DECEMBER 2021

A Case for a Human Rights-based Approach to Indian Aquaculture Systems

A Literature Review

by **Neena Elizabeth Koshy**

International Collective in Support of Fishworkers (ICSF) Trust

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Edited by

Kiran Mittal

Photo by

Neena Elizabeth Koshy

Layout & Cover Design

Jointfamily Design, Chennai
www.jointfamilydesign.com

Published by

International Collective in Support of Fishworkers (ICSF) Trust
No. 22, First Floor, Venkatrathinam Nagar
Adyar, Chennai 600 020, India
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ISBN 978-93-80802-75-6

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Preface

As an important animal protein production system, aquaculture has the world's focus. It is on a fast track of growth, especially in developing countries which are global leaders of aquaculture. The world of research is flush with literature on many aspects of aquaculture which poses the question of the requirement for yet another study on the sector. It was noticed that most studies on aquaculture deal with the technical side of culture. Though rare, papers dealing with environmental aspects are also available. However, literature on the social dimensions/human rights aspects of aquaculture are almost non-existent. Therefore, the current study is an effort in this direction to highlight the human rights dimensions of aquaculture in India, the second largest contributor to aquaculture production in the world. As a sector that is fast spreading in expanse, especially in rural areas, it provides the much needed employment, income, food security, livelihoods etc., and it is imperative that the development happens in a socially and environmentally just and viable manner. This is a prerequisite for the sector to continue contributing to the sustainable development goals. It is in this context that the International Collective in Support of Fishworkers Trust (ICSF) commissioned the study titled *A Case for a Human Rights-based Approach to Indian Aquaculture Systems: A Literature Review*. This is of immense importance as the human dependence on the sector is very high. The objective of the study is to understand the strengths of legislation, guidelines, schemes and other government documents with regard to the defence of human rights; review and analyse the environmental and social impacts of aquaculture systems as seen in the literature review; and to suggest a set of recommendations that could help fill the gaps in the current systems as identified within the limitation of a desk review.

The International Labour Organization (ILO) states that inclusive growth and decent work is the bedrock of sustainable development in any sector - this holds especially true for the aquaculture sector which has a very large dependent population. It is hoped that the study will help open a window on human rights dimensions of the sector and catalyse further studies on these aspects. Such studies, and those that follow, will help mainstream a human rights-based approach in aquaculture and encourage further discussions on the same on national and international platforms. Such efforts will help make visible the hitherto invisible human face of the sector.

This study would not have been possible without the inputs provided by a number of aquafarmers interviewed for the study; along with scientists of various research institutions such as Central Marine Fisheries Research Institute (CMFRI) and Central Institute of Brackishwater Aquaculture (CIBA).

Neena Elizabeth Koshy
Thiruvananthapuram, Kerala
December 2021

Abbreviations and Acronyms

AP	Andhra Pradesh
APDoF	Andhra Pradesh Department of Fisheries
AUC	area under culture
BBC	British Broadcasting Corporation
BFDA	Brackishwater Fish Farmers Development Agency
BMP	best management practices
bn	billion
BPL	below poverty line
CAA 2005	Coastal Aquaculture Authority Act 2005
CEBPOL	Centre for Biodiversity Policy and Law
CELAC	Community of Latin American and Caribbean States
CIBA	Central Institute of Brackishwater Aquaculture
CIFE	Central Institute of Fisheries Education
CIFRI	Central Inland Fisheries Research Institute
CMF	Changing Markets Foundation
CMFRI	Central Marine Fisheries Research Institute
COFI	Committee on Fisheries
COVID-19	Coronavirus Disease 19
CRZ	coastal regulation zone
CSO	civil society organisations
DAHDF	Department of Animal Husbandry, Dairying and Fisheries
DES	Directorate of Economics and Statistics
DLC	district level committee
DoF	Department of Fisheries
EIA	environment impact assessment
EJF	Environment Justice Foundation
EP	estimated production
ETP	effluent treatment plant
FAO	Food and Agriculture Organization of the UN
FARD	Fisheries & Animal Resources Development
FFDA	Freshwater Fish Farmers Development Agency
FFPO	Fish Farmers Producer Organisation
FMFO	fish meal and fish oil
GAP	good aquaculture practices
GI	galvanised iron
GIFT	Genetically Improved Farmed Tilapia
GO	government order
GoAP	Government of Andhra Pradesh
GoI	Government of India
GVA	gross value added
ha	hectare
HDPE	high density polyethylene
HRF	human rights framework
HTL	high tide line
ICAR	Indian Council for Agriculture Research
ICSF	International Collective in Support of Fishworkers
ILO	International Labour Organization
IMC	Indian Major Carps

