CAGE FISH FARMING IN INDIA AND BANGLADESH

Prospects for Bilateral Cooperation

CUTS International

#2112

Cage Fish Farming in India and Bangladesh

Prospects for Bilateral Cooperation

Published by

CUTS International

Consumer Unity & Trust Society

D-217, Bhaskar Marg, Bani Park, Jaipur 302016, India

Ph: 91.141.2282821, Fx: 91.141.2282485

Email: cuts@cuts.org, Web: www.cuts-international.org

© CUTS International, September, 2021

Supported by

Sweden Sverige

TROSA TRANS-BOUNDARY RIVERS OF SOUTH ASIA

OXFAM

This Research Report has been published as a part of the CUTS project entitled, "Transboundary Rivers of South Asia (TROSA)" undertaken with the support of the Swedish International Development Cooperation Agency (Sida) and managed by Oxfam.

The views expressed here are those of CUTS International and can therefore in no way be taken to reflect the positions of Sida and Oxfam.

ISBN 978-81-8257-287-4

Printed in India by MS Printer, Jaipur

#2112

Contents

List of Tables and Figures

Abbreviations

ADB	Asian Development Bank
AOC	Aqua One Centre
ATMA	Agricultural Technology Management Agency
BCR	Benefit Cost Ratio
BFRI	Bangladesh Fisheries Research Institute
CAGES	Cage Aquaculture for Greater Economic Security
CARE	Cooperation of American Relief Everywhere
CBCF	Culture Based Capture Fisheries
CIFRI	Central Inland Fisheries Research Institute
CMFRI	Central Marine Fisheries Research Institute
CMSGUY	Chief Minister's Samagra Gramya Unnayan Yojana
DFID	Department for International Development
DoF	Department of Fisheries
EUS	Epizootic Ulcerative Syndrome
FEAP	Federation of European Aquaculture Producers
FFDA	Fish Farmers' Development Agency
FPOs	Farmer Producer Organisations
FRP	Fibre Reinforced Plastic
GAFRD	General Authority for Fish Resources Development
GBM	Ganges, Brahmaputra and Meghna
GI	Galvanised Iron
HA	Hectare Area
HDPE	High Density Poly Ethylene
ICAR	Indian Council of Agricultural Research
IMC	Indian Major Carp
IMF	International Monetary Fund
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
KVK	Krishi Vigyan Kendra

ìg	*Microgram*
MG	Milligram
MoFL	Ministry of Fisheries and Livestock
MT	Metric Tonne
NFDB	National Fisheries Development Board
NGOs	Non-Governmental Organisations
NORAD	Norwegian Agency for Development Cooperation
NPV	Net Present Value
PMU	Project Monitoring Unit
PPT	Parts Per Thousand
PVC	Poly Vinyl Chloride
RAS	Recirculation Aquaculture System
R&D	Research and Development
SGDP	State Gross Domestic Product
SHGs	Self-Help Groups
SIDA	Swedish International Development Agency
SIFS	Small Indigenous Fish Species
TROSA	Trans-boundary Rivers of South Asia
USAID	US Agency for International Development
UT	Union Territory
WSAS	Water Spread Area

Acknowledgement

Many landowners interested in aquaculture may not have the financial and physical resources or the practical experience to start a large-scale aquaculture operation. Growing fish in cages can be a means for landowners with existing ponds to produce fish for secondary sources of income and gain aquaculture experience. Cage culture is an intensive form of aquaculture of growing fishes in net cages, allowing free water flow. Farming fish in an existing water body removes one of the biggest constraints of fish farming on land, i.e., the need for a constant flow of clean, oxygenated water.

Cage farms are positioned in a way to utilise natural currents, which provide the fish with oxygen and other appropriate natural conditions. Thus, this is a low-impact farming practice with high returns and a low carbon footprint.

In India and Bangladesh, cage culture is a relatively new inland aquaculture practice. It brings in new opportunities for optimising fish production from the reservoirs and lakes and developing new skills among fishers, entrepreneurs, women, and other local communities residing alongside the water resources in the countries.

This research study titled 'Cage Fish Farming in India and Bangladesh: Prospects for Bilateral Cooperation' aims to generate evidence supporting a business case for traders and producers of cage fish farming in Assam (India) and Bangladesh. While exploring the potential locations for cage fish farming in India, the study also gauged the perceptions of local communities, including women, on the possible benefits of trade via transboundary waterways between India and Bangladesh.

The project team would like to acknowledge all the support availed during the study from various individuals and organisations. We offer our sincere thanks to Oxfam for implementing the regional programme Transboundary Rivers of South Asia (TROSA) and The Swedish International Development Cooperation Agency (Sida) to support the programme. Special thanks to Jyotiraj Patra, Santanu Dam and Avinash Singh of TROSA's Programme Management Unit (PMU) for their continuous support and guidance throughout the entire project duration.

We are also grateful for the assistance and collaboration of Chandan Chetri, Vinuthna Patibandhla, Shobhit Chepe, Directorate of Fisheries, Government of Assam, Oxfam India, and Oxfam Bangladesh,

The project team would also like to thank all the stakeholders who have been consulted during the implementation phase of this project at various levels. We are also highly grateful to (Late) Arun Roy for his continuous support and guidance as a research consultant.

We sincerely thank Madhuri Vasnani, Mukesh Tyagi and Rajkumar Trivedi for editing and layouting and publication support. We are also grateful to G C Jain and Sudhir Kumar for managing the financial and budgetary aspects of this project. Many other names deserve special mention but could not be referred here for want of anonymity. We thank them all for their support. Finally, any error that may have remained is solely our responsibility.

Project Team
CUTS Centre for International Trade, Economics and Environment
(CUTS CITEE)
CUTS International

Contributors

Yatika Agrawal

Yatika Agrawal is a Research Associate at CUTS International. She has completed her Master's in Economics with specialisation in Development Studies from Symbiosis School of Economics, Pune. She has done internships with GME, FICCI, PAC, and RIDCOR and volunteered at other organisations. Her interest area includes sustainable development, livelihood, and gender development.

Srijata Deb

Srijata Deb is currently pursuing her Master's in Public Policy (MPP) from St. Xaviers, Mumbai. She worked as a Research Associate at CUTS International. She holds a graduate degree in Economics from Delhi University and a post-graduate diploma in Liberal Arts from Ashoka University. She has around two years of experience in the field and desk-based research related to trade, sustainable development, livelihoods and regional connectivity.

Deepmala Ghosh

Deepmala Ghosh is a Research Associate at CUTS international. She has completed both her Master's and Bachelor's degree in Economics from Pondicherry University in September 2020. Her research interest lies in International Trade, Statistics and Econometrics, Health Economics, Labor Economics, Gender and Trade, Microfinance.

Saurabh Kumar

Saurabh is a Fellow at CUTS International. He holds a Ph.D. in international relations from Jawaharlal Nehru University. He has experience of around ten years in field-based research. He has worked at the London School of Economics and Political Science, the UK as a Post-Doctoral Fellow.

Udita Sharma

Udita Sharma worked as a Research Intern at CUTS International. She is pursuing B.A.LLB. (Hons.) at National Law University, Odisha. She has worked with various organisations engaged in field-based research. She has a keen interest in the areas of gender, international trade and the environment.

Veena Vidhyadharan

Veena is a Fellow at CUTS International. She holds a doctorate in agricultural science (Agronomy) from Rajasthan Agricultural University, Bikaner. She has over 15 years of experience in research and project management related to agriculture, climate change, transboundary water governance and livelihoods. Before CUTS, she was with the Department of Agriculture, Government of Kerala.

Preface

Bipul Chatterjee
Executive Director
CUTS International

The unorganised sector of fish cultivation is most prevalent in the lower parts of Assam and the adjoining areas of Bangladesh, having numerous river islets called chars. Over the last few years, a new narrative of socio-economic development has evolved around the inland waterways as drivers of change in the marginalised border areas along the banks of the Brahmaputra River.

This narrative recognises that opportunities offered by transboundary inland waterways can be explored through mutual cooperation at the sub-regional level. A number of stakeholders push this concept of cross-border trade of fish gather the support of the governments of India and the Government of Bangladesh. The production and cross-border trade of fish through transboundary rivers of India and Bangladesh offer the potential to increase bilateral economic cooperation and improve the livelihood opportunities of local communities.

In this context, CUTS International undertook a study on the prospects of cage fish farming production and supply chain in India and Bangladesh under the regional programme "Transboundary Rivers of South Asia" (TROSA) as part of its Year-4 activities. It explored the production and trade prospects of cage fish farming in the Assam region and tapped the potentials of the emerging arena to make the benefits accessible to the participating communities. The report entails the observations collected during the field work and has also come out with some specific recommendations to facilitate the *status quo* for the local communities to promote empowerment of local indigenous communities, including youth and women.

I want to thank Oxfam, Novib, the Netherlands for implementing the TROSA programme and the Swedish International Development Cooperation Agency (Sida) for its generous support. My special thanks to Jyotiraj Patra, Project Manager – TROSA at Oxfam Cambodia, for his continued support, guidance and cooperation.

I extend my gratitude to the Directorate of Fisheries, Government of Assam, Oxfam India and Oxfam Bangladesh for their support and engagement at various levels and capacities. Sincere thanks are also due to (Late) Arun Roy, an expert on River Engineering & Inland Water Transport Operations, and Consultant, CUTS International, for his inputs and overall guidance in conducting the study.

Executive Summary

The Ganges, Brahmaputra and Meghna (GBM) is a transboundary river system that holds cultural, religious, economic and political importance for Bangladesh and India. These perennial rivers provide a range of ecosystem services, including agriculture, fisheries, navigation, tourism, trade and hydropower, sustaining the lives and livelihoods of millions of riverine communities.

Cage fish farming gained traction due to the depletion of fish catches and massive destruction of aquatic life by huge vessels

Historically, GBM rivers have been used as trade through waterways. However, over time infrastructural impetus on land-based transportation systems has resulted in suboptimal efficiency due to over-saturation, economies of scale and environmental sustainability.

Communities residing in these rivers were dependent on such economic activities. It is thus imperative to revive these rivers for the social development of these communities. TROSA programme is being implemented to achieve similar goals of reduced poverty and the right protection of these communities through multiple stakeholders.

This report titled "Cage Fish Farming in India and Bangladesh: Prospects for Bilateral Economic Cooperation" is a project TROSA led by CUTS International.

The study aims to generate evidence regarding the potentials of enclosed fish culture amongst the local communities of Assam *vis-à-vis* its cross-border trade prospects. It entails an elaboration on the economic, technical and social parameters to explore the scope, benefits and constraints with specific recommendations to enhance the opportunities of the arena.

The study has followed a qualitative and quantitative approach to reach its conclusions. This is inclusive of the field-based research to provide the optimal results in the situation. In addition to this, secondary data and literature has been relied upon to provide a holistic outlook. The fieldwork was conducted in Guwahati, Koliabor and Abhyapuri of Assam, India.

The research has highlighted that cage fish farming gained traction due to the depletion of fish catches and massive destruction of aquatic life by huge vessels. Southern states of India are already utilisng the technique for better socio-economic profits. The

eastern and north eastern states have started to kick off the practice in their states too.

Cage fish projects are guided by National Fisheries Development Board (NFDB) under the 'Guidelines for Cage Culture in Inland Open Water Bodies of India'. The Directorate of Fisheries in Assam has installed a floating fish tank with the help of Fibre Reinforced Plastic (FRP) floating modular units in Koliabor and Assam. The Directorate of Fisheries Assam initiated the project under the Chief Minister's Samagra Gramya Unnayan Yojana (CMSGUY).

The cage fish farming culture has extensive benefits in terms of lowered labour costs, the scope of pre-planning of fish harvesting, the possibility of sequential and distinct harvesting of different fish species and added prospects of engaging women in the sector

At present, cage culture in the country is restricted to non-flowing water bodies and dams/beels. This is happening despite the existence of unutilised secondary channels in several wide river systems. Thus, there is a need to explore the potentials of cage fish farming in such secondary channels of wide free-flowing rivers within a fenced area for commercial purposes.

However, it was noted that the fishing done in Indian rivers mostly targets the natural fish resource. There is very little effort by agencies/individual fishers to augment the fish population of these rivers, followed by planned fish extraction.

The cage fish farming culture has extensive benefits in terms of lowered labour costs, the scope of pre-planning of fish harvesting, the possibility of sequential and distinct harvesting of different fish species and added prospects of engaging women in the sector. It has been highlighted that the initial capital cost of cage culture is high due to the utilisation of pre-fabricated FRP modular floats. However, improvisation in this regard can drastically reduce capital costs and further popularise cage fish farming.

Bangladesh, in particular, is a country well-endowed with a large wetland area comprising diversified fisheries resources. The country holds immense potential to enhance trade and revenue through diversified fishing resources. Reports highlight that fish production has increased significantly over the years. It has been estimated around 43 lack metric tonne in 2018-2019 (Department of Fisheries, Bangladesh, Ministry of Fisheries and Livestock).

The export value of fish and aquatic invertebrates, from Bangladesh to the rest of the world, stood at US$45,000mn. This has enhanced employment opportunities for the local communities as well. Official statistics show that more than 18 million people depend on the fish and fisheries sector.

