-quality protein and is rich in omega-3 fatty acids and vitamins such as D and B2. Fish is recognized as an important component in the diet for healthy growth and development of children. In this regard, fish rearing must be an integral part of the SAP s to ensure early access to fish in the child's diet.

4.3 Product diversification

Fish product diversification must now look beyond dried and smoked fish. In this regard communities need to explore additional methods to diversify and market fish products. Bhutan has recently seen a boom in the production of home-made meat-based pickles (*Shakam azey*). Pickles or simply *azey* is an integral part of the Bhutanese culinary culture and consumed every day by people from all walks of life. CCFMP with the support from the Department of Agricultural Marketing and Cooperatives (DAMC) can develop such diverse fish products.

5. Gaps due to lack of capacity building initiatives to achieve a proper cross learning in the country

The annual fish production is close to 200 MT in 2020 (RNRSD, 2020). However, the fish consumption in the country is about 1300 MT which is being met through import. It is evident that fish production in the country has increased ever since the establishments of aquaculture center, but not at a rate commensurate with the demand. There exist bottlenecks that prevents the development of the sector due to the factors such as gaps in the infrastructure, technical competency of the extension personnel both in the districts and regional level and technical know-how on the part of fish farmers. As highlighted above, only seven fisheries technical expertise currently supports aquaculture and fisheries developmental activities with few Animal Science graduates that often breed poor service delivery from the technical stand point. In this regard, there exists a manpower gap in quantity as well as quality.

Similarly, since most of the extension agents and fishery focal persons working in districts and regional level comes from different background, there is need to provide competency-based training for aquaculture and fisheries. Such training should also include fish farmers, and LUC youths that have not availed technical training so far. Capacity building through exposure visits, study tours, cross-learning programmes, short term training and long term training can uplift the development pace of aquaculture and fisheries in Bhutan. The wide gaps due to lack of capacity building initiatives to achieve a proper cross-learning in the country will be realized if above shortcomings are addressed collaboratively by the SAARC Agriculture Centre (SAC). The faith of aquaculture and fisheries in Bhutan lies with the wisdoms and guidance of the SAC.

6. Conclusions and recommendations

The development of holistic and inclusive national sustainable development strategies is essential for Bhutan to overcome the various challenges and issues

in aquaculture and fisheries. Government needs to recognize pertinent challenges to legitimize the complex and complicated issues through policy interventions. The concerned legislative body should direct deliberate possible efforts to address critical policy gaps highlighted above to enable achieving aquatic animals' food security. Aquaculture and fisheries face a series of capacity gaps ranging from technical to institutional, religion to policy that requires different mode of interventions to address the issue. These factors are challenging but of critical importance to address the technical glitches so as to fasten better stability and sustainability in the country. Bhutan will achieve its target of fish self sufficiency if weak policy and legal framework are resolved technically, religiously, and socially through close collaboration with SAC. This paper recommends the institution such as SAC and equivalent international body to extend both financial and expertise skills to uplift the underdeveloped Aquaculture and Fisheries in Bhutan.

References

FAO. (1999). Future Challenges in World Fisheries and Aquaculture. In Proc. *Committee on Fisheries*, 23rd Sesson. 15-19th February 1999. Food and Agriculture Organization, Rome, Italy.

Khanal, G. P. (2020). Country Status Report: Bhutan. p. 7-13. In Giri, S. S. ed., 2020. *Country Status Reports: Underutilized Fish and Marine Genetic Resources and Their Amelioration.* SAARC Agriculture Centre, South Asian Association for Regional Cooperation, Dhaka, Bangladesh.

MoAF. (2010). Harachhu Capture Fishery Management Plan. Ministry of Agriculture & Forests. Royal Government of Bhutan.

MoAF. (2014). Strategy Document for Development of Wild Fisheries in Bhutan. Department of Livestock, Ministry of Agriculture & Forests, Royal Government of Bhutan.

MoAF. (2019). Guidelines on Cost Sharing Mechanism for the RNR Sector. Ministry of Agriculture and Forests. Royal Government of Bhutan. Thimphu, Bhutan.

MoE. (2021). Food and Dietary Guidelines for School-aged Children in Bhutan. Ministry of Education. Royal Government of Bhutan.

NLC. (2018). Land Use Certification. *National Land Commission's quarterly newsletter*. 5(2), Royal Government of Bhutan. Thimphu, Bhutan.

RGoB. (2007). The Land Act of Bhutan 2007. Royal Government of Bhutan. Thimphu, Bhutan.

RGoB. (2008). The Constitution of the Kingdom of Bhutan, Article 5(3). Royal Government of Bhutan. Thimphu.

RNRSD. (2020). Annual Livestock Statistics 2020. Renewable Natural Resources Statistics Division. Directorate Services. Ministry of Agriculture and Forests, Royal Government of Bhutan. Thimphu: Bhutan.

Wangchuk, K. (2018). Aquaculture and Fisheries Development in Bhutan: Current Scenario, Policy Environment and Future Direction. p.125-132. In Giri, S.S, ed., 2018. *Policy framing for control of transboundary aquatic animals diseases*. SAARC Agriculture Centre, South Asian Association for Regional Cooperation, Dhaka, Bangladesh.

Chapter- 5

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in India

Prathibha Rohit, **Pratap Chandra Das** and **Shinoj Parappurathu**

Indian Council of Agricultural Research, Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare, Government of India

Abstract

Fisheries and aquaculture play a pivotal role in India's economy and contributes significantly to the food and nutrition security of the fish-eating population in the country. The sector has recorded an average annual growth rate of 8-10% over the past two decades. The continued vibrancy observed in the fisheries and aquaculture sectors in the country is largely due to the elaborate network of institutions and governance mechanisms that have been developed over years since independence (1947). Both formal and informal networks adorn the fisheries administrative, governance and management regime in India, with their formats diverse in terms of affiliation, ownerships, organizational framework, activity spheres, mode of operation, and so on. This country status paper summarizes the broad architecture of the above network and demonstrates how cross learning among the SAARC member countries could address the regional and sub-regional challenges therein.

Keywords: India, formal and informal networks, aquaculture and fisheries, institutions, governance

1. Introduction

Fisheries and aquaculture play a pivotal role in India's economy through their livelihood-supporting and income-enhancing prospects, netting together close to 28 million fishers, fish farmers and other intermediaries along the fish value chain (DoF, 2020). The sector contributes to the food and nutrition security of the fish-eating population in the country. India's blue economy which aims at the sustainable use of oceanic resources for the promotion of climate-smart and inclusive growth through a host of wide-ranging economic activities considers fisheries and aquaculture to be its key components. Presently, India holds the distinction of having the 4th largest capture (marine and inland) fishery and 2nd largest aquaculture, with an overall fish production that contributes to 7.6% of total global fish production (FAO, 2020). In 2019-20, India's total fish production stood at 14.2 million metric tonnes (MMT) which is the third largest in the world. In economic terms, this translates to 7.3% of the gross value added (GVA) of

agricultural and allied sectors and 1.2% of the total GVA in triennium ending (TE) 2018-19. Estimates show that the sector grew at an average annual rate of 8-10% over the past two decades, surpassing most other sub-sectors of agriculture. Foreign exchange earnings through exports of fish and fishery products is another major contribution of the sector to the country's economy, which was valued at about USD 6.73 billion in 2018-19. Seafood exports which has been the second largest exported product after rice, accounted for about 2.5% of total exports and close to 20% of agricultural exports from India (GoI, 2019). Of this, shrimp exports alone contributed to about two-thirds. (DAHD&F, 2018).

India's total fish production has shown a phenomenal increase from 0.75 MMT in 1950-51 to 14.2 MMT in 2019-20. After the inception of planned development (1950), the first few decades of growth in the sector were mainly focused around the capture fisheries and allied activities wherein, mechanization of fishing fleet, innovations in navigation and fish scouting techniques and intensification in fishing efforts through multi-day trips paid rich dividends. However, the last two decades witnessed a gradual plateauing of fish production from the capture sector at an average level of 3.2 MMT, but the slowdown more than offset by incremental growth coming from the culture sector. Aquaculture, has exhibited a staggering growth momentum, with production soaring from less than half a million tonne in 1980 to close to 10 MMT at present. While the country's 2.41 million hectare (M ha) of freshwater resources form the basis of freshwater aquaculture, the vast coastal brackishwater area and the inland saline area (1.16 M ha) have been put to use for the land-based aquaculture activity, mostly the shrimp farming that produces more than 0.8 MMT of cultured shrimp per year. The breakthrough in aquaculture came mainly in the form of advances in carp breeding and grow-out technologies in 1980s which were successfully adopted by the farmers and entrepreneurs resulting in substantial public and private investments. Success in large scale farming of brackish water shrimps also contributed considerably to the spectacle, despite constraints in the form of disease incidence and widespread crop loss in the late 1990s and early 2000s. Consequently, nearly three-fourths (73.7 %) of the total fish production presently comes from the inland production systems which are mature with sound technological and infrastructural establishments as well as management support (ICAR, 2011).

The vibrancy of growth associated with the sector rests to a great extent on the elaborate network of institutions and governance mechanisms developed over years in the country since independence (1947). Both formal and informal networks adorn the fisheries administrative, governance and management regime in India, with their formats diverse in terms of affiliation, ownerships, organizational framework, activity spheres, mode of operation, and so on. The

following section summarizes the broad architecture of the network along with the major players involved, stakeholders and their domains of activity.

2. Existing thematic networks for addressing regional and sub-regional challenges in aquaculture and fisheries

The development in the fish production sector has been the result of the holistic participation of the farmers, entrepreneurs and others associated with the production chain. Fisheries Departments of the Union Government and the States, research institutes, government and non-governmental organisations, co-operative societies and federations, financial institutions and private entrepreneurs, with their strong support from various centrally and state supported schemes have catalysed the process.

2.1 Public sector networks

2.1.1 Departments and Organizations under the Union Government

At the national level, the overall management and development of India's fisheries sector is spearheaded by the Department of Fisheries (DoF) under the Ministry of Fisheries, Animal Husbandry and Dairying (MoFAD), Government of India (GoI). Till 2019, the DoF (part of the erstwhile Department of Animal Husbandry and Fisheries, DAHD&F) was with the Ministry of Agriculture and Farmers' Welfare (MoA), when a new ministry was carved out to look after the special needs of the sub-sectors of fisheries, animal husbandry and dairying. A whopping Rs. 200.5 billion has been allocated to this Ministry in the Union Budget in 2020. The DoF is directly responsible for matters relating to formulation of policy and schemes relating to development of inland, marine and coastal fisheries. The range of activities and responsibilities that come under the purview of the Department include (i) promotion and development of fishing and fisheries and its associated activities, including infrastructure development, marketing, exports, and institutional arrangements (ii) development of fish feed and fish products industry (iii) welfare of fishermen and fisher-folk (iv) liaison and cooperation with international organizations (v) fisheries statistics, (vi) mitigation of the effects of natural calamities, (vii) regulation of fish stock import, quarantine and certification (vii) legislation and other related matters (viii) supervision of fisheries institutes and (ix) financial assistance through State agencies/Co-operatives. On these matters, the Department functions according to the cardinal principles of the constitution of India and subject to relevant national legislations and policies in effect from time to time. The important organization/Institutes presently working under the DoF towards this cause are the Fishery Survey of India (FSI), Mumbai, the Central Institute of Fisheries Nautical and Engineering Training (CIFNET), Kochi, National Institute of Fisheries Post Harvest Technology Training (NIFPHATT), Kochi and the Central

Institute of Coastal Engineering for Fishery (CICEF), Bangalore. The FSI has got a fleet of research and exploratory vessels under its wing that helps in undertaking fish stock assessment and other related exercises on a regular basis.

The National Fisheries Development Board (NFDB) was established in 2006 at Hyderabad with an aim to enhance fish production and productivity in the country. At present, it is working under the DoF/MoFAD supports the aquaculture sector through development projects. It has also set up a centralised Freshwater Fish Brood Bank (NFFBB) facility at Bhubaneswar and also supporting State Governments in establishing Brood Banks to ensure availability of quality seed to the farmers.

The Department of Agricultural Research and Education (DARE), MoA through its network of research institutes under the Indian Council of Agricultural Research (ICAR) has been spearheading research, capacity building and human resource development in agricultural and allied sectors in the country. There are eight fishery research institutes in the Fisheries Division of ICAR which include (i) ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi; (ii) ICAR-Central Institute of Fisheries Technology (CIFT), Kochi (iii) ICAR-Central Institute of Brackish water Aquaculture (CIBA), Chennai, (iv) ICAR-Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, (v) ICAR-Central Institute of Fisheries Education (CIFE), Mumbai, (vi) ICAR-Central Inland Fisheries Research Institute (CIFRI), Barrackpore, (vii) ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow and (viii) ICAR-Directorate of Coldwater Fisheries Research (DCFR), Bhimtal. These institutes work on key areas of fisheries and aquaculture and have contributed to the development of a strong foundation towards basic, strategic and applied research in the sector. Technologies generated through these networks have been providing strong support for the development of both capture fisheries and aquaculture sector, and contributed enormously towards increasing fish yield in the country. Over the years, technologies have been generated for induced breeding, seed production and grow-out culture of more than 40 freshwater species cultured in pond, cage and pen environment, including their husbandry, nutrition and pathological aspects. Similarly, seed production and grow-out technologies of more than 12 species including five species of shrimp have been developed to undertake brackish water pond and marine cage farming. The marine capture sector has also witnessed phenomenal development during the post independent era. Mechanisation of fishing fleets, improvement in crafts and gears through innovative designs, by-catch reduction devices, ecosystem-based fisheries management, policies and guidelines for responsible fisheries governance, technologies for bioprospecting of marine flora and fauna and efficient post-harvest value addition and storage are some of the key interventions of the fisheries research institutes of ICAR. Other research

organizations under the ICAR engaged in interdisciplinary research and extension activities such as the Central Island Agricultural Research Institute (ICAR CIARI), Port Blair; Central Coastal Agricultural Research Institute (ICAR CCARI), Goa; ICAR Research Complex for Eastern Hill Region (ICAR RCEHR), Barapani; ICAR Research Complex for Eastern Region (RCER), Patna and Indian Institute of Water Management (ICAR IIWM), Bhubaneswar have also been contributing to fisheries and aquaculture development in multiple ways. The Central Research Institute for Dryland Agriculture (ICAR CRIDA) is the national nodal point for the National Innovations in Climate Resilient Agriculture (NICRA) which is being implemented at large number of Research Institutes of ICAR, State Agricultural Universities and Krishi Vigyan Kendras (KVKs) since 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology.

Apart from DARE, the Department of Animal Husbandry and Dairying (DAHD) and the Department of Agriculture, Co-operation & Farmers Welfare (DAC&FW) under the same Ministry have also contributed significantly for the fisheries and aquaculture development through their cross-cutting activities and networks. The Ministry of Commerce is another key player with a significant role in development of the fish production and trade in the country. The Marine Products Export Development Authority (MPEDA) under the Ministry of Commerce is instrumental in promoting the export of fish and fishery products in fresh and value-added forms. The major focus areas of MPEDA include market promotion, capture fisheries, aquaculture, processing infrastructure & value addition, quality control, research and development. This statutory body has its own research wing, seagoing facilities and also funds for research programmes in aquaculture and postharvest technologies. The Rajiv Gandhi Centre for Aquaculture (RGCA) is the R&D arm of MPEDA registered as a society, and is dedicated to augment the Indian seafood exports through sustainable culture technologies, seed production and distribution. Network for Fish Quality Management and Sustainable Fishing (NETFISH), the extension arm of MPEDA stands for improving the quality of fishery products exported from the country and the sustainability of fishery resources as well. It also contributes by imparting knowledge to fisher folk, processing workers, technicians, other fishery stakeholders etc. on fish quality management, conservation of fish resources and sustainable fishing. National Centre for Sustainable Aquaculture (NaCSA) is another outreach organization established by MPEDA in the year 2007 for uplifting the livelihood of small-scale shrimp farmers and promotes them for adoption of better management practices to enhance their production potential and profit.

The Department of Biotechnology (DBT) under the Ministry of Science and Technology as well as the Ministry of Earth Science plays a crucial role by

nurturing and supporting a number of research and development projects and networks that helped in bringing about technological breakthroughs and innovations in the aquaculture and fisheries sectors.

The Coastal Aquaculture Authority (CAA), Chennai established through an Act of the Parliament in 2005 provides for regulating the activities connected with coastal aquaculture and related activities. The Authority takes measures for regulation of coastal aquaculture by prescribing guidelines, and ensures that coastal aquaculture does not cause any detriment to the coastal environment and that various coastal aquaculture activities leads to the sustenance of the livelihoods of various sections of people living in the coastal areas.

The National Institute of Oceanography (NIO) headquartered at Goa is another public funded research organization working under the umbrella of the Council for Scientific and Industrial Research (CSIR) that co-ordinates a number of research programmes closely related to the oceans and marine resources. Other relevant research / development organizations that have direct or indirect bearing on India's fisheries and aquaculture through integrated research and outreach programmes include – Indian Meteorological Department (IMD), Pune; Institutes and Centres under the Earth System Science Organization (ESSO) such as Centre for Marine Living Resources and Ecology (CMLRE), Kochi; National Centre for Ocean Information Services (INCOIS), Hyderabad; Indian Institute of Tropical Meteorology (IITM), Pune; National Institute of Ocean Technology (NIOT), Chennai; National Centre for Polar and Ocean Research (NCPOR), Goa; National Centre for Earth Science Studies (NCESS), Thiruvananthapuram; National Centre for Coastal Research (NCCR), Chennai and the research institutes under the Indian Space Research Organization (ISRO), Bengaluru.

2.1.2 State Fisheries Departments

As per the seventh schedule of the constitution of India, fisheries are designated as a state subject. In matters related to fisheries development and governance, the principle of co-operative federalism enshrined in the constitution envisages a complementary role for the union government over the responsibilities of the state governments. Every State and Union Territories of the country has a Fishery Department for development and co-ordination of aquaculture and fisheries sector. While these Departments work directly under the State Ministry, they form the important linkage between the Centre and States for implementation of the central schemes. Almost every Fishery Department has their research and development wing and a network of extension mechanism in all the districts. The State Fishery Departments are basically responsible for addressing the sub-regional and regional issues pertaining to the fish production sector in the States. Towards this objective, many state governments have established public sector undertakings, welfare boards and other similar quasi-government

agencies/entities to supplement the activities of the Fishery Departments. For instance, the Tamil Nadu State Government has established the Tamil Nadu Fisheries Development Corporation Ltd. (TNFDC) and the Tamil Nadu Fishermen Welfare Board (TNFWB) that facilitates production-enhancing, processing and marketing of fish and fish products and other fisher folk welfare activities in the state. Similarly, the Kerala government has created agencies such as the Kerala State Coastal Area Development Corporation (KSCADC), Agency for Development of Aquaculture, Kerala (ADAK), Fish Farmers Development Agency (FFDA), Brackishwater Fish Farmers Development Agency (BFFDA), Kerala Fishermen's Welfare Fund (KFWEB), and societies such as State Fisheries Resource Management Society (FIRMA) and Society for Assistance to fisherwomen (SAF) to discharge various functions related to fisheries and aquaculture development. Besides planning and implementation of the State and centrally funded schemes, the Fishery Department and its affiliated agencies also establish linkage between the research organisations, universities, developmental agencies and the end users to ensure effective implementation of the schemes and programmes.

2.1.3 Agricultural/Fisheries University Network

There are three Central Agricultural Universities and 63 State Agricultural Universities functioning as part of the National Agricultural Research System (NARS) which are dedicated to the service of agricultural and allied sectors including fisheries and aquaculture. These Universities with their technically qualified man power, elaborate professional networks, laboratories and other infrastructural facilities as well as field stations have their share of contribution to the sector. This includes services such as research, education, extension, business incubation, training and consultancy, and is being taken up by the regional research stations and colleges under the state university network. Traditionally, such activities in fisheries and aquaculture form a part of the State Agricultural Universities (SAUs) which in turn form an integral component of the NARS. However, in recent years, several autonomous universities with exclusive and specialized focus on fisheries and aquaculture have come up in many states. Apart from these, a number of traditional public sector universities and newly formed private universities have dedicated Departments that offer courses and curriculum programmes on fisheries, aquaculture and other related subjects thereby strengthening fisheries and aquaculture education in India.

2.2 Financial Institutions

Fishing and aquaculture activities have become increasingly capital intensive over time. Apart from the investments made using own funds of individuals and private entrepreneurs, institutional financing has a crucial role to play in the

sector to enable efficient production and marketing activities. A considerable part of this capital requirement is being met by the elaborate network of banking institutions which consists of 12 public sector banks, 22 private sector banks, 46 foreign banks, 56 regional rural banks, 1485 urban cooperative banks and 96,000 rural cooperative banks in addition to co-operative credit institutions (IBEF, 2020). Apart from this, a number of non-banking financial institutions, informal money lending agencies and individuals also contribute to the credit requirements of the sector on a regular basis (Parappurathu et al., 2019).

The National Bank for Agricultural and Rural Development (NABARD) is the apex public finance institution vested with the responsibility of regulating and licensing the regional rural banks (RRBs) and apex co-operative banks as well as extending credit and refinance for the development of agricultural, allied sectors since its establishment in 1982. NABARD has an extensive network of 31 regional offices and 336 district development offices across the country besides 6 training establishments. The self-help group (SHG)-bank linkage programme and the Kisan credit card scheme (KCC) initiated and implemented by the bank had considerable impact for the small and micro enterprises in India's rural agricultural sector including fisheries and aquaculture.