INR	Indian Rupees
KFP	Kerala Fisheries Policy
kg	kilogram
KLWS	Kolleru Lake Wildlife Sanctuary
MoAFW	Ministry of Agriculture and Farmers' Welfare
MoFAHD	Ministry of Fisheries, Animal Husbandry and Dairying
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
mmt	million metric tonnes
mn	million
MPEDA	Marine Products Export Development Agency
NASO	National Aquaculture Sector Overview of the FAO
NBA	National Biodiversity Authority
NBFGR	National Bureau of Fish Genetic Resources
NEERI	National Environmental Engineering Research Institute
NFDB	National Fisheries Development Board
NFF	National Fishworkers' Forum
NFP	National Fisheries Policy (Draft) 2020
NGO	non-governmental organisation
NIFAP	National Inland Fisheries and Aquaculture Policy (Draft) 2019
NKM16	Neel Kranti Mission 2016
NPM	National Policy on Mariculture
OECD	Organisation for Economic Co-operation and Development
OFP 2015	Odisha Fisheries Policy 2015
OSCA	Odisha State Cooperatives Act
OSCC	open sea cage culture
PFCS	Primary Fisher Cooperative Societies
PMMSY	Pradhan Mantri Matsya Sampada Yojana
PPP	public private partnership
ppt	parts per thousand
SC/ST	Scheduled Caste/Scheduled Tribe
SDG	Sustainable Development Goals of the UN
SEZ	special economic zone
SHG	self help group
SIA	social impact assessment
SIFFS	small indigenous freshwater fish species
SOFIA	State of Fisheries and Aquaculture of the FAO
SPF	specific pathogen free
SSF Guidelines	Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication
TN	Tamil Nadu
TNIE	The New Indian Express
UN	United Nations
USA	United State of America
USFDA	United States Food and Drug Administration
UT	Union Territory
WBFP	West Bengal Fisheries Policy
WBLLRM	West Bengal Land & Land Reforms Manual
WSSV	White Spot Syndrome Virus

Glossary

Bargadar
(As per the West Bengal Land Reform Act 1955)

"Bargadar" means a person who under the system generally known as adhi, barga or bhag cultivates the land of another person on condition of delivering a share of the produce of such land to that person; [and includes a person who under the system generally known as kisani [or by any other description] cultivates the land of another person on condition of receiving a share of the produce of such land from that person;]

Bheries

Bheries are shallow water bodies embanked by low earthen dykes all around and located in various mouzas/administrative districts, in the north, north-east, and south of the Sundarbans 24 – Parganas district. (CIFRI, 1986)

Central Sector Schemes

These are schemes that are entirely and directly funded, formulated and executed by the central government, based on subjects from the Union List. Besides, there are some other programmes that various Central Ministries implement directly in States and UTs, though under these schemes, the financial resources are not shifted to states.

Centrally Sponsored Schemes

Central Sponsored Schemes on the other hand are schemes that are implemented by state governments. However, the cost of these schemes is borne on a shared basis in the ratio of 50:50, 70:30, 75:25 or 90:10. Under the cost ratio, the larger portion is always borne by the Centre. CSS is a system under which the centre assists the state government financially to get schemes implemented.

Hypophysation

It is the process of injecting a water soluble extract of a pituitary gland (mostly of cyprinid or salmonid origin) into a fish to induce ovulation or spermination. Such hormones are especially used for cyprinids *(FAO Aquaculture Glossary)*.

Khazans

In Goa, the khazans are coastal wetlands that are traditionally owned/managed by village associations or gaunkaris also known as comunidades. It went through various systems before settling on the current farmer associations managing the khazans *(refer Iyer, 2014)*

Ovaprim

A synthetic commercial formulation which is a liquid peptide preparation that contains an analogue of salmon gonadotropin releasing hormone and a brain neurotransmitter (dopamine) inhibitor. This may aid spawning by stimulating ovulation and spermiation in sexually mature fish (USFDA).

Tank Fishery

A reservoir or place for the storage of water, whether formed naturally or by excavation or by construction of embankments, which is being used for pisciculture or for fishing, together with the sub-soil and the banks of such reservoir or place, except such portion of the banks as are included in a homestead or in a garden or orchard and includes any right of pisciculture or fishing in such reservoir or place.

U-shaped Recovery

It means that the economic damage lasts for a longer period of time before eventually reaching the baseline level of growth again. The economy bounces back, but the damage at the bottom lingers for a while.