Cage culture was first introduced to Bangladesh in the late 1970s (Ahmed, 2010). Fisheries and aquaculture are the second-largest export industry and the most critical contributors to export earnings in Bangladesh. At present, inland open, aquaculture and marine sectors are facing various constraints such as wetland degradation, overexploitation, and

use of destructive gears, siltation, and closure of natural fish passes, use of pesticides and agrochemicals, discharges of industrial wastes and loss of natural breeding grounds through habitat degradation. Likewise, the cage fish farmers also hinder certain hurdles like construction costs, thefts, unaffordable cash requirements for supplementary feed, and incompatibility between the immediate need from earning daily income among the poorest and the seasonal income that cage culture can offer.

Cage culture was first introduced to Bangladesh in the late 1970s

The projects for enhancing cage fish farming in Bangladesh are guided and supervised by the Department of Fisheries (DoF) under Bangladesh's Ministry of Fisheries and Livestock (MoFL). The CARE-CAGES (Cage Aquaculture for Greater Economic Security) project is the most significant project working solely for the cage fish farmers in the country. The Project was initiated in September 1995, began cage-aquaculture activities in 1996, and is now working with approximately 4,200 households through 45 partner non-governmental organisations (NGOs).

However, despite these efforts and projects, the practice is yet to be popularised in all the strategic locations in the country. Several challenges, including poor access to information, conflicts over the public water bodies, high price feed and theft and vandalism, have been identified for the slow growth of the culture in the country.

Additionally, it has also been highlighted that the interventions and the funding aids hardly reached the poor or the local stakeholders. To overcome these obstacles, reform measures for widespread adoption of cage culture and benefit the small farmers in the country need to be adopted.

Some of the key recommendations for cage fish farming in India and Bangladesh include:

- Access to land and water is pivotal for cage fish farming. Conventional aquaculture development initiatives that emphasise the promotion of technology and provision of targeted extension services are unlikely to reach the functionally landless and the extremely poor without access to land and water.

- Cage fish farmers require human capital and skills, social capital, financial capital, and a vital operating environment, including support infrastructure, facilities, and access to markets.

- Secure access rights are critical when the landless gain access to water bodies or ponds through lease or other access arrangements for fish farming. Without binding and long-term agreements on access rights, cage fish farmers are vulnerable. Eviction is common when access is not secure, and interrupted operation can result in loss of investment that the poor cannot recover.

- Most direct beneficiaries of fish seed and development technologies in Bangladesh are not the poorest people. The initiatives and strategies need to recognise specific and prevalent features of poverty among the intended beneficiaries, including overcoming key barriers for entry into cage culture and adoption of technologies and mitigating risks to which the poor are particularly vulnerable.

- It should be ensured that the cages placed in a planned manner will ensure biodiversity to combat the environmental concerns in this sector. Moreover, the quality of rivers should not be hampered.

1 Introduction

In India, cage culture in inland water bodies was initiated for the first time in air-breathing fishes in swamps, raising major carps in running waters in Yamuna and Ganga at Allahabad and raising carps snake heads and tilapia in lentic water bodies of Karnataka

The earliest record of cage culture practices dates back to late 1800 in Southeast Asia, particularly in the freshwater lakes and river systems of Kampuchea. Marine fish farming in cages traces its beginning to the 1950s in Japan, where fish farming research at the Fisheries Laboratory of the Kinki University led to the commercial culture of yellow tail Seriola quinqueradiata and developed into a significant industry as early as 1960. Since 1970, Thailand has developed cage culture techniques for two important marine finfish: the sea bream (Pagrus major) and grouper (Epinephelus spp.).

Large-scale cage farming of groupers was established in Malaysia in 1980. Korea started cage culture in the late 1970s, and by the end of 1980, cage culture of the olive flounder (Paralichthys olivacens) and black rockfish (Sebastes schlegeli) was established and developed into a successful aquaculture industry in the 1990s.

Cage culture of groupers (Epinephelus spp.) in the Philippines has been practiced since the 1980s. Mariculture of milkfish in the 1990s led to the further growth and development of the industry. In Europe, the cage culture of rainbow trout (Oncorhynchus mykiss) in freshwater began in the late 1950s and in Norway, Atlantic salmon (Salmo salar) followed in the 1960s. More than 40 per cent of its rainbow trout comes from freshwater cages. Salmonid culture is currently dominated by production from Norway, Scotland and Chile. Cage culture of fish was adopted in the US in 1964.

Currently, many fish species have been cultivated in various designs and sizes of cages in Asia, Europe and other parts of the world. Tilapia and carp predominate in freshwater cage culture in Asia, while salmonids are commonly farmed in Europe and America (Gopalkumar, 2009).

Even though sea cage farming has been advancing in many Asia-Pacific countries such as China, Indonesia, Japan, the Philippines, Taiwan, Vietnam and Korea in recent years, it remains to be commercialised in India. The Central Marine Fisheries Research Institute (CMFRI) has been taking pioneering and massive steps towards this direction currently.

In India, cage culture in inland water bodies was initiated for the first time in air-breathing fishes in swamps, raising major carps in running waters in Yamuna and Ganga at Allahabad and raising carps snake heads and tilapia in lentic water bodies of Karnataka. Thereafter the cages have been used for rearing fry in many reservoirs and floodplain wetlands to produce advanced fingerlings for stocking main water bodies (Karnatak & Kumar, 2014).

Reservoirs contribute considerably to the inland fish production of India, which has been estimated at 93,700 tonnes. Despite this fact, reservoir fish production has been treated as a by-product, giving it less importance as a fish production system. For this reason, reservoir fisheries have not made significant progress in the country and do not contribute to the inland fish production of the country to the extent they could. Reservoirs in India offer ample scope for fish yield optimisation through effective management.

The prime objective of cage culture in inland open water is to stock reservoirs and culture of economically important fishes to augment fish production

The reservoirs of India have a combined surface area of 3.25 million hectares (ha), mostly in the tropical zone, which makes them the country's most important inland water resource, with huge untapped potential. The sheer magnitude of the resource makes it possible to enable a substantial increase in production by even a modest improvement in yield.

Further, the importance of reservoirs derives mainly from the advantages from environmental and social perspectives. There is a need to dovetail the twin objectives of yield optimisation and environmental conservation. Fish yields of 50 kg/ha/year from small reservoirs, 20 kg/ha/year from medium-sized reservoirs and 8 kg/ha/year from large reservoirs have been realised while still leaving scope for enhancing fish yield through capture fisheries, culture-based fisheries and cage culture.

The success rate of auto-stocking is meagre in Indian reservoirs, especially in smaller ones. Many of the smaller reservoirs dry up during the summer, partly or entirely, with no stock surviving. The prime objective of cage culture in inland open water is to stock reservoirs and culture of economically important fishes to augment fish production. Stocking with the right fish species, using seed of appropriate size and introducing it at the right time is essential to optimising fish yield from reservoirs.

Though 22 billion fish fry is produced every year in India, there is an acute shortage of fish fingerlings available for stocking reservoirs. Where fingerlings are available, transporting them to reservoirs usually incurs high fingerling mortality. In this context, producing fingerlings in situ in cages also offers an opportunity for supplying stocking materials, which are vital inputs towards a programme of enhancing fish production from Indian reservoirs (Karnatak & Kumar, 2014).

In addition to this, women are actively involved in allied fisheries

activities like fish seed collection, fishing of juvenile fishes, collection of mussels, edible oysters, sea weeds, fish marketing, fish processing and product development. Women are particularly active in post-harvest fisheries; in marine fisheries sector, and comprise about 75 per cent of those engaged in fish marketing and contribute in significant ways to the food security needs of a diverse range of consumers.

With proper measures, the communities above can engage and explore the arena of cage fish farming thereby increasing the financial returns for the nation and themselves

Training and micro finance are provided to encourage and organising them into groups and capacity building, which are the thrust areas for enhancing their involvement and participation in the fishery sector. Formation of Producer Organisations helps the weaker sections to collectively take up activities and market their produce through value addition (NABARD, 2018).

With proper measures, the communities above can engage and explore the arena of cage fish farming thereby increasing the financial returns for the nation and themselves. Therefore, this issue becomes significant to tap its potential and an expansion of its benefits to the different communities to benefit the individuals and the nation.

Given this background, this study will have five different sections. The next section would highlight the socio-economic dialogue over cage fish farming practices, emphasising the economic viability of the cage culture. Further, the third section will explain the operations of cage culture, its advantages, constraints and cost and revenue trends.

Section four and five emphasise the prospects of exploring the culture in the states of Assam in India and various learnings, in terms of policy suggestions and the role of the private and development sector in enhancing the cage aquaculture, it can adopt from other countries where such cultures are prevalent.

The last section will conclude and focus on what can be done, moving forward, to enhance the popularity of the cage culture in India and Bangladesh.

2 The Socio-economic Dimension of Cage Culture

A robust governance platform based on co-management principles is essential for responsible cage culture operations to be undertaken by the community

Unlike the land-based aquaculture undertaken on private land, cage culture is practiced in common property resources. Thus, giving rise to the discourse of the ownership of the cage installed in the reservoirs. The discourse needs to address certain issues.

Firstly, it should be noted that the government owns almost all large and medium reservoirs in the country or its related agencies and fishing activities are conducted in these reservoirs considering these water bodies as common property resources with free or almost free access. Secondly, fishes produced from these reservoirs are essentially natural resources and traditional and local fishing communities tend to have primary natural rights over these produces. Additionally, these communities' livelihoods depend on catching fish from such reservoirs. Reservoir fishing is also sometimes allowed as a means to rehabilitate ousted from the dam project site.

Cage culture can adversely impact the interests of local fishers by restricting their access to the fishing grounds, obstructing their pathways, and contributing to a decline in fish catch if cage culture affects the natural productivity of the water body. Thus, it becomes imperative to ensure that the expansion of cage culture does not impair the livelihood and income of fishers. However, at the same time, it is equally important to utilise the additional fish production potential through cage culture.

These conflicts can be avoided by empowering the fishermen to conduct cage fish farming and regular fishing collectively. Allowing individual investors and corporate organisations to take control of the cage culture to follow a purely revenue-oriented approach will hamper the spirit of inclusive growth of riverine communities and further lead to social tension. Thus, the community (or a group of community members) should own the cages as common property. They should be the beneficiaries of this technology, even in a Public-Private Partnership (PPP) mode.

A robust governance platform based on co-management principles is essential for responsible cage culture operations to be undertaken by the community. When a private

entrepreneur or investor is allowed to undertake cage culture, the government, through strong policies, should protect the interest of the local fishers and fisher communities, who have the primary rights to the natural resource.

But the existing fishermen cooperative societies have poor track record of functioning as a responsible entity to work as a group. This throws a big challenge on the government to organise and empower the fisher communities and develop capacity among them to take up cage culture. Self Help Groups (SHGs), cooperative societies or other such groups should be given licences to undertake cage culture. A conflict management cell should be established to address the complaint.

Cage farming offers tremendous scope for boosting fish production in the country

Cage farming offers tremendous scope for boosting fish production in the country. The vast water resources and conducive environmental conditions in the coastal waters are excellent for large-scale cage farming. Multispecies cage farming can be developed in a commercial way with minimum investment in the country. Cage farming could be taken up as a highly profitable alternate avocation by the fishermen individually or in groups. The comparatively low initial investment cost and recurring expenditure, ease of operations, short duration of culture and high returns per unit volume make cage aquaculture a widely accepted farming practice.

Economic viability plays a crucial role in the successful adoption of any farming technology. The initial investment and recurring expenditure associated with the development and maintenance of infrastructure are low in cage farming compared to shore-based farming practices. Gross income realised through cage farming is high since high-value fishes having great demand in the domestic and export markets are cultured. The market opportunities for cage farmed fishes are plenty in the domestic and export sectors due to their superior quality and freshness. Economic viability and financial feasibility analysis help the farmers and fisher folk make investment decisions and efficiently allocate scarce resources to achieve the maximum economic benefits.

The economic indicators also assist in developing lending policies, repayment options or subsidies to the sector by policy makers or financial institutions. CMFRI has standardised cage farming protocols for different types of cages in sea, estuaries and coastal waters. The factors affecting the economic viability of cage farming are explained below. The economic viability of cage farming depends on the availability and selection of suitable sites, capital and operational expenses, yield, market potential, promotional schemes and government policies.

Selecting a suitable site for cage farming is an essential criterion for the economic viability of cage fish farming. Since the site for cage fish

farming can directly impact the success, capital investment and operational expenses, yield and mortality rates.

Under such circumstances, the following points should be considered while selecting a cage fish farming location. These include:

- Areas prohibited for aquaculture activities by the regulatory authorities should be avoided for installation of cages;
- The site should be away from other uses like navigational routes, fisheries, tourism or marine protected areas;
- In the case of open sea cage farming, care needs to be taken to ensure appropriate lease rights or legally valid authorisation to the fishermen groups, self-help groups, or fishers cooperatives before installation of cages; and
- Environmental or topographical aspects in the site also should be given due weightage before selecting the cage sites. For instance, considerations regarding water depth, carrying capacity, water quality requirements, winds, waves, currents, tides and bottom substrate.