2.3 Fishery Co-operatives

Co-operative movement has strong roots in India, having spread across a number of diverse sectors, and time-tested for its efficacy to bring about changes in the livelihoods of a substantial section of resource poor famers and entrepreneurs. The first fishery co-operative in India was established in 1913, when a fisherman society was organized in the name of 'Karla Machhimar Co-operative Society in the state of Maharashtra. Soon, followed suit by the fishermen of West Bengal and Tamil Nadu, the structure continued to grow over years into multifunctional units at various levels (ICAR, 2011). Presently, the fishery co-operative network in India has over 3.35 million members hailing from all over the country. The network has a federated structure with an apex national level federation, a number of state/regional federations, district-level societies and primary co-operative societies (Annexure 1).

The National Federation of Fishers Cooperatives Ltd. (FISHCOPFED), presently the apex national-level federation of the co-operative network in India was registered in the year 1980 under the Maharashtra State Cooperative Societies Act. Given its apex role, presently it is governed under the Multi State Cooperative Societies Act 2002. The administrative control of the Federation is under the MoFAD, Government of India. FISHCOPFED is having 110 member institutions including the Government of India and the National Co-operative Development Corporation (NCDC), and a nominal membership of 18,407 all over the country. Its main objectives are to promote and develop the fishery

cooperative movement of India, to educate, guide and assist fishers in their efforts to build up and expand the fishery cooperative sector and serve as an exponent of cooperative opinion in accordance with cooperative principles. It is one of the best service delivery systems in the country empowering the poor fisher members.

At the state level, there are 21 fishery co-operative federations which function mostly in independent and autonomous mode. Under them, there are 139 regional/district level co-operatives, and 21,741 primary societies. The state-level fishery co-operative federations with active support from their extended network have been playing a prominent role in undertaking and co-ordinating a variety of developmental functions for developing fisheries and aquaculture over decades. Their key interventions include ensuring the right of first sale of harvested fish to fishermen, providing technical and logistical support at the fish landing centres, extending credit and insurance coverage, provision of safety gears for fishers at subsidized rates, promoting innovative and scientific fish production practices, facilitating input and service delivery, microfinance and microinsurance, operation of retail fish marketing networks and cold chains, extending technical and financial assistance for fish marketing and primary processing activities, value added product development and sale, skill development and business incubation programmes for entrepreneurs and fisherwomen. Some of these federations have also ventured into eco-tourism and sport-fishing activities in recent times. Some widely popular and successful state-level fishery co-operative federations in India include: The Karnataka State Co-operative Fisheries Federation Ltd. (KSCFF) established in 1954, Kerala State Co-operative Federation for Fisheries Development Ltd. (MATSYAFED) established in 1984; West Bengal State Fishermen's Co-operative Federation Ltd. (BENFISH); A.P. State Fishermen Co-operative Societies Federation Ltd. (AFCOF); Tamil Nadu State Apex Fisheries Co-operative Federation Ltd. (TAFCOFED) and Gujarat Fisheries Central Co-operative Association Ltd. (GFCCA).

2.4 Farmers Producer Organizations (FPOs)

Farmer Producer Organizations (FPOs) are non-political legal entities formed by primary producers with a view to enhance their business opportunities through organized service delivery systems. An FPO can have various legal forms including co-operatives and societies but the recent thrust is to encourage incorporation of farmer producer companies (FPCs) which is a hybrid between co-operative society and private limited company. The main aim of FPOs is to ensure better incomes for their member farmers through integration of input delivery services as well as produce marketing services under the larger umbrella of a legally tenable organization so as to benefit from associated

economies of scale. FPCs with fishers and fish farmers as members are only limited in number. This is mainly due to the disproportionate emphasis given by the government to the crop sector so far in the FPO-related policies and programmes. However, this lacuna was recognized lately and an announcement was made to set up 500 Fish Farmer Producer Organizations (FFPOs)/ Fish Farmer Producer Companies (FFPCs) under the on-going flagship scheme, *Pradhan Mantri Matsya Samapada Yojana* (PMMSY) with an objective of economically empowering the fishers and fish farmers. To harness this opportunity, a number of small holder fish farmers, fishermen and entrepreneurs in various parts of the country are gearing up for forming new FPCs.

2.5 Non-Government Organisations (NGOs)

There are a number of domestic and international non-governmental organisations (NGOs) that are actively engaged in developmental and conservation activities related to India's fisheries and aquaculture sector. Their range of activities and sphere of influence vary considerably depending on the source of funding, basic objectives and linkages. Some of the notable areas of NGO interventions include protection and conservation of marine ecosystems, habitats and vulnerable organisms, climate change adaptation and mitigation, protection of the rights and livelihoods of the fisher folk communities, input and service delivery, fish marketing, value addition and allied activities as well as provision of social safety nets. Some of the prominent NGOs that have been maintaining longstanding stakes in India's fisheries/aquaculture include: the South Indian Federation of Fishermen Societies (SIFFS) based in Trivandrum; Dakshin Foundation, Bangalore; Action for Protection of Wild Animals (APOWA) and Alacrity in Odisha; Wildlife Trust of India, Noida, the Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore and Centre for Aquatic Livelihood-Jaljeevika, Pune. The organizations such as the Society for Indian Fisheries and Aquaculture (SIFA) and Aquaculture Foundation of India (AFI) promote sustainable fisheries and aquaculture through provision of latest technologies, products, services, equipment and machineries to benefit the fish farmers and act as a common platform for various stakeholders in the sector. Some of the international NGOs such as Greenpeace and WWF that have cross cutting objectives have their presence in fisheries sector too. However, some of them such as the Sustainable Fisheries Partnership (SFP), The World Forum of Fish Harvesters and Fish Workers (WFF), Wildlife Conservation Society-India (WCS-India), Asian Fisheries Society (AFS), and the International Collective in Support of Fish-workers (ICSF) take exclusive interest in the fisheries sector and have an active presence in India. Similarly, a number of digital networks also operate in various spheres related to fisheries and aquaculture. Some such prominent networks operating in India include the

Marine Mammal Research and Conservation Network of India (http://www.marinemammals.in); Wildlife Conservation Network (https://wildnet.org); Students' Sea Turtle Conservation Network (www.sstcn.org); IUCN Freshwater Fish Specialist Group (IUCN-FFSG)) & Freshwater Fish Conservation Network of South Asia (FFCNSA) ((http://www.iucnffsg.org) and TRAFFIC (TRAFFIC | Wildlife trade specialists).

2.6 Private/ Corporate Establishments

Sectorial growth of aquaculture largely depends on availability of quality seed, feed, fertilizers, therapeutics, etc. While technology generation for production of quality seed and feed have been the responsibility of the research organisations both in government and private sector, the effective adoption of these technologies can be possible only when these inputs are made available for larger commercial use. Therefore, the allied industries involved in producing these inputs are also important for aquaculture development. The last two decades have witnessed participation of many corporate entities in the aquaculture development process both in research and production-oriented activities. Similarly, several enterprises have established feed mills and units for production of other aquaculture inputs. Supply of balanced fish feed has enabled the aquaculture industry in achieving higher fish production. Similarly, timely availability of many drugs and therapeutics had significantly reduced the risk of crop loss and thereby, promoting the aquaculture activity. The fishing vessel and gear industry, seafood processing industry and small and medium enterprises engaged in post-harvest handling and value addition, cold storage, and other logistical support also have their share in development of fisheries and aquaculture in India.

2.7 Fishermen/ Fish Farmers' /Traders' Associations

Associations of fishermen, fish farmers and traders have played a significant role in shaping the development narrative of India's fisheries and aquaculture sectors. During the past half a century, many of these associations and unions have remained an integral part of mass agrarian movements that helped the grassroots level workers and the small-scale producer community in securing their basic rights and gaining certain level of bargaining power in a sector that was then heavily polarized by the disparities in resource endowments and access to technology. In the marine fisheries sector, these associations represented the interests of different factions of the fishermen community that are segregated by the 'technological divide' and having competing interests (Kurien, 1978; Sinha, 2012). For instance, in southern India, there are separate associations for owners of trawlers, purse seiners, ring seiners and non-motorized units, with differing points of view on fisheries management. Some of these associations maintain political leanings and remain affiliated to the dominant political parties of the

region. The Boat Owners' Associations that have active presence in most of the major fishing harbors across coastal India play multiple roles in organizing the vessel-owning community and taking care of their routine requirements such as assured supply of fuel, logistic support, market assistance, insurance cover and so on. Majority of these associations have their activity limited in a particular state or region though there are a few national-level associations with a pan-India presence. The National Fish Workers Forum (NFF) registered under the Trade Union Act of India, is a national federation of state level small and traditional fish workers' unions of India. The NFF has affiliated organizations in all the coastal states and union territories of the Indian mainland and focuses on protecting the life and livelihood of the fishing communities, fisheries resources, biodiversity and natural environment. It also is a major partner of the international movement of the fishing communities led by World Forum of Fisher Peoples (WFFP) (Nayak and Vijayan, 2006). Fish farmers in some states have formed associations and unions and take active part in the aquaculture activities through planning and working in a more organized manner. They remain in constant touch with the range of business entities in the sector and strive to ensure adequate supply of seed, feed, equipment and machinery, bank credit, insurance coverage and other inputs and services for their member farmers. The Seafood Exporters Association of India (SEAI) is an association of the exporters with a motto to protect and promote the interests of the marine product export industry and find solutions for larger global issues that could adversely affect India's seafood export prospects. In nutshell, such associations and unions often form an important linkage between the fishers, farmers, the government machinery and the larger civil society in understanding emerging issues and constraints and responding to them in a collective manner.

2.8 Other International/ Inter-governmental Organizations

A number of international development agencies have been taking active interest in development of fisheries and aquaculture sectors of India. The Food and Agricultural Organization of the United Nations (FAO) maintains constant engagement with Indian fisheries through the Committee on Fisheries (COFI) and its sub-committees. The Bay of Bengal Large Marine Ecosystem (BOBLME), which is an eight-country regional forum, is being hosted by India at Chennai. Similarly, the Bay of Bengal Programme - Inter-governmental Organization (BOBP-IGO), another four-member regional forum hosted by India is mandated to enhance regional cooperation and provide technical and management advisory services for sustainable coastal fisheries development and management in the Bay of Bengal region. The World Fish Centre, Penang in recent years has been associated with aquaculture and livelihood improvement projects in India. The fisheries and aquaculture related matters that require regional co-operation in South Asia is addressed through South Asian Association for Regional Co-

operation (SAARC) and its arm, the SAARC Agricultural Centre (SAC), Dhaka. The International Fund for Agricultural Development (IFAD) is an international financial institution and a specialized agency of the United Nations that undertakes wide-ranging developmental activities in India's fisheries and aquaculture sectors. India is also associated with various other global and regional bodies dealing with fisheries such as the Indian Ocean Tuna Commission (IOTC), Asia-Pacific Fishery Commission (APFIC); Network of Aquaculture Centres in Asia and the Pacific (NACA); Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region (INFOFISH); Convention for Conservation of Antarctic Marine Living Resources (CCMLR); Commission for International Trade on Endangered Species (CITES); International Whaling Commission (IWC) and Indo-Pacific Fisheries Commission (IPFC).

3. Role of Governance instruments and private sector in supporting fish farmers and fishers through cross learning

3.1 Fisheries governance structure and regulatory instruments

The Seventh Schedule of the Constitution of India at Entry 57 of List 1 specifies Fishing and Fisheries beyond Territorial Waters as Union Subject, whereas Entry 21 of List II speaks of Fisheries as a State Subject. Reading both the Entries together, it follows that control and regulation of fishing and fisheries within territorial waters is the exclusive province of the State, whereas beyond the territorial waters, it is the exclusive domain of the Union. The Union Government acts as a facilitator and coordinator responsible for policy formulation, carrying out fishery research and channelizing funding support to the states in line with the national priorities and the commitments made to the State/UT Governments. As noted before, the MoFAD within the purview of its allocated business is mandated to assist the coastal States and the UTs in development of fisheries within the territorial waters, besides attending to the requirements of the sector in the exclusive economic zones(EEZ). DoF under the ministry acts as the focal point for fisheries development and management in the country. Therefore, management of fishery in the EEZ requires close coordination between the Union and the States (ICAR, 2011; GoI, 2018).

Fishery in general is open access in India and is governed by different acts introduced by the government over the years. Majority of these deals with the regulation of marine fisheries. The most relevant ones which have either direct or indirect bearing on the governance of fisheries and aquaculture are the following:

- The Wild Life (Protection) Act, 1972,
- Marine Products Export Development Authority Act, 1972

- The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976
- MFR (regulation) Bill, 1978 formulated after the EEZ declaration,
- Indian Coast Guard Act, 1978
- Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Rules, 1982
- Environment (Protection) Act, 1986.
- Trade Unions (Amendment) Act 2001
- The Biological Diversity Act 2002
- Coastal Aquaculture Authority Act 2005,
- Coastal Regulation Zone, Notification, 1991 (re-notified in 2011 and 2019)
- Wetlands (Conservation and Management) Rules, 2010
- National Policy on Marine Fisheries, 2017

The challenges encountered in the fisheries sector, have been addressed through several interventions with the aim of sustainably exploiting the resources available in coastal and inland waters with due consideration for their conservation and protection. In 2004, the Government of India brought out the first Comprehensive Marine Fishing Policy, which set a framework for sustainable development of the fisheries sector in the millennium. To keep pace with the unfolding new requirements from harvest and sustainability point of view, the Government subsequently brought out the National Policy on Marine Fisheries, 2017 after elaborate stakeholder consultations. The government is presently in the process of bringing out a comprehensive 'National Fisheries Policy' that addresses the development priorities of all sub-sectors of fisheries and aquaculture including inland fisheries, mariculture, post-harvest processing and value addition.

However, there is still no law in effect to regulate the operation of Indian-owned fishing vessels operating in the EEZ, beyond and adjacent to the territorial waters. The Indian Marine Fisheries Bill, 2021 which is scheduled to be introduced in the parliament is expected to fill this legislative vacuum. The provisions under the Wildlife (Protection) Act, 1972 have been used to set up marine parks/ sanctuaries along the coastline in India with the larger objective of protection/ conservation of fauna and flora without infringing on the livelihoods of traditional fishers.

3.2 Marine Fishing Regulation Acts of the coastal States/ Union Territories

The marine fishing activities within the territorial waters of maritime states are governed by the respective Marine Fisheries Regulatory Acts (MFRAs). These were first conceived in response to the growing conflicts in the coastal waters

during the late seventies. To reduce the conflicts and allow for regulation of fisheries in the territorial waters, the then Ministry of Agriculture formulated a Model Bill, which was circulated to the coastal States/UTs in 1979. The states of Kerala and Goa were the pioneering states to pass their own MFRAs in the year 1980 and other maritime states followed suit in subsequent years (List of MFRAs is provided in Annexure 2). The MFRAs contain several provisions to regulate, restrict or prohibit unsustainable / destructive fishing practices, to define access rights, to impose spatial and temporal fishing restrictions and to make licensing and registration of fishing vessels compulsory. Clauses to penalize non-compliance and appellate provisions are also inbuilt in them so as to ensure fair governance of fishing and related activities. The notable management measure that has been strictly enforced in all the maritime states and coastal Union territories is the 'closed fishing season' presently observed for a period of 61 days that coincide the peak fish breeding period in order to avoid catching of spawning and juvenile fish. Presently, the Union Government exercises closure of fishing and is enforced by the coastal State/UTs through 'Executive Orders'. Other major instruments include regulation of mesh size to avoid catching of juvenile fish, legal sizes for commercially exploited fish species, regulation of gear to avoid over-exploitation of certain species and reservation of zones for various fishing sectors to provide exclusive rights to traditional fishermen to fish unhindered in near shore areas. In 2017, the state of Kerala introduced minimum legal size (MLS) for 58 commercially exploited fish species for the first time in India to control juvenile fishing. The encouraging results from this experience have prompted several other coastal states to bring about changes in their MFRAs to accommodate MLS regulations. Other important aspects of regulation include vessel movement control, vessel inspection, and colour coding of vessels. Measures such as issue of biometric cards to fishermen and centralized online database on registration status of fishing boats are the latest steps being implemented with the help of states to facilitate better sea safety arrangements as well as monitoring of vessel movements (Parappurathu et al., 2017).

3.3 Major developmental schemes and programs

Developmental efforts in fisheries and aquaculture in India from time to time are mainly co-ordinated and implemented through schemes administered by the union government and the respective governments of the states and the UTs. During 2015-2019, the Centrally Sponsored Scheme titled "Blue Revolution: Integrated Development and Management of Fisheries" (both marine and inland) with a total outlay of Rs. 30.0 billion has been the main vehicle for such centre-state co-ordination on fisheries development. From 2020 onwards, the scheme was re-organized under the umbrella flagship scheme, PMMSY – mandated with sustainable and responsible development of fisheries sector in India at an allocation of Rs. 200.5 billion for holistic development including

welfare of fishers. PMMSY is being implemented in all the States and Union Territories for a period of 5 years from FY 2020-21 to FY 2024-25. The scheme is designed to address critical gaps in the fisheries value chain from fish production, productivity and quality to technology, post-harvest infrastructure and marketing. It aims to modernize and strengthen the value chain, enhance traceability and establish a robust fisheries management framework while simultaneously ensuring the socio-economic welfare of fishers and fish farmers. It is targeted to attain an additional fish production of 7.0 MMT, to double fisheries exports to Rs. 1000.0 billion and to generate 5.5 million employment opportunities for socio-economic development through PMMSY.The scheme, like other previous schemes has separate components for streamlining the funding: (i) Central Sector Schemes (CS) and (ii) Centrally Sponsored Schemes (CSS) wherein part of the project cost is shared by the State governments based on certain set of guidelines. Apart from the above umbrella scheme, the state governments design and implement a number of state-specific schemes and programmes to meet the developmental needs of the sector from time to time.

3.4 Extension, business incubation, skill development and training

Effective participation of private entrepreneurs in fisheries and aquaculture activities is ensured through a slew of mechanisms for technology demonstration and piloting, business incubation, skill upgradation, training and capacity development programmes, with active support from research and development institutions as well as local self-government organizations. India has an elaborate network for frontline extension and technology transfer of agricultural and allied technologies that include Agriculture Technology Information Centres (ATIC)-single window for technology dissemination at ICAR research institutes and SAUs; Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK)-extension wings of the ICAR at district level; and Agribusiness incubators (ABI) in selected research centres and universities to promote potential technologies into commercial ventures by involving promising entrepreneurs. Apart from this, there are a number of successful private extension models spearheaded by corporate companies and strengthened by input dealers, Agribusiness Centres and Agri Clinics at local levels. These have proved to be effective in providing information and support services, inputs, credit and marketing assistance, organizational and capacity development as well as entrepreneurship development (Sajesh et al, 2018). The training needs of fish farmers and fishers are met to a great extent by KVKs, Research Institutes and public entities such as Agricultural Skill Council of India (ASCI), MPEDA, RGCA, SAUs, and training establishments run by State Departments.

4. Case studies on cross-learning applications that improved fisheries and aquaculture in the country

Notwithstanding the tremendous achievements in terms of production and productivity enhancements, the capture and culture fisheries in India have however witnessed several challenges. Fortunately, most of the disruptions in production were overcome through suitable interventions by a synergy of individuals, research departments, fisheries societies, Federations, State fisheries and Central Fisheries Departments. The consumer demand for fish has been ever increasing and an equilibrium in supply-demand gap can be achieved through a combination of aquaculture and improved capture techniques. The section below provides accounts of some notable cases where networking across entities has helped the sector tide over crises and maintain a steady growth momentum.

4.1 Control of the Epizootic ulcerative syndrome (EUS) in carps

The Epizootic ulcerative syndrome (EUS) in fish is considered the most dreaded disease ever in the aquaculture sector of the country. It is primarily caused by the invasive water mould *Aphanomyces invadans* that grows on a body lesion and invades the body cavity and produces mycotic granulomas in all the visceral organs (Viswanath et al., 1998). This water mould was first recorded in the natural waters of India in 1988, and since then, has plagued almost all fishes inhabiting in it and has had a catastrophic impact on the fishery. With its entry into the culture system, EUS had played havoc in all the geographic regions of the country, seriously impeding the aquaculture activity. Almost every stakeholder from farmers to researchers have played a role in trying different formulations, starting from plant materials, chemical application or combination of both to contain the disease outbreak. Various formulations had been used by farmers but with limited success of disease control. However, ICAR-CIFA has developed CIFAX, a chemical formulation which by far has been the most effective one to control the EUS in grow-out pond. Subsequent extension efforts with active support from line departments and local-level development agencies made it possible to broad-base the impact of this technological intervention, thus resulting in effective control of the disease all over the country.

4.2 Interventions to overcome impact of White Spot Syndrome Virus (WSSV) in shrimp farming

Largescale intensive and organized shrimp farming, mostly of *Penaeus monodon*, began in the 1990s and the sector achieved remarkable success during the following five-year period (Vijayan, 2018). Organizations such as the MPEDA, DBT and through initiatives such as Andhra Pradesh Shrimp Seed Production Supply and Research Centre (TASPARC) and Orissa Shrimp Seed Production Supply and Research Centre (OSPARC) were instrumental for this noteworthy

evolution of shrimp farming in the country. However, aquaculture of *P. monodon* was severely affected by White Spot Syndrome Virus (WSSV) leading to a total collapse of multi-million shrimp farming activity since 1995. A therapeutic solution to control and prevent the spread of the virus leading to mass mortality of the farmed shrimps was to adopt suitable preventive strategies. Specific Pathogen Free (SPF) and Specific Pathogen Resistant (SPR) brood stock of *L. vannamei* were introduced in 2009 with encouragement in the form of subsidy for pond development, construction of new ponds, first year inputs, etc. under centrally sponsored (DoF, GoI, NFDB, MPEDA) subsidy schemes implemented by majority of the State Governments through FFDA/ BFFDAs for different categories of farmers (Koteswari et al., 2014; Aquaculture Authority News, 2019; Salunke et al., 2020). The combined involvement of the government, research organisations, CAA, and shrimp farmers societies have helped bringing shrimp farming activities back on track.