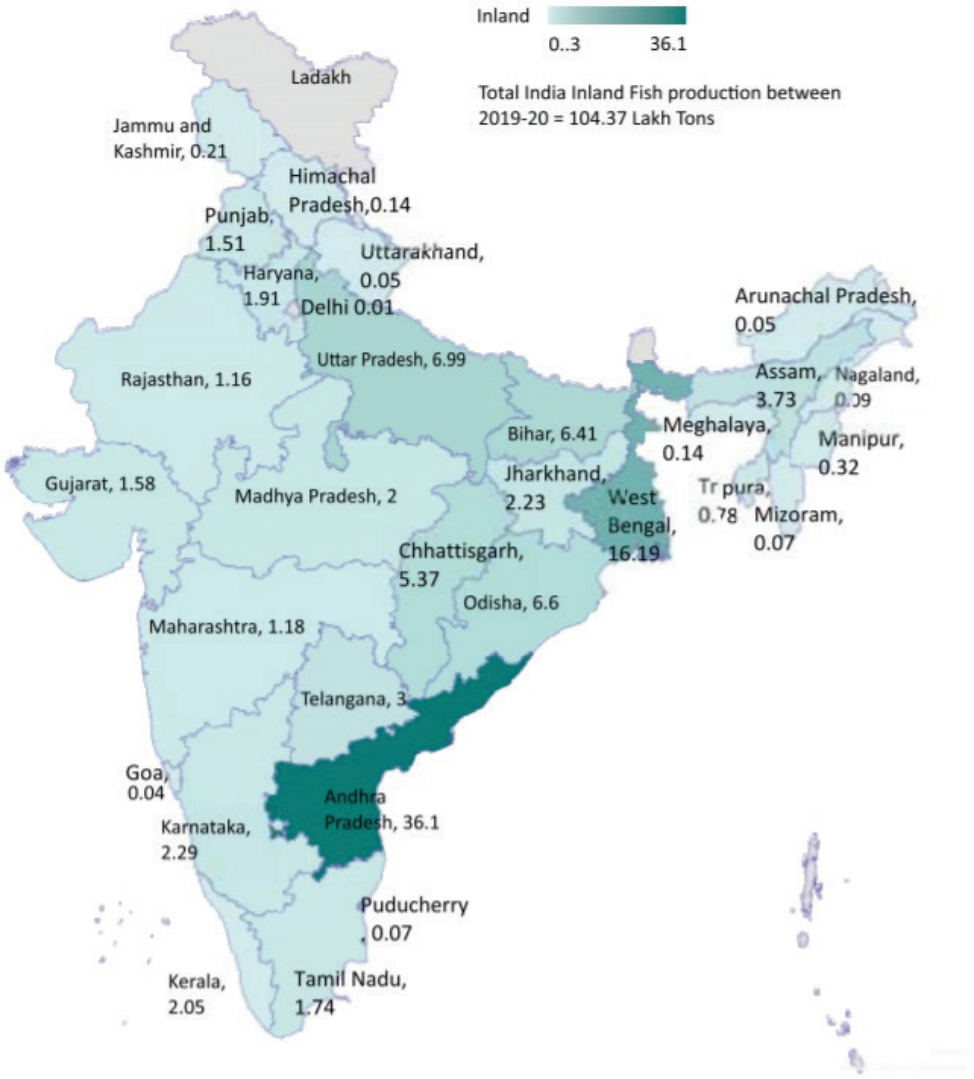
V-shaped Recovery

It shows that the economy bounces back quickly to its baseline before the crisis. This is one of the most optimistic recovery patterns because it implies that the downturn did not cause any lasting damage to the economy.

Wasteland

Waste Lands (Requisitioning and Utilisation) Act, 1952, defines it as any land classified in the record-of-rights published under the Bengal Tenancy Act, 1885 (8 of 1885) as nutan patit, puratan patit, layek patit, gar layek patit or layek jungal and includes any land or water area which, in the opinion of the State Government, has not been adequately used for the production of crops or fish for a continuous period exceeding two years but does not include land, forming part of [* * * *] any homestead, farmhouse, burning or burial ground or any place of worship.

Figure 1: Map of Total Inland Fish Production in India (2019-2020)
(~74% of inland fish produced is from aquaculture)



Source: Handbook of Fisheries Statistics 2020, MoFAHD

States as per Type of Aquaculture Practiced (Top States Underlined)
Brackishwater: Andhra Pradesh, Odisha, West Bengal, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra, Gujarat
Freshwater: Andhra Pradesh, West Bengal, Odisha, Uttar Pradesh and all states as shaded in the map above
Inland Saline: Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, West Bengal
Mariculture: Tamil Nadu, Karnataka, Odisha, Kerala, Gujarat, Maharashtra, Andhra Pradesh

1. Introduction

Aquaculture is seeing a boom world over with global production achieving 114.5 mn tonnes in live weight (SOFIA, 2020). The world, excluding China, clocked an aquaculture growth rate of above 5% in 2018, with more than 95% of the total production contributed by developing countries and 82% of the total by just five Asian nations, namely China 57.9%, India 8%, Indonesia 6.6%, Viet Nam 5.04% and Bangladesh 2.93%. The four countries where aquaculture contributed more than 50% of their total fish production are China (76.5%), India (57%), Bangladesh (56.2%) and Viet Nam (55.3%) (SOFIA, 2020). Aquaculture has been a traditional activity in most of these countries providing essential food, nutrition and supplemental income to local communities.

India stands second in the world with respect to aquaculture production (refer Table 1). Gross Value Added by fisheries and aquaculture in 2018-19 amounts to 1.12% of the national GDP and contributed 7.28% to the GVA by agriculture (DoF, MoFAHD, 2020). The fisheries and aquaculture sector employs ~28 mn people directly and almost 50 mn, if allied sectors are factored in (MoFAHD, 2020; PMMSY, 2020). Fish production has grown from a mere 0.75 mmt in 1950-51 (71% production constituted by marine and 29% by inland) to 14.16 mmt in 2019-2020 (marine production at 3.72 mmt and inland production at 10.43 mmt) (MoFAHD, 2020) (refer Table 2). In the year 2019-20, India produced 7.7 mmt of farmed fish. Almost 100% of marine fish production comes from capture fisheries. Thus, it can be safely assumed that 74% of inland fish produced and 54% of total fish produced by the country is contributed by the aquaculture sector (MoFAHD, 2020).

Table 1: Top 5 Aquaculture Producers of the World

Year → / Countries ↓	1995 (mmt) (% contribution to total aquaculture production in the world)	2018 (mmt) (% contribution to total aquaculture production in the world)
China (mainland)	15.9 (65.03)	47.6 (57.93)
India	1.66 (6.8)	7.1 (8.61)
Indonesia	0.64 (2.63)	5.43 (6.61)
Viet Nam	0.38 (1.56)	4.13 (5.04)
Bangladesh	0.31 (1.3)	2.41 (2.93)

Source: SOFIA 2020

Table 2: Fish Production in India

Items	2015-2016	2019-2020
Total Fish Production (mn mt)	10.76	14.16
Total Inland Fish Production (mn mt)	7.16	10.43
Total Marine Fish Production (mn mt)	3.6	3.72
Total Culture, both inland and marine in mn mt; figures in brackets denotes the % in total production of the year	5.7 (53)	7.7 (2018-19) (54.73)

Source: Compiled from the Handbook of Fisheries Statistics 2018 (MoFAHD, 2019), Handbook of Fisheries Statistics 2020 (MoFAHD, 2020); 6th Draft National Fisheries Policy 2020

Research papers indicate that only 40-60% of the available ponds and tanks (Jayasanker 2018; CEBPOL, NBA 2018) and only 13% of the available brackishwater resources are utilised for culture (Ghoshal et al, 2015), making a case for further expansion (both vertical and horizontal) which is also emphasised in the Sixth Draft of the National Fisheries Policy (December, 2020). Though in a nascent stage, mariculture is being upheld as a promising sector, with a current almost negligible contribution to having a potential to increase its total fish production to four to eight million tonnes (6th Draft NFP, 2020).