In this regard, the following considerations should be addressed.

- The usual depth of a cage is 4-6 m and a depth of water of 6-10 m at low tide is ideal for sea cage farming. Sufficient depth under the cage is necessary to maximise water exchange and avoid oxygen depletion and accumulation of waste. The selected sites should be free from industrial, domestic or agricultural pollutants
- The carrying capacity is the maximum level of production that a particular site is expected to sustain. Intensive farming results in the accumulation of wastes and deterioration of water quality that can lead to fish mortality. Less intensive farming may lower productivity. It is vital to assess the carrying capacity of the sites to ensure economically viable and sustainable production systems.
- Ensuring the proper quality of water is an essential criterion for any aquaculture activity. The major water quality parameters considered for site selection in cage farming consist of temperature, salinity, dissolved oxygen, pH, turbidity, inorganic nitrogen, total inorganic phosphorous, chemical oxygen demand, chlorine, heavy metals and pesticides.
- The moderate wind is beneficial to cage farms, whereas strong winds generated by cyclones can destroy the cage structure and fish stocked in cages. Areas having strong wind action should be avoided for cage installation. For floating cages in the sea, wind velocity should not exceed 10 knots. Wave height is influenced by wind velocity and wave energy increases proportionately with a square of wave height. The maximum limit for wave height is 1m. A weak and continuous current stream is favourable to

cage farming, whereas excessive current damages floating structures, cages and adversely affects the fish behaviour.

- The permissible limit of current velocity for cage farming is 0.05-1 ms-1. The current velocity reaches up to 1.2 ms-1 in many places on the Indian coast and such areas should be avoided for marine cage farming. Similarly, tide amplitude of <1m is preferred for marine cage culture. Monsoon season is avoided for marine cage farming as the current velocity is unpredictable during this period.
- A sandy or gravel bottom is generally preferred for cage installation, whereas a muddy or rocky bottom causes difficulties for the safe anchorage of cages (Rao, 2012). Geographical Information Systems (GIS) can be applied to analyse such environmental issues in coastal zones for aquaculture activities.

Table 1: Sites of Cage Culture in India

Cage culture sites	Maritime state
Sutrapada (Veraval)	Gujarat
Kalamb (Mumbai)	Maharashtra
Karwar (Uttara Kannada) and Byndoor (Mangalore)	Karnataka
Cochin (open sea & backwater) and Vizhinjam (Thiruvanathapuram)	Kerala
Uppada (Kakinda), Vishakapatnam, Nellore, Antarvedi, Narsapur (East Godavari), Srikakulam and NagayaLanka, (Krishna estuary, Machilipatnam)	Andhra Pradesh
Chemmanchery (Chennai), Kanyakumari, Mandapam	Tamil Nadu
Pahuj Reservor (Das et al, 2009) (Jhansi)	Uttar Pradesh
Dahod Reservoir (Karnatak & Kumar, 2014) (Bhopal)	Madhya Pradesh
Hirakund Reservoir and Balasore	Odisha
Khelma (Barak Valley, Cachar District) (Kakati, Bhgawati & Baishya, 2018) Sibasthan Beel, Mer Beel and Samaguri Beel (Nagaon District), Sorbhog Beel (Barpeta), Charan Beel (Morigan District)	Assam

3 Indicative Economics of Cage Culture

Cage culture can be established in any suitable body of water, including lakes, ponds, mining pits, streams or rivers with proper water quality, access and legal authority

Cage culture is an emerging mechanism of rearing fish from fry to fingerling, fingerling to table size, or table size to marketable size. This rearing occurs while the fishes are enclosed in a cage that maintains the free exchange of water with the surrounding water body. The cage is enclosed on all sides with mesh netting, made from synthetic material to resist decomposition even after being in contact with water for extended periods (Karnatak and Kumar, 2014).

The operation of cage culture involves:

1. Stocking: The stocking density of fish depends on the cages' carrying capacity and the feeding habits of the cultured species. Furthermore, for those species belonging to the lower levels in the food chain, stocking will also depend on the primary and secondary productivity of the sites. The optimal stocking density ensures optimum yield and low disease prevalence. This can vary with the species and sizes of these species.

2. Feeding: Several factors, including biological, climatic, environmental and economic issues, may impact the feeding patterns of the fishes in cages. For instance, different species have varying food intake, feeding frequency, digestibility and conversion efficiency. Such factors alter the net yield, survival rates, fish sizes and overall production from the cage. Secondly, trash fish is the main feed for yellowtail, grouper, bream, snapper, and other predatory fish species cultured in marine cages. The shortage of trash fish is a major problem in many countries with large-scale cage farming.

3. Farm management: Efficient farm management depends heavily on the competence and efficiency of the farm operator about feeding, stocking, minimising loss due to diseases and predators, monitoring environmental parameters and maintaining efficiency in technical facilities (Gopalkumar 2009).

Advantages

1. Resource use flexibility: Cage culture can be established in any suitable body of water, including lakes, ponds, mining pits, streams or rivers with proper water quality, access and legal authority. This flexibility makes it possible to

exploit underused water resources to produce fish.

2. Low initial investment: Relative to the cost of pond construction and its associated infrastructure (electricity, roads, water wells), cage culture in an existing body of water can be inexpensive. Cages often do not require aeration or any electrical source at low densities (relative to pond surface acreage). Cage materials are not especially expensive and many kinds of cages can be constructed with little experience.

3. Simplified cultural practices: Cages lend themselves to the straightforward observation of the fish. Observing fish behaviour, especially feeding is critical to anticipating and avoiding stress and diseases, which often occur in cage culture.

4. Simplified harvesting: Cages are usually harvested by moving them into shallow water, crowding the fish into a restricted area, and simply dipping them out of the cage. Or, the cage can be lifted partially out of the water so that the fish are crowded into a smaller volume, and then the fish dipped out. This makes it possible to partially harvest fish from cages for local niche markets or personal consumption.

5. Multi-use of water resources: The confinement of fish in cages should not hinder other uses of the water resource, such as fishing, boating, swimming, irrigation or livestock watering. As carp feed at a low tropic level, rearing carp fingerlings has minimal impact on the environment. Polyculture of carp species with various feeding habits makes wise use of resources, as the different feeding habits of various species and their acceptance of a wide range of supplemental feeds maximises fingerling uptake of feed while minimising competition among species, feed waste and the resulting pollution.

6. Elimination of losses to predation: Cage culture eliminates losses to predation and facilitates prophylactic measures to contain any disease outbreak, allowing very high fingerling survival rates. It effectively uses manpower, as daily maintenance routines and monitoring are relatively simple, and harvesting is rapid, easy, sure and complete.

7. Cost effective: As cage culture can be practiced intensively, high yields can be achieved very cost-effectively.

8. Source of alternative income: Cages make use of existing water bodies. Thus, it can be given to non-land-owned fishermen communities, whose income is affected by many reasons in the fishing sector. It, therefore, acts as an alternative income for such groups (Karnatak and Kumar, 2014).

In addition to the above advantages, insights from CUTS field visits have indicated the following:

- Cage fish farming reduces labour cost greatly as minimum labour is required for fish

feeding, cleaning of cages and fish extraction. While three to four labours are required regularly for feeding the fish, keeping the pond clean of unwanted growth of algae, water hyacinth, unwanted species and for harvesting, only one labour is required for 10 cages of 4 meters X 4 meters width and the same man can do harvesting as it will only mean lifting the cage and taking out the fish.

- The wastage of fish food is minimum and the feed is utilised only by the targeted variety of fish being cultivated.
- Harvesting can be done sequentially, cage by cage, while all the fish being grown for a natural pond gets agitated.
- Growth of fish lings and harvesting can be pre-planned cage-wise while not possible for a natural pond.
- Different species of fish can be cultivated in different cages and they will not disturb each other. This option is not available for pond fish cultivation.
- The scope of women's participation in this culture is immense. Given that activities in cage fish farming can be preplanned and hardly require extensive labour, women can take up this activity at ease.

The scope of women's participation in this culture is immense. Given that activities in cage fish farming can be preplanned and hardly require extensive labour, women can take up this activity at ease

Constraints

Cage culture, despite its benefits and advantages, tends to have a few constraints. Firstly, cages occupy space on the surface of water bodies and, if poorly positioned, may disrupt navigation or diminish the scenic value of the reservoir. Poorly placed cages may alter current flows and worsen sedimentation. Further, cages with inappropriate intensity or poorly managed cages may lead to eutrophication owing to the spillover of unconsumed fish feed and fish waste to the surrounding environment.

Certain months of the year, when strong winds or heavy floods are experienced, cages may be damaged. However, this risk can be avoided by anchoring batteries of cages in protected inlets, which restrict strong currents and waves.

In addition to this, there are several constraints about the fish. For instance, fish feed must be nutritionally adequate and fresh. Caged fishes get significantly less natural food and thus depend on the manufactured supplements for their required nutrition. Feed must provide all necessary proteins (down to specific amino acids), carbohydrates, fats (including essential fatty acids), vitamins and minerals for maximum growth.

Moreover, fish diseases are a common problem in cage culture and they can cause catastrophic losses. Wild fish around the cage can transmit diseases to the caged fish. The crowding in cages promotes stress and allows disease organisms to spread rapidly. On certain occasions, wild fish, turtles and fish-eating birds can harm the caged fish unless proper precautions are taken.

Proper water quality is necessary for efficient cage culture. Localised

water quality problems, particularly low dissolved oxygen, are common in cage culture. The high fish densities and high feeding rates often reduce dissolved oxygen and increase ammonia concentration in and around the cage, especially if there is no water movement through the cage.

A high stocking density creates a stressful environment for the fish and stress damages the immune system. The risk of disease is, therefore, high. Cage culture can introduce or disrupt disease and parasite cycles, change the aquatic flora and fauna and alter the behaviour and distribution of local fauna (Gopalkumar, 2009). Low dissolved oxygen within cages may not affect other organisms in the lake, pond or stream.

Large-scale expansion of cage farming necessitates exploring better marketing opportunities in the domestic and overseas markets

Efficient marketing channels are essential components of economically sustainable farming activities. The declining catches from marine capture fisheries and growing demand for quality fish products offer enormous opportunities for marketing farmed fishes. The cage farmed fishes are primarily sold through local fish markets or at farm gates and fetch a premium price owing to their superior quality and freshness.

Various institutional organisations, including Central Marine Fisheries Research Institute (CMFRI), State fisheries departments, Cooperative banks and Non-Governmental Organisations (NGOs) involved in promoting cage farming in the country, also undertake market promotion activities through online portals, live fish sales or fish harvest meals. However, large-scale expansion of cage farming necessitates exploring better marketing opportunities in the domestic and overseas markets.

Capacity building of small-scale fishers or fish farmers in the country to improve the entrepreneurial capabilities, market promotion through fishermen/ farmers co-operatives or Farmer Producer Organisations (FPOs), better storage and transport infrastructure and value-added products need to be promoted for tackling the future marketing challenges.

Lastly, vandalism and poaching pose severe challenges to the cage culture. Caged fishes are an easy target for poachers and vandals. Cages must be placed where access can be controlled and poaching risks reduced.

Costs Involved in Cage Fish Farming

The significant components of cost in cage farming are *capital* and *operational* costs. The former includes investments in cage frames, nets, accessories, mooring and cage installation charges, in addition to miscellaneous charges for storage and transportation of fish and feed. Moreover, major operational cost components include costs of feed, seed, labour charges for feeding and harvesting and maintenance costs for cage frame and accessories.

Aged fishes are an easy target for poachers and vandals. Cages must be placed where access can be controlled and poaching risks reduced

The cage production system consists of a floating structure, net materials and mooring system with a round or square-shaped net cage to hold and grow fish and can be installed in seas, lakes, rivers or reservoirs. However, the associated costs vary for cage culture practices in the open sea, estuarine and brackish water across various activities conducted under cage culture.

The annual fixed cost is calculated from the total investment cost based on depreciation and interest on fixed capital. The depreciation for cage frame is calculated for an expected life of seven years for sea cages and five years for backwater and estuarine cages. The depreciation on nets, floats and accessories was calculated for an expected life of five years.

Capital Costs

Cage culture requires a certain amount of capital investment for the mechanism to gain the traction it deserves. The major components of capital investment in cage fish farming are as follows.

Table 2: List of Components of Costs and Revenues in Cage Farming

Capital Investment
1. Cost of cage frame
2. Cost of nets
3. Cost of floats and accessories
4. Mooring and installation charges
Total fixed cost (1+2+3+4)
Depreciation (20%)
Interest on fixed capital (12%) Annual Fixed cost (5+6) –A
Operational costs
Cost of seed
Cost of feed
Labour charges
Boat hiring, harvesting and miscellaneous expenses
License fee
Total operational cost (7+8+9+10+11) -B Total cost(A+B)
Returns
Production (kg)
Price(’/kg)
Gross revenue(12x13)

Cage culture requires a certain amount of capital investment for the mechanism to gain the traction it deserves

i. **Cage frame and accessories:** A fish cage system consists of four components, namely the floating collar, cage net, anchor and mooring system. Floating type cages are practiced in Indian waters. Sea cages are preferably circular-shaped as they can withstand sea conditions better than rectangular or square shapes. Circular cages also make the most efficient use of materials and have the lowest cost per unit volume.