4.3 Disease surveillance to reduce crop loss

In fish farming, the animals are stocked in more density than that in the natural ecosystem and in that way, exposed to pathogen attack. However, apart from a few parasitic and bacterial infections with external identifying feature on the body, many of the disease and infection often go unnoticed. This happens mostly in stressed condition resulting in poor growth and yield. However, with increased level of farming, research thrust on health management has been stressed in the recent years. At present, disease surveillance programme is in place at a national level and being implemented in 17 states to track and report the occurrences of the disease (Jena and Das, 2020). The programme under the name 'National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)' was first initiated by the MoFAD in 2013 with the support of NFDB at an estimated cost of about US$ 6 million. The program involves active partnerships between State Fisheries Departments, Fisheries Colleges and ICAR Fishery Institutes. Similarly, a number of disease diagnostic kits have been developed over the years which aids in early detection of disease in fishes. A number of chemicals and drugs are also available to prevent and treat diseases which have helped in reducing the loss.

4.4 Increasing seed production for aquafarming

The entire aquaculture system till the middle of last century was relying entirely on wild fish seed collected from riverine and brackishwater sources. Besides uncertainty in timely availability, such seed sources were marred with mixing of unwanted seeds along with the desired one which often led to low survival and growth. Various universities and Research Institutes in the country worked towards finding a solution. Development of the induced breeding technology

through hypophysiation by the erstwhile Pond Culture Division of CIFRI (Presently ICAR-CIFA) and strongly supported by the Government with implementation of several schemes including the AICRP on Spawn Prospecting (later merged with Composite Fish Culture to one AICRP) in 1970s was a breakthrough in this regard. Since the successful demonstration of composite fish culture technique through AICRP, there was a huge demand for carp seed and it led to scarcity of the pituitary gland (PG). This prompted the intervention of the pharmaceutical companies to produce a synthetic analogue substitute for the PG extract. As a result, inducing agents like Ovaprim, Ovatide, Wova FH, etc. are available to seed producers which has not only increased the seed production efficiency, but also helped in breeding a wide range of cultivable fishes in addition to carps. Simultaneously, the technology for induced breeding and standardization of seed production protocol was achieved through interventions by the farmers and researchers over the years. Today, India is self-sufficient in supply of freshwater fish fry supply to the aquaculture sector and the seed production of more than 40 important freshwater cultured species have been standardised (Raizada et al., 2019).

Similarly, in brackishwater sector, seed production technologies have been developed for five indigenous and one exotic marine shrimp, ensuring a continuous seed supply for shrimp farming despite substantial increase in demand. Technology for induced breeding and seed production has also been established for more than ten species of backishwater and marine finfishes during the last decade through the concerted efforts of ICAR-CMFRI, ICAR-CIBA, RGCA and other fisheries research organisations of the country. Assured availability of seed of these commercially important food fishes has widened the scope of finfish farming in brackishwater pond and cage culture in open sea. Further, development of an array of seed production technologies of more than twenty high-valued ornamental fish has strengthened the ornamental trade and the country is moving towards a healthy public -private partnership enterprise in this realm (GoI, 2020).

The need-based seed production technology developed and popularised mainly by research institutions has now reached commercial scale. Such development in fish breeding and seed production technologies over the years is a typical example of cross-learning among stakeholders by integrating and empowering the entrepreneurs, fisheries development agencies, State/UT Fisheries Departments and Fisheries Research Institutes with regard to financial, technical and marketing aspects.

4.5 Development of mechanisms to ensure quality of fish seed

Quality seed is the key to success of grow-out farming. However, due to lack of certification and hatchery accreditation in the freshwater sector, the fish seed

production sector has largely remained disorganized. As a result, hatchery owners in several States were not following the basic norms in hatchery operations. While there was high demand for seed, availability of space to raise broodstock and maintain them in the farm was constrained. As a result, many hatcheries were producing seed based on the availability of broodstock. Since hybridization is possible among three species of Indian major carps (catla, rohu and mrigal) and kalbasu, the unscrupulous use of these species based on availability had led to widespread production of hybrid seed, particularly in the eastern and north-eastern states, resulting in the poor grow-out performance and low yield. However, many State Fishery Departments have implemented special drive for increased awareness among the farmers and hatchery owners about the benefit of using good quality seed. Support in terms of various schemes had been ensured. Some States have already formulated their 'State Fishery Policy' and have increased vigilance to restrict the hybridization process. Hatchery certification for quality seed has been initiated at several places. Use of cryopreserved sperms of fishes has been used in some hatcheries to improve the seed quality. Selective breeding programmes were implemented in the research Institutes to improve the quality of the seed as in case of rohu, catla, freshwater prawn and Amur carp. Farms in different areas across the major producing States have been identified to propagate the use of improved seeds. The NFDB has established a National Freshwater Fish Brood Bank facility at Bhubaneswar to ensure supply of improved breeder seeds of important cultivable species to different States. At the same time, NFDB has supported establishment of State Level Brood Bank facility to further widen the supply of quality seed to the farmers. Such efforts over the years have transformed the seed production sector to an organized one with production of quality seed to ensure better fish yield.

4.6 Ensuring adequate fingerlings supply

Fingerling of fishes are the appropriate stocking size considered for the success of grow-out farming due to their higher post-stocking survival. However, there has always been a dearth in the supply of fingerling partly because of the reluctance of the farmers to spare the three months of culture period for seed rearing. Non-availability of fingerlings leads to fry stocking in grow-out ponds which often resulted in poor survival and low production. Over the years, efforts were made by the State Fisheries Department and other extension machineries to create awareness on the benefit of stocking larger seeds (fingerlings) for better survival and production. Several schemes have been implemented from time to time towards achieving this goal - a notable one was the launching of 'Mission fingerling' by Govt. of India in 2017 (DAHD&F, 2017) that aimed to produce 426 crores fish fingerlings and 25.50 crores post larvae of shrimps and crabs in the country. Besides, the NFDB is also promoting *in situ* rearing of fish fingerling for release in the open waters to strengthen the culture-based capture fishery.

Early breeding protocol, off season breeding, use of specialized brood stock diet for early maturation (CIFABROOD™ by ICAR-CIFA), high density seed rearing for stunted juvenile production are some of the tools developed and used in the aquaculture sector for ensuring round-the-year availability of juveniles for grow-out stocking. These developments have opened up avenues for the farmers to practice varied cropping pattern such as single stock multiple harvests, multiple stock multiple harvest and multiple cropping, all realizing higher productivity.

4.7 Promotion of bi-species, poly culture and Integrated Multi Trophic Aquaculture

Development of carp farming in the country has been mostly based on the composite farming of the Indian major carps (catla, rohu and mrigal) or along with the exotic carps (silver carp, grass carp and common carp) that ensures optimum utilization of the total pond niches. Over the years, while silver carp has lost its popularity, bottom dwellers such as common carp and mrigal have been gradually discarded due to harvest problem and slow growth. As a result, rohu has come up as the major species constituting almost 80-90% of the stock and the rest is of catla. Although this bi-species culture is against the principle of composite fish farming, farmers have promoted such practice due to the market driven demand for the two species and has been adopted in almost all parts of the country.

The bi-species and poly culture have been adopted in mariculture too with several compatible food fishes being cultured simultaneously. This concept has been popularised and encouraged by departments and is well accepted by fish farmers. The Integrated Multi Trophic Aquaculture (IMTA), where organisms of different trophic levels are farmed to improve production efficiency, reduce waste, and provide ecosystem services, such as bio-remediation is being encouraged by different departments. Integrated farming involving finfishes, shrimps, bivalves and seaweed is being practiced in estuarine and open sea cage farming with very good yield (CMFRI, 2015,2016,2019; Johnson et al., 2019a).

4.8 Cage farming in open waters

The country is having approximately 0.195 million km of rivers and canals, 3.15 million ha reservoirs and 0.5 million ha flood plain wetlands. Fish production potential of these open waters have largely remained underutilised until the last decade. Fish yield from reservoirs have been reported to be 82 kg ha^{-1}, despite having the production potential of 500, 250 and 100 kg ha^{-1} from small, medium and large reservoirs, respectively (Jha, *et al.*, 2013). Efforts have been made over the years to promote fish production in these inland waters. Several States have framed their Reservoir Fishery Policies for overall management and sustainable increase in fish production. Cage farming in the reservoirs has been

overwhelmingly supported by the Ministry of Agriculture and the NFDB. A National Level Committee to Develop Guidelines for Cage Culture in Inland Open Waters' (NCGCC) was constituted in 2016 and entrusted with the mandate to assess the potential of cage farming to increase production, income and employment generation; to assess environmental and socio-economic impact of cage farming; and suggesting the mode of upscaling of cage farming on a sustainable basis (NFDB, 2016). Many State Fishery Departments with support from NFDB have promoted large scale cage farming in reservoirs. States like Chhattisgarh and Jharkhand have been undertaking large scale cage culture of exotic *P. hypophthalmus* in reservoirs and rivers. Similar attempt of cage farming has also been undertaken by the Fishery Department of Odisha in the Rushikulya and Mahanadi River system and in the Hirakud reservoir.

Cage farming of finfishes in the estuarine and open sea has been an important intervention made during the recent past spearheaded by ICAR-CMFRI with great success in the country. In the face of limited suitable land area and with the responsibility of enhancing production to meet the increasing demand for fish, farming food fishes in open waters using cages was initiated by CMFRI in mid-2000s. (Rao, 2012; Rao et al., 2013; Philipose et al., 2017; Johnson et al., 2019b; Megarajan et al., 2018) The transition from capture-based mariculture to availability of hatchery produced seeds, faster growth rate of marine fishes with production as compared to land-based aquaculture was quick. The synergistic association of the research institutes in developing the open sea cage farming technology followed by success in seed production of marine finshes, encouragement provided by the line departments to the farmers, the marketing agencies and the enthusiasm of the farmers has contributed to faster expansion of cage farming a major intervention in the PMMSY programme to increase the fish production in all suitable open waters.

4.9 Seaweed farming

Seaweed farming in the country was initiated more than three decades ago through trials of *Gracilaria edulis* farming along the southeastern coast of Tamil Nadu. Interventions from research organizations such as the Central Salt and Marine Chemicals Research Institute (CSMCRI) and CMFRI, further contributed to the advancement of the seaweed farming. However, seaweed farming largely remained unorganized and impetus for large scale farming of seaweed came with the involvement of local fishers, especially women. This was coupled with interventions such as arrangements for marketing the harvested seaweeds and with the permission granted by the Government to cultivate the exotic red algae *Kappaphycus alvarezii*. Large scale farming of seaweeds was subsequently made possible through collaborative efforts involving National research institutes, State fisheries Departments, SHGs, FFPO and IFFCO and by ensuring funding

support for training, demonstration, financial assistance programmes and establishment of seaweed processing units. (CSMCRI, 2002; Immanuel and Sathiadhas, 2004, Krishnan and Narayanakumar, 2010). The success of these efforts was apparent for the first time when the cultivation technology was transferred to PepsiCo India Holdings Ltd. in 2001 and eventually to M/s. Aquagri Processing Pvt. Ltd (Anon, 2003). The implementation of seaweed farming schemes through the SHG *Kutumbam* (family) model yielded better coordination among the seaweed farmers and also resulted in higher productivity (Kaladharan et al., 2019). National financial institutions like the State Bank of India (SBI) and NABARD provided financial support through loans for commercial seaweed farming. In recent times, there is a renewed focus on seaweed farming with the announcement of a slew of research and development programmes by various Departments of the government, success achieved by the research institutes in development of a number of commercial products from seaweeds and the newfound enthusiasm observed in the industry and entrepreneurs to capitalize the emerging opportunities.

4.10 Mussel farming

The green mussel (*Perna viridis*) is an important and popular marine edible bivalve especially in Kerala. The scientific farming technology developed by ICAR CMFRI in the 1980s enabled quick adoption, which in turn ensured a steady supply of green mussel in the region. The ease of culture and the high demand subsequently resulted in rapid horizontal expansion and establishment of large mussel farms by the aquafarmers and women's Self-Help Groups (SHGs). Financial assistance for these early efforts was made available through Swarnajayanthi Gramaswa Rosgar Yojana (SGSY), a scheme that takes care of economic empowerment of weaker sections and focuses attention on poverty alleviation through organized Self-Help Groups. The mussel farming activities flourished in Kerala mainly because of the cohesive actions and collaboration of different networking institutions and mussel farmers in the region. The green mussel seeds for farming were mainly sourced from the wild and year-round availability of seeds gradually became a limiting factor. The technology for mass scale seed production of green mussels by ICAR-CMFRI over the last few years has addressed this gap and is now able to supply good quality green mussel seeds to the farmers. However, of late, the green mussel farming has been witnessing setbacks mainly due to prevalence of disease. The issue is being closely monitored by research institutions. These transient problems however can be solved with the right interventions from research organizations, aquafarmers, line departments and with handholding by government and non-government organisations so that mussel farming gets back to its past glory.

4.11 Organized marketing of fish and fishery products

Fish and fishery products are highly perishable commodities and unless the fishes are well preserved and transported to the destination (consumers) in the shortest time, the quality as well as the value of the commodity get affected. Most of the fish produced in the inland sector are consumed in the domestic market. Though part of the marine catch is exported, a big share is taken by the domestic consumers. Value addition increases the shelf life to a certain extent but domestic preference is mostly for fresh fish. Good marketing channels with excellent cold chain networks therefore are crucial in this sector. The MPEDA and Export Inspection Council (EIC) through awareness and support schemes have emphasised the need for maintaining the quality of fishes especially fishes that are to be exported. Establishment of modern processing plants including fish meal plants, hygienic drying methods also have gone a long way opening better avenues for marking and procuring a fair price for these valuable but highly perishable commodity even during glut landings. However, except in few states, the domestic fish marketing system until recent years has remained mostly disorganized. Perishability of the fish in disorganized marketing system has been a major constraint to realize fair market price of the commodity. While absence of suitable transportation facility restricts longer distance movement, the glut production often severely affects sale price as well as keeping quality of the product at the end user level. The NFDB along with the State Fishery Departments have implemented several schemes to strengthen the cold chain facility and establish state-of-the-art fish markets in different places. Schemes supporting the retailers and venders through supply of vehicles and insulated fish vending machines were also put in place. Organization of the fish producers on sub-regional basis has helped in organized harvesting and transport of fish. Further, promotion of the cold chain facility in the system has not only increased the reach to interior areas, but also ensured price stability of the commodity. Improvements in marketing channels also figures as an important aspect in the blue revolution and PMMSY schemes being implemented by the Department of Fisheries, Government of India.

4.12 Dealing with dwindling natural population and depleting capture fishery

Over the years, while research Institutes have increased the knowledge base and capacity building of the line departments to address the challenges such as overfishing, climate change impacts and marine pollution, the planning and implementing agencies have intensified efforts to increase awareness among the local communities about the importance of participatory management of open water resources for improved and sustainable productivity, ecosystem health and better livelihood support. Habitat fingerprinting, stock assessment, spatial

planning, benchmarking for sustenance of aquatic ecosystem health, pollution abatement, fish disease surveillance, etc. have been some of the major aspects stressed for improving the ecosystem. Similarly, community participation in the observation of fishing holiday, mesh size regulation, seed ranching, etc. have strengthened the natural stock population.

4.13 Invasion/incursion of alien and unconventional fishes

Illegal entry of the alien species into the culture system has been a continuous problem in the freshwater sector. These fishes are brought illegally through the porous border to raise in culture system due to their higher growth potential and wide adaptability. Some of the cultured alien fishes in the country include stripped catfish (*Pangasianodon hypophthalmus)*, African Catfish (*Clarias gariepinus*), red-tilapia (*Oreochromis niloticus*), red-bellied-pacu (*Piaractus brachypomus*) and bighead (*Aristichthys nobilis*) all of which had illegal entry. Although some of these species have proven their culture potential, escape of others like tilapia and African catfish to open water courses and subsequent establishment has brought potential invasive effect on the original fish population in open water system. Efforts have been made over the years to raise awareness among the farmers about the potential consequence of promoting such illegal alien species to our ecosystem. While Government of India have banned culture of species like African catfish, cautious approach has been adopted for scrutinizing these alien species before regularizing them in the country.

Poor fishery management, impact of changing climate and improved harvesting interventions often have resulted in changed species composition, and resultant landing of unconventional resources. However, this challenge has been addressed in a novel way so that these resources have been managed well and are fully utilized. One such instance during the last decade and a half is the huge landing of blowfish (*Lagocepahalus* spp.). This blowfish was not considered as a tablefish and used to be accounted only as trash. Moreover, when fished and caught in the cod end of the net, it caused a lot of damage to the other commercially important fishes trapped in the cod-end as well as damaged the net with its sharp teeth. The boat owners, the marketing agencies, the processing plant units and the fishermen jointly decided to find a way out to use this fish in a more gainful manner. Initially, the fishmeal plants agreed to include this fish as a raw material for the preparation of fish meal and agreed to pay the similar price as for other low valued fishes. Later, scientific investigations revealed that the fish is safe for human consumption and that there is good scope for getting higher value for the catch through suitable handling and value addition. Accordingly, the blowfish was well iced, brought ashore, pre-processed (beheaded, degutted and de skinned) at the landing centre itself and marketed

for domestic consumption. Further, the gonads of the species supposedly have a curative value in south east Asian countries, and was preserved and sold separately to agents engaged in this business. Thus, a resource that was thoroughly disliked by the fishers and fetched very little value even among the low valued catch is now considered a tablefish fetching a good market price. The networking of the boat owners, crew, marketing agents, processing plants and department officials have equally contributed to this change over.

The red tooth triggerfish (*Odonus niger*) is another classic example of how a low value fish can by gainfully used thus enhancing its market value. The unprecedented landings of the red tooth triggerfish during recent past, and attaining the top position in the marine fish landing in most of the coastal states was of great concern to all stakeholders of the marine fisheries sector. The fish valued only as much as the low value trash fish, is now utilized and used for the preparation of surimi a fully exported product, thus enhancing its market value. The waste generated during surimi production is taken by the fishmeal plants for production of fish meal. This was achieved once again due to the strong networking between different groups engaged in fishing, marketing processing and exporting activities.

5. Gaps due to lack of capacity building initiatives to achieve a proper cross learning

Major constraints impacting the growth of marine capture fisheries include limited scope for expansion due to overcapacities in territorial waters, weak enforcement of regulations, inefficient management and prevalence of less efficient fishing practices. Inadequate infrastructure especially, in fishing harbours, landing centers, cold chain and distribution systems, deficiencies in processing and value addition, high wastage, lack of proper systems in place to ensure traceability and certification, non-availability of skilled manpower, etc. are some of the other factors constraining the growth of the capture fisheries. In inland capture fisheries, seasonal nature of fishing operations, depleted stocks in natural waters, issues related with tenure and lease rights, use of obsolete technology for harvesting coupled with low capital infusion are some of the significant limiting factors.

Specific problems affecting the growth of aquaculture include poor physical condition of resources (specially the water quality) in many culture systems, lack of species diversity and diversity in their culture practices, lower productivity, inadequate regulatory mechanism and increased incidents of disease. Infrastructure-related, logistical and institutional deficiencies such as gaps in input and service delivery system, low levels of investment, inadequate access to institutional credit and high cost of credit, inadequate infrastructure for pre-

production, production, post-harvest and processing facilities, low adoption of technologies and shortage of skilled manpower for extension services, etc. dampen the vibrancy associated with aquaculture activities in a number of culture systems in the country (GoI, 2017, 2019a,b,c, Gopalakrishnan et al., 2019).

The above weaknesses can be addressed to a considerable extent by strengthening the knowledge and service networks in the sector and by capitalizing on the elaborate institutional mechanisms presently available in the country. Emulating successful experiences and cross-learning from one another not only from actors and networks within the country but from across regional and global platforms can facilitate this process in no less terms.

6. Conclusions and Recommendations

The role of the networking systems, be it informal or formal, its crucial role in addressing the challenges in any sector is undeniable and it's not an exception in the case of aquaculture and fisheries. The paper provides an insight of the role of existing networking systems in India in adoption, popularisation and acceptance of solutions in the form of technologies for production enhancements, policy interventions for crisis management, conservation and protection of resources as well as conflict management among different stakeholders in the aquaculture and fisheries sectors in India. This can be catalyzed cross learning between government and semi-government organisations, private entrepreneurs, line departments and stakeholders and emulating success achieved in addressing similar challenges in other countries. Regular interactions and sharing of ideas, challenges and solutions in the fisheries and aquaculture sector with other SAARC member countries would definitely help to identify the existing gaps, enhance the capacity to address the similar challenges and develop suitable informed tangible solutions which would ultimately benefit the farmers, fishers and scientists among the SAARC member countries.

Recommendations:

1. Necessary legislative, policy, scientific, infrastructural and logistic support may be ensured to maintain the growth in fisheries sector to meet the growing demand for fish and to secure income and employment security of fisher folk and fish farmers.
2. Research innovations and technological breakthrough are crucial to sustain productivity and efficiency of future fishery production systems. This may be ensured by prioritizing and implementing appropriate research and developmental programs in the sector and by strengthening the network involving scientific establishments, development departments, civil society

organizations, as well as the fishermen and fish farming community at the grassroots level.

3. In the marine fisheries sector, there should be considerable focus on sustainable management, habitat conservation and responsible fisheries governance.
4. Stock assessments and data collection systems needs to be given priority to facilitate informed decision making on key areas.
5. Freshwater and brackishwater culture systems need research focus on promising culture practices such as Recirculating Aquaculture System (RAS), biofloc, polyculture and IMTA.
6. Applications in frontier areas of research and technology such as, genomics and biotechnology, artificial intelligence, bio-informatics, etc. need to be harnessed through greater investments and other appropriate interventions.
7. Mariculture sector (cage culture, seaweed culture, bivalve culture) needs comprehensive development especially in the areas of leasing policies, seed and feed development, hatchery development, etc.
8. Post-harvest 'value addition' and 'value creation' need further boost to strengthen domestic as well as export value chains of fish and fish products.