Though the marine statistics puts out the number of fishers, marine fishing villages, and segregated data on non-mechanised and mechanised, the inland fisheries statistics talk only about the productive resources and provide figures in an aggregated manner. It is high time that not only are the available resources and culture potential be put out with respect to aquaculture statistics but also the human dimensions be made more evident for the inland sector. This becomes even more pertinent as the contribution of inland fisheries and aquaculture (currently pegged at ~74%) in total fisheries production of India is on a steady upward curve.

The literature available on aquaculture in India indicates a minimal focus on environmental and social concerns, with a stark absence of the human-rights dimensions of the sector. An attempt to comprehensively look at the aquaculture sector in India and to recommend a human rights-based framework to aquaculture development is the objective of the study titled *A Case for a Human Rights-based Approach to Indian Aquaculture Systems: A Literature Review*.

The study intended mainly as field research to explore the human-rights dimensions not usually found in aquaculture literature, especially in India, was converted to a desk-based research due to the COVID-19 pandemic. The original objectives of the study were as given below:

- to look into the aspects of the new blue revolution from an aquaculture lens in general and human development in particular, especially in view of SDGs 1, 2, 5, 8, 14 and 16.

- identify areas where new trends are being adopted such as cage fisheries in reservoirs, mariculture in coastal waters, and make case studies on the same.
- work on a gender and age disaggregated status for a block in a selected state in different aquaculture production systems.
- examine if aquaculture offers alternate livelihoods to fishers.
- assess threats facing fishing communities from aquaculture operations, including from new tenure arrangements.
- identify occupational safety and health issues in aquaculture systems.
- probe whether the learnings of the earlier experiences are being considered and addressed, especially the impact on communities and ecosystems.
- propose how aquaculture development in India can be made consistent with a human rights-based approach towards sustainable development and good governance.

The above objectives have been changed to adapt to the current situation. The modified study is divided into nine sections that provide various aspects of aquaculture - from its development in India; the legal documents and policies of the government impacting current aquaculture development; the major culture systems (as per the current focus of the policy environment in India); aquaculture growth as witnessed in a few culture-important states; social and environmental impacts of aquaculture; employment in aquaculture followed by a section on women in aquaculture. The final concluding section provides recommendations to address the gaps observed by the study, followed by how the aquaculture discourse that is currently production centric could be steered towards following a human rights-based framework.

2. Development of Aquaculture in India

Aquaculture has been practised traditionally in India with its existence dating back to 321-300 BC (National Aquaculture Sector Overview (NASO, FAO), 2020). It was practised in ponds as well as in areas seasonally inundated with water. Among the earliest forms of aquaculture documented in India, and still in practice, is the rice-fish culture along the western seaboard, and fish culture as seen in West Bengal and the north-eastern states. Examples of traditional rice-fish practices are the *pokkali* (named after the salt tolerant *pokkali* rice variety) fields of Kerala; the *ghazanis* of Karnataka; *khazans* of Goa; and *bheries* of West Bengal (Alikunj 1968; Silas 1968 cited in Sathiadas et al, 1989; Chandramohanan and Mohanan 2012). In *pokkali* fields of Kerala and *khazans* of Goa, it was mainly paddy-fish culture, while it was fish culture along with salt production in the *ghazanis* of Karnataka (Alagarwsami,1981). In Kerala most of the *pokkali* fields were private property and fields were sometimes leased out to farmers for the cultivation of shrimps and other fish. Detailed accounts of the management and property regimes of the *khazans* of Goa are also available.

History of aquaculture development in India is detailed in the country profile page on the FAO website (NASO, 2020). The below list gives a snapshot of the major milestones with respect to aquaculture growth in India.

- Evolution of aquaculture in India to modern systems started with the establishment of the Pond Culture Division of the Central Inland Fisheries Research Institute (CIFRI) in Cuttack in 1949. It was the first step in recognizing aquaculture as a major area of work for food/protein production as well as a source of livelihood and employment. However, it was limited to the freshwater culture of the Indian Major Carps in the backyard ponds of West Bengal, Orissa and Bihar, using wild collected seeds (Ramakrishna et al 2013).
- The second landmark was the evolution of hatchery techniques, hypophysation (Ramakrishna et al 2013), the development of Ovaprim which increased seed production from 490 mn fish fry in 1973-1974 to 20,000 mn in 2000s (Silas, 2003) etc. This too was limited to freshwater carp aquaculture.
- The launch of the Centrally Sponsored Scheme of Fish Farmers' Development Agency (FFDA) and National Programme for Fish Seed Development, and the successful demonstration of carp polyculture in West Bengal, all happened in and around the 1970s. FFDAs were established to popularise freshwater aquaculture for increased fish production, increased rural employment, increased protein availability, etc., by providing financial and technical support to aspiring farmers (Gautam et al, 2017). According to the Planning Commission Report (2012) this scheme brought 0.75mn ha under improved aquaculture and took 1.3 mn

beneficiaries under its fold, giving a major acceleration to freshwater aquaculture in India. These culture systems were low on input costs, were mostly environment friendly and produced affordable fish for domestic markets. However, there are examples of extreme freshwater culture in states like Andhra Pradesh, where carp culture evolved around the Kolleru Lake.