The cage frame should be made of robust, durable and non-toxic materials. The cage frame for the open sea can be made from galvanised iron (GI), High-Density Poly Ethylene (HDPE), Poly Vinyl Chloride (PVC), aluminum, timbre or plastic materials. Metals and wooden frames require coating with water-resistant paint.

Cage frames are fabricated to withstand rough conditions in the Indian seas. HDPE pipe PE100 or B/C Class GI pipes (1.5") are preferred for cage frames. HDPE cages are lightweight and long-lasting, whereas galvanised iron cages are cost-effective. HDPE cages are recommended for open sea cage farming in India and GI cages for protected bays, estuarine waters and brackish water areas. Square cages are commonly used for coastal cage farming.

Based on various locations and techno-economic feasibility trials, CMFRI has identified 6m diameter cage as the ideal size for sea cage farming. The 6m dia GI cage is provided with 100-120 cm tall handrail connected using vertical and diagonal supports above the base collar. For floatation, 10 barrels of 200 l capacity filled with 30 lb air are used. The GI cage structure is coated with single coat epoxy primer and double coat epoxy paint to prevent corrosion (Philipose and Sharma 2012; Rao et al. 2013).

ii. **Cage nets:** The cage designs developed by CMFRI consist of three types of nets: *(i) Outer Predator Net* is required to protect the fishes from predator attacks; *(ii) Inner Net* is significantly used to stock fishes and *(iii) Bird Net* is required to protect the stock from birds. The outer net is essential to prevent the entry of predators into the cage.

Cage nets are made of HDPE and the mesh size varies with the size of fish stocked. Considering the strength, durability and cost factor, braided HDPE netting of 3 mm thickness and 60 mm/ 80 mm mesh size is recommended. The recommended dimension of predator net is 7 m diameter and 6 m depth.

Fine meshed velon, nylon or HDPE material of 10-16 mm mesh size is used as hapa/ nursery nets. Additionally, grow-out nets are normally made of

twisted HDPE twine of 1.5-2 mm thickness and are 18 mm/25 mm/40 mm/60 mm mesh size depending on the size of the fish stocked. These nets are essential for fish rearing at different stages of their growth. A protective bird net of nylon/ HDPE of 60-100 mm mesh must be overlaid on the cage to prevent predatory birds.

iii. **Mooring System:** Mooring system/assembly holds the cage in the desired position and at desired depth using mooring lines, chains and anchors. Gabion boxes (mesh boxes filled with rocks or concrete blocks) of 3 m x 1.5 m x 1m filled with 3-5 tonnes of dead weight and mild steel mooring chains of 10-14 mm can be used for mooring. An alternate mooring line of 22 mm pp rope or 20 mm iron rope is also required for providing additional safety to the cage in the sea.

Fixed mooring system is recommended for estuaries and backwaters. In fixed mooring, long posts are driven into the bottom bed and the cage is attached directly either with ropes or with metal hooks or tyres. The expected life span of a cage structure with a mooring system is assumed as seven years and nets and floats as five years with additional annual maintenance costs.

Operational Costs

The major components in operational cost consist of feed, seed, labour charges, boat hiring, harvesting and maintenance costs for cage frame and accessories.

i. **Seeds:** Cobia (Rachycentron canadum), Silver Pompano (Trachinotus blochii), Asian Seabass (Lates calcarifer), Snappers (Lutjanus sp.), Groupers (Epinephelus sp.) and Spiny Lobster (Panulirus sp.) are suitable species for sea cage farming. The seed cost varies with the size of fingerlings and stocking density. The average cost per seed varies from 20-50 RS for cobia, pompano and seabass, depending on the size of the fingerlings. A few government-owned private hatcheries produce the seeds of cobia, pompano, Asian seabass, and groupers.

ii. **Feeds and feeding:** Like in any other aquaculture operation, a significant share of the operational expenses goes for feeds and feeding in cage farming. Feed costs constitute nearly 50-75 per cent of operational expenses. By developing cost-effective feeds and judicious scheduling of feeding, the economic benefits of cage farming can be maximised. It also minimises feed wastage and environmental pollution. The recommended feeding rate is

10 per cent of the bodyweight for juveniles, which can be reduced to 3 per cent as fish grows with progress in culture. The feed cost varies from 20-25/ kg for trash fish and '75-90/kg for formulated feed. Proper storage of feeds is essential to maintain the quality. Cold storage preservation or freezers are preferred for the storage of feeds to maintain quality (NFDB 2018; Rao et al. 2013).

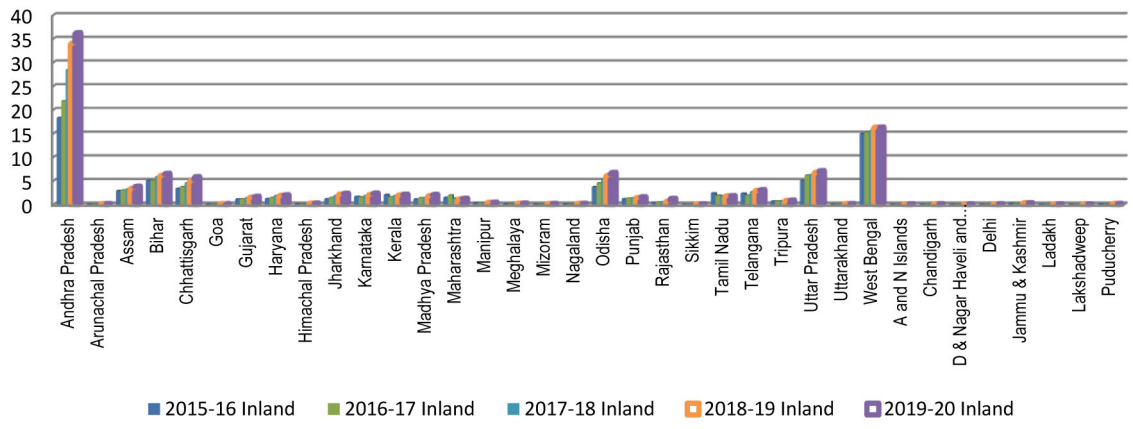
iii. **Cage maintenance:** Cage maintenance involves routine monitoring for adjusting the feeding, monitoring of environmental parameters, diseases or predators to minimise operational costs to achieve maximum economic benefits. The entire structure, including cage frame and mooring, needs to be routinely inspected. Necessary maintenance and repairs should be carried out. Timely exchange of net cage by replacing with a fresh one, cleaning nets, and mending of damaged nets are also essential to ensure water quality and facilitate faster growth of fishes." (Aswathy et al. 2020).

4 Cage Fish Farming in India

India has about 8 lakh ha of floodplain wetlands (beels, jheels, mauns, chaurs, pats) spread across the numerous river basins in the country. Major wetland areas are in the States comprise – Assam: 1.10 lakh ha, West Bengal: 0.42 lakh ha, Bihar: 0.05 lakh ha, Uttar Pradesh: 1.33 lakh ha, Odisha: 1.80 lakh ha, Arunachal Pradesh: 0.42 lakh ha, Kerala: 2.43 lakh ha, Manipur: 0.04 lakh ha, J&K: 0.06 lakh ha, Gujarat: 0.12 lakh ha, Haryana: 0.10 lakh ha (Total: 7.98 lakh ha). Wetlands of Assam, West Bengal, Bihar, Uttar Pradesh, Odisha, Arunachal Pradesh and Manipur are amongst the most important from fisheries point of view and account for 7.50 lakh ha of wetland water spread area (WSA)" (National Fisheries Development Board, 2019)

Additionally, the major species for cage fish farming in certain parts of the country are as follows: Catla (Catla catla), Rohu (Labeo rohita), Mrigal (Cirrhinus mrigala), Silver carp (Hypophthalmichthys molitrix), Grass carp (Ctenopharyngodon idella), Common carp (Cyprinus carpio), Kurhi (Labeo gonius), Mali (Labeo calbasu) and Java Puthi (Puntius sarana).

Figure 1: Inland Fisheries State-wise Production



Source: Handbook on Fisheries Statistics, 2020; Ministry of Fisheries, Animal Husbandry & Dairying 2021

Table 3: India's Export/Import of Fisheries

Year	Export	Import	% Share in India's total export	% Share in India's total import
2014-15	5,249.51	61.69	1.6915	0.0138
2015-16	4,486.29	67.18	1.7104	0.0176
2016-17	5,501.05	58.85	1.9942	0.0153
2017-18	6,850.91	90.54	2.2571	0.0194
2018-19	6,256.88	106.28	1.8956	0.0207
2019-20	6,159.23	129.30	1.9655	0.0272
2020-21	5,235.38	151.62	1.7941	0.0384

Source: Ministry of Commerce and Industry, GOI 2021

Fish occupies an important place in the lives of the state's people, and fish farming has been one of the common activities in rural areas

In the context of Assam, the state is endowed with vast fishery resources in the form of ponds, derelict water bodies, beels, and reservoirs, among others, which cover about 2.86 lakh ha. In addition, the two major river systems — the Brahmaputra and the Barak — cover around 4820 km. Along with their 53 tributaries, these river systems have formed the backbone of the state economy. Sustainable development and management of the potential resources for productive purposes can supplement the state's food and nutritional security.

Fish occupies an important place in the lives of the state's people, and fish farming has been one of the common activities in rural areas. More than 90 per cent of the people of the state prefer to fish in their meal, leading to an ever-increasing demand for fish. Thus, the Fishery Sector is considered an important economic activity in the socio-economic context in Assam, providing scope for employment generation, especially in the rural areas through fish production and its related activities. Fish production in the state has reached a level of 3.07 lakh MT during 2016-17 against the estimated nutritional demand of 3.42 lakh MT.

The contribution of the Fishery Sector to the State's Gross Domestic Product (SGDP) is Rs. 472,119 lakh with a growth rate of 4.68 per cent as per a quick estimate of 2015-16 (Economic Survey, Assam 2016-17)."

The main fish production strategy, horizontal expansion, is being accomplished by creating new ponds and reclamation and renovation of existing areas, followed by fish culture. On the other hand, thrust on vertical expansion is given through productivity enhancement with improved and advanced culture practices and better sustainable management practices.

The available resources of water and land in Assam provide excellent opportunities for the

development of fishery. These include:

1. Ornamental fish farming: Assam is the repository of 265 species of indigenous ornamental fishes, which have greater demand in the international market. At present, the export trade of ornamental fish in India is about Rs. 10 million, where the north-eastern states alone contributed 85 per cent to the total export trade. Therefore, the sector has great potential for supporting livelihood through the breeding and culture of indigenous ornamental fish species.

Integrated fish farming offers great scope for generating rural employment in Assam

2. Culture of small indigenous fish species (SIFS): Small indigenous fishes such as Mola (Amblypharyngodon mola), Puthi (Puntius spp.), Bata (Labeo gonius), Singara (Mystus spp.), Singi (Heteropneustes fossils), Kawai (Anabas testudineus) has high demand with a high price in the local market. These species are also cultivable in small ponds (200-400 m2) and attain full-grown table size within three to six months (Gogoi et al, 2015). This culture of SIFS does not require much labour and cost, so the culture of SIFS can improve the livelihood of small fish farmers with lesser inputs.

3. Beel fisheries: The flood plain wetlands have the potential to yield 2.0 to 2.5 t/h/yr in a semi-intensive culture system (Gogoi et al, 2015). The fish production from beel was estimated at around 49,470 tonnes in 2011-12, which contributes 20.29 per cent of fish production of the state. The productivity from beel fisheries can be enhanced through culture-based capture fisheries with community participation in approximately 3513beels of varied sizes.

4. Diversification of aquaculture: The adoption of various non-conventional aquaculture techniques will enhance productivity manifolds. For instance, integrated fish farming offers great scope for generating rural employment in Assam. Integrated fish farming can be rice cum fish culture, poultry cum fish culture, dairy cum fish culture and pig cum fish culture. Fish farmers can maximise their farm output using plant and animal residues of agriculture and animal husbandry as the significant component of feeds and fertiliser in fish culture.

The rice-fish integration is believed to be the most appropriate for livelihood security and optimum utilisation of available land water resources. The integrated rice-fish gives the provision for higher income to the farmers. The rice-fish integration possesses great potentials in 2.3 million hectares of seasonally flooded rice land of Assam. By stocking fish in the flooded rice fields, the fish production achieved up to 1.0 t/ha/yr. In addition, the cage culture has immense potential for development and further the expansion of aquaculture in the state. Cage culture of potential fish species ensures more harvested produce per unit area in rivers and beels with greater depth and will provide quality fingerlings to stock in beels and rivers.

Further, bamboo or nylon "pens" can be used to make enclosures in the shallow margin of water bodies. It can be erected in seasonal water bodies, which receive a high volume of water for four to six months during the flood. This pen culture can be significantly utilised for raising fry and fingerlings. Examples of Fish-prawn culture have additionally been cited. This mechanism ensures better economic returns to the fish farmers by rearing prawns with high market values with fishes.