Acknowledgements:

The authors sincerely thank Dr. J.K. Jena, Deputy Director General (Fisheries Science), Indian Council of Agricultural Research, New Delhi for the nominating the authors to attend as well as present the country status paper during the Regional Consultation Meeting on "Cross-learning for Thematic Regional/Sub-regional Challenges in Aquaculture. The encouragement and constant support provided by Dr. A. Gopalakrishnan, Director, ICAR-CIFT and Dr. S.K. Swain, Director, ICAR-CIFA is gratefully acknowledged. The help rendered by our colleagues and friends posted in different parts of the country in collection and collation of information essential for the preparation of this document is sincerely appreciated.

References

Anon. A. (2003). Seaweed cultivation and utilization. *National Academy of Agricultural Sciences*, vol 22. Policy Paper, India, p. pp 5.

Aquaculture Authority News. (2019). Shrimp Farming in India – Lessons and Challenges in Sustainable Development. Vol1(1).

CMFRI (2015). Annual Report 2014–2015, Mariculture: Trial on Integrated Multi Trophic Aquaculture (IMTA) in a participatory mode, p. 219; Kochi, India.

CMFRI (2016). CMFRI Annual Report 2015-16. Central Marine Fisheries Research Institute, Kochi, 296 pp.

CSMCRI (2002). Biennial report Central Salt and Marine Chemicals Research Institute 2000–2002, Marine Algae: Seaweed Cultivation and value addition, p. 59–60; Bhavnagar, India http://www.csmcri.org/Files/Biennial_00-02.pdf as accessed on August 11, 2016.

CMFRI, Library (2019). *Central Marine Fisheries Research Institute All set for a blue revolution***.** ICAR News, 25 (3). pp. 14-20.

DAHD&F (2017). Mission Fingerling Action Plan: 2020 towards Blue Revolution. Pp 29. Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare, Government of India

DoF (2019). Pradhan Mantri Matsya Sampada Yojana (PMMSY) 2020, Department of Fisheries (DoF), Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, 25 p.

FAO (2020). The State of World Fisheries and Aquaculture 2020: Sustainability in Action, Food and Agriculture Organization of the United Nations, Rome. 206 p, https://doi.org/10.4060/ca9229en.

FISHCOPFED (2020). Website of The National Federation of Fishermen Co-operatives Ltd. available at http://www.fishcopfed.in/ , accessed in July, 2021.

GoI (2017). National Policy on Marine Fisheries, Ministry of Agriculture and Farmers' Welfare, Government of India.

GoI (2019a). Agricultural Statistics at a Glance 2018, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, Government of India (GoI).

GoI (2019b). Report of Blue Economy Working Group-3 on Fisheries, Aquaculture & Fish Processing, Economic Advisory Council to the Prime Minister, Government of India (GoI).

GoI (2019c). Report of Blue Economy Working Group – 3 on Fisheries, Aquaculture and Fish Processing submitted to Economic Advisory Council to the Prime Minister, Government of India.

GoI. (2020). Government of India Ministry of Fisheries, Animal Husbandry & Dairying Department of Fisheries.2020. Promotion of ornamental fisheries under PMMSY.

Gopalakrishnan, A., Kirubagaran, R., John George, Ponniah, A. G., Gopakumar, G., Mohamed, K. S., Krishnan, P., Imelda, Joseph, Ignatius, Boby, Jayakumar, R. Raju, M. S., Sreepada, R. A. Shinoj, P. and Rajesh, N. (2019) *Draft National Mariculture Policy 2019 (NMP2019) Report of the Committee constituted by the National Fisheries Development Board (NFDB), Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India.* CMFRI Marine Fisheries Policy (17). ICAR - Central Marine Fisheries Research Institute, Kochi.

IBEF (2020). Website of India Brand Equity Foundation, available at https://www.ibef.org/industry/insurance-sector-india.aspx accessed in July, 2021.

ICAR (2011). Handbook of Fisheries and Aquaculture, Indian Council of Agricultural Research, New Delhi.

ICAR (2019). Technologies Breeding and Seed Production of Finfishes and Shellfishes. Indian Council of Agricultural Research, New Delhi, p. 43.

Immanuel, S. and Sathiadas, R. (2004). Employment potential of fisherwomen in the collection and post-harvest operations of seaweeds in India. *Seaweed Res Util.* 26:209–215.

Jena, J.K., Das, P.C. (2020). Role of Research support in the development of aquaculture in India. In: Indian Aquaculture-2020. Chapter3. pp 13-22. Sugunan, V.V., Suresh, V.R., Murthy, C.K. (Eds). Society for Indian Fisheries and Aquaculture, Hyderabad. p 223.Johnson, B., Abdul Nazar, A KJayakumar, R., Tamilmani, G., Sakthivel, M., Ramesh Kumar, P., Anikuttan, K. K., Samal, A.K. and Sankar, M. (2019a). *Integrated Multi-Trophic Aquaculture (IMTA): A technology for uplifting rural economy and bio - mitigation for environmental sustainability***.** Aquaculture Spectrum, 2 (5). pp. 9-18.

Johnson, B., Abdul Nazar, A K.,Jayakumar, R., Tamilmani, G., Sakthivel, M., Ramesh Kumar, P., Gopakumar, G. and Zacharia, P. U. (2019b). *Adoption of sea cage farming of cobia (Rachycentron canadum) by fishermen self-help groups as a diversified livelihood option: A success story from Ramanathapuram District, Tamil Nadu, India***.** Indian Journal of Fisheries, 66 (3). pp. 118-124.

Kaladharan, P., Johnson, B., Abdul Nazar, A.K., Ignatius, B., Chakraborty, K. and Gopalakrishnan, A. (2019). Perspective plan of ICAR-CMFRI for promoting seaweed mariculture in India. Mar. Fish. Infor. Serv., T & E Ser., No. 240.

Koteswari, N., Sheela Immanuel., Leo Cyril, A.R., Viswanatha, B.S. (2014). Impact of aqua societies on shrimp farming in Andhra Pradesh, India. Fishery Technology 51, 130-135.

Krishnan, M. and Narayanakumar, R. (2010). Socio-economics of seaweed farming in India. Central Marine Fisheries Research Institute, Kochi, India, Special Bulletin No 104:103.

Kurien, J. (1978). Entry of big business into fishing: its impact on fish economy, Econ. & Pol. Weekly, 13 (36): 1557-1665.

Megarajan, S., Ranjan, R., Xavier, B., Muktha, M., Edward, L., Sadhu, N. and Ghosh, S. (2018). *Alternative marine finfish species for Coastal and Open Sea aquaculture in India-Current status and challenge***s.** Fishing Chimes, 37 (12). pp. 18-31.

Parappurathu, S., Ramachandran, C., Baiju, K.K. and Xavier, A.K. (2019). Formal versus informal: Insights into the credit transactions of small-scale fishers along the South West Coast of India, Marine Policy, 86: 144-155.

Parappurathu, S. and Ramachandran, C. (2017). Taming the fishing blues: Reforming the marine fisheries regulatory regime in India, Econ. & Pol. Weekly, Vol. 52 (45): 73-81.

Philipose, K, K., Loka, J., Murugan, S.T., Dube, P., Sanjeev D., Rao, K, S., Sonali, S. M. and Vaidya, N. G. (2017). *Marine cage farming of Asian seabass under participatory mode - A success story***.** Marine Fisheries Information Service; Technical and Extension Series (231). pp. 13-15. ISSN 0254-380 X

Raizada, S., Pravin, P., Kumar, A.T., Jena, J.K. (2019). ICAR Technologies: Breeding and Seed Production of Finfishes and Shellfishes. Indian Council of Agricultural Research, New Delhi. pp. 66. Royal Offset Printers, New Delhi.Rajesh, N., Ignatius, B. and Joseph, I. (2019) *Technological advancement in Mariculture in India for*

*production enhancement and sustainability***.** In: Advances in Marine Fisheries in India, 18-23 February 2019, Kochi.

Rao, G. S. (2012). *Cage Culture: Mariculture Technology of the Millennium in India***.** In: Handbook on Opensea Cage Culture. Central Marine Fisheries Research Institute, pp. 1-14.

Rao, G. S and Joseph, I., Philipose, K. K. and Mojjada, S. K. (2013). *Cage Aquaculture in India***.** Central Marine Fisheries Research Institute, Kochi.

Sajesh, V. K., Padaria, R.N. and Sadamate, V.V. (2018). Pluralism in agricultural extension in India: Imperatives and implications, Economic Affairs, Vol. 63, No. 4, pp. 1017-1025.

Salunke, M., Kalyankar, A., Chandraprakash, D., Shingare, M. and Khedkar, G.D. (2020). A review of shrimp aquaculture in India, historical perspective, constraints, status, and future implications for impacts on aquatic ecosystem and biodiversity, Reviews in Fisheries Science and Aquaculture, 28 (3): 283-302, DOI: 10.1080/23308249.2020.1723058.

Sinha, S. (2012). Transnationality and the Indian Fish workers' movement, 1960s-2000, Journal of Agrarian Change, 12 (2&3): 364-389.

Vijayan, K. K. (2018). Shrimp farming in India: status and way forward. In: Balasubramanian C. P., Shyne Anand, Kannappan S. and Biju I. F. Training manual on recent advances in farming of pacific white shrimp (*Penaeus vannamei*), Training manual. series, no-14, 2018, 126 pp.

Viswanath, T.S., Mohan, C.V. and Shankar, K.M. (1998). Epizootic Ulcerative Syndrome (EUS) associated with a fungal pathogen, in Indian fishes: histopathology- a cause for invasiveness. Aquaculture 165:1-9.

Annexure 1.

Fishery Co-operative Network in India

Name of the State / UT	Number of Societies (level)				No. of members
	State Level	Regional Level	District Level	Primary Level	
Andhra Pradesh	1		13	2,347	260579
Arunachal Pradesh				11	230
Assam	1		2	520	90000
Bihar	1			510	410007
Chhattisgarh	1		5	765	26154
Goa				20	1503
Gujarat	1		3	263	26045
Haryana				116	1276
Himachal Pradesh				45	5837
Jammu Kashmir				1	18
Jharkhand	1		1	384	22853
Karnataka	1		2	566	204689
Kerala	1			651	460486
M.P.	1		1	2,290	85731
Maharashtra	1	2	36	3,315	332636
Manipur	1		3	485	14,258
Meghalaya				18	611
Mizoram	1			47	1656
Nagaland				267	9234
Odisha	1	5		657	138143
Punjab			1	1	18
Rajasthan	1		1	34	4130
Sikkim				8	230
Tamil Nadu	1		11	1,355	679117
Telangana	1		10	4,348	302002
Tripura	1			142	22967
UP	1		22	1,011	54521
Uttarakhand				13	634
West Bengal	1		20	1,433	131578
Andaman & Nicobar Islands	1			41	1361
Daman and Diu				7	3176
Lakshadweep				6	2910
Puducherry	1		1	64	58525
Total	21	7	132	21,741	3353115

Source: FISHCOPFED, 2021

Annexure 2.

List of MFRAs of State/UT governments in India

i. The Kerala Marine Fishing Regulation Act and Rules 1980 (Act 10 of 1981)

ii. The Goa Marine Fishing Regulation Act, 1980

iii. The Maharashtra Marine Fishing Regulation Act 1981, Government of Maharashtra

iv. The Orissa Marine Fishing Regulation Act 981 (Orissa Act 10 of 1982) and the Orissa Marine Fishing Regulation Rules 1983

v. The Tamil Nadu Marine Fishing Regulation Rules 1983

vi. The Karnataka Marine Fishing Regulation Act, 1986

vii. The Andhra Pradesh Marine Fishing Regulation Act, 1994 xxi. Lakshadweep Marine Fishing Regulation Act, 2000

viii. The Gujarat Fisheries Act, 2003

ix. Andaman and Nicobar Marine Fishing Regulation Act, 2003

Chapter- 6

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in Pakistan

Rehana Kausar

Senior Scientific Officer, Aquaculture and Fisheries Program, NARC, PARC, Pakistan
E-mail: rehanatiwana@gmail.com

Abstract

Fisheries as a growing sector has huge potential in the economic growth and nutritional security of people in Pakistan. However, there are a lot of challenges in augmenting the fish production from the marine, coastal, inland, freshwater and cold-water fisheries in the country. Potential avenues can be harnessed with the support of the various organizations and the formal and informal network already available in the country. A brief description on how each sector can contribute in the development of this sector in Pakistan is presented in this chapter. The possible thematic areas related to aquaculture and fisheries with a possible learning from all cross-disciplinary areas have been imbibed in developing this status paper. Few guidelines in this direction are also provided which can benefit the general policy planning and stakeholders.

Keywords: inter-disciplinary, fish, Pakistan, networks

1. Introduction

1.1 Location of Pakistan in south Asia

Pakistan is located between 23°42′ and 36°55′N, and 60°45′ and 75°20′W in the South Asia. It has a coastline of about 1100 km stretching from the borders with India on the east to the border with Iran to the south-west and the Arabian Sea to the south. The continental shelf averages 50,270 km in width and is generally wider in the south-eastern portion (Sindh) and narrower in the north-west (Balochistan).

1.2 Fishery and aquaculture in Pakistan

Pakistan is an agricultural country with abundant natural water resources. Freshwater and marine water are the primary resource for aquaculture. Rivers, lakes, ponds, and water dwelling places cover an area of roughly 8,563,820 km^2 (Jarwar, 2008) They are considered aquaculture-friendly and serve as a foundation for future aquaculture growth. With a 1120 km coastline, there is a lot of potential for coastal fisheries. Furthermore, Pakistan controls a 350-

nautical-mile-long open sea Despite these huge aquaculture resources, the fisheries industry has not improved significantly. The main issue is aquaculture practise. Only freshwater aquaculture methods have been developed and utilized while the coastal and deep-water marine sources are still not utilized for aquaculture. As a result, we are dependent totally on the natural availability of fish. The aquaculture farming system's production is expected to be between 179,900 and 600,000 metric tonnes, depending on the natural catch (Minfal,2012). Aquaculture contributes 1% to Gross Domestic Product (Nazir., et al., 2016). Because of limited culture, the majority of the contribution comes from catch fisheries. Fisheries are essential for Pakistan's national economy since they contribute considerably to employment, income, and food production (PBS, 2017). Aquaculture is often conducted on a limited scale in locations where the soil is unsuitable for agricultural purposes. Through the Department of Fisheries and donor-funded initiatives, the government has recently focused on aquaculture development

1.2.1. Aquatic resources

(a) Marine resources

The Exclusive Economic Zone (EEZ) was established in 1976, providing the country with a fishing region of roughly 1,96,600 (Laghari, 2018) km^2 in addition, in 2015, the EEZ was expanded by 150 nautical miles. The Arabian coastline Sea stretches for roughly 1,120 km between the coastlines of Sindh and Makran in Balochistan. The Makran coast is steep, rocky, and narrow, measuring 12 to 32 km in length. The Sindh coast, on the other hand, has a 40-120 km coast region that is largely flat and suitable for trawlable ground. There are a few islands along the coast of Pakistan. Because the coast protrudes into the sea in the form of capes and peninsulas. Hence, only a few sites, cut off into several small and large bays. The Indus River forms a vast estuary delta that provides excellent breeding grounds, refuge, and nurseries for shrimp, fish, and other marine species.

(b) Inland sources

Pakistan has a diverse irrigation system that includes lakes, rivers, and canals. The natural lakes have covered approximately 1,09,78 hectares (Laghari, 2018), High-altitude lakes suited for cold water fishing include Saif-ul-Mulook in the North West Frontier Province (NWFP), Satpara in Gilgit-Baltistan, and Hanna in Balochistan province. While Sindh contains a number of warm-water lakes, Manchar and Kalri are two of the largest and most popular. Sindh's Thatta, Larkana, and Sanghar districts have several tiny lakes. The Indus River and its tributaries are the country's primary sources of freshwater fisheries. The Indus River runs from the Northern Areas to the Arabian Sea, passing through the

NWFP and Punjab, Sindh, and ultimately to the Arabian Sea. The Indus River, which includes a number of dams and reservoirs, is one of the world's largest canal systems, delivering water to an enormous irrigation network across Punjab and Sindh provinces. This running and stagnant water cover about an area of 4.57 million hectares,while waterlogging covers an area of about 2.225 million hectares. Mangla, Tarbela, Chashma, Hab, Khanpur, and Warsak, on the other hand, are Pakistan's largest reservoirs, covering around 80,613 hectares and playing a significant role in freshwater fisheries. (Kausar, 2017). Along with this, the Potwar Plateau includes over a hundred tiny dams known as barani dams (rain-fed) with tremendous aquaculture potential. All of these resources aren't being put to good use when it comes to raising fish. As in the Pakistan aquaculture is fairly new activity and private sector has constructed dug-out fish farms. It is estimated about 13000 fish farms with an area of approximately 60,470 ha with Sindh having 49,170 ha, Punjab 10,500 ha, Khyber Pakhtunkhwa (KPK) 560 ha and the other provinces (Baluchistan, Jammu Kashmir (JK) and Northern Area (NA) 240 ha (Laghari, 2018) Unfortunately, aquaculture is characterized by low production per unit area due to low input.

1.2.2. Production system

Semi-intensive type of aquaculture system is commonly practiced in Pakistan. The fish farming based on mostly *Labeo rohita*, *Cirrhinus mrigala*, *Catla catla*, *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idellus*, and *Hypophthalmichthys nobilis* species. Some of these species, such as *Catl catla, Labeo rohita*, and *Cirrhinus mrigala*, command premium market prices due to customer preferences. While catfish, snakeheads, and tilapia aquaculture are still in the early stages of development. The Fisheries Development Board took a bold step in introducing tilapia and training farmers to improve tilapia cultivation and quality. Rainbow trout is a cold-water fish species (Salmo trutta and *Oncorhynchus mykiss*). Trout breeding and culture are becoming increasingly popular in Gilgit-Baldistan. However, the output is not great enough to demand of the country, and to export. The*tor tor*, snow trout, *Tenualosa ilisha*, *Lates calcalifer*, *Mystus seenghala* and *Rita rita*, can be grown in Pakistan that possess special significance.

Aquaculture has yet to achieve a substantial level of diversity, ranging from multi-species to mono-species cultivation, and from extensive to intense techniques. To enhance food security, the government is now supporting semi-intensive and intensive aquaculture methods, as well as communal water body cultivation, fish stocking in reservoirs, lakes, earthen ponds, tanks, and a little cemented or fibre glass tanks. . While local fish farmers need to be exposed to cage culture, pen culture, recirculatory aquaculture, intensive culture, and integrated aquaculture systems. As a result, such aquaculture should be

promoted as a priority in order to boost aquaculture production per unit area and improve the socioeconomic situation of fish farmers.

2. Networks supporting fisheries and aquaculture activities in Pakistan

2.1 Institutional setup and stakeholders' involvement

In Pakistan, aquaculture is a provincial responsibility. The Provincial Departments of Fisheries in Punjab, Khyber Pakhtunkhwa and Sindh are working actively towards the conservation and management of inland waters and the development of aquaculture in their respective provinces. In Baluchistan, the Provincial Departments of Fisheries is involved mainly in marine fisheries but also has a component responsible for inland fisheries. The fisheries departments in the northern areas are relatively small and mainly aimed at the management of the trout fisheries.

At the central level, fishery is overseen by the office of the Fisheries Development Commissioner (FDC) working under the Ministry of Food, Agriculture and Livestock (MINFAL). 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 MINFAL, 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 MINFAL. Some universities in the country are also involved in basic fisheries research such as University of Agriculture; Faisalabad, University of Veterinary and Animal Sciences Lahore, University of Sindh, Jamshoro, Center of Excellence of Marine Biology, University of Karachi, Quaid-e- Azam University, Islamabad, Bahaudin Zakaraya University, Multan, University of Peshawar, Peshawar, University of Punjab, Lahore and Government College University, Lahore.

2.2 Research Institutes supporting fisheries in the country

Research Institutes that support fisheries sector in Pakistan are Pakistan Agricultural Research Council**;** Fisheries Research Institute, Manawa, Lahore, Punjab Fisheries Department, Trout Multiplication Research Center, Gilgit**,** National Institute of Oceanography, Pakistan, and Center of Excellence for the Marine Biology these departments work for the betterment and solving problems related to fisheries.

2.3 Stakeholders' involvement

There shall be need for capacity building of stakeholders for; responsible fishing, fish processing, packaging and value addition, fishery waste utilization, energy conservation in fishing and fish processing, food safety and quality.

Provincial fisheries department as well as at central level institution and private sectors are the key stakeholders of the fishery sector development.

Main objectives of all these departments are;

- to promote and facilitate measures to improve the marketing and also to promote and facilitate producer-owned and controlled organizations for fish, shrimps, and marine food products within Pakistanand the export thereof, without indulging in such business.
- to promote, facilitate and support the development and dissemination of appropriate aquaculture technologies for smallholders in Pakistan, and to undertake capacity building of all stakeholders in the fisheries sector
- to promote and facilitate methods for improved aquaculture in order to ensure and enhance human nutrition through the promotion of locally produced fish and shrimps' products
- to promote aquaculture in Pakistan as primary vehicle for poverty alleviation amongst small and land-less farmers with special emphasis on the empowerment of women and to provide a platform for research and development.

3. Thematic networks for addressing regional and sub- regional challenges in aquaculture and fisheries

3.1 Management and regulatory agencies

Management and regulatory agencies such as Federal Ministry of Food Security and Research Division; Provincial Ministries for Fisheries, Pakistan Agricultural Research Council, Marine Fisheries Department, Fisheries Development Board, National Institute of Oceanography, Pakistan, Ministry of Environment, Ministry of Ports and Shipping, Ministry of commerce, Punjab Fisheries Department, KPK Fisheries Department, Baluchistan Fisheries Department, Sindh Fisheries Department, Northern Areas Fisheries Department, AJK Fisheries Department and respective research institutes work to control irregular fishing, and facilitate to promote fisheries in the region and mitigate the emerging problems and find best solution for existing and upcoming problems.