- The United States and the Japanese markets drove the demand for shrimp post 1960s, which was mostly met by capture fishery. The share of shrimp in marine fisheries exports increased from 30 to 77% in quantity while it increased from 41 to 90% in value during the period 1960-1974 (Kurien, 1978). This pushed shrimp into the limelight as a promising foreign exchange earner, and catalysed India's efforts to produce shrimp through scientific aquaculture. This saw a major breakthrough of inducing prawns into maturity through eyestalk ablation by Central Marine Fisheries Research Institute (CMFRI) in 1963 (Vijayan & Balasubramaniam, 2019). However, the actual boom started in the early 1990s with the success of *Penaeus monodon* commercial hatchery in Andhra Pradesh (Vijayan & Balasubramaniam, 2019). This marked the onset of intensive monoculture of the Giant Tiger Shrimp *P. monodon*, driven by the international seafood market demand. According to the Supreme Court Judgement of S. Jagannath vs Union of India & Ors on 11 December, 1996, *the environmentally benign forms of aquaculture gave way to semi-intensive and intensive forms of aquaculture in the coastal spaces of India.*

  Disease propensity due to intensive monoculture of *P. monodon*, decreased the interest in the culture of the prawn and initiated a period of sluggishness in the sector. This is evidenced by a 40% reduction in the area under culture (AUC) of the species when figures of 2001-02 are compared to that of 2017-2018, with estimated production (EP) also showing a dip from 102,940 tonnes to 57,691 tonnes in respective years. However, it is interesting to note that the intensity of production indicates an increase from 0.67 to 0.97 tonnes per ha (Marine Products Export Development Authority (MPEDA), 2020).

- The second wave of brackishwater aquaculture is currently being witnessed with the culture of the exotic Pacific white leg shrimp, *Litopenaeus vannamei*. The species was first introduced as a trial in 2001 from Hawaii via the Taiwan Province of China (Mathew et al, 2004). Post this, MPEDA issued a public notice warning against the illegal culture of *L. vannamei*. A National Strategic Plan for Aquatic Exotics and Quarantine was drawn in 2002. However, its culture was permitted on a pilot scale from 2003 (Ravichandran, P in CIBA, 2012; Babu et al, 2013), and later legalised in 2009-2010 after a risk analysis study by Central Institute of Brackishwater Aquaculture (CIBA) and National Bureau of Fish Genetic Resources (NBFGR), and based on the Guidelines for Regulating Hatcheries and Farms for Introduction of *L. vannamei* issued through the Coastal Aquaculture Authority (CAA) rules (Ponniah,

2012). Biosecurity issues, environmental sustainability concerns, importance of setting up of quarantine facilities, shortlisting of specific pathogen free (SPF) broodstock suppliers, restriction of production of SPF seeds in approved hatcheries, supply of seeds to approved farms, etc. were the steps taken under the above mentioned guidelines.

Tacon et al (2011) indicate that aquaculture development in any country is bound to see an upward curve where its ecosystem (legal and otherwise) facilitates the same. This is true for India where it is seen as a sunrise sector, and the push for it is easily palpable. The following section examines the regulatory frameworks determining aquaculture development in India.

3. Regulatory Frameworks for Aquaculture in India

In the year 2016, the Government of India launched the Blue Revolution 2.0 or the Neel Kranti Mission 2016 (NKM16) which directs the state to formulate the Mission Plan for tapping the full potential of inland and marine culture fisheries of the country by developing it as a professional modern world class industry. The document also mentions doubling fishers and farmers income as well as ensuring sustainability by addressing biosecurity and other environmental concerns - two major concerns in the aquaculture subsector. Towards bringing in the blue revolution, the central government drew up the Pradhan Mantri Matsya Sampada Yojana with two components - the Central Sector Scheme and the Centrally Sponsored Scheme. Policies such as the Draft National Fisheries Policy 2020 were announced. The erstwhile Department of Fisheries, Animal Husbandry and Dairying of the Ministry of Agriculture was elevated to the rank of a ministry in May 2019 and renamed the Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD). This goes to establish in unambiguous terms the intent of the Government of India with respect to fisheries and aquaculture. Some of the policies, guidelines and mission documents with implications for aquaculture are discussed below.

3.1 Sixth Draft National Fisheries Policy 2020

The sixth draft National Fisheries Policy 2020 indicates in its objectives that fishers and fishfarmers will be at the core of the policy and promises to ensure their wellbeing. It also assures sound management and sustainable development of the resources and associated habitats, maintaining ecosystem integrity, and meeting the food and nutritional requirements of the population. The heavy intent on aquaculture is seen as a common thread throughout the document and the word repeats 80 times (120 if only the word 'culture' is searched for) in comparison to just 12 times of the term 'capture' or just 8 times of the phrase 'capture fisheries'. The draft policy indicates vertical intensification and technology improvement as the way forward. The document points out minimal supplementary feed dependence with an indicative tone of where the industry needs to pull up its socks. The policy identifies diversification as the key to further expansion of the sector, namely diversification of species, diversification of technology, etc. This, it states, is the stepping stone to the next aquaplosion which is indicated as desirable. The first time the word aquaplosion was used was with regard to Kolleru carp culture which led to the reduction of the Lake in terms of its size as well as in terms of the services it provides.

Under the brackishwater culture section it is indicated that coastal land which is otherwise of limited economic use be leased out for farms or infrastructures to support farms. This measure needs to be given more thought as these lands will be under use by the local communities for

various consumptive and non-consumptive purposes. These communities will not be getting an alternate area for these purposes if these are leased out for aquafarming and related activities.