Lastly, Substrate-based aquaculture, which relies on plant twigs, dried stems, and banana leaves and bamboo, can be conducted. This, promotes the growth of periphyton, which is significant live fish food. Thus, xeng fishery possesses an excellent potential for a good harvest of fish from rivers and beels.(Gogoi et al, 2015)

Present Status of Development and Management of Resources in Assam

Although the resources potential for fish production is high, scientific fish farming and management are being practiced considerably in a small portion. Culture-based capture fisheries' enhancement programme has been undertaken in some of the beels and low-lying areas, which has increased productivity to an extent with a maximum of 1,600 kg/ha/Year.

Riverine fisheries are being exploited with little conservation effort and no specific intervention. The riverine fisheries, that is, rivers and beels are under Assam Fisheries Development Corporation Ltd; Fisheries Administrative Departments, Government of Assam; Deputy Commissioners and Sub-Divisional Officers (Civil) Panchayats through leasing out to individual /Co-operative societies.

Figure 2: Fish Production in Assam (Lakh MT)

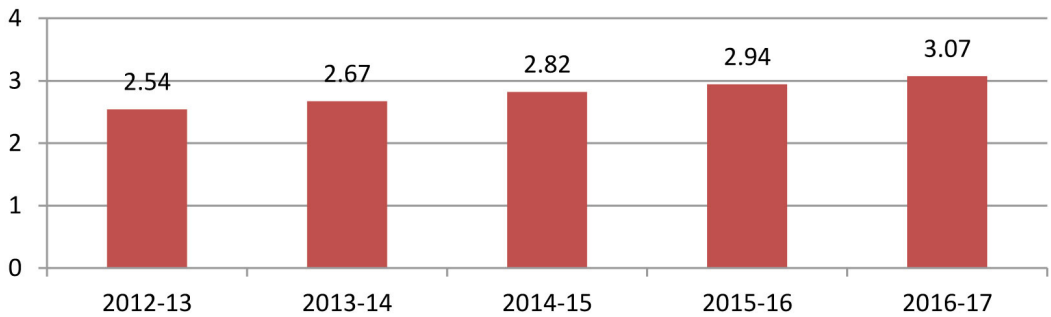


Table 4: Fish & Fish Seed Production for last Five Years

Year	Fish Production (lakh MT)	Fish Seed Production (Million nos. - fry)
2012-13	2.54	4364
2013-14	2.67	4546
2014-15	2.82	4585
2015-16	2.94	5678
2016-17	3.07	6758

Source: Fisheries Director, Government of Assam

Fish yield from floodplain wetlands has been estimated at 400-800 kg/ha/yr, against 1,500-2,500 kg/ha production potential. Harvesting is a major problem in most of them as they are usually weed-choked, obstructing the use of fishing gear. The presence of predators often results in high natural mortality of stocked fishes, causing low productivity. Therefore, enclosure culture systems are adopted to augment fish production from floodplain wetlands. A captive seed stock is grown to fingerlings (in-situ or ex-situ) on formulated feeds, protected from predators, stocked in the main water body or cages and harvested in due time. This is referred to as Culture-Based Capture Fisheries (CBCF).

Selecting the right combination of fish species, based on trophic structure and potential of such wetlands, stocking seeds of appropriate size (80-100 mm) and releasing them at the right time are essential to fully utilise all ecological niches and optimise fish yield from wetlands. Species most suitable for stocking in wetlands/beels include: Indian Major Carps (improved varieties), Indigenous Minor Carps, Exotic/Chinese Carps, among others.

First Trial Cage Fish Farming in Abhayapuri, Assam

The Deputy Fisheries Development Officer in Assam has installed the state's first trial on cage fish farming at Abhayapuri, Assam. The state government is funding the cage firming project in collaboration with the agencies undertaking the work. In this regard, the government provided Rs 14 lakhs, and the agency spent the rest.

The trial has shown significant potential for the cage culture in the premise. In many ways, the cultivation in the cages has shown more benefits than cultivating the fish in a natural pond. For instance, a small case of 10 meters X 10 meters intense farming is possible and during trial 8,000 fish lings can be cultivated in a dedicated 4 meters X 4 meters cage. Such intense farming is not possible in a

Cage culture in Abhyapuri under CMSGUY

Fish reared in cages of Abhayapuri

Fish Farmer at work in Abhayapuri

natural pond. Additionally, the feeding of fishes being bred in cages can be controlled extensively. This is not possible while cultivating fish in a natural pond.

However, it has been observed that since this project is the first of its kind, it was not entirely possible to provide costing of fish cultivation in a natural pond *vis-a-vis* that in a cage.

Cage Fish Farming Project at Koliabor, Assam

The State Fisheries Department has installed a floating fish tank with the help of Fibre Reinforced Plastic (FRP) floating modular units of size 8m X 6m each. The Department has initiated the project under the Chief Minister's *Samagra Gramya Unnayan Yojana* (CMSGUY).[1]

Fishes are not very active in deep water where sunlight does not have much effect and, therefore, cage farming will be best suited for 6 feet -10 feet depth

The pilot project is installed at Borgholi Village of Koliabor district, where the water body, a huge *beel* (a lake-like wetland with stagnant water) belongs to the fisheries department. The project's total cost is Rs 30 lakhs, the cooperative/firm paid ₹6 lakhs (20 per cent) and the ₹balance ₹24 lakhs (80 per cent) was provided as subsidy by the Department.

The required floating modular buoys (a floating object) have been procured from Chhattisgarh as cage fish farming has been operational in Chhattisgarh and Jharkhand for several years. The supplier supplied the buoys and also installed the cages at the site. Each FRP floating box forming the cage is around 2 ft X 2 ft. X 2 ft. There was a male/female hinge on all four sides for attaching other modular boxes to form the cage.

The cages are placed at +20 feet depth. Nets were covering all four sides and also the bottom. However, the depth of each tank was only 4 feet (bottom net placed at 4 feet) from the topwater surface. The cages can go a maximum of 10 feet deep as the sunlight will reach maximum up to that depth. Fishes are not very active in deep water where sunlight does not have much effect and, therefore, cage farming will be best suited for 6 feet -10 feet depth.

Under the project Pangash, Kawai, Rohu, Katla, Java Chitol and Puti fishes are being attempted for cultivation. The feed being used is floating feed and the quantity of feed per tank of 6m X 8m varies depending on the growth of the fish. Initially, the feeding is less, but as the fish lings grow up, their consumption also goes up. The fish food was found to be sourced from Karnataka. It was noticed that fish feed is also available in West Bengal, Bihar and Bangladesh. It was noticed that several beels exist in Koliabor, Naogaon, Goalpara,

1. Chief Minister's Samagra GramyaUnnayan Yojana (CMSGUY): A five-year mega-mission called Chief Minister Samagra Gramya Unnayan Yojana (CMSGUY) was launched in the Financial Year (FY) 2016-17, which is scheduled to culminate in the FY 2021-22, coinciding with 75 years of India's Independence. The main objective of the mission is to double the farm income, in unison with the vision of Indian Prime Minister Narendra Modi.

Cages installed in Bongaigaon

Bongaigaon district and in many more. The Fisheries Department of Assam is planning to set up a fish feed plant in Koliabor itself.

There was no arrangement of temperature control or turbidity control and it was working as a part of natural beel. Further, fish culture (open fish culture) is being conducted in the rest of the beel and the same is under control by the same society.

No electricity is required other than only one light point attached to the tanks in the caretaker's cabin – a 10 ft X 8 ft room constructed with G.I. Sheets on the floating modular boxes.

The excreta of the fish are removed from the net just by shaking the net. However, if fine mesh nets are used, the bottom shall need scrapping.

In India, the river flow during the monsoon season is very high and maintaining a cage with floaters in the river during the monsoon may be difficult. So, the cage can be laid in the channel will be around mid-October and withdrawal of the cage could be by April/May.

It is understood that in certain places in India, sections of rivers are auctioned by the State Fisheries Department. There is an 'Ijaradar'/ 'Mahaldar' who is awarded the right of fishing in that section through a bidding process. Though it is possibly mandatory to award such fishing rights only to fishermen cooperative/societies, it is understood that many interested agents take over the rights by paying a lump sum amount to the fishermen cooperative/societies.

The project's beneficiaries include fishermen and their cooperative societies such as SHGs and fish farmers. The overall increase in wetland fish production would improve the livelihoods of fishers and fish vendors and provide

nutritional security to the surrounding rural population.

- A committee comprising representatives from the State Fisheries Department, Fisheries Development Corporation, ICAR-CIFRI, SAU-COF/ KVK, ATMA would identify and select wetlands/beels for development. NFDB would provide financial assistance to the States having wetland resources for enabling an institutional setup and development in a project mode. The following criteria would be followed when selecting the wetlands specific to the project. Wetlands/beels having a water spread area (WSA) 10 ha and above.
- Wetlands that are not within the restricted or prohibited area
- Both registered and unregistered perennial wetlands
- A community-based combination strategy should be adopted
- Wetlands leased out to a Cooperative Society would be selected
- The State Fisheries Department/ Corporation shall organise the stakeholders' community into a Cooperative Society where wetlands/beels are leased out to individuals,

The Fisheries Department of Assam is planning to set up a fish feed plant in Koliabor itself

The various components under the project will include:

(i) Construction/Renovation of Wetland Embankment.
(ii) Stock Enhancement.
(iii) Procuring Stocking Material:
  a) Rearing Fry in Pens
  b) Rearing Fry in Cages
  c) Rearing Fry in Ponds

Construction/Renovation of Embankment: Most natural wetlands were developed 10-20 years ago and require strengthening embankments to facilitate stock enhancement and increase fish production. Need-based renovation/construction of embankment to appropriate width and height is required to hold flood-water and prevent the escape of fish stock.

Stock Enhancement: Wetlands/ beels were initially connected with rivers and there was free flow of water and auto-stocking of fish during the rainy season. Now, the connecting channels of most of them are either silted up or encroached upon or blocked for constructing water control devices by the Flood Control Department, all of which have prevented auto-stocking. Therefore, stock enhancement is of paramount importance in wetlands to increase fish production.

Further, wetlands/beels have many carnivorous and uneconomical weed fishes, which either eat the bulk of the stocked small-sized fish or compete with them for food and space. It is practically impossible to remove all the carnivorous species. Thus, all these factors are responsible for poor growth and survival of fish and low fish production in wetlands. To overcome this problem, large-sized fingerlings (at least 100 mm) need to be stocked in these water bodies to escape from carnivores and fish production and productivity can be increased significantly to attain the potential of 2,500 kg/ha/year.

Procuring Stocking Material: Most states with wetlands are self-sufficient in fish seed (spawn/fry) production for stocking in aquaculture ponds, but there is a scarcity of grown-up seed (advanced fingerlings) required for stocking in wetlands/beels. Advanced fingerlings are not readily available at the beel site, and bringing them from a distant farm is uneconomical due to high mortality and transportation cost. The problem can be overcome by raising fingerlings in situ in cage and pen enclosures or ex-situ in rearing ponds constructed in the peripheral areas of wetlands. Fish fry of 2-4 cm size is to be procured from government-registered farms only.

- **Rearing Fry in Pens:** Shallow peripheral area of wetlands is suitable for installing pens. Pen culture, especially for raising stocking material, offers a great scope for effective utilisation of available wetland water resources for fisheries enhancement that will significantly improve the socio-economic status of poor beel-fishers. Different sizes of pens can be installed in beels, but a 0.2 ha area pen is ideal. Pens may be constructed using HDPE mesh/netting or a bamboo-split fence. HDPE pens last longer than bamboo pens.

- **Rearing Fry in Cages:** Wetlands also offer good scope for installing cages to rear fish seed to stocking size or for further culture to table fish. At least one battery consisting of six cages (each 6 x 6 x 3 m or 6 x 4 x 2 m, depending on size and depth of beel) can be installed at selected locations. Cages may be free-floating or fixed. Floating HDPE cages with GI pipe-frames are preferred as they last longer than bamboo-framed floating cages.

- **Rearing Fry in Ponds:** Low-lying wetlands/beel is suitable for constructing rearing/stock ponds at a low cost. These low-lying areas are vulnerable to encroachment and it is one of the biggest threats to beel fisheries.

Table 5: Cost and Production Statistics of Cage Fish Farming

Item	Amount/Quantity
Setup Cost: Strengthening Wetland Embankment, De-weeding, Construction of Rearing Ponds (up to 0.5 ha), etc.	Rs. 6.0 lakh
Inputs Cost: Pen (0.2 ha)/ Cages (6x6x3 m); fish fry/fingerlings; manures/fertilizers, supplementary feed; etc.	Rs. 3.0 lakh
Estimated fish Production from Wetland/ha/Cycle	2,500 kg
Estimated Returns/ha/Cycle (Rs. 100/kg fish)	Rs. 2.5 lakh
Estimated Returns/ha/Year (2 Cycles)	Rs. 5 lakh
Net Returns/ha/Year	Rs. 2 lakh
Net Returns from a 10 ha Wetland/Year	Rs. 20 lakh

Source: National Fisheries Development Board

Construction of rearing/ stock ponds at the low-lying peripheral areas will help prevent encroachment and enhance production. Rearing pond area may be 0.20-0.50 ha with a depth of 1.0-1.5 m, so that after rearing fish fry to fingerlings, the same pond can be used for grow-out to table size fish.