4. Role of cross-learning application, to facilitate fisheries and aquaculture in Pakistan

Food security has become a significant problem as the world's population grows, resulting in poverty and unemployment. According to, United Nations data Pakistan's current population is 219,511,630 people, or 2.83 percent of the world's total population. As the world's population grows, so does the demand for protein. This situation is dangerous and has raised serious concerns among government and other groups. According to Pakistan's Economic Survey (2018-2019), agricultural contributes 18.5 percent of the country's GDP, with livestock accounting for 60.54 percent of agriculture and 11.22 percent of GDP. The agriculture sector's performance remained weak in the previous decade due to low fodder crop productivity. For food security, it is critical to improve agriculture productivity through improving per acre yield. Agriculture, cattle, and fisheries all have significant production potential in Pakistan, so their development is critical for economic growth and prosperity. As we are facing food security issues, we must seek for alternate protein sources to fulfil the protein demands of an ever-increasing population. Aquaculture is a very feasible technique of producing food (protein) that is more efficient than production of cattle, pork, pigs, or chickens. Protein shortage in humans can cause a variety of issues such as malnutrition, frailty, and increased infant mortality. Increasing in fish production can mitigate the problem. Fish is an animal protein source that also offers important nutrients and helps to prevent eye, bone, brain, liver, and kidney issues. As a result, increased fish consumption is both a viable replacement for food security and an excellent supply of animal protein. Fish is a supplementary source of protein in Pakistan. Fish is the most common water protein, accounting for 7% of total protein and 80% of animal protein intake. Pakistan has an extremely low yearly fish intake of 1.9 kilograms per capita, compared to 20 kilograms in advanced countries. Fish production in Pakistan from natural catch is about 600,000 metric tonnes, whereas aquaculture produces 179,900 metric tonnes. Aquaculture accounts for 1% of the gross domestic product (GDP). Because of the scarcity of culture, capture fisheries play a significant role. Fish prices are rising as a result of greater input and less production, as well as rising population demand. It is paramount important that all water resources in Pakistan should be effectively exploited for optimum aquaculture production in order to overcome the food security emerging issue and full fill the demand of protein scarcity in region and water diversion should be done in rivers and canals so that a regulated amount of water may be sent to a pond and then returned to the river to increase fish production. Pockets should be created in lengthy rivers, channels, and canals to allow for effective water use. Aquaculture production should be carried out in all reservoirs, lakes, earthen ponds, and tanks.

5. Major challenges for fisheries sector in Pakistan

Aquaculture sector is developing in Pakistan, but the development pace does not match with the potential. Numerous factors restrain the aquaculture development such as: lack of coordination among institutions including Government; non-governmental organizations, Research, institutes, Universities, shortage of national and international research projects as well as limited human resources, especially in the areas of production system, fish nutrition, fish diseases and fish genetics. There is inadequate technical support services to fish farmers such as training packages and materials including with inadequate capacity, limited budget for basic research and development projects and insufficient scientific awareness to design aquaculture research and development projects. There is also improper fishery policy and guidelines for the developing aquaculture and expensive commercially produced seed and lack of quality fish seed; less interest of private sector, highest per unit cost due to improper management of production units.

5.1 Environmental issues

Water pollution from oil spills at the ports and harbors; household and industrial waste; and effluents and agricultural run-off polluting the water resources are serious environmental issues impacting aquacultural development in Pakistan. 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, and agricultural run-off, which used to spill into inland lakes in the past (Manchar, Haleji, Dhabeji), but now being diverted to the lower Sindh coast have been the main threats to the marine environment. Due to growing pollution, degradation, and habitat loss,fish population is significantly is declining in the ocean. Water abstraction, drainage of wetlands, dam construction, pollution and eutrophication have also contributed to 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 localized 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. Other factors such as shipping; overfishing, coastal development, tourism, and industrialization have severely affected the marine life along the Karachi port. It also affects the sea birds, sea mammals, causes different diseases to different fishes and shell fishes, and can affect human beings if they eat those fishes.

5.2 Social issues

The fishing industry in Pakistan is a direct descendant of the fishermen that have been fishing in these waters for hundreds of years. Karachi began to emerge as a major center for fishing and fisheries in 1945 when the Fisherman's Cooperative Society (FCS) was formed to look after the welfare of the fishermen that were fishing in Sindh coastal waters and landing their catch in Karachi. Traditional fishing methods are using by farmers so there is need to improve literacy, vocational training, and other educational programs in fishing communities. There is need to develop different fisheries training centres in different regions to train the manpower with aquaculture-related subjects including primary and secondary curricula in areas of high fisheries production potential, or where livelihoods depend strongly on the sector. There is need to support alternative or complementary livelihood activities in fishing communities through increasing access to credit and savings schemes and the provision of micro-finance initiatives. There is need to promote the participation of women, and aware them with benefit from their involvement, in aquaculture, post-harvest and other livelihood activities. Only research program of PARC exists for aquaculture sector and that too is limited due to human resources constraints. 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. This deficiency in research system reflects the level of low priority which has been given to the sector in the past.

5.3 Planning issues

The Poverty Reduction Strategy Paper (PRSP) of Pakistan, emphasizes the significant role of the fisheries sector in the national economy and for food security of the country. The PRSP proposes to address the issue of rural poverty through the accelerated distribution of state-owned land to small farmers, which is of importance to aquaculture development as land availability is an important constraint. Eighty one percent of the farmers have less than 5 hectares available for their activities. During the Pakistan Development Forum 2005 held on April 26th of the same year, the fisheries sector was highlighted several times. In the same forum, fisheries was identified under the SME (small and medium enterprises) sector Phase II development and shrimp farming was declared as one of the major activity under the Value Chain Progress during a presentation at the Pakistan Development Forum 2005. All the above indicate the strong interest and willingness of the government to support the development and enhancement of fisheries and aquaculture sectors.Government of Pakistan (GOP) has now adequate attention to the fisheries and aquaculture sector, it deserves.

5.4 Management issues

The main managerial issues of the aquaculture sector include lack of Brackish water aquaculture, Lack of diversification in species and systems, only limited number of fish species are under cultivation since very long time. High input cost 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. No commercial fish feeds are currently being produced in Pakistan; however, some experimental feeds have been prepared and utilized very effectively.

5.5 Issues related to export of aquaculture products

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 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. 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.

6. Conclusion

There is an increasing awareness among fish consumers about environmental protection, food safety, and social equity issues in Pakistan and abroad. Therefore, it is important to introduce environment friendly and cost-effective technologies, food safety standards and decent work environments in the fisheries and acquaculture sector. Assessment of the climate change impacts and increasing the capacity of farmers to adapt to climate change and develop policy initiatives which help in adaptation and mitigation of negative impacts are also equally important. Promoting species diversification, infrastructure development, and enhancing fish production and productivity in natural waterbodies are some other policy issues that Pakistan need to urgently address.

7. Recommendations

- Strategy to develop fisheries sector includes development of responsible fishing systems for inland and marine capture fisheries incorporating principles of by catch 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.
- There shall be investment by both the public and private sector in aquaculture development at both small scale and commercial/industrial levels

References

Agriculture Organization of the United Nations. Fisheries Department. (1997). *Aquaculture development* (Vol. 5). Food & Agriculture Org.

Chandio, J. (2014). Crisis of federalism in Pakistan: Issues and challenges. *Federalism in Asia and beyond The Wildbad Kreuth Federalism Days 2012*, 119.

Jarwar, A. A. (2008). A status overview of fisheries and aquaculture development in Pakistan with context to other Asian countries. *Aquaculture Asia*, *13*(2), 13-18.

Kausar, R. (2017). Best management practices in aquaculture in pakistan. *Best Management Practices in Aquaculture*, *69*.

Laghari, M. Y. (2018). Aquaculture in Pakistan: Challenges and opportunities. *International Journal of Fisheries and Aquatic Studies*, *6*(2), 56-59.

Minfal, P. K. (2012). Ministry of Food Agriculture and Livestock Pakistan. *Website http://www. minfal. gov. pk*.

Nazir, K., Yongtong, M., Hussain, K., Kalhoro, M. A., Kartika, S., & Mohsin, M. (2016). A study on the assessment of fisheries resources in Pakistan and its potential to support marine economy.

Pauly, D., & Froese, R. (2012). Comments on FAO's State of Fisheries and Aquaculture, or 'SOFIA 2010'. *Marine Policy*, *36*(3), 746-752.

PBS. Pakistan Bureau of Statistics, Government of Pakistan. http://www.pbs.gov.pk/. 2017.

Subasinghe, R. P. (2003). An outlook for aquaculture development: major issues, opportunities and challenges. *Review of the State of World Aquaculture, Rome Italy: FAO*.

http://www.minfal.gov.pk/, 2012. FAO. National Aquaculture Sector Overview: Pakistan. Fisheries and Aquaculture Department. 2017. Das, H. 2018. Aquaculture: A new trend and a big opportunity in Sindh, Pakistan. Journal of Aquaculture. 22: 26-27.

Chapter- 7

Cross-learning for Addressing Emergent Challenges of Aquaculture and Fisheries in Sri Lanka

Asoka J. M. and **Kalyani Hewapathirana**

Director, Coastal Aquaculture Development,
National Aquaculture Development Authority of Sri Lanka
Director Fishing Operation Department of Fisheries and Aquatic Resources, Sri Lanka

Abstract

Island nations seems to have a natural way of getting into fishery and related activities by virtue of their vicinity to the marine and coastal resources. But often there are various challenges encountered while managing the fishery and its resources. There are various multi-disciplinary efforts to be considered while effectively regulating the fishery in the islands. In this chapter we are looking into the networks and organizations and major thematic areas to be addressed for improving fishing in the islands. We have introduced the general fishery and related activities in the country by providing the fisheries profile and went on discussing the resources and opportunities we have while probing into various gaps to be addressed in sorting-out the challenges we face in the country.

Keywords: Island, fish, management, opportunities, inter-disciplinary

1. Introduction/ Background

Sri Lanka is surrounded with warm and nutritious marine waters nourished with many rivers originated from mid of the country, has an extensive coast-line with brackish water lagoons and inland fresh water lakes and reservoirs, gives the wealth of fishery resources to the island providing opportunities for both marine capture fisheries and aquaculture.

The fisheries sector Contribute to 1.3 percent of the GDP of Sri Lanka and provides 70 percent of the animal protein intake in the country. Despite contribution to the food security of the population, the sector provides about 540,000 direct and indirect employment opportunities. Further, it plays a major role in foreign exchange earnings to the country. Being an island Sri Lanka has dense populations in the coastal belt and around 2 million people directly engage in fisheries and aquaculture and related occupations.

The marine fisheries of Sri Lanka mainly conducted as capture fisheries in lagoons, coastal waters, offshore and High seas while the culture-based fisheries

are being conducted in the lagoons in pens, constructed ponds in shore areas and inland manmade ponds, and in perennial fresh water reservoirs.

Annual Fish Production in Sri Lanka (2019)

Sector	Production)Mt)
Marine Sector	**415,490**
• Coastal waters	242,580
• Offshore / High Seas	172,910
Inland and Aquaculture Sector	**90,340**
• Inland Capture Fisheries	73,230
• Aquaculture Fisheries	10,710
• Shrimp Farms	6,400
Total Production	**505,830**

2. Regional and sub regional challenges in Fisheries and Aquaculture.

In marine capture fisheries regional and sub regional challenges are twofold.

Type 1- Beyond national jurisdictions regional and sub regional challenges

Type 2- Within national jurisdiction (Domestic) regional and sub regional challenges.

Sri Lanka's high seas fisheries sector has mainly engaged in tuna and tuna like species and mostly operated in offshore areas and high seas. Therefore, marine capture fisheries in Sri Lanka is being highly affected by type 1 challenges as stated above. Those include resource depletion due to over fishing, by catch and catching of juveniles, use of non-selective and harmful gears, marine pollution, effects of climatic change (sea temperature rise, ocean acidification, coral bleaching),territorial issues, marketing issues, illegal, unreported/unregulated fishing, increased fuel prices, unsatisfactory cost and benefit, global pandemics and disproportionate burden etc. Sri Lanka cannot overcome such issues individually. Therefore Sri Lanka has become a party to number of the formal network of global, regional and sub regional corporations.

Though nations are separated in political territories and the jurisdictions of oceans demarcated, the fast-moving marine fish, does not restrict to any demarcated area. The markets for the fish are all over the world and subjected to trade agreements and conditions. These factors further emphasize the need of multinational regional corporation to overcome the issues and challenges.

Most of the fisheries and aquaculture rights, their control, conservation and management measures are governed under a common umbrella of UN conventions and the Agreements of FAO at global level. It is important to become

a party to, such international organizations and the regional and sub regional organizations to strengthen the conservation, management, development and regulatory measures and to resolve the issues and challenges in a collaborative manner.

These organizations provide a platform to discuss and adopt measures for better management of resources, to share the knowledge of technical knowhow for the betterment of the industry.

Moreover, Sri Lanka considers being a party to global, regional sub regional organization is also a cross learning opportunity to gain better understanding on stock status for planning of the fisheries industry, gain the knowledge on new technologies and build up bilateral and multilateral relations leading to enhance the productivity of fisheries and aquaculture sector and market relations. Further it helps to take precautionary and timely actions preventing any unexpected damages safeguarding the entrepreneurs in the sector.

Regional multinational organizations which Sri Lanka is a party

Indian Ocean Tuna Commission (IOTC)

Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC)

Bay of Bengal Project (BOBP IGO)

Network of Aquaculture Centers in Asia-Pacific (NACA)

International Fund for Agricultural Development (IFAD)

International Maritime Organization (IMO)

Asian Development Bank (ADB)

South Asia Co-operative Environment Programme (SACEP)

South Asian Association for Regional cooperation (SAARC)

Indian Ocean Rim Association (IORA)

United Nations (UN)

Food and Agricultural Organization (FAO)

International Organization for Standardization (ISO)

International Labour Organization (ILO)

World Meteorological Organization (WMO)

The type 2 challenges are comparatively less in marine fisheries compare to aquaculture. Sri Lanka's marine fisheries is highly diversified. It is a multi-species, multi gear and multi-zonal fishery within national jurisdiction. In addition it is highly seasonal depending on the monsoon pattern. Therefore in addition to the challenges mentioned type 1 above it has challenges such as

disputes among different gear users, native fishers and migratory fishers those travel from monsoon area to non- monsoon areas, and among the fishers those violate the spatial and temporal conditions. In the near coastal continental waters the resource have been depleted and catch per unit effort has become law. In shore arras user conflicts take place among the hoteliers tourist industry people, recreational facilities and industries and aquaculture and other development activities. However, implementation of integrated development plans, stakeholders consultations, are being carried out minimizing the conflicts and ensuring the sustainable resource use. Yet there have been issues due to lack of overall coordination and the compromise.

Aquaculture is highly affected by the effects of global climatic change such as long-lasting draughts, change of weather patterns, floods, shifting of rain fall patterns, salinity changes, spreading of exotic aquatic plants and organisms, and emergence of new strains of pathogens and diseases. Therefore. It is important to keep records, collect data and conduct research covering vast geographic areas to do predictions and prepare future plans, resolve the issues of the industry working in collaboration with multinational organizations such as NACA, SACEP and INFOFISH. Lack of recorded historical data and less research work are the great challenges to the industry.

The aquaculture sector of Sri Lanka faces many disruptions due to lack of cross learning among different government Departments such as Land registry, Wildlife, Irrigation, Forest, Environment, Archeology, private institutes, general public, environmentalists, NGOs, individual land owners and water users from a common water bodies.

Moreover, other than the user conflicts the feed price, high operational cost, high electricity charges, spreading of pathogen and diseases, lack of pathogen free brood stock and resistant varieties, unsatisfactory cost and benefit, violation of crop calendar, global pandemics are challenges in the industry where cross learning becomes very important.

Under the 13th amendment of the constitution of Sri Lanka fisheries is a devolved subject and regionally control by the Provincial Counsel in some parts of the country. Therefore, it is essential to get the concurrence of Provincial Counsels to implement the decisions arrived by the Central Government. It is a challenge in the occasions of when does amendment and passing of new Act on fisheries and at the stage of getting the approvals for the large-scale fisheries projects etc, which make delays to the process.

3. Governance instruments and private sector interventions supporting fishers in the country.

Ministry of Fisheries is the apex organization in Sri Lanka for the development of fisheries sector. The Ministry directly engages implementation of the national policy and programs on fisheries and aquaculture. It prepares strategies and plans on sustainable utilization of fisheries resources in Sri Lanka. Different organizations have been established under the Ministry to implement the national policy and the sectoral policies formulated by the Ministry. Ministry is responsible for the administration of marine fisheries sector in the Exclusive Economic Zone (EEZ) of 517,000 square kilometers and 489,000 hectares of the brackish & freshwater fisheries sectors. The Ministry of Fisheries has 6 institutions functioning under its purview, and mobilizes their resources human, physical and financial to achieve the targets spelt out in the Fisheries Sector Development Plan.

3.1 Institutions under the purview of the Ministry of Fisheries Sri Lanka and their functions.

Department of Fisheries and Aquatic Resources ((DFAR)

Implement Fisheries and Aquatic Resources Act No. 02 1996 for Conservation, Management, Development and regulation of marine fisheries

The DFAR Head office has seven divisions: Fisheries Management, Development, Quality Control, Operation, Information Technology, Training, and Investigation, Administration and Finance Division. DFAR has island wide administration network covering all 15 coastal districts controlled by an Assistant director and further divided into 133 Fisheries Inspector divisions. 20 harbor monitoring centers have been established at fishery designated fishery harbours. The Monitoring control and surveillance is conducted 24/7 basis at FMC in Head office and 21 radio communication centers over the island with the assistance of Navy, Marine Police and the Coast Guard officials. The distress situations at sea are being attended through the communications of Marine Rescue Coordinating Centers (MRCC) of the region.

National Aquaculture Development Authority (NAQDA)

Implement National Aquaculture Development Authority Act, No. 53 of 1998 for development of inland fisheries and aquaculture

NAQDA contribute to the improvement of the socio-economic conditions and food security of rural societies through alleviation of poverty by increasing freshwater and brackish water fish production and introducing new technologies for utilization of aquatic resources for small, medium and large

scale enterprise development. NAQDA has 12 district level aquaculture extension centers, freshwater and brackish water aquaculture development and training centers and ornamental fish breeding and training center. An Ornamental fish and aquatic plant accessories and information center has been facilitating the entrepreneurs.

National Aquatic Resources Research and Development Agency ((NARA)

Implement NARA, Act, No. 54 of 1981 to conduct Scientific Research & Development

NARA is the national institute conducting research and development in the field of fisheries and also provides services for development and sustainable utilization of living and non-living aquatic resource. The institute has separate divisions to conduct research on Inland Aquatic Resources, Marine Biological Resources, Socio-Economic & Marketing, Fishing Technology, Environmental Studies, Post-Harvest Technology, Oceanography & Marine Sciences, National Hydrography, and Monitoring and Evaluation Division. It has six Regional Research Centers at district level in the country.

Ceylon Fishery Harbours Corporation :(CFHC)

Management and development of harbours

CFHC provide facilities and services together with supporting infrastructure for anchoring, landing, auctioning and whole sale of fish. CFHC has recently adopted a development plan, which is in line with the Sri Lanka's overall development plan and on par with other prominent fishing-oriented countries in the region.

Ceylon Fisheries Corporation (CFC)

Marketing arm

CFC fulfill its duties and responsibilities towards the general public by assuring quality fish at an affordable price available at stalls throughout the island. The pricing policy of Ceylon Fisheries Corporation was determined in order to ensure affordable prices to consumers ensuring the food security. Further CFC purchase fish from fishermen for reasonable price at the point of landing and on shores without the involvement of intermediators. CFC purchase fish from the fishers whenever they have face issues on of marketing of their fish production.

Cey-nor Foundation

Supply of inputs (gear and craft)

The key activity of Cey-Nor is constructing high-quality fiber vessels at competitive rates. The company also offers a vast range of fishing nets and allied products associated with the fishing industry to its customers.

The formal fisheries governance system has facilitated the cross learning of fisheries and aquaculture by bringing the regulatory, research, marketing, operational and service providing institutes under the purview of a single ministry. However with regard to the aquaculture many disrupting factors arise at operational level among Govt. Departments, private sector organizations, general public and , individuals.

3.2 Existing physical network

Significant amount of physical network is within the Government administrative system. The office spaces, harbors, research stations and laboratories, training center, markets etc. are already in place however these need improvements and upgrading with the new technologies available in the world. In addition, the private sector also provides physical support for the industry which discussed extensively under the point 3.6 of this report.

3.3 Existing digital network.

Electronic tools such as computers, tabs and smart phones and the systems of application, devices and resources that generate, store and process data are very useful to facilitate fisheries industry. These systems are being now extensively used in the fisheries sector in Sri Lanka.

Existing of satellite-based vessel monitoring system at DFAR to monitor offshore and high seas fishing, fishing ground forecasting system at NARA, weather forecasting system at Meteorological Department and their networking with the private and public telecommunication systems is very useful for the industry. However, the major challenge is that lack of data transmission towers covering whole areas of the country.

All institutions under Ministry are digitalized and systems apply for the betterment of the sector. Organization websites, online applications, social media, are being used to advertising, massaging, instructing, training, to accept applications, issuance of licenses, registration, information sharing, data reporting, marketing etc. Further maintenance of updated data bases on vessel registration, production levels and research data improves and make efficient the management process. Most institutions have been restructured by incorporating Information and Technology (IT) division to have institutional

digital networking connecting the district level offices to the head office. As a result, the fisheries sector in Sri Lanka has been able to conduct office duties online during the global pandemic situation.