The draft policy also pushes mariculture into the centre stage and emphasises the negligible mariculture production achieved by the country so far in comparison to the projected potential of 4 to 8 mmt. Given that the sector is in its nascent stage, it is proposed that any development starts with marine spatial planning by preparing a blueprint of suitable sites/areas and developing a leasing policy based on it. The space will be allocated on a priority basis to small-scale traditional fishing communities for sea cage farming. The seed will be produced in biosecure facilities in open ocean beyond 12 nautical miles without causing hindrance or harm to normal fishing and other maritime activities. It also makes special mention of formulating guidelines that deal with issues like access to fishing grounds and encroachment of fishing areas to reduce conflict between fishers and fishfarmers. The policy also indicates conducting carrying capacity studies and environmental impact assessments (EIA) for promoting sustainable mariculture in the country. For all these well thought out measures to be effective, proper monitoring and control is crucial. These are aspects that need strengthening for sustainable aquaculture development in India.

Currently sea cage culture has been initiated on a pilot basis at some places and is undertaken commercially in some parts of coastal India despite the absence of a mariculture leasing policy or a mariculture policy. A common factor with the development of mariculture and freshwater aquaculture is the stress on cage culture in open water bodies. The Guidelines for Sea Cage Farming in India: Towards a Blue Revolution (DAHDF, 2018) mentions that cage culture, if done in at least 1% of the nearshore waters, can deploy 820,000 cages which could increase production by 3.2 mn tonnes.

An interesting aspect that emerges from the policy is the shift in production systems. Until recently aquaculture production was from three major ecosystems - freshwater, brackishwater and marine waters. The developments prior to this policy, culminating in the draft policy under discussion, has in no ambiguous terms placed saline/alkaline inland aquaculture at par with the three systems mentioned above. Moreover, emphasis is on the expansion of shrimp/prawn farming in these saline lands. The legislation also indicates conversion of lands unfit for agriculture cultivation to aquaculture ponds. This, if allowed to proliferate in an unregulated manner, could result in a huge environmental and social cost, probably weighing heavily on the local community.

The policy also stresses the need to treat aquaculture at par with agriculture with most of its benefits, namely power supply, loan facility, crop insurance etc., to be extended to the subsector. Mention of the need for small holding aquaculture and establishment of farmer producer organizations is a

welcome step. However, this should not overrule the existing structures such as the Fish Farmer Development Agency (FFDA) and Brackishwater Fish Farmer Development Agency (BFDA).

The policy indicates the need for developing an independent leasing policy and empowering local communities to manage resources. It acknowledges the need to stress on biosecurity and for a coordinated effort between the centre and the state to mitigate and control aquatic diseases. It also talks about encouraging best management practices (BMP) and good aquaculture practices (GAP), but there is no mention of its mandatory formulation and implementation, which is a deviation from the earlier drafted National Mariculture Policy (2017) subsumed by the NFP (Draft) 2020.

3.2 Coastal Aquaculture Authority Act, 2005 (CAA, 2005)

The objective of the Act is to establish a Coastal Aquaculture Authority to regulate activities connected to coastal aquaculture (which includes both saline and brackishwater culture). It issues guidelines to ensure responsible aquaculture that does not negatively impact the coastal environment. This is aimed at regulating coastal activities and protecting the livelihoods of the coastal community. Any coastal aquaculture farm or traditional farm is to be registered before it is operationalised, and registration will be valid for 5 years with an eligibility to extend for another five years.

All farms should comply with the following: no coastal aquaculture within 200m from HTL and none in creeks, rivers, backwaters within the CRZ. However, farms such as those operating in these zones before the CAA, experimental farms of research institutes and non-commercial farms can carry on with their activity.

3.3 Coastal Aquaculture Authority Rules, 2005

According to the rules, it is the function of the authority to see that no agricultural land, mangrove, salt pan, wetland, common village land and those used for public purposes, and land under sanctuaries and national parks, is converted to an aquaculture farm. The authority is also to advise states/Union Territories and central government to draw up strategies based on the survey conducted by it of the entire coast of India; advise state governments to come up with common water intake and discharge canals and establish a common effluent treatment plan. It has to fix standards with regard to the use of seed, feed and other growth supplements used in coastal aquaculture, and monitor the compliance of the farms to environment protection measures. It is also responsible for the collection and dissemination of socio-economic data with respect to coastal aquaculture; popularise sustainable utilization and fair and equitable sharing of coastal resources; direct owners to carry out modification with regard to stocking density, use of antibiotics/chemicals and other pharmacological components in aquaculture.

3.4 Guidelines for Regulating Coastal Aquaculture 2005

Coastal aquaculture involves any type of brackishwater and saline culture of crustaceans, finfishes and molluscs. However, the guidelines emphasise the need for shrimp aquaculture to be environmentally responsible and socially acceptable to enhance its positive contribution to coastal communities. While the guidelines encourage practising extensive as well as improved traditional aquaculture, they discourage semi-intensive or intensive methods as they exert greater pressure on the environment and have larger social impacts. The document also gives guidelines on site selection; on construction and preparation of shrimp farms; water quality and its management; wastewater management; and the parameters that should be followed on seed production, selection and stocking; feed and feed management; health management of shrimp and use of chemicals and drugs. It gives a list of drugs that are banned for use in shrimp culture as well as puts out the maximum permissible limits of certain chemicals in fish and fishery products. The document also provides guidelines for environment impact assessment; encourages cluster approach of shrimp farm development; measures to protect the livelihoods of the coastal communities etc.