Centrally Sponsored Scheme on Development of Inland Fisheries and Aquaculture and Initiatives

The Government of India formulated and launched the Centrally Sponsored Scheme on the "Development of Inland Fisheries and Aquaculture" under the macro-management approach

India is endowed with vast resources in ponds, tanks, rivers, canals, reservoirs, lakes and other water bodies. Thus, cage fish farming seemingly has immense scope for developing fisheries to strengthen food security, generate employment opportunities, and attract foreign investment.

Keeping this in view, the Government of India formulated and launched the Centrally Sponsored Scheme on the "***Development of Inland Fisheries and Aquaculture***" under the macro-management approach in States/UT's during the 10th Plan. The total outlay approved for the entire 10th Plan period is Rs 135.00 crore. The following components are approved under the scheme:

- Development of Freshwater Aquaculture
- Development of Brackishwater Aquaculture
- Coldwater Fisheries and Aquaculture
- Development of Waterlogged Areas
- Productive Utilisation of Inland Saline/Alkaline Soils for Aquaculture
- Integrated Development of Inland Capture Resources (reservoirs/rivers etc.)

The scheme states that the expenditure on developmental activities will be shared on a 75:25 basis by the Government of India and the State/UT Governments regarding all components above. The first two components, namely, *Development of Freshwater Aquaculture* and *Brackish water Aquaculture* are to be implemented by Fish Farmers' Development Agency (FFDA). The remaining four components are to be implemented through the Fisheries Department of the respective States/UT's. The total cost of the implementation will be levied on the states/UTs, on base, and incremental staff salary, vehicle maintenance, office contingencies, and land acquisition, whenever necessary.

Under this context, the cost of purchasing vehicles will continue to be shared on 50:50 basis between the Government of India and the State/UT Governments.

Therefore, the Government of India's share is in the form of grant-in-aid for all the items given under each component as per the approved norms. Subsidy on these items is given only once to a beneficiary. In addition to an individual beneficiary, the financial assistance under the above components of the scheme is also

available to Self-Help Groups (SHGs), Women Groups and Fisheries Co-operative Societies. The State/UT Governments on all these components have to make a matching contribution.

Besides this, the balance amount for the components may be obtained as a loan made available to the beneficiaries through FFDA's/States/UT Fisheries Department from participating banks. Subsidy for all approved items under the scheme can also be given to a beneficiary if the remaining cost of items is contributed by him from his/her own resources and is duly certified by the FFDA's/States/UT's Fisheries Department.

The future development of aquaculture depends on establishing resilient market linkages, adopting new and innovative production technologies, managing and utilising the less utilised water resources

The implementing agencies have to furnish quarterly/annual progress reports indicating physical and financial achievements regularly in the prescribed format already communicated to the State/UT Government. The agency's accounts shall be subject to audit by Chartered Accountants appointed by the agency and/or by such other officers of Government of India/State/UT Governments as required under the rules and report should be intimated to this Ministry.

The State/UT Governments have to ensure that the proposals for the various components are complete in all aspects, accompanied by detailed progress reports of the central share released during the preceding years and reasons for shortfalls. The availability of budgetary provision in the State Budget should be specifically indicated in the proposal (Department of Animal Husbandry and Dairying). An 'Aqua One Centre' (AOC) would be established to provide technical services.

- The AOC would register fishers holding lease or fishing rights of Wetland.
- Where the beneficiaries choose to avail AOC advisory services, ₹1,200/- will be charged per crop towards registration, monitoring water quality, growth and health. If not, this amount will be released to beneficiaries as part of the input cost.
- The AOC will carry out an inspection/ field visit and submit the report to the Project Monitoring Unit (PMU), in the prescribed format.

The PMU will compile and submit reports to NFDB, crop-wise separately for each Wetland 4.3

Conclusion and Recommendations

Fish and fish products have presently emerged as India's largest group in agricultural exports, with 5.2 lakh tonnes in terms of quantity and ₹7,200 crores in value. This accounts for around 3 per cent of the total exports of the country and nearly 20 per cent of the agricultural exports. More than 50 different types of fish and shellfish products are exported to 75 countries around the world.

There is a large untapped potential in fisheries and aquaculture, which can considerably improve the livelihoods of various communities, including women. The future development of aquaculture depends on establishing resilient market linkages, adopting new and innovative production technologies, managing and utilising the less utilised water resources.

The existing Self-Help Groups (SHGs) should be encouraged to take fishery as a key income by providing financial support to the riverine communities

In the context of Assam, the state is endowed with copious fishery resources but lacks infrastructural facilities. These gaps hinder fish production significantly.

Establishments of hatcheries that provide quality seed in desired quantities at the time stocking fish in various water bodies, nutritionally balanced diets or feed, nutritionally balanced fish feed can be supplied to fish farmers by establishing fish feed manufacturing plants in the neighbouring areas, soil and water testing laboratories can be built to determine the quality of soil and water, which is favourable for fish growth, enabling regular diagnosis of diseases at health centres, special facilities for fishes post-harvest should be provided to the fishermen, such as cold storage and transportation facilities. These suggestions, when effectively implemented, will lead to expansion of the cage culture and not force the fishermen to sell their produce at lower prices.

In addition to these, several measures to generate awareness, monitor proper information dissemination and conduct capacity building programmes and establishment of research and development centres with adequate facilities to research fishery development through dietary (feed) intervention, curing of diseases, genetic improvement, improvement of gears and standardisation of breeding are carried out.

The existing Self-Help Groups (SHGs) should be encouraged to take fishery as a key income by providing financial support to the riverine communities. The sector holds immense potential in generating employment for women. However, women would require extensive training to rear fingerlings.

5 Cage Fish Farming in Bangladesh

Bangladesh holds immense potential to enhance trade and revenue through diversified fishing resources. The three most diversified fisheries resources of the country are inland open, culture and marine. However, over the past 15 years, aquaculture has become an increasingly prominent sub-sector

Bangladesh is a country of rivers. It is well-endowed with a large wetland area comprising of diversified fisheries resources. This makes the country's fish and fisheries an imperative sector for economic growth. The country holds immense potential to enhance trade and revenue through diversified fishing resources. The three most diversified fisheries resources of the country are inland open, culture and marine. However, over the past 15 years, aquaculture has become an increasingly prominent sub-sector. Aquaculture production in 2000–01, which was 7.87 lakh MT, became more than threefold in 2016–17 at 23.18 lakh MT (Shamsuzzaman et al. 2020).

The overall growth performance from aquaculture continues to display a relatively increasing trend. The reason for such impressive performance of the sector is the introduction of new technologies, supportive extension services at farmer's level, improvement of farming in pond aquaculture, among others.

On the contrary, the Inland capture production has begun to lag in the recent few years. The reasons for the decline in the capture of fishes through inland open, culture and marine sectors are different constraints. These include wetland degradation, overexploitation, use of destructive gears, siltation, closure of natural fish passes, use of pesticides and agro-chemicals, discharges of industrial wastes and loss of natural breeding grounds through habitat degradation.

In addition to this, the country has limited access to marine fisheries resources in the Bay of Bengal, and other potential marine resources remain unutilised at a commercial scale. Therefore, given the decrease in capture fisheries production, the increasing demand for fish protein, and the complications for the augmentation in the output from beels, canals, lakes, river and estuaries, aquaculture is moving towards intensification to boost the country's economy.

Moving a step forward, the prolific wetlands of the country, in addition to the Haors, Baors, Beels, rivers and other floodplains, can currently be used for cage culture. This practice allows the growth of a higher quantity of fishes in cages than ponds and has thus gained little traction among fish farmers of late. It is practiced in many countries in Asia, Europe, and North America.

Table 6: Annual Fish Production in Bangladesh

Production (Metric Tonnes)			
Year	**Inland Fisheries**	**Marine Fisheries**	**Total**
2016-17	3496958	637476	4134434
2017-18	3621954	654687	4276641
2018-19	3724310	659911	4384221

Source: Department of Fisheries Bangladesh, Ministry of Fisheries and Livestock 2020

In the context of Bangladesh, cage fish farming was introduced in the 1970s. However, the mechanism could not be popularised. Despite the country's active deltaic presence, the presence of cage farming in aquaculture is limited.

In 2018, cage culture involved about 1.29 lakh cubic metre of water area with a 27 kg/cubic meter productivity rate. These statistics show a culture's growth rate from previous years of approximately 48.49 per cent (Fisheries Statistics of Bangladesh, 2018).

Small scale cage fish farming provides the landless poor in the country with an access to income opportunity as there are limited investment requirements

Small scale cage fish farming provides the landless poor in the country with an access to income opportunity as there are limited investment requirements. Access to low-cost fish feed, ease of handling and harvesting, and income potential and food security, are the main benefits of cage fish farming that the country can utilise.

However, it was informed by fish farmer and other stakeholders that constraints are related to the wider adoption and sustained use of fish cages by the poor. These constraints include construction costs, thefts, unaffordable cash requirements for supplementary feed, and incompatibility between the immediate need to earn daily income among the poorest and the seasonal income that cage culture can offer.

Although fish-cage farming has been introduced among the poor, its adoption has remained restricted. Under that context, the concerned government, governmental departments, development partners, researchers

Table 7: Bangladesh Export and Import of Fish (US$mn)

Year	Export	Import
2016	586297	42740
2017	584813	46491
2018	520752	46567
2019	527703	82913
2020	451006	44663

Source: ITC Trade Map Database 2021

and non-government organisations can play an essential role in the wide-ranging advancement of the fisheries sector.

Cage Culture in Bangladesh: Existing and Emerging Trends

After the country's pilot cage fish farming project in 1970, several experiments were conducted by the Faculty of Fisheries, Bangladesh Agricultural University, and Bangladesh Fisheries Research Institute for successful implementation. Thereafter, several other initiatives and projects have been undertaken to enhance the growth of the culture in the country.

Feed the Future Aquaculture is a USAID-funded five-year aquaculture and nutrition activity to sustain positive aquaculture sector growth in the country

For instance, Feed the Future Aquaculture is a USAID-funded five-year aquaculture and nutrition activity to sustain positive aquaculture sector growth in the country. Further, the initiative encourages poor villagers to actively engage in cage fish culture and try to popularise the cage culture in Bangladesh. The project primarily seeks to help women while their male counterparts are active helping hands in caring for the cages.

In addition to this, The Department of Fisheries also conducted a cage culture project in Kaptai Lake during 1985 and 1986 (Ahmed, 2010). The largest cage culture project, Cage Aquaculture for Greater Economic Security, was initiated by CARE Bangladesh in 1995 until 2000.

At the institutional level, the following bodies are involved in aquaculture and fisheries in Bangladesh:

1. Department of Fisheries (DoF) under the Ministry of Fisheries and Livestock (MoFL) is the sole authority with administrative control over aquaculture in Bangladesh. The DoF is managed by a Director-General and has two main sub-departments, namely, inland and marine. The main responsibilities held by the DoF include planning, development, extension and training.

2. Bangladesh Fisheries Research Institute (BFRI) conducts and coordinates research and, to some extent training.

3. Bangladesh Rural Development Board is responsible for the fisheries component of integrated rural development.

Table 8: Cage Fish Production in Bangladesh

	2016-17	2017-18	2018-19
Water Area (Ha)	1.10 lakh cu. meter	1.29 lakh cu. meter	1.76 lakh cum
Production (MT)	2490	3523	3802
Productivity (kg/ha)	25 kg/cum	27 kg/cum	22 kg/cum

Source: Department of Fisheries Bangladesh, Ministry of Fisheries and Livestock 2020

4. Land Administration and Land Reform Division are responsible for the leasing of public water bodies.

5. Export Promotion Bureau is responsible for the export of fisheries products and the Bangladesh Frozen Foods Exporters Association, which is also involved in the export of frozen shrimp, fish, and fish products.

6. The country's universities are responsible for higher-level fisheries education.

7. External Resource Division under the Ministry of Finance is responsible for external aid for aquaculture development.

8. Bangladesh Krishi (Agriculture) Bank, Bangladesh Samabay (Co-operative) Bank and some other commercial banks are responsible for issuing credit to the aquaculture sector.

9. Many of the national and international NGOs provide credits to the fish farmers and take up projects for aquaculture extension and development.

10. International organisations (DFID, Danida, NORAD, JICA, World Bank, IMF, ADB) provide grants and credits for aquaculture development.

11. Under the Ministry of Youth, Youth Development Training Centers deals with extension and the training of unemployed young people and fish farmers.