However, Sri Lanka is ranked among the countries with the poorest internet quality in in the world. The internet coverage is not equal all over the island. Therefore, this has to be rectified to improve smooth functioning of the line agencies at regional and sub regional levels giving good cross learning ability.

3.4 Existing educational and academic network

Fisheries sector needs professionals, from the streams of science, economy, law, technology, and sociology backgrounds related to the industry. The educational system is not fully addressing this issue. The human resource component in the fisheries sector is high but well trained and knowledgeable fishermen in marine and aquaculture sector is less in number. The opportunities and infrastructure for study and learning of fisheries in the country are as follows.

National Institute of Fisheries and Nautical Engineering (NIFNE) provide basic education to graduate and post graduate level targeted for the fishermen and fisherwomen who are directly engaged in fishing operations. NIFNE Offers number of vocational training courses to cater the requirement of fishermen with low entry requirements promising factor to encourage the fishermen to attend. These courses differ in nature and primarily focus on the technical knowledge of deep-sea operations and maintenance of boats and include aquaculture, especially ornamental fish farming and inland aquaculture. NARA and NAQDA also conduct educational certificate courses with practical training on inland fisheries and aquaculture. The major issue is the changing of the attitudes of the people.

The universities provide undergraduate and post graduate education on course modules in fisheries and aquaculture. Six major universities under the government conduct these programs. NIFNE is also comes under University Grant Commission and starts the courses from basic level.

Other than the government institutes very few private educational institutes conduct educational programs for fisheries.The Colombo International Nautical Engineering College (CINEC) is one of the private institutes that conducts courses related to marine fisheries. The Government Technical Colleges and Sri Lanka Navy also conduct training program to marine fishers on nautical engineering and boat repairs.

Dissemination of knowledge is in poor condition except for the scientific journals published by universities, NARA and the Science Foundation of Sri Lanka. The

mass media and social media is less used to aware people on importance of the fisheries, fish farming and nutritional value of fish.

3.5 The private sector network

The private sector provides the necessities and accessories for the industry. Ice production, manufacture of fishing boats (Boat yards), Feed suppliers, Laboratories (PCR testing, fish Quality, water quality test, residual monitoring), provision of Navigational equipment's, Gears, Spare parts are mainly provided by the private sector.

3.6 Co-operative network

There are civil organizations such as fisher associations and industry related associations those work for the benefit of the fishers. These are very important at the field level to resolve the regional and sub regional issues in fisheries. Few examples of such organizations are;

- The National Fisheries Federation of Sri Lanka- ensure the rights of Fishers
- Small scale Fishers Federation (Sudeesa) - conducts advocacy, economic, social and educational programmes to strengthen and empower communities in self-reliance.
- National Fisheries Solidarity Movement-, organizes fishermen to lobby the government to defend their rights and to bring about good environmental practice in coastal areas
- Multiday Fisheries Boat Owners Organization
- Sri Lanka Aquaculture Development Alliance (SLADA)
- Divers Association
- Beach Seine Fisher Association
- Sri Lanka Association for Fisheries and Aquatic Resources (SLAFAR)
- Scientific experts Association, Forum for conduct Research on fisheries and publication.
- Sri Lankan Association for Fisheries and Aquatic Resources (SLAFAR) is a non-profit association
- Shrimp Breeders Association (SBA) and Shrimp Armer Organizations
- Management Committees
- Co-management Committees
- The Seafood Exporters' Association of Sri Lanka (SEASL) promote the interests of companies engaged in the export of seafood products from Sri Lanka

- Fisheries Improvement Projects (FIP) - improving Sri Lankan fisheries, towards achieving sustainable exploitation of marine resources. currently work on crab net fishery and longline fishery.

Other than the above there are number of informal networks operated in Sri Lanka in the forms of INGOs and NGOs , assisting in numerous ways for the sustainable development of fisheries and facilitating the cross learning.

4. Case studies on cross-learning applications that improved fisheries and aquaculture in the country

4.1 How Fish consumption become better emerging thoughts of food security in the aspects of health conditions

There is a rising trend of incidents of non-communicable diseases such as diabetes, heart diseases, blood pressure, stroke, eyesight loss, anemia, malnutrition and obesity, overweight, and arthritis in Sri Lanka. According to the health sources the main factor for these diseases is the unhealthy dietary habits. The staple food in Sri Lanka is rice served with curries prepared using coconut milk and the breakfast, and dinner mostly made of wheat or rice floor with lot of carbohydrate. The doctors in Sri Lanka advise people to take less starch, less sugar and less fatty food. And instruct to eat more vegetables and fish instead to prevent health risks.

Fish is considered as a unique source of protein and long chain polyunsaturated fatty acids. However, fish consumption in Sri Lanka is determined by the availability of fish, price and socio-demography of fish consumers. The fish supply to the mid country is very poor. The choice of fish in the market were determined by various factors such as taste, smell, appearance nutrition, availability price and health, quality etc. Consumers pay more attention on quality and then the price, taste and nutritional values.

Therefore, coordination with the health sector is very important to encourage people to consume fish and it is essential from the fisheries sector to make fish available every corner of the country for reasonable price and with promotions of consumer preference. This new area of cross learning is very important to the country to safeguard the health conditions of the people and to bring the importance of fish farming at large medium and small scale levels in all parts of the country.

The survey conducted on the UNLOCKED POTENTIAL OF INLAND FISH TO CONTRIBUTE TO IMPROVE NUTRITION IN SRI LANKA Saman Athauda and Jeevika Weerahewa, Faculty of Agriculture, University of Peradeniya and published at FAO reveals that, protein-energy malnutrition and micro-nutrient deficiencies are important public health issues in Sri Lanka. According to the

2016 Demographic & Health Survey, the prevalence of wasting among children under 5 years of age is alarmingly high at 15.1 percent in comparison to the regional prevalence of wasting in Asia of 9.7 percent. The National Micronutrient Survey conducted in 2012 revealed that 15.1 percent of children under 5 years of age were anemic. Sectoral disparities exist with the prevalence of anemia in rural areas significantly higher than the national average, with rates of up to 26.9 percent. This national survey also revealed that roughly one third of Sri Lankan women suffer from anemia, with the prevalence of anemia rising to 35.4 percent among pregnant women and 32.5 percent among non-pregnant women. In addition, zinc, vitamin A and calcium deficiencies are prevalent, particularly in several poorer rural regions across the country. Fish are not only a source of proteins and healthy fats; they also provide a unique source of essential nutrients including long-chain omega-3 fatty acids, iodine, vitamin D and calcium. Fish plays a crucial role in nutrition and thus, promoting fish in the diet is among the strategies to alleviate protein-energy malnutrition and micro-nutrient deficiencies. This policy brief discusses the potential of introducing more inland fish to the diets of Sri Lankans, particularly vulnerable groups

4.2 Uplifting of the Shrimp Aquaculture industry in Sri Lanka

Brackish water shrimp farming has been the most lucrative commercial aquaculture activity in Sri Lanka since it started in the mid-1980s. Although the industry initially emerged in the Eastern Province (Batticaloa district), it collapsed due to civil disturbances in the area. Subsequently, the industry saw a revival in North Western Province (NWP) during the 1980s resulting in a rapid growth in both farm extent and foreign exchange earnings. As a result, North Western coastal belt became the hub of the shrimp farming industry in Sri Lanka. By the end of 1999, an estimated total of 1300 prawn farms covering an area of 4,500ha and 80 hatcheries with an annual capacity of 750 million post larvae had developed in the area. The industry recorded its peak economic performances in the year 2000 by earning Mn.US $69.4 worth of foreign exchange for the total exported volume of 4855 MT. Sri Lankan exporters have enjoyed a good market for their product over the past. Japan, U.S and EU countries are the most important markets for Sri Lankan shrimps.

The shrimp industry in NWP has been affected by the outbreak of diseases severely in year 2004. Several diseases have been reported time to time, among which three viral diseases; Yellow Head Disease, White Spot Disease (SEMBV) and MBV type virus disease, caused major economic damages to the industry. The damage caused by diseases left certain operators virtually helpless, with serious liquidity problems. Problems worsened due to the fact that a majority of the farms depended on the Dutch Canal as the common source of the supply of water. The water intake and discharge was carried out using the same canal

connecting 03 lagoons Chilaw, Mundal and Puttalam, constructed in the 17th Century. Due to this reason, pollution or diseases occurring in one farm spread rapidly to other farms through this common source of water. It was understood that this type of farming can create negative impact to the environment, especially deterioration of water quality in Dutch Canal was affected to create positive environment to the spread of White Spot disease. National Aquatic Resources Research and Development Agency is the research arm of Ministry of Fisheries & Aquatic Resources Development, has estimated that area of 2,000ha. per year can be used for the sustainable farming according the quality and quantity of water in the Dutch canal.

The National Aquaculture Development Authority (NAQDA) is expected to play a major role in this development and a Shrimp Farms Monitoring Unit has already been established to oversee the development of the shrimp aquaculture in a regularized and sustainable manner. The core idea behind this policy is to improve the industry by developing a viable partnership between private and public sectors, which is mutually beneficial. While the private sector is encouraged to take the lead role in the business by investing their resources and using their entrepreneurial skills, government is expected to facilitate their effort by mobilizing the necessary resources and ensuring sustainable utilization of them over long run in a nature friendly manner.

The shrimp production of the country came down to 1570MTs in 2005 due to poor management of health of the shrimp aquaculture industry and it was a severe setback to the industry. Therefore, it was imperative to find a solution to sustain shrimp farming through prevention of haphazard stocking and also to carry out shrimp farming based on the carrying capacity of the Dutch Canal with minimizing disease risk and optimizing the shrimp production in suitable areas. To reach this objective, concept of a crop calender and zoning was introduced. Crop calendar is not a new concept for Sri Lanka and it is already implemented in paddy farming. The paddy farming area is determined according to the carrying capacity of the irrigation reservoirs in the dry zone . Crop calendar of shrimp farming in NWP is formulated in consultation with relevant stakeholders such as farmer organizations, Shrimp Breeders Organizations, National Aquatic Resources Research and Development Agency, Department of Fisheries & Aquatic Resources, National Aquaculture Development Authority of Sri Lanka etc. In each year two calendars are formulated, for two halves of the year. When zoning the shrimp farming technical, scientific, social & geographical information are gathered and considered. Special attention is given to following areas.

1. Rainfall patterns in Yala, Maha seasons.

2. Geographical and ecological features, help to mitigate spread of White Spot disease and also other related factors which could improve productivity of the farming in the areas of zoning.
3. Variation of the water quality parameters in main water source. (Dutch Canal)
4. Shrimp Post Larvae production and variation of the post larvae quality during the year.
5. Temperature of shrimp farming area.
6. Implementation of best management practices in respect of the zones.
7. Trends of spreading of White Spot disease in the shrimp farming area.

Based on the above factors shrimp farming area was divided in to 36 zones keeping in mind the need for minimizing the spreading of White Spot disease and also to enhance the productivity of farming in the respective zones.

Three crop cycles are also formulated per year based on two major monsoonal rain periods as rains have an impact on salinity and other water quality parameters of the Dutch Canal.

1.	Pera Yala	March 01st – Sep. 15th
2.	Post Yala	May 01 – October 31st
3.	Maha Yala	Sep. 15th – March 15th of the next year

Other water quality parameters also considered when identifying the crop cycle of each sub zones. For example, period of low temperature in the year is more favourable for spread of White Spot disease. Therefore, minimum number of shrimp farmers is allowed to farm during this period. High risk periods, for infection of White Spot disease in respect of all the zones have been identified. Farming was allowed in each zone to avoid high risk periods. High risk period categorized on the factors depending on the water quality parameters, which are favorable for infection of White Spot disease. Turbidity of the water is also an important factor considered during dry season. In the rainy season the fluctuation of water quality such as pH, salinity and the temperature are taken into account. Though some zones were suitable in respect of water quality especially salinity of the water source due to the rain, thermal decline could take place during this period. The farmers of the zone were asked to follow the best shrimp farming practices very strictly and no deviations were allowed. Each sub zone has a Farmer Association. All information in respect to these sub zones are collected by respective Farmer Association. eg. Post Larvae requirements of the farming area in sub zones are brought to stakeholders consultative meeting for the formulation of crop calendar by the representative of Farmer Association. After formulating the crop calendar it has to be tabled at the advisory committee to the shrimp industry, which composed of government officers, researchers, policy makers and Farmer Association representative. When formulating the

crop calendar for the next culture cycle the experience obtained from the implementation of the calendar in the previous culture cycle were taken in to consideration.

Shrimp production and the shrimp farming area were gradually increased due to implementation of the crop calendar. With the implementation of crop calendar it is realized that crop calendar is one of the strategies for Eco-system approaches to shrimp farming in North Western province to obtain maximum sustainable production of shrimps based on the carrying capacity of main water source with minimum impact on the Eco-system.

Through the implementation of the crop calendar risks of contamination with pathogens could be minimized by avoiding high risk periods. Best periods for stocking for each sub zone and the area that can be brought under shrimp farming during these periods based on the carrying capacity of the water body. However, there are some constraints for the implementation of the crop calendar. All these constraints are people related. Driven by the greediness for money some farmers violated the crop calendar (illegal farming). Further incidences of non – implementation of management practices was also rampant. Absence of a legal framework hampered the regulatory functions. In order to provide legal framework, regulations were made under National Aquaculture Development Authority Act of 1998 for the implementation of the crop calendar and for the formulation of Aquaculture Development Societies and registration of the same.

5. Gaps due to lack of capacity building initiatives to achieve a proper cross learning in the country

There are a lot of gaps in the technical know-how in Sri Lanka and it has directly affected the development of Fisheries and Aquaculture. Following are some of the capacity development needs of the service experts related to aquaculture in Sri Lanka.

5.1 Establishment of hatchery technology on Marine ornamental fish, Sea cucumber and Milkfish

Sri Lanka exports marine ornamental fish and Sea cucumber by collecting from the wild and increase the pressure on wild stocks. It was noted that some of the wild populations of ornamental fish and Sea cucumber has been depleted due to various reasons such as over fishing, destruction of habitats, coral breaching, siltation of sea bed and marine pollution etc. This will affect exports of marine ornamental fish and sea cucumber. Therefore, it is imperative to introduce breeding in captivity of marine ornamental fish and sea cucumber to verify the breeding technology, promote farming to reduce pressure on wild fishery. Therefore NAQDA commenced the construction of marine ornamental fish and

Sea cucumber hatchery in order to verify the technology and produce seeds for farmers. As breeding technology of these species has been developed in some countries, hiring of experts on breeding of these species in Sri Lanka will be benefited to commence operation of these two hatcheries.

Major constraint to develop milk fish farming in Sri Lanka is lack of fish seed. Although few farms operations depend on wild caught seeds there is no breeding technology for Milkfish. Commencing of commercial farming of milk fish use as bait could save foreign exchange within the country reducing imports of bait for fishing. So, it is planned to introduce hatchery technology and farming with high technology by encouraging fishermen to use milk fish as bait for tuna fishing that will save foreign exchange. Therefore NAQDA commenced the construction of Milkfish hatchery in order to verify the technology and produce seeds for farmers. As breeding technology of milkfish has been developed in some countries, obtaining assistance of expert to establish technology for breeding of Milkfish in Sri Lanka will be benefited to commence operation of this hatchery.

5.2 Training of NAQDA officers on hatchery technology of Crab and marine finfish

The mud crab (*Scylla serrata*) has been identified as a species with high potential for aquaculture since it is a species that is cultivable, grows fast and highly acceptable both in the local and export markets. Currently commercial scale crab culture is not practiced in Sri Lanka. Training of NAQDA officers on hatchery technology of Crab will be benefited to expand crab farming .

Similarly, marine fin fish seeds are required for the development of marine fin fish farming in Sri Lanka. NAQDA succeeded in breeding Sea bass and following species have been identified for breeding; Barramundi/Asian sea bass (Lates calcarifer), Grouper (Epinephalus sp.), Snappers (Lutjanus sp.), Silver promfret (Pampus argenteus), Sea bream (Pagrus major), Mahi mahi (Coryphaena hippurus), Cobia (Rachycentron canadum). By establishing breeding technology and issuing of seeds of these species, it will be created livelihoods to coastal communities through direct employment, reduce pressure on wild fishery and generate export revenue. Therefore, Training of NAQDA officers on hatchery technology of marine finfish will be beneficial to expand marine finfish farming in Sri Lanka.

6. Conclusion and recommendation

To have good cross-learning in the fisheries and aquaculture sector in the country, a holistic approach in the regional and sub regional fisheries developments is essential. The managers, expirees, assistants, fishers, private

sector and the line agencies has to be trained on several aspects to have an overall knowledge on to understand the outcome of such developments. This can be archived through capacity building from top to bottom up to grass root level

Sri Lanka would like to highlight following factors to be addressed at South Asian level to mediate cross learning practices in the region.

1. Provide success stories in the region those developed their fisheries and aquaculture by having a long lasting National Policy for each sector without cross cutting in the sectoral planning.
2. Capacity development on biological, technical, development planning, project implementation aspects.
3. Training on and experience sharing on brooder stock and hatchery management
4. Training on new technologies
5. Sharing of information on Successful case studies on integrated fish farming
6. Sharing experience on successful co-management systems
7. Development of regional fisheries educational programs between the institutions and offering of scholarships and fellowship.
8 Maintain regional legal document e-library
9. Conduct "training of trainers" courses forpolicy makers, development planners and field workers.
10. Sharing of publications and training materials among and management/planning institutions, and between research institutions in developed and developing countries
11. Conduct seminars, conferences or workshops on conflict management in fisheries.
12. Demonstration trials on new techniques and the success or advantages.

References

Draft National Aquaculture Development Authority of Sri Lanka Annual Report – 2020.

The survey conducted on the UNLOCKED POTENTIAL OF INLAND FISH TO CONTRIBUTE TO IMPROVE NUTRITION IN SRI LANKA Saman Athauda and Jeevika Weerahewa, Faculty of Agriculture, University of Peradeniya, (http://www.fao.org/3/ca5514en/CA5514EN.pdf)

Chapter- 8

Invited Paper

Streamlining Science-Policy Linkage for Fisheries Management in South Asia: Lessons from Regional Initiatives

P Krishnan[1], **Rajdeep Mukherjee**[2], **M Sri Hari**[3] and **G Kantharajan**[4]

[1] Director, Bay of Bengal Programme Inter-Governmental Organisation. Chennai, India.
[2] Policy Analyst, Bay of Bengal Programme Inter-Governmental Organisation, Chennai, India
[3] Assistant Professor, Centurion University of Technology & Management, Gajapati, India
[4] Scientist, ICAR- National Bureau of Fish Genetic Resources, Lucknow, India
E-mail: krishnanars@bobpigo.org

Abstract

The need for two-way communication between policy and science is long understood, yet it has remained a challenge, especially in developing countries. In this book chapter, we have presented case studies of diverse scientific frameworks, which were successful in initiating informed policy measures. The lessons learned were useful in the context of regional fisheries management. Fish stocks, especially commercial stocks for which data are available are dwindling since the 1970s. As many of these fish stocks are shared and transboundary in nature, appropriate regional action is needed to conserve them. In this context, the scope of regional fisheries bodies has been evaluated for scaling up such interventions to facilitate effective regional decision-making processes.

Keywords: Fisheries Management, Scientific strategies, Regional aquaculture, Frameworks, RFBs

1. The science-policy gap in fisheries management

Marine fisheries is a complex system to manage. The modern fisheries management was developed only during last seven decades to address two concerns: (1) sustainability of resources, and (2) optimization of economic benefits. Meeting these objective needs a judicious mix of science and policy that still remains a challenge.

The Food and Agriculture Organization of the United Nations (FAO) defines fisheries management as "the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources ,and

formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities to ensure the ***continued productivity of the resources*** and the accomplishment of ***other fisheries objectives***"(FAO 2002). It shows that fisheries management comprises two processes. The first process is about "information gathering, analysis, planning, and consultation", which could be summed up as science and the second process is about "decision-making, allocation of resources, and formulation and implementation", which can be termed as policies. While, in an ideal situation, science and policies are streamlined in the management framework, in the real world, these two processes vary considerably in time-scale, skill and knowledge requirement, rigor, and urgency, with the science often lagging behind policy needs but policy often is unaware of scientific developments. For example, a recent review of the use of decision-making tools (DSTs) in the Baltic countries reported that the DST supply is low for recently emerging topics, such as non-indigenous species, marine litter, and underwater noise and lacking awareness and experience was the major obstacle for using existing DSTs (Schumacher et al. 2020).

The problem is further pronounced in the case of regional fisheries management. At the regional level, gaps and deficiencies at the national level were added up to opt for a more formidable choice. In addition, regional policies required balancing of national interests, which again is a far more complex process than aligning interests within the national boundaries.

However, in recent years several successful examples of scientific frameworks have emerged in the South Asian region which could streamline science and policy in the management framework. A review of these frameworks, delineated in the following sections, shows that these projects successfully integrated technology to address the time lag and operational unfamiliarity with the DSTs to develop a two-way communication tool. We have argued that in the case of regional fisheries management, the application of the drawn lessons could immensely benefit the parties involved by ensuring the policy implementation without any prejudice but is backed by strong scientific evidence.