3.5 Guidelines of the National Fisheries Development Board

Formed in 2006, the National Fisheries Development Board has brought out a series of guidelines over the years which are listed below, most of these pertain to aquaculture namely, intensive aquaculture in tanks and ponds; coastal aquaculture; cage culture in inland open water bodies; open sea cage farming, etc.

3.5.1 Guidelines for Intensive Aquaculture in Ponds and Tanks

These guidelines indicate that there is a total of 2.4 mn ha that could be brought under freshwater aquaculture out of which 33% (0.8 mn ha) should be brought under intensive aquaculture to double the production from 2.2-5 tonnes/ha/year. The guidelines also talk about subsidies to be given to farmers who have past performance in aquaculture. The amount earmarked for intensive aquaculture in ponds and tanks is INR 6.2 mn.

3.5.2 Guidelines for Coastal Aquaculture

The document indicates an availability of 1.4 mn ha that could be brought under brackishwater aquaculture out of which 150,000 ha is under production and aims to bring additional 150,000 ha (100,000 ha for shrimp and 50,000 ha for finfish) under production. The guidelines focus on imparting training on best management practices (BMPs) as the document indicates that the lack of BMPs was largely responsible for the bust witnessed by shrimp aquaculture in the late 1990s.

3.5.3 Guidelines for Fisheries Development in Reservoirs

This comes under culture-based capture fisheries. The guidelines call for the establishment of a

reservoir policy by every state as a prerequisite for their further development. The policy should name the beneficiaries to whom the socio-economic benefits would accrue and the developments should ensure the benefit of the poorest of the poor. The document, unlike other guidelines, underlines the importance of clear leasing rights and leasing periods (suggesting a 10-15 year period for sustainability) which need to be laid out at the onset, and also goes on to elaborate the methodology to arrive at the lease amount.

3.5.4 Guidelines for Cage Culture in Inland Open Water Bodies (2016)

Though the guidelines are for optimising fish production in reservoirs and highlights the role of cage culture in achieving the same, they caution against any unplanned expansion that could harm the environment and social equity. The document advises against augmenting fish production by negatively impacting the livelihood of traditional/local fishing communities. The need to ensure that aquaculture growth is sustainable and inclusive, and in harmony with principles of ecological integrity, natural resource conservation without conflict with other users of water and land is underlined in the document. It highlights the absence of not only a policy framework to govern freshwater culture but also the lack of an umbrella agency to regulate or oversee freshwater aquaculture activities. However, it points to the existence of a "Policy Framework for Aquaculture Development in India'' submitted by CMFRI to DAHDF in 2014. Though this framework was meant for mariculture, the basic tenets laid down can be modified for guiding freshwater aquaculture development, especially the proposal of a District Level Task Committee to implement guidelines and inspect whether BMPs are followed.

The document urges the states to draw a list of water bodies in which culture can be carried out. It further goes on to guide on the carrying capacity of the reservoirs and gives a fair picture of the number of cages that can be allowed based on the different types of water bodies and suggests that advocates of cage culture should follow a precautionary approach while dealing with data deficient systems. This document clearly acknowledges that rights on the fish resource is the primary right of the local fisher communities. It states that *under special circumstances, if a private entrepreneur or investor is to be brought to the scene, 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.* It also emphasises the importance of establishing conflict management cells to address complaints. This document also cautions on following a purely revenue driven model and insists on empowering the local fishing communities. It further emphasises that cage culture should be of social relevance. One of the main achievements from cage culture, other than increased production, should be an improved standard of living for the weakest of the society. These guidelines also mention the importance of safety at work. It is a welcome change that this document underscores the need for a social focus which is much required for such interventions to be meaningful to the local community.

The document encourages the culture of *Pangasianodon hypophthalmus* and Genetically Improved Farmed Tilapia (GIFT) and this has to be seen with caution. However, guidelines on the culture of these species have been given and strict adherence to the same is emphasised. It goes on to say that culture of any other exotic species other than the above two is strictly prohibited in cage culture in water bodies.

3.5.5 Guidelines for Sea Cage Farming (2018)

India aims to increase its fish production from 10 mmt to 18 mmt by 2030, with the additional 8 mmt to be provided by aquaculture. Sea cage culture is considered as one of the interventions which could immensely support this effort. The document advises to bring at least 1% of the coastal inshore water under sea cage farming, contributing an additional 3.2 mn tonnes from 8,20,000 cages. Currently 1500 cages are installed with a production capacity of 1500 tonnes. This type of culture is envisaged in open seas, sheltered bays, lagoons with suitable water quality etc. The guidelines predict that with an estimated production potential of 50 times more than shore-based facilities, sea cage farming would augment seafood production in a sustainable manner, thus meeting both foreign and domestic demand for seafood. The guidelines suggest adoption of an integrated approach for the success of sea cage farming which includes activities such as manufacturing of cage frames, cage nets, mooring assembly, establishment of hatcheries, nursery rearing units, feed mills etc.

The species that are promoted in cage culture are all fed species and most of them are carnivorous as well, namely sea bass, cobia, silver pompano, grouper, etc., requiring 30-40% protein rich feed which is usually fish/animal-meal based or oil cake based feed. However, the guidelines indicate that the number of cages to be allowed at a particular site is to be decided by the carrying capacity of the area, which if not considered, could lead to transmission of diseases, parasites etc., and affect the larger fauna and flora.

Apart from these guidelines, NFDB has targeted its efforts through various missions namely - Mission Cage culture; Mission Brackishwater-Saline Aquaculture; Mission Mariculture; etc. The emphasis is on undertaking the targeted activities on a mission mode for timely achievement of predicted results.