Tilapia cage culture is one of the most popular aquaculture practices used in Chandpur area to better utilisation of the inland open water like the River Dakatia

In the current context, several rural districts in Bangladesh are witnessing a growing trend in the usage of cage culture for cultivating fish. For instance, over 350 youths have successfully cultivated Tilapes fish in 820 cages in Sadar, Raipura and Monohardi Upazilas of Narsingdi district (Dhaka Tribune, 2019).
Sources at the District Fisheries office have reported that many fishermen in Narsingdi Sadar, Raipura and Manahardi Upazilas have been engaged in the cultivation of monosex Tilapies fish in the floating cages in the Meghna River and its branches. In addition to this, Manahardi Upazila has several fishermen who are utilising cage culture for cultivating tilapes.

In Dattapara area in Narsingdi Pourashava piloted its first cage fish farming project in 2011. Initially, only four cages were installed to test the feasibility of the culture in the region. With the demonstration of positive results, the number of cages has been increased to approximately 150 per farmer. It has been further highlighted that an individual farmer in this region is able to cultivate about 300-400 fish from each cage.

Tilapia cage culture is one of the most popular aquaculture practices used in Chandpur area to better utilisation of the inland open water like the River Dakatia (Hossain et al, 2017). About 3,500

Box 1: CARE-CAGES Project in Bangladesh

The CARE-CAGES Project (Cage Aquaculture for Greater Economic Security) was initiated in September 1995, began cage-aquaculture activities in 1996, and is now working with approximately 4,200 households through 45 partner non-governmental organisations (NGOs) (McAndrew, 2002).

The only pathogens that have been observed in caged fish are the parasitic isopod Alitropus typus (Milne-Edwards, 1840), and epizootic ulcerative syndrome (EUS). EUS affects mostly Java barb (Barbodes gonionotus) during the winter season, resulting in chronic low-level mortalities. Although found sporadically in other sites, A. typus only significantly affects cage-farming operations in one river in the Jessore region. It is suspected that a large amount of aquatic vegetation present in this river is a prerequisite for large parasite numbers. This parasite makes cage culture impossible due to 100 per cent fish mortalities in late spring. When the monsoon begins, parasite numbers reduce, and there is milder damage and no mortalities with lower numbers. Other pathogens may be present, however, due to lack of appropriate resources, these have not been observed.

Fish health concerns for CARE-CAGES largely relate to providing quality fingerlings and feeds, good site selection and cage management. A breakdown of mortalities for the CARE-CAGES project for 1998 and 1999 is provided, and key issues relating to fish health are highlighted. Total losses of stocked fish were reduced from 36 per cent in 1998 to 22 per cent in 1999.

All categories (stocking mortalities, mortalities during culture, escapees, poaching and others) were reduced, principally due to greater farmer experience in this new culture system.

Table 9: Number of Households and Cages under CARE-CAGES Project in Bangladesh

	1996	1997	1998	1999	2000
Number of households	10	308	632	1987	4,200
Number of cages	30	520	959	2698	5,500

Source: CARE-CAGES Project 2021

cages are in operation now in Chandpur along the Dakatia River, 500 cages in Laxmipur along the Meghna River (Baqui & Bhujel, 2011).

These statistics have encouraged other areas to initiate the cage culture in the river areas. These developments have been instrumental in transforming lives of the riverine communities in Bangladesh. The cage fish farming techniques used in these districts have generated employment for rural individuals, along with fulfilling their nutritional demands.

The new devised technology of fish scientists has made a new chapter in fisheries sector. Cage culture could be a practical solution to boost fish production as land is scarce to make ponds for aquaculture.

Challenges and Concerns

Despite successfully demonstrated culture and a considerable number of people trained through various projects, cage in Bangladesh is yet to become a widely adopted practice. The limited experience in the country has highlighted certain restrictions in cage culture. These include difficulty placing cages in the reservoirs due to submerged trees, unavailability of suitable sites for cage culture mainly because of the drawdown practices, the vulnerability of cages to adverse weather, theft, vandalism and pollution. Additionally, allocation of rights in publicly owned water bodies is also a challenge known to discourage fish farmers from adopting this culture.

Cage culture could be a practical solution to boost fish production as land is scarce to make ponds for aquaculture

Furthermore, throughout Bangladesh, there are many and varied water bodies offering considerable potential for fish cultivation. But poor farmers are unable to provide all the inputs required for intensive production methods.

Environmentally, the waste from the cages is released untreated surroundings, impacting not only the aquatic life in the region but also the farmers and other resource users.

In the context of Bangladesh, the following challenges were found.

- There is limited documentation associated with these aspects in inland water bodies. One case is the development of cage culture technology in baors and ponds in Bangladesh, introduced as an income-generating activity for landless women by CARE (CARE, 1996). The results of initial activities suggested technical and economic viability. However, these activities were not sustained due to resource use conflict (or at least perceived conflict of interest), mistrust between stakeholders and security problems. The fish farmers themselves were reportedly still interested but were unable to continue. It was concluded that there was a need for greater stakeholder involvement in the early planning stages, not only to assess the resource use and control patterns but also to encourage greater understanding of the technology, for example, in terms of the potential benefits of cage culture the fisheries.

- It is clear that while technical knowledge is vital to assess the range of options, which might be feasible, this must also be closely tied in with the perspectives of those who will potentially use the technologies and those whose lives may be directly or indirectly affected by such change. In Bangladesh, owners of lakes, reservoirs or ponds can include Government institutions, whole communities, co-operative groups, kin groups and individuals/ individual households. Thus, control of water resources can sometimes be closely tied with usage. Under this context, a particular group may have the

right to manage the fish culture/capture or even a particular capture method. In contrast, others will have rights to abstraction for irrigation. The community as a whole may have rights of use for domestic and livestock needs. This causes challenges about ownership rights of the water resources.

- Additionally, there are different aspects of resource use conflict, which can influence cage or other aquaculture development. First, there is the potential for conflict between direct and physical resource use relating to space and access to, or competition for, water or inputs. Conflicts may arise due to social or cultural values (for example, prohibiting the use of animal manures in ponds) or perceived conflicts of interest due to misunderstanding of the changes occurring (CARE, 1996), reported pond owners suspecting fish farms taking stock from their ponds. There may also be social conflicts within communities, which, although not related to specific activities or resources, may influence success, resulting in malicious damage. It was also highlighted that established fish cages in the country are being built in a scattered manner, which makes defining roles and responsibilities of various stakeholders particularly challenging (Parvez, 2018).

- Simple theft is a major problem for fish culture, and cages may be particularly vulnerable to stock concentrations.

- Another concern is rivers are a significant source of all kinds of fish in the country; however, not all kinds of fish can be reared using cages, especially given the lack of technology and workforce in this sub-sector.

- Cage fish farming was being increasingly adopted when it first came into existence in the

country. However, the growth slowed down soon after. The reason for this, especially in Chandpur, was flagged due to rising prices of feed. Many poor farmers had to quit because of the high prices of feed.

- Environmentally, cages put in place miles after miles can deteriorate the water quality of the rivers. This is particularly concerning in rivers with low depth and a slow flow of water. Additionally, river water is likely to be polluted if a chemical feed is used.

- Fishpond owners and cage operators often face the threat of poaching. Theft risks increase when fishponds or cages are far from farmers' households. Surveillance requires labour inputs, for which the returns are not immediate. These constraints have limited the feasibility of fish farming to some extent, especially among households headed by females, who, on their own, are unable to protect their assets against an unfavourable social environment.

- Industries are being developed at a rapid rate in Bangladesh, causing damage to the environment through pollution. Aquatic pollution from oil spills and the release of effluents have been increasing daily, posing a potential threat to aquaculture. Conversely, intensification of aquaculture also contributes to environmental degradation. In particular, freshwater fish culture poses a potential health hazard in Bangladesh, as most people still use pond waters for washing, bathing and sometimes drinking. The farming of fish in cages is not without environmental concern. Bangladesh Poribesh Andolon (BAPA) highlighted that the water flow in rivers would be slow because of the obstruction imposed by the setting up a large number of cages. At present, most industrial effluents are discharged into rivers untreated, leading to degradation of the aquatic environment. Therefore, the impacts of such pollution and the extent of damage need to be adequately assessed and documented. This is essential for sustainable aquaculture development.

Policy Recommendations and Suggestions

The Fisheries and Livestock Ministry of Bangladesh is working on framing a policy on cage culture in inland water, which remains untapped despite the vast potential to augment fish production. The draft policy seeks to include all flowing rivers and water bodies that are suitable for cage culture.

In addition to the provisions made in the policy by the Department of Fisheries in the country, the following suggestions (Asian Development Bank) can be adopted further to enhance cage fish farming.

- Access to land and water is pivotal for cage fish farming. Conventional aquaculture development initiatives that emphasise the promotion of technology and provision of targeted extension services are unlikely to reach the functionally landless and the extremely poor without access to land and water.

- Cage fish farmers require human capital and skills, social capital, financial capital, and a vital operating environment, including support infrastructure, facilities, and access to markets.

- Secure access rights are critical when the landless gain access to water bodies or ponds through lease or other access arrangements for fish farming. Without binding and long-term agreements on access rights, cage fish farmers are vulnerable. Eviction is common when access is not secure, and interrupted operation can result in loss of investment that the poor cannot recover.

- Most direct beneficiaries of fish seed and development technologies in Bangladesh are not the poorest people. The initiatives and strategies need to recognise specific and prevalent features of poverty among the intended beneficiaries, including overcoming key barriers for entry into cage culture and adopting technologies and mitigating risks to which the poor are particularly vulnerable.

- To combat the environmental concerns in this sector, it should be ensured that the cages placed in a planned manner will ensure the biodiversity and the quality of rivers are not hampered.

6 Learnings from other Countries for India and Bangladesh

Egypt's economic success in the aquaculture sector has been driven majorly by the country's policy intervention. The Egyptian government designed the national aquaculture 2030 strategy

The cage culture is relatively new in India and Bangladesh; however, certain countries have achieved severe strides in their cage fish produce by overcoming the environmental, socio-economical and operational challenges, either through policy interventions or technological and/or operational advancements.

The state of Assam and the concerned locations in Bangladesh can contemplate over adapting these reforms and mechanisms to enhance its cage fish produce and establish uninterrupted market linkages for the same.

Following, several learnings from China, Egypt and Europe have been provided. The prospects of implementing similar interventions in Assam and India can be extensive.

Egypt

Egypt's economic success in the aquaculture sector has been driven majorly by the country's policy intervention. The Egyptian government designed the national aquaculture 2030 strategy (Brugere & Ridler, 2004).

The plan focuses on further developing freshwater aquaculture that encompasses cage farming and desert aquaculture for improving fish quality and production. In addition to this, several other policy interventions have been implemented in Egypt to enhance cage fish farming development further. These include:

(i) Efficient use of freshwater: There has been a focus for fish production systems to use freshwater more efficiently through the Recirculation Aquaculture System (RAS) (Government of India, 2017) and integrated cultures. The system comprises land-based fish farms that allow year-round controlled fish production.

In a RAS, fish are reared in indoor tanks in a controlled environment rather than open ponds. The recirculating system filters and cleans water for recycling through fish culture tanks. RAS facilities can use freshwater, as well as marine or brackish water. The system stably ensures high-quality fish production (throughout the year).

In RAS, the risk of diseases is reduced, resulting in low mortality rates. The system is also advantageous due to its low water requirements and relatively small space (area) to produce high

output levels (Mbowa, Odokonyero & Munyaho, 2017).

(ii) Financial resources for cage aquaculture: Studies (Mbowa *et al.,* 2017) show that government's financial interventions have not reached the small and middle scaled cage culture enterprises. In addition to this, financial institutions are hesitant to finance cage culture projects due to a lack of knowledge about the sector and their inability to conduct a thorough risk assessment.

Consequently, small and medium aquaculture enterprises have primarily been relying on informal credits, which are, in most cases, not consistent, with conditions that may not be favourable.

Considering the above, the Egyptian government has implemented a few innovative financial interventions. The Multi-Sector Support Programme and the Agricultural Research and Development Fund[1] have been executed to provide soft loans for the aquaculture sector. Similar to this, the Social Fund for Development was initiated to overcome further the financing challenges cage culture entrepreneurs and enterprises face.

Other forms of financial support provided to aquaculture farmers include informal arrangements such as purchasing inputs on credit. Suppliers often provide inputs such as feeds and seeds on credit to farmers. Such credit options are interest-free and allow for deferred. Another arrangement consists of traders providing cage fish farmers with credit opportunities for purchasing inputs, whereby farmers sell fish to them at harvest time at an agreed price. Still, unfortunately, in most cases, the price is below market price.

(iii) Land access: Egyptian farmers usually obtain land through rent from a government agency – General Authority for Fish Resources Development (GAFRD) (Mbowa *et al.*, 2017). This process has eased land access for aquaculture production, given that the land rents are set at low levels to allow affordability by farmers. However, the challenge is that lease periods are short (between 3 to 5 years). The government plans to extend the five-year lease period to a maximum of 25 years.

Other than leasing land, some private farmers purchase land on their own to invest in the costly fixed infrastructure for intensive aquaculture farming. Fish feeds and fingerling production: Feed mills have been established to produce fish feeds. There are registered feed mills that produce extruded fish feeds, and small-scale pelletising units.

Pelletising units are used to pelletise farmer's feed ingredients and utilise simple technologies without air driers. For fingerling production, private hatcheries are licensed by the Egyptian GAFRD, but there are also unlicensed private hatcheries in operation.