2. Conserving the coral reefs in South Asia

Corals are foundational species that appeared 425 million years ago and are responsible for creating the structural complexity and high productivity of coral reef ecosystems (Kitahara et al., 2016). There are more than 1500 species and nearly 900 reef-building scleractinian corals (Arulananthan et al., 2021). The south Asian region has a share of 4.2% (10,949 km^2) of the global cover of coral reefs and they are distributed in Bangladesh, India, Maldives, Myanmar, Pakistan, Sri Lanka, and the Chagos archipelago. More than 75% of the reefs in this region are concentrated along Lakshadweep-Maldives-Chagos Ridge. Other significant reef systems are found in the Gulf of Mannar, and around parts of Sri

Lanka (GCMRN, 2021). Also, 31% of South Asian coral reefs are located within Marine Protected Areas (MPAs); almost all of these are in "Fully or Highly Protected" areas. India has a total of 208 Sclreactinian species of corals from 15 families (Venkataraman, 2011). The highest number of corals is from the Andaman and Nicobar Islands (177 species). In India, reefs are distributed in the Gulf of Kutch, Gulf of Mannar, Andaman and Nicobar Islands, and Lakshadweep. Also, patchy reefs are present near Ratnagiri and Malvan coasts. In Sri Lanka, Arulananthan et al. (2021) have reported a total of 113 hard coral species which belong to 40 genera. In terms of coral species diversity, the reefs in Sri Lanka are comparable to Indian territorial reefs. Coral communities in Bangladesh are restricted to the St. Marlin Islands which are located in the northeast part of the Bay of Bengal. Habib and Islam (2021) have reported 98 species of hard corals from 18 families and 37 genera in Bangladesh. Amongst the South-Asian countries, Maldives has the highest coral cover of 4513 km^2 and is the eighth largest coral reef system in the world (MRC, 2011). It has two of the largest natural atolls in the world: Thiladhunmathi Atoll with a total surface area of 3,788 km^2 and Huvadhoo Atoll with a total surface area of 3,278 km^2.

2.1 Issues in the conservation of coral reefs in South-Asia

Multiple environmental stressors significantly impact the growth of coral reefs. Monitoring the changes in the distribution, abundance, and health of coral reef species is one of the important aspects of coral reef ecology (Hamylton, 2011). There are various natural and man-made threats such as *tsunami*, cyclones, predation, mining, destructive fishing methods, bio-invasion, mangrove destruction, unsustainable tourism, and pollution, which directly or indirectly affect the coral reefs (Chandrasekaran et al., 2008; Kamalakannan et al., 2010; Baswapoor and Irfan, 2018). In recent times, increased sea surface temperature, sea level rise, and ocean acidification as a result of climate change are the major factors responsible for coral reef destruction (Krishnan et al., 2011). However, there is a lack of spatiotemporal data along with an appropriate resolution to understand the factors affecting coral health. To assess the reef health and the impact on coral reefs by various factors, a faster and more complex analysis is necessary.

2.2 Technological interventions in the conservation of coral reefs

Development of spectral signatures for coral life forms

To monitor the healthy and bleached coral reefs and to identify the different coral species, the development of spectral signatures are required. Hochberg et al. (2003) developed a worldwide spectral library for coral reef benthic communities with 13,100 numbers of spectra. In South Asia, only a few studies have been undertaken in the Gulf of Kachchh (Chaudhury, 2012; Arora et al., 2019) and the

Gulf of Mannar region (Nimalan et al., 2021). Both high resolution (AVIRIS, Sentinel-2) and moderate resolution (Landsat-7, Landsat-8) sensors are now used for coral reef mapping and monitoring. *In-situ* spectral characteristics of the individual coral reef forms are necessary to provide baseline data for analyzing the satellite data (Figure 1 and 2). Clark et al. (2000) monitored the spectral discrimination of coral mortality rate after a coral bleaching event in French Polynesia with an accuracy of 85%. The development of spectral signatures along with field spectroscopy is a potential non-invasive tool to provide first-hand information on the health of the corals concerning pigment changes at the organism or colony level.

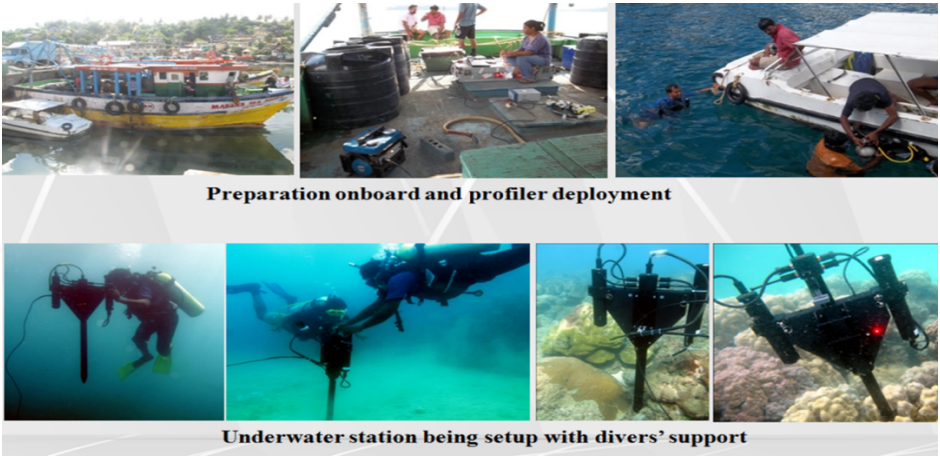


Figure 1: Steps involved in *in-situ* observation of spectral signatures.

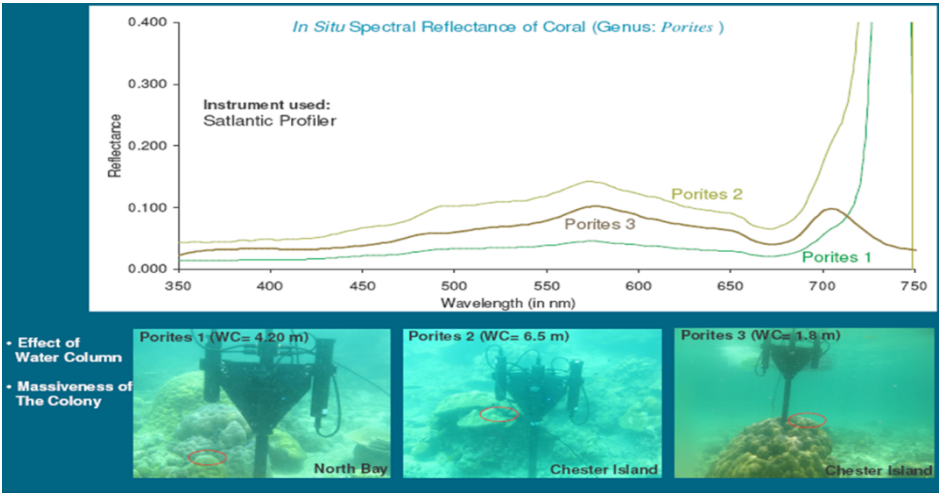


Figure 2: Spectral reflectance of *Porites* spp., collected from the Andaman Seas

A study conducted by Krishnan et al. (2013) using Satellite Altimetry-based Map of Sea Level Anomaly (MSLA) data and Weather Research and Forecasting

(WRF) Modeling System in Richie's archipelago revealed that, in addition to increased SST, eddies in and around coral reef areas might cause thermal related stress to the coral reef. Several oceanographic factors such as eddies remain unnoticed unless they are directly involved in affecting coastal health. Further, the effect of the storm will be more in shallower regions while in the deeper regions, the damage might be due to the settlement of debris and sand that had been brought down from the shallower regions. Island mass effect is thus considered an acritical factor in determining the resilience of coral reefs to bleaching in the face of increased incidence of bleaching events caused by the changing climate. Mass bleaching events of corals due to elevated SST also have differential effects on coral communities (Figure 3). Bleaching events in the Andaman Sea during 2010 revealed that branching corals such as *Acropora* spp., were the worst affected, whereas the massive corals were found to have relatively withstood the elevated SST (Krishnan et al., 2011). It is also necessary to study the molecular mechanism of association between corals and symbiotic algae during the bleaching events (Krishnan et al., 2018).

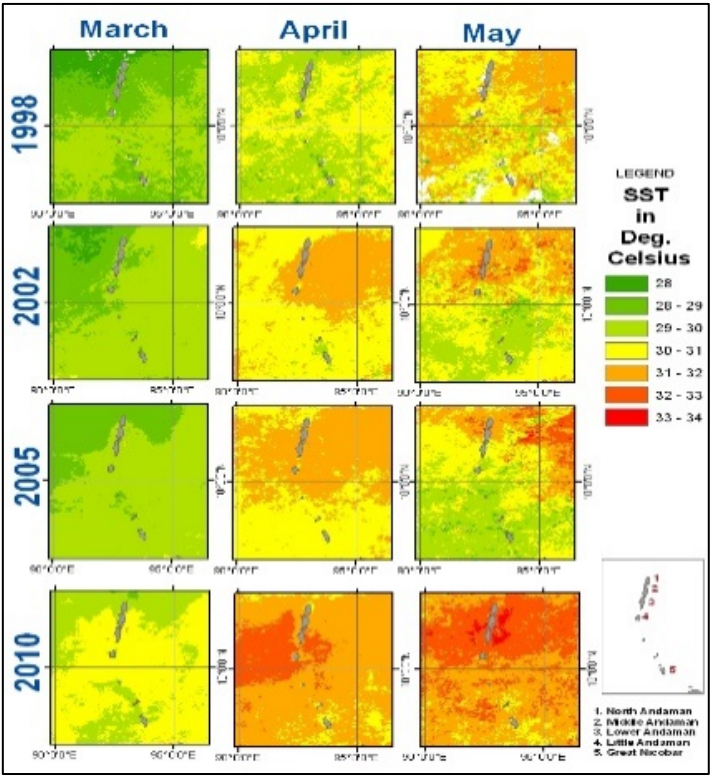


Figure 3: SST Pattern over the years when coral bleaching events were observed in Andamans

There are various ways for developing a decision support system to manage reef resources. But there is a need to garner more information to support scientific

management. The use of satellite imagery and underwater photography has solved the problem of data lags largely and brought a new understanding of coral bleaching and provided necessary evidence for the policy making.

3. Biodiversity portal: For a better understanding of marine resources

Regional open access biodiversity portals are now emerging as a favored model to share scientific data in a usable format to support decision-making and policy implementation. However, there are several issues in the creation and the maintenance of the biodiversity portals. According to Costello et al. (2016), these are: (a) Scattered data across different databases and the need for integration of all the information available; (b) Lack of long-term support from institutions and scientists; (c) failure to keep the database updated, and (d) Lack of financial support to maintain and develop online biodiversity databases. Effective thematic and geographically delimited portals (Table 2) provide a framework for networking and collaboration among data providers, scientists, and managers.

Table 2: Examples of biodiversity databases related to the marine environment

Database	Information available	Hosted/Managed/Sponsored by
Global Biodiversity Information Facility (GBIF) https://www.gbif.org/	Open access to data about all types of life on Earth	Various Governments and the GBIF secretariat
FishBase (https://www.fishbase.de/home.htm)	Taxonomy, biology, trophic ecology, life history, and uses, as well as historical data on fish species.	Hosted by Quantitative Aquatics, incorporated and scientifically guided by a Consortium of 12 international members
SealifeBase (https://www.sealifebase.ca/home/index.php)	Taxonomy, biology, trophic ecology, life history, and uses of non-fish marine organisms	Jointly by Sea Around Us and Q-Aquatics inc and managed by the Fishbase consortium
CephBase http://www.thecephalopodpage.org/cephbase.php	Life history, distribution, catch, and taxonomic data on all living species of cephalopods	Sloan Foundation
LarvalBase http://www.larvalbase.org/	A new module in FishBase; only scarce information is available about fish larvae.	FishBase consortium
Ocean Biodiversity Information System https://obis.org/	Ocean biodiversity and biogeographic data	GBIF and the Intergovernmental Oceanographic Commission of UNESCO

Database	Information available	Hosted/Managed/Sponsored by
ReefBase http://www.reefbase.org/global_database/	Location, status, threats, monitoring, and management of coral reefs in over 120 countries and territories	WorldFish, Penang, Malaysia
International Coral Reef Initiative https://icriforum.org/restoration/coral-restoration-database/	Knowledge of coral restoration.	ICRI and James Cook University
World Mangroves database https://www.marinespecies.org/mangroves/	Database, fact sheet, distribution map, automated key for mangroves	Flanders Marine Institute (Vlaams Instituut voor de Zee), Ostend, Belgium.
GLOMIS (GLObal Mangrove database and Information System) http://www.glomis.com/	Database of scientific literature relating to mangroves, institutions, and scientists working on all aspects of mangroves	University of the Ryukyus, Japan
Eschmeyer's Catalog of Fishes https://www.calacademy.org/scientists/projects/eschmeyers-catalog-of-fishes	Reference for taxonomic fish names	California Academy of Sciences
Global Invasive Species Database http://www.iucngisd.org/gisd/	About alien and invasive species that negatively impact biodiversity	Invasive Species Specialist Group (ISSG) of the IUCN
Aquatic Genetic Resource Information System of India (AqGRISI) https://aqgrisi.nbfgr.res.in/	Information on systematics, biology, type specimen, disease, habitat, distribution, patent, fish nutrition, and bibliography on fish resources reported in India	National Bureau of Fish Genetic Resources (NBFGR), Lucknow of the Indian Council of Agricultural Research (ICAR).

3.1 CoMBINe – An interactive biodiversity portal: A model

The Coastal and Marine Biodiversity Integration Network (CoMBINe) developed by the National Centre for Sustainable Coastal Management, Chennai of Ministry of Environment, Forest and Climate Change, Govt. of India, is a unique coastal and marine biodiversity web portal. It combines multiple

databases in a single platform that allows searching from independent, multiple, heterogeneous datasets on Indian coastal and marine flora and fauna. The database includes all macro plants (seagrass, mangroves, seaweeds) and animals (Phylum Porifera to Chordata) inhabiting the Coastal Regulation Zone (CRZ) (I to IV) as defined in the CRZ notification-2011 of India. A complete and comprehensive database is designed with 62 fields covering taxonomy, anatomy, biology, conservation, molecular, spatial, spectral, and others. CoMBINe has two major components *viz.*, (i) developing and sustaining a web portal to serve as a national repository for coastal biodiversity and (ii) developing and operationalizing an innovative schema for character-based field identification through re-engineering conventional taxonomy. The information available in this portal is collected on an ongoing basis from Five global databases such as FishBase, WORMS, IndOBIS, Biosearch, and GBIF.

As of now, there is no comprehensive database or portal available for the South Asian marine region. Therefore, either developing a new portal in line with the existing interactive biodiversity portal, *i.e.*, CoMBINe, or upkeeping the existing one is recommended for a better understanding and management of marine resources.

4. Assessment of socio-economic vulnerability: An approach for evidence-based planning

4.1 Need for Socio-Economic Vulnerability Index

Assessment of coastal vulnerability is gaining importance worldwide (Dolan and Walker, 2004). Results from the vulnerability assessment help the policymakers to take systematic efforts in minimizing the exposure of the coastal communities to natural hazards and also improve their preparedness and resilience to adverse events. Factors that are responsible for the vulnerability of the coastal community have to be assessed spatially for planning appropriate actions for climate adaptation (Lee et al., 2015). The socio-economic vulnerability index (SEVI) describes the relative socioeconomic characteristics of communities in terms of poverty, unemployment, educational attainment, linguistic isolation, and percent of income spent on housing.

4.2 Socio-Economic Vulnerability Index (SEVI): For evidence-based planning

The vulnerability of the community to climate change is determined by factors, such as Exposure (E), Sensitivity (S), and Adaptive capacity (AC) (Parry et al., 2007; Islam et al., 2014). The socio-economic vulnerability is largely determined by the internal structure of any social system that decides the sensitivity of societies and communities and also helps to cope with damages from external shock (Umamaheshwari et al., 2021). The overall vulnerability of the system is measured by the Cumulative Vulnerability Index (CVI). The CVI is a

consolidated measure of vulnerability to understand the relative position of one geo-socio-economic unit (village/taluk/district/state/country) in relation to another unit, and to prepare appropriate interventions (Krishnan et al., 2018). The SEVI is calculated as socio-economic Sensitivity (SI-R) and socio-economic adaptive capacity (ACI-R) indices. The index value ranges from 0-1, where a higher value implies higher vulnerability and *vice versa*. The SEVI can be applied to assess the effectiveness and/or impact(s) of a programme or policy by reproducing the index values of contributing indicators. The major advantage of SEVI is that it can be assessed using both secondary and primary data. It is also considered the befitting tool for gauging the mood and status of fisher households; hence a more participative and bottom-up approach is adopted to building community confidence and resilience in the long term.

SMF-Small and Marginal Farmers, **AL**-Agricultural Labourers, **FP**-Fisher Population, **FSM**-Food Sufficiency/ Malnutrition, **PD**-Population Density, **SCST**-Schedule Castes/Schedule Tribes Population, **NSA**- Net Sown Area, **AR**-Annual Rainfall, **DNR**-Dependence on Natural Resources, **DNT**-Distance to Nearest Town, **DNH**-Distance to Nearest Hospital, **TC**-Transport and Communication, **EDR**-Economic Dependency Ratio, **AM**-Access to Market, **NIA**-Net Irrigated Area, **GD**-Groundwater Development, **LP**-Livestock Population, **ES**-Education Status, **HA**-Household Amenities, **HC**-Housing Condition, **CI**-Community Infrastructure, **PGR**-Population Growth Rate, **GR**-Gender Ratio

Figure 4: Framework for assessment of socio-economic vulnerability depicting the prioritized indicators based on their weightages for SEVI (%)

5.0 Evidence-based conservation of Ecologically Sensitive Areas

5.1 Ecologically Sensitive Areas and their role in maintaining biodiversity

Ecologically Sensitive Areas (ESA) are land and water areas containing natural features or ecological functions of such significance as to warrant their protection in the best long-term interest of the people and environment. ESAs are a novel Indian attempt, which has been identified and notified under the Environment (Protection) Act, 1986. ESAs are biodiversity hotspots or biogeographic regions with a significant reserve of biodiversity. The MPAs account for only 5.81% of the total surface area and about 5% of India's total protected areas (PAs). The coastal and marine ESAs are under pressure on account of increased anthropogenic activities on the coast.

5.2 Framework for identification of priority areas for conservation

The Ministry of Environment, Forests and Climate Change, India, with its subsidiary institute, namely National Centre for Sustainable Coastal Management (NCSCM), Chennai made a nationwide effort to identify and gather information on all qualified ESAs and prioritize them. This has addressed the long-time need of shifting away from blanket recommendations to a scientific way of using a decision support system with appropriate regulatory frameworks also encompassing the need for the socio-economic development of people including their livelihoods. A classic example is the case of Vembanad Lake, a Ramsar site. This lake, although a Critically Vulnerable Coastal Area (CVCA), is managed in such a way that the population residing in the villages near the lake could continue to use the lake water as a livelihood source. Similar frameworks were developed for other critical areas across India. These examples indicate how best South Asian countries with population pressure and inevitable resource dependence can manage critical and vulnerable aquatic bodies.

6.0 Advances in fisheries resource management

6.1 Identifying Mesoscale eddies: An alternate for Potential Fishing Zone (PFZ) advisory

ESSO-Indian National Center for Ocean Information Services (INCOIS) provides Potential Fishing Zone (PFZ) advisory daily, which gives the locations of fish aggregation. These PFZ maps have information on the major landing centers, bathymetry, latitude-longitude information, and also the probable shifts of PFZ. However, in the case of Islands, they are mostly under cloud cover for more than eight months of the year, which obscures optical and thermal imagery and hinders the generation of PFZ advisories (Grinson et al., 2014). Since Altimeter data is not affected by clouds and mild rain, the gridded altimeter-based Sea Level Anomaly (SLA) data can be used to easily identify mesoscale eddies.

Mesoscale ocean eddies (eddies) are coherent rotating vortices of water with radial scales ranging from 25–250 km and lifetimes of 10 to 100 days. Mesoscale eddies increase biological productivity by vertical and horizontal mixing of the water column in the pelagic zone. It can be used to overcome the disturbances by cloud cover, by integrating SSH (Sea Surface Height) data into the PFZ map which is derived from Chlorophyll-*a* and SST, which subsequently gives the information about Mesoscale eddies (Anand et al., 2014). A recent study by Anand et al. (2020) revealed the significant positive influence of eddies on the fish caught in certain zones. Thus, altimeter data identifying mesoscale eddies can be used for augmenting the currently operational PFZ advisories during periods of persistent cloud cover.

6.2 How best the strategy can be used in South Asia?

Five South Asian countries (Bangladesh, India, Maldives, Sri Lanka, and Pakistan) are blessed with vast coastlines under the significant influence of various monsoon currents. The marine fishery resources of these countries can be effectively exploited by implementing the integrated PFZ advisories as described in the earlier section. South Asian fisheries are mostly of small-scale nature and have got potential for better management and production. Some of the resources concerning deep sea, transboundary, and island fisheries are not exploited to the optimal level. The use of PFZ, however, reduces the scouting time of fishing vessels, thereby reducing fuel consumption and carbon emission.

7.0 The role of the Regional fisheries bodies in streamlining science and policy

The need for regional cooperation through a suitable mechanism such as the regional fisheries bodies was validated in the United Nations Law of the Sea of 1982 (UNCLOS) in the context of the shared and transboundary resources. This was further cemented when in 2001, the United Nations Fish Stock Agreement (UNFSA) entered into force. Regional Fisheries Bodies are of two types: one with largely management mandates (Regional Fisheries Management Organizations, RFMOs) and the other with the largely advisory mandate (Regional Fisheries Advisory Bodies, RFABs). Out of 22 RFMOs and 24 RFABs around the world, 2 RFMOs and 3 RFABs are working in the Indian Ocean region (Løbach et al., 2020).

Given the current situation in the marine fisheries where it is reported that the fraction of global fishery stocks within biologically sustainable levels decreased from 90% in 1974 to 64.6% in 2019, the sustainable management of fish stocks at the regional and global levels demand immediate, and viable action. Further, in recent times, fishers are moving towards the high seas for exploitation of deep-sea resources, which requires an area-based management plan, achievable

through cooperation among the regional fisheries organizations. This is also necessary to manage the shared, straddling and transboundary fishery resources occurring between multiple exlusive economic zones. In addition, sharing of successful fisheries management strategies emerged through scientific evidence to create a win-win situation for the regional collaborating partners through sustainable utilization of resources and livelihood improvement.

Therefore, there is a growing interest on strengthening the RFBs through different international initiatives. The experience from existing scientific framework shows that the RFBs in South Asia should identify the major issues pertaining to the countries and involve in advising or implementing measures that can ensure long-term conservation and sustainability of the living resources. Regular sessions should be held to monitor the implementation of recommendations or decisions.

Regional bodies should not only focus on fisheries but also need to have a broader spectrum covering coastal resources, such as coral reefs, mangroves, seagrass beds, etc. Concepts such as ESAs are restricted to India; these bodies should identify the areas using the standardized framework and recommend it to the respective governments. RFBs in the region can jointly host a participatory region-specific biodiversity portal which not only holds the taxonomic information of the species but also has all the available information particular to the species in detail, which will be helping in various geospatial decision-making and management of fishery resources.

Regional bodies can work in cooperation with organizations responsible for the identification of fish grounds and can disseminate information to various countries, which will result in various benefits for the whole region. In the future, all regional bodies working in South Asia can step into strengthening governance by advising or implementing the ecosystem approach to fisheries and adopting the precautionary approach for the long-term sustainability of the resources.

8.0 Conclusions

Unlike the prevailing system of fisheries and aquaculture management in South Asia, there is a need for a scientific way of implementing regulation frameworks. This book chapter discusses in depth various possible avenues where scientific knowledge with a pragmatic approach can culminate into a guiding framework for the South Asian region. Case studies and examples on ecological, resource management and fishing together with the possible data sources and institutional framework are discussed in the various sections to engage the targeted policy planners in all South Asian countries. This is a broad sketch of what we can do more in the sector. There are wonderful avenues, useful

frameworks, regional platforms, and national bodies that can altogether synergize their efforts to manage the inland, coastal and marine resources in the region.

References

Arora, M., Gujrati, A., Chaudhury, N.R. and Patel, R.C., 2019. Benthic coverage and bottom topography of coral reef environment over Pirotan reef, Gulf of Kachchh region, India. Geocarto International, 34(10), 1089-1097.

Arulananthan, A., Herath, V., Kuganathan, S., Upasanta, A. and Harishchandra, A., 2021. The Status of the Coral Reefs of the Jaffna Peninsula (Northern Sri Lanka), with 36 Coral Species New to Sri Lanka Confirmed by DNA Bar-Coding. Oceans, 2(3), 509-529.

Anand, A., Krishnan, P., George, G., Goutham Bharathi, M.P., Kaliyamoorthy, M., Hareef Baba Shaeb, K., Suryavanshi, A.S., Kumar, T.S. and Joshi, A.K., 2014. The influence of mesoscale eddies on a commercial fishery in the coastal waters of the Andaman and Nicobar Islands, India. International Journal of Remote Sensing, 35(17), 6418-6443.

Anand, A., Krishnan, P., Kiruba-Sankar, R., Suryavanshi, A., Lohith Kumar, K., Kantharajan, G., Choudhury, S.B., Manjulatha, C. and Babu, D.E., 2020. Feasibility of targeted fishing in mesoscale oceanic eddies: a study from commercial fishing grounds of Andaman and Nicobar Islands, India. International Journal of Remote Sensing, 41(14), 5011-5045.

Baswapoor, S. and Irfan, Z.B., 2018. Current Status of Coral Reefs in India: Importance, Rising Threats and Policies for its Conservation and Management. Working Paper-2016-175, published by Madras School of Economics, Chennai, India, 22p.

Chandrasekaran, S., Nagendran, N.A., Pandiaraja, D., Krishnankutty, N. and Kamalakannan, B., 2008. Bioinvasion of *Kappaphycus alvarezii* on corals in the Gulf of Mannar, India. Current Science, 94(9), 1167-1172.

Chaudhury, N.R., 2012. Spectral characteristics of selected hermatypic corals from Gulf of Kachchh, India. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 39, 333-338.

Clark, C.D., Mumby, P.J., Chisholm, J.R.M., Jaubert, J. and Andrefouet, S., 2000. Spectral discrimination of coral mortality states following a severe bleaching event. International Journal of Remote Sensing, 21(11), 2321-2327.

Costello, M.J., Appeltans, W., Bailly, N., Berendsohn, W.G., de Jong, Y., Edwards, M., Froese, R., Huettmann, F., Los, W., Mees, J. and Segers, H., 2014. Strategies for the sustainability of online open-access biodiversity databases. Biological Conservation, 173, 155-165.

Dolan, A.H. and Walker, I.J., 2006. Understanding vulnerability of coastal communities to climate change related risks. Journal of Coastal Research, SI39(III), 1316-1323.

GCMRN, 2021. Status of Coral Reefs of the World: 2020. Available at: https://gcrmn.net/2020-report/.

Grinson, G., Sarma, K., Bharathi, G., Kaliyamoorthy, M., Krishnan, P. and Kirubasankar, R., 2014. Efficacy of different modes in disseminating potential fishing zone (PFZ) forecasts-a case study from Andaman and Nicobar Islands. Indian Journal of Fisheries, 61(1), 84-87.

Habib, K.A. and Islam, M.J., 2021. New Distributional Record of Twelve Scleractinian Corals From Saint Martin's Island, Bangladesh. Bangladesh Journal of Zoology, 49(1), 3-18.

Hamylton, S., 2011. Estimating the coverage of coral reef benthic communities from airborne hyperspectral remote sensing data: multiple discriminant function analysis and linear spectral unmixing. International Journal of Remote Sensing, 32(24), 9673-9690.

Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide and implications for coral reef remote sensing. Remote Sensing of Environment, 85(2), 159-173.

Islam, M., Sallu, S., Hubacek, K., & Paavola, J. (2014). Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. Regional Environmental Change, 14(1), 281-294.

Kamalakannan, B., Jeevamani, J.J.J., Nagendran, N.A., Pandiaraja, D., Krishnan Kutty, N. and Chandrasekaran, S., 2010. *Turbinaria* sp. as victims to *Kappaphycus alvarezii* in reefs of Gulf of Mannar, India. Coral Reefs, 29(4), 1077.

Kitahara, M.V., Fukami, H., Benzoni, F. and Huang, D., 2016. The new systematics of Scleractinia: integrating molecular and morphological evidence. In: Goffredo, S., Dubinsky, Z. (eds) The Cnidaria, past, present and future (pp. 41-59). Springer, Cham.

Krishnan, P., Grinson, G., Vikas, N., Titus-Immanuel, T., Goutham-Bharathi, M.P., Anand, A., Kumar, K.V. and Kumar, S.S., 2013. Tropical storm off Myanmar coast sweeps reefs in Ritchie's Archipelago, Andaman. Environmental Monitoring and Assessment, 185(6), 5327-5338.

Krishnan, P., Purvaja, R., Sreeraj, C.R., Raghuraman, R., Robin, R.S., Abhilash, K.R., Mahendra, R.S., Anand, A., Gopi, M., Mohanty, P.C. and Venkataraman, K., 2018. Differential bleaching patterns in corals of Palk Bay and the Gulf of Mannar. Current Science, 114(3), 679-685.

Krishnan, P., Roy, S.D., George, G., Srivastava, R.C., Anand, A., Murugesan, S., Kaliyamoorthy, M., Vikas, N. and Soundararajan, R., 2011. Elevated sea surface temperature during May 2010 induces mass bleaching of corals in the Andaman. Current Science, 100 (1), 111-117.

Lee, J.R., Maggini, R., Taylor, M.F. and Fuller, R.A., 2015. Mapping the drivers of climate change vulnerability for Australia's threatened species. PLOS One, 10(5), e0124766.

Løbach, T., Petersson, M., Haberkon, E., & Mannini, P. (2020). Regional fisheries management organizations and advisory bodies: Activities and developments, 2000–2017. FAO Fisheries and Aquaculture Technical Paper-651, 112p.

MRC, 2011. Coral Reef Research Programme. Marine Research Centre. Available at: http://mrc. gov.mv/356/crrp/#more-356

Nimalan, K., Thanikachalam, M. and Usha, T., 2021. Spectral characteristics of coral reef benthic compositions in Gulf of Mannar. Journal of Earth System Science, 130(1), 1-7.

Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linden, P.J. and Hanson, C.E., 2007. IPCC, 2007: climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK.

Umamaheswari, T., Sugumar, G., Krishnan, P., Ananthan, P.S., Anand, A., Jeevamani, J. J. J., ... and Rao, C.S., 2021. Vulnerability assessment of coastal fishing communities for building resilience and adaptation: Evidences from Tamil Nadu, India. Environmental Science and Policy, 123, 114-130.

Saroj, J., Gautam, R.K., Joshi, A. and Tehseen, P., 2016. Review of coral reefs of India: distribution, status, research and management. International Journal of Science, Environment and Technology, 5(5), 3088-3098.

Schumacher, J., Bergqvist, L., Van Beest, F.M., Carstensen, J., Gustafsson, B., Hasler, B., Fleming, V., Nygård, H., Pakalniete, K., Sokolov, A. and Zandersen, M., 2020. Bridging the science-policy gap–toward better integration of decision support tools in coastal and marine policy implementation. Frontiers in Marine Science, 7, 587500.

Venkataraman, K., 2011. Coral Reefs of India. In: Hopley, D. (ed) Encyclopedia of Modern Coral Reefs. Encyclopedia of Earth Sciences Series. Springer, Cham.

Report of the Regional Consultation Meeting on Cross-learning for Thematic Regional/ Sub-regional Challenges in Aquaculture and Fisheries among the SAARC Member States

3 - 4 August 2021

1. Title of the program

Regional Consultation Meeting on "Cross-learning for Thematic Regional/ Sub-regional Challenges in Aquaculture and Fisheries" (Virtual)

2. Objectives:

i. Develop thematic area wise networks
ii. Implement cross-learning opportunities among the Member States.
iii. Identify regional/ sub-regional projects on thematic areas related to development for aquaculture and fisheries in South Asia.

3. Date: 3-4 August 2021

4. Host Organization: SAARC Agriculture Centre

5. Partnership (if any): Nil

6. Brief summary

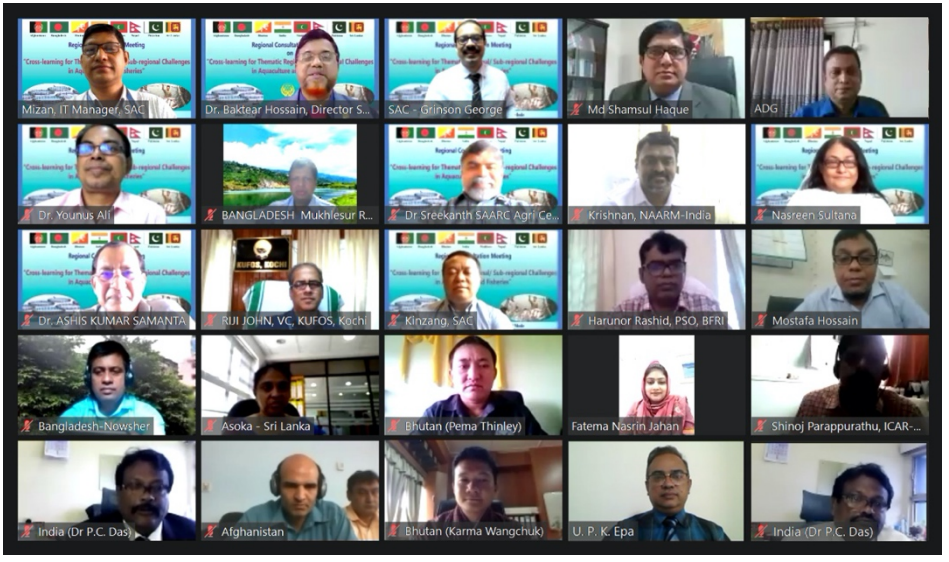
SAARC Agriculture Centre (SAC) organized a two-day regional expert consultation meeting on "Cross-learning for Thematic Regional/ Sub-regional Challenges in Aquaculture and Fisheries" during 03rd and 04th August, 2021 in virtual mode.

Mr. Md. Shamsul Haque, Additional Foreign Secretary (SAARC & BIMSTEC), Government of the People's Republic of Bangladesh graced the inaugural session as the Chief Guest.

Dr. K. Riji John, Hon'ble Vice Chancellor, KUFOS, India and Mr. K.H. Mahbubul Haque, Additional Director General, Department of Fisheries, Bangladesh graced the occasion as Special Guests. Dr. Grinson George, SPS (Fisheries), SAC welcomed the gathering.

The inaugural session was chaired by Dr. Md Baktear Hossain, Director, SAARC Agriculture Centre. The National Experts from six SAARC Member Countries including Afghanistan, Bangladesh, Bhutan, India, Pakistan, and Sri Lanka presented their country paper.

Professor Dr. Mostofa A R Hossain, Bangladesh Agricultural University and Professor Dr. U P K Epa, University of Kelaniya, Sri Lanka chaired the technical session 1 & 2 respectively. The program coordinated by Dr. Grinson George, Senior Program Specialist (Fisheries), SAC. After presentation of country status report of South Asian Nations, another paper was presented from renowned resource speaker Prof. Dr. Krishnan Pandian, ICAR-NAARM, Hyderabad, India. The group sat together and discussed during the technical Session 3 i.e. recommendation session on 4th August 2021 (second day). The recommendations were finalized during the meeting. Dr. Md. Baktear Hossain, Director, SAARC Agriculture Centre chaired the technical session-3 and Dr. Grinson George, Senior Program Specialist (Fisheries) coordinated the entire program.



7. Salient achievements

In a major development in reducing the impact of climate crisis in aquaculture and fisheries in the region, the South Asian Association for Regional Cooperation (SAARC) countries have sought for regional cooperation to implement strategies in battling the climate-induced fallouts in the sector. A consultative meeting of fishery scientists representing from India, Bangladesh, Sri Lanka, Pakistan, Afghanistan and Bhutan held by the SAARC Agriculture Centre (SAC) has felt

the urgent need for implementing strategies such as introduction of climate-friendly technologies in fisheries and aquaculture as well as measures for sustainable utilisation of the resources. The meeting came up with this suggestion after the experts identified climate crisis a major concern in aquaculture and fisheries sector of South Asian countries. The experts voiced concern over dwindling marine catch and aquaculture production, environmental disruption in aquatic ecosystem and its rippling effect on livelihood of the stakeholders owing to climate change and associated developments. They suggested that technologies of seaweed farming and integrated multi-trophic aquaculture (IMTA), including cage fish farming could be adopted to reduce the impacts of the crisis to a certain extent. "The sector could use 'green fishing vessels' with built-in design features for energy saving and fuel saving technologies to reduce carbon emission", they said. Increase in frequency and intensity of cyclones, storms and extreme weather conditions causes drastic decrease in marine fishing days, habitat destruction, depletion of commercially important resources and other ecosystem changes in marine and inland aquatic system which ultimately affect the livelihood of those depending on the sector, according to the fishery experts from the SAARC countries. They pointed out that increasing trend of floods, long-lasting droughts and salinity changes are posing severe threat to inland aquaculture.

"The member countries have demanded for regional cooperation among the nations and a platform for cross-learning and knowledge sharing to check the fallouts in the best possible way in the time of climate change", said Dr Md. Baktear Hossain, Director of the SAC. In marine fisheries, need for capacity building for exploitation of deep-sea resources was raised by India, Bangladesh and Sri Lanka, scarcity of quality seeds and shortage of other input materials were the major gaps faced by the member countries in inland aquaculture, he said. "Based on the discussions in the meeting, the SAC has come up with a set of recommendations to address such issues. Technical collaboration for knowledge sharing and capacity building among the SAARC countries and setting up of regional network for seed bank and germplasm transfer are some of the suggestions", he added.

8. Recommendations (Consultation meeting/workshop)

1. Regional network on thematic areas for fisheries and document the probable regional programmes related to fisheries and aquaculture in South Asia
2. Aquatic animal health surveillance in all countries and interlinking the networks across SAARC countries
3. SAARC regional network on fish seed bank including germplasm transfer, harmonized-certification process, technical know-how, and infrastructure establishment

4. South Asian collaboration for exploring knowledge sharing and capacity building by establishing tuna/ hilsa fisheries network
5. Technical collaboration for transfer of technology from production to consumption value chain in aquatic products by enabling SAAF conference/ exhibition/ webinar series/ guided study tours/ capacity building/ knowledge sharing/ co-farming studies
6. Promoting discussions and cross-learning on 1) Policies, laws and regulations on aquaculture and fisheries harmonizing between environment conservation and livelihood development 2) strengthening social-safety-nets in SAARC countries
7. Facilitate cross-country demonstration trials for flagged regional issues in aquaculture and capture fisheries
8. Establishment of a regional centre of excellence in fisheries and aquaculture in the South Asian University
9. HRD for fisheries professionals in South Asia –SAARC UG, PG, PhD fellowships and facilitating student exchange, short and medium-term training opportunities
10. E-repository separately for SAARC aquaculture and fisheries laws and regulations and aaccess sharing of South Asian institutional repositories for aquaculture and fisheries professionals
11. Promoting climate resilient aquaculture and fisheries technologies using SAARC network

9. Challenges and lesson learned

There are scientific gaps inhibiting the implementation of rules and regulations for sustainable management of fisheries and aquaculture. Some possible solutions can be looked upon in satellite remote sensing, numerical modelling, stake holder perception, prioritization of spatial sensitiveness to ecosystems and many more with right interference from the stakeholders. Referring to the existing disparity in socio-economic standards of the stakeholders, the SAARC body recommended for promoting discussions and cross-learning on strengthening 'social-safety-nets' with emphasis on ensuring socio-economic security of the stakeholders, and policies, laws and regulations harmonising between environment conservation and livelihood development. Establishment of referral laboratories for aquatic animal health management, a Centre of excellence in aquaculture and fisheries in the region and e-repository for information sharing were also listed in the recommendations. Marine pollution, increased fuel prices, illegal, unreported and unregulated fishing, increasing length of value chain, resource crunch and lack of adequate infrastructure are some of the other major issues raised in the meeting by representatives of member countries.

List of Participants (Name, affiliation and contact details)

AFGHANISTAN

Mr. Khalilullah Frough
Head of Fishery, Directorate General of Livestock and Animal Health, Ministry of Agriculture, Irrigation and Livestock (MAIL), Phone: +93797118386, Khalilullah.frough@gmail.com

Mr. Rahmatullah Akbari
Manager of Plan and Livestock Statistics, Directorate General of Livestock and Animal Health, Ministry of Agriculture, Irrigation and Livestock (MAIL)
Phone: +93787044160, E-mail: Rahmat60akbari@gmail.com

BANGLADESH

Md. Mukhlesur Rahman
Senior Assistant Director, Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, 13 Shahid Captain Mansur Ali Avenue, Department of Fisheries, Matshya Bhaban, Ramna, Dhaka1000. Cell No.: 01711071888. E-mail: mukhlesdof@gmail.com

Md. Nowsher Ali
Assistant Director, Department of Fisheries, Bangladesh
Room-307, 3rd Floor, Matshya Bhaban, Ramna, Dhaka, Cell No.: 01716335010, E-mail: mnali28bcs@yahoo.com

BHUTAN

Pema Thinley
National Research & Development Centre for Aquaculture (NR&DCA)
+975-1770-6631 (Mobile) or +975-06-251-200 (O), Email: pemathinley2@moaf.gov.bt

Karma Wangchuk
National Research Centre for Riverine & Lake Fisheries, Haa, DoL, MoAF
Phone: +975-17334743, Email: karmaw@moaf.gov.bt

INDIA

Dr. P.C. Das
Indian Council of Agricultural Research, Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare, Government of India.
Principal Scientist, ICAR-CIFA, Bhubaneswar. Mobile: (+91)9437100265, 7749998864, E-mail: pratapcdas@yahoo.com, Pratap.das@icar.gov.in

Dr. Prathibha Rohit
Indian Council of Agricultural Research, Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare, Government of India.
Principal Scientist and Head, Mangalore Regional Centre of ICAR CMFRI, P.B.No.244, Hoige Bazar, Mangaluru-575 001, Karnataka, India. Telephone: Office +91 824 2424152, Mobile: +91 9916129255, Email: prathibharohit@gmail.com, prathibha.rohit@icar.gov.in

PAKISTAN

Dr. Rehana Kausar
Pakistan Agriculture Research Council, Islamabad, Pakistan
Senior Scientific Officer, ASI, NARC

SRI LANKA

H. Kalyani
Department of Fisheries And Aquatic Resources
hewakal2012@gmail.com , +94 777 200 089

Asoka J. M.
NAQDA
asokajm@yahoo.com, 0094 714397722

Other Participants

Mr. Md. Shamsul Haque
Additional Foreign Secretary (SAARC & BIMSTEC), Bangladesh

Dr. P. Krishnan
Director, BOBP-IGO

Dr. K. Riji John
Hon'ble Vice Chancellor, KUFOS, India

Mr. KH. Mahbubul Haque
Additional Director General, Department of Fisheries, Bangladesh

Prof. Dr. Mostafa A. R. Hossain
Professor, BAU, Bangladesh

Prof. Dr. U.P.K. Epa
University of Kelaniya, Sri Lanka

Participants of SAARC Agriculture Centre

Dr. Baktear Hossain
Director

Dr. Grinson George
Senior Program Specialist (Fisheries)

Dr. Sreekanth Attaluri
Senior Program Specialist (Crops)

Mr. Kinzang Gyeltshen
Senior Program Specialist (NRM)

Dr. Nasreen Sultana
Senior Program Specialist (Horticulture)

Dr. Ashis Kumar Samanta
Senior Program Specialist (Livestock)

Dr. Younus Ali
Senior Technical Officer

Dr. Fatema Nasrin Jahan
Senior Program Officer

SAARC Agriculture Centre (SAC)
BARC Complex, Farmgate, Dhaka-1215, Bangladesh
Phone: +88-02-41024776, Email: director@sac.org.bd
Website: www.sac.org.bd

ISBN:978-984-35-2764-6
9 789843 527646