Europe

In Europe, aquaculture is a highly diverse industry that engages various species, mechanisms, and activities. This has established innovative economic technologies in the sector, translating into enhanced employment opportunities, efficient utilisation of resources and added scope for better and productive investment. Consequently, the contribution of aquaculture to local and international trade has also increased (European Commission, 2002).

The Federation of European Aquaculture Producers (FEAP) has been established to promote and participate in research projects that contribute to innovation and development of the various European fish farming sector

In this regard, several European countries have made efforts to develop the sector further. For instance, "The Code of Good Practice for Scottish Finfish Aquaculture" (Marine Scotland, 2015). However, the European parliament remains the overarching decision-maker.

The European Commission recognised the importance of aquaculture in the same frame as the reform of the Common Fisheries Policy and the necessity to develop a strategy for the sustainable development of this sector (Hossain, et al, 2018).

The Federation of European Aquaculture Producers (FEAP) has been established to promote and participate in research projects that contribute to innovation and development of the various European fish farming sector. Under this strategy, emphasis was laid on the policies and regulatory frameworks, which encompass cage and pen cultures. The FEAP has successfully engaged itself in projects relating to cooperative research, capacity building and skill development, communication and dissemination actions and networked workshops.

The FEAP has also developed a Code of Conduct. This Code addresses the areas that the Federation considers to be of prime concern. Additionally, the role of the Code is to encourage and establish principles for best practices in the sector and the sub-sectors of aquaculture.

In addition to this, several non-governmental organisations (NGOs), civil societies and development agencies have been addressing the impact of aquaculture on the environment, including pollution, food safety and the influence on wild fish populations.

China

China has been making remarkable progress in terms of the development of cage aquaculture. It has been highlighted that the striking feature of such progress is the change in production structure.

The readjustment and optimisation of the production structure to avoid resource exploitation remain the most important factor for the country's sustainable and rapid development of the cage culture.

Additionally, the country's focus has been to establish and implement new technology and develop a healthy culture. The key milestone in such efforts included accelerating the transfer of

scientific and technological achievements into commercial production. These technological interventions include developing stain seed and breeding technologies, disease prevention and food safety control systems, among others.

Additionally, several other factors contributed extensively to the increasing trends (Wang, 2001) in China's fish cage culture, such as increment in the number of fish species cultured, establishing strong goodwill ambassadors for the adoption of cage culture by big and small farmers, along with production efficiency and excellent market competitiveness.

China has been making remarkable progress in terms of the development of cage aquaculture. It has been highlighted that the striking feature of such progress is the change in production structure

On the policy front, the country waived rents for the use of open waters, facilitating interest-free or low-interest loans, and dispatching experts to disseminate aquaculture techniques and experimental demonstrations to farmers.

Under this context, the focus areas for policy and technical interventions in India and Bangladesh that hold the potential of reaping extensive benefits from the cage culture are as follows:

1. First and foremost, encouraging cage fish farming and bring the cage culture's socio-economic benefits to the forefront. This can be done through meetings, consultations, nadi baithaks and collaborative R&D by centre-state agencies and civil societies.

2. Assistance in the form of easing finances through formal and informal sources and capacity building via knowledge sharing workshops can be conducted to promote good practices in the sector.

3. Establishment of a committee, similar to the FEAP, in the state of Assam and strategic locations in Bangladesh, catering to the needs and concerns of the existing and emerging cage fish farmers while also encouraging the adoption of good practices in the sector.

   Given the advantages and the simplicity of the activities undertaken to rear fishes in cages, it is imperative to note that the culture is a profitable venture with immense scope to enhance bilateral trade and cooperation between India and Bangladesh. The vast water resources of these countries that are left unutilised hold sever potential to be locations for establishing cages and further popularising the local communities' culture.

   However, the absence of leasing policies and regulatory measures and large-scale promotion of the culture has become difficult. In addition to this, the lack of surveillance measures in these water bodies has led to severe losses to farmers.

Therefore, it is pivotal to formulate policies and regulate measures to safeguard the needs of these small-scale farmers. Furthermore, policies that consider the environmental implications of the same.

Reference

Ahmed, N. (2010). Bangladesh Study Examines Potential for Prawn Cage Farming in Bangladesh. Global Aquaculture Advocate. Available at: https://www.researchgate.net/publication/261527862

Aswathy, N., Joseph, I., Ignatius, B., & Joseph, S. (2020). Economic viability of Cage fishfarming in India. CMFRI Special Publication No. 134. Available at: http://eprints.cmfri.org.in/14274/

Baqui, M.A., Bhujel, R.C. A Hands-on Training Helped Proliferation of Tilapia Culture in Bangladesh. Better Science, Better Fish, Better Life proceedings of the ninth international symposium on tilapia in aquaculture. Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.960.9769&rep=rep1&type=pdf

Beveridge, M.C.M., Stewart, J.A. Cage Culture: limitations in Lakes and Reservoirs Food and Agriculture Organisation, Rome. Available at: http://www.fao.org/3/W8514E/W8514E18.html

CARE. (1996). CARE, Dhaka, Bangladesh. Available at: http://www.fao.org/3/W8514E/W8514E18.html

Das, A.K., Vass, K.K., Shrivastava, N.P., & Katiha, P.K. (2009). Cage Culture in Reservoirs in India (A Handbook). WorldFish Center Technical Manual No. 1948. Available at: http://pubs.iclarm.net/resource_centre/WF_2496.pdf

Das, P., Borah, S., Yadav, A.K., & Bhattacharjya, B.K. (2018). Openwater Fisheries of Assam and Strategies for its Development. Vol. 38 No. 1 & 2. Available at: https://www.researchgate.net/publication/329013582_Openwater_Fisheries_of_Assam_and_Strategies_for_its_Development

Department of Animal Husbandry, Dairying & Fisheries. (2017). Mission Mariculture- 2020 & 2022, Action Plan, Towards Blue Revolution. Available at: https://nfdb.gov.in/epublication

Department of Animal Husbandry, Dairying & Fisheries. (2017). Recirculatory Aquaculture System (RAS), (Pangasius Fish Production), Action Plan, Towards Blue Revolution. Available at: https://nfdb.gov.in/PDF/E%20Publications/8%20Recirculatory%20Aquaculture%20System_RAS%202017.pdf

Dhaka Tribune. (2019). Fish cultivation in cage brings profit for youths. Available at: https://www.dhakatribune.com/business/2019/03/14/fish-cultivation-in-cage-brings-profit-for-youths

Department of Fisheries Bangladesh. (2018). Yearbook of Fisheries Statistics of Bangladesh, 2017-18. Available at: https://fisheries.portal.gov.bd/sites/default/files/files/fisheries.portal.gov.bd/page/4cfbb3cc_c0c4_4f25_be21_b91f84bdc45c/Fisheries%20Statistical%20Yearboook%202017-18.pdf

Global Aquaculture Outlook in the Next Decades: An Analysis of national aquaculture Production Forecasts to 2030, FAO. (2004). FAO Fisheries Circular No. 1001. Available at: http://www.fao.org/3/y5648e/y5648e.pdf

Gogoi, B., Kachari, A., Dutta, R., Darshan, A., Das, D.N. (2015). Fishery based livelihood approaches and management of fishery resources in Assam, India. International Journal of Fisheries and Aquatic Studies. 2(4): 327-330. Available at: https://www.fisheriesjournal.com/vol2issue4/Pdf/2-4-80.1.pdf

Gopakumar, G. (2009). History of cage culture, cage culture operations, advantages and disadvantages of cages and current global status of cage farming. National Training on Cage Culture of Seabass;. Available at: http://eprints.cmfri.org.in/6007/1/2._Gop.pdf

Hossain, R.A., Rahman, A., Akhter, S., Hosain, E., Naser, M.N. (2017). Intervention of Tilapia cage culture in the River Dakatia: Threaten or blessed to local fish diversity. International Journal of Fisheries and Aquatic Studies; 5(1): 228-232. Available at: https://www.fisheriesjournal.com/archives/2017/vol5issue1/PartD/4-5-100-407.pdf

Kakati, B.K., Bhagawati, K., Baishya, S. (2018). Cage culture of commercially important fish species in a flood plain wetland of barak valley, Assam. Journal of Entomology and Zoology Studies. 6(4): 1799-1802. Available at: https://www.entomoljournal.com/archives/2018/vol6issue4/PartAD/6-4-283-837.pdf

Karnatak, G.; Kumar, V. (2014). Potential of Cage Aquaculture in Indian Reservoir. International Journal of Fisheries and Aquatic Studies, 1(6); 108-112. Available at: https://www.researchgate.net/publication/263560942_Potential_of_cage_aquaculture_in_Indian_reservoirs

Masser, M.P. (1997). Cage Culture Site Selection and Water Quality. Southern Regional Aquaculture Center. Publication No. 161. Available at: http://agrilife.org/fisheries2/files/2013/09/SRAC-Publication-No.-161-Cage-Culture-Site-Selection-and-Water-Quality.pdf

Mbowa, S., Odokonyero, T., Munyaho, A.T. (2017). Harnessing floating cage technology to increase fish production in Uganda. Economic Policy Research Centre. Research Series No.138. Available at: https://media.africaportal.org/documents/Harnessing_Floating_Cage_Technology_.pdf

McAndrew, K. (2002). Risks To Small-Scale Cage Farmers In Bangladesh, With Emphasis On Fish Health Experiences Of The Care-Cages Project. Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development. FAO Fish. Tech. Pap. No. 406. Available at: http://www.fao.org/3/y3610e/y3610E22.html

Ministerial Group for Sustainable Aquaculture's Scottish Technical Standard Steering Group. (2015). Marine Scotland- A technical standard for Scottish Finfish Aquaculture. Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2015/06/technical-standard-scottish-finfish-aquaculture/documents/00479005-pdf/00479005-pdf/govscot%3Adocument/00479005.pdf

Overview of Small-Scale Freshwater Aquaculture in Bangladesh. Asian Development Bank. Available at: https://www.adb.org/sites/default/files/evaluation-document/35933/files/aquaculture-ban.pdf

Parvez, S. (2018). Fish farming in cages spreading out. The Daily Star. Available at: https://www.thedailystar.net/business/fish-farming-cages-spreading-out-1533949

Rao, G.S. (2012). Successful cage culture (farming) initiatives by CMFRI during the 11 th Five Year Plan. Fishing Chimes. Vol. 32 No.1. Available at: http://eprints.cmfri.org.in/8966/1/Fishing_Chimes_V.32.1_G_Syda_Rao.pdf

Sectoral Paper on Fisheries and Aquaculture. Farm Sector Policy Department, 2018. National Bank for Agriculture and Rural Development Available at: https://www.nabard.org/auth/writereaddata/file/Fisheries%20and%20Aquaculture.pdf

Shamsuzzaman, M.M., Mozumder, M.M.H., Mitu, S.J., Ahamad, A.F., & Bhyuian M.S.(2020). The economic contribution of fish and fish trade in Bangladesh. Aquaculture and Fisheries. Vol. 5(4): 174-181. Available at: https://doi.org/10.1016/j.aaf.2020.01.001

Wang, Y. 2001. China P.R.: a review of national aquaculture development. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 307-316. NACA, Bangkok and FAO, Rome.

Yianliang, W. (2001). China P.R. 1: A review of National Aquaculture Development. Aquaculture in the Third Millennium. Pp 307-316. Available at: www.fao.org/3/ab412e/ab412e19.html

About the Project

India and Bangladesh share 54 common trans-boundary rivers and waterways. These rivers can generate opportunities for the local communities in the sub-region through economic, political and socio-cultural interactions between the two countries. Cross-border trade, tourism and connectivity between these two countries through these rivers and inland waterways hold immense socio-economic potential. However, these have not been utilised to their fullest potential owing to several political, navigational and regulatory challenges. Thus, there is a need to connect and acknowledge such routes and rivers for trade of niche and locally originated commodities at a small scale.

Given this backdrop, CUTS International is implementing a project titled "Trans-boundary Rivers of South Asia" (TROSA), which is supported by the Swedish International Development Cooperation Agency (Sida) and managed by Oxfam. The project aims to reduce poverty of marginalised and vulnerable river basin communities through increased access to, and control over, water resources, over which their livelihoods depend.

For details, please visit:
https://cuts-citee.org/trans-boundary-rivers-of-south-asia-trosa/

CUTS International

Established in 1983, CUTS International (Consumer Unity & Trust Society) is a non-governmental organisation, engaged in consumer sovereignty in the framework of social justice and economic equality and environmental balance, within and across borders. More information about the organisation and its centres can be accessed here: http://www.cuts-international.org.

CUTS International

D-217, Bhaskar Marg, Bani Park, Jaipur 302 016, India
Ph: 91.141.228 2821, Fax: 91.141.228 2485
Email: cuts@cuts.org, Website: www.cuts-international.org

Also at Delhi, Kolkata and Chittorgarh (India); Lusaka (Zambia); Nairobi (Kenya); Accra (Ghana); Hanoi (Vietnam); Geneva (Switzerland) and Washington DC (USA).