For **Mission Cage Culture 2022** (2017), fourteen states have been identified for immediate action (Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttarakhand and Uttar Pradesh) for a targeted installation of 25,000 cages over a period of six years starting from 2016 upto 2022, with a targeted production of 75,000 mt. **Mission Brackishwater/Saline Aquaculture 2022** (2017) states that

only 12% of the available 1.2 mn ha of brackishwater is used for culture as well as 12% of the available 1.4mn ha of saline water areas. This aquaculture will be considered on a mission mode in 13 states, namely Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Odisha, Pondicherry, Tamil Nadu and West Bengal for coastal brackishwater while Rajasthan, Haryana and Punjab are chosen for inland saline water aquaculture to produce 0.785mmt in addition to the current 0.393 mmt in five years from 2017-2022. This includes establishment of 185 hatcheries (135 for shrimp and 25 each for sea bass and mudcrab); 9 fish feed mills (with a total cost of INR 630 mn; one in each state mentioned above barring Rajasthan, Haryana, Punjab and Pondicherry). **Mission Mariculture 2020 & 22** (2017) is to especially promote cage culture in all maritime states and UTs, with efforts concentrated towards production of sea bass, cobia and silver pompano.

The Prime Minister's Scheme for Fisheries Resources, *Pradhan Manthri Matsya Sampada Yojana* 2020, (PMMSY) relaunched as a post COVID-19 measure, with supposedly INR 200.5 bn infused into it, underlines the route envisaged for aquaculture development in the country. The strategy of PMMSY is to give priority to securing and promoting the interest (social, physical and economic) of fish farmers. Key aims of the scheme are to increase export earnings from approximately 6.3 bn USD (2018-2019) to 13 bn USD (2024-25); large scale promotion of alkaline/saline inland areas for aquaculture; give boost to new technologies which include cage culture which is pushed in open water bodies such as reservoirs, coastal and marine areas, etc. The scheme also emphasises adoption of a cluster/area-based approach and stress on high-value species such as sea bass, scampi, mudcrab, *P. indicus*, etc.

All the above mentioned policies and schemes are under the umbrella *Neel Kranti Mission* 2016 (NKM 16) or the Blue Revolution, clearly indicating that aquaculture, its intensification, (vertical) integration with cluster-based approach, adoption of modern technology, is the way forward for India. Premising on the above stated, we will look at different aquaculture systems prominent in India.

4. Aquaculture Systems of India

India is traditionally an aquaculture nation. Currently, it has progressed phenomenally in freshwater, brackishwater and saline/alkaline aquaculture. Each sector is independently dealt with here to understand its tangent of development.

4.1 Freshwater Aquaculture

The Indian Major Carps (IMC) are the main constituent of inland fisheries in India, contributing a total production (in 2019-20) of 5.95 mn tonnes (Handbook of Fisheries Statistics, 2020). The carps are cultivated under various aquaculture technologies, however the Kolleru Carp culture model which is widely practised has been discussed below.

4.1.1 Kolleru Carp Culture

Lake Kolleru in Andhra Pradesh is the largest aggregation of aquaculture farms outside China (Belton et al, 2017). It is a natural flood control system which two major rivers, Krishna and Godavari, drain into. The lake is a provider of many ecosystem services including water for domestic and agricultural purposes (rice farming is the major occupation of the area), and supporting lives and livelihoods in myriad ways (providing food, fish, vegetables, grazing area for local cattle, material used to thatch houses, etc.). To underscore the importance of this system and the services it provides, Kolleru Lake was declared a Wildlife Sanctuary (KLWS) in 1999 and later a Ramsar site (Azeez et al, 2011).

The literature surveyed indicates that the aquaculture development in Andhra Pradesh began with carp culture in 1976 in Kolleru Lake (Ramakrishna et al, 2013), with the state government playing a very proactive role in the evolution towards its boom. The first intervention was when the lake area was allotted to Scheduled Caste and Backward Classes in 1940 (Rao et al, 2006) for practising agriculture. However, increasing incidents of floods, low returns, high labour costs etc., prompted the farmers to convert their land into aquaculture ponds (Ramakirshna et al, 2013; Rao et al, 2006; Azeez et al, 2011). In 1976, the government constructed 133 ponds (Ramakrishna et al, 2013) as part of a livelihood development programme (Belton et al, 2017). The initial success of carp aquaculture attracted so much interest that together with the government, banks started to lend money to agricultural farmers of the area who had suffered repeated crop failures due to flooding. This encouraged the conversion of loss-making agricultural lands to high profit earning fish farming ponds (Rao et al, 2006). The joint efforts of the Department of Animal Husbandry and the Department of Agriculture to promote integrated agriculture fell short before the intervention of the Department of Fisheries who gave loans through Corporate Land Mortgage Banks for building

fish tanks for furthering aquaculture (Jayanthi et al, 2006). However, the cyclone of 1977 wreaked havoc for small farmers who were unable to repay loans in the event of crop loss, easing the entry of big private entrepreneurs into the aquaculture sector (Belton et al, 2017). From no land under carp culture before 1976, 158.5 sq km was converted into aquaculture ponds by 2000 through conversion of agricultural lands (whose spread reduced from 128 sq km in 1977 to 44.1 sq km in 2007) as well as the lake area. There was also a similar increase in human settlements from 3.3% (1997) to 7% (2007) around the lake, (Pattnaik et al, 2014) indicative of successful aquaculture. This increased the stress on the ecosystem.

The status of protection conferred upon Kolleru Lake could not save the lake from disintegration when profits took an upper hand in decision making. The aquaculture-political nexus was so strong that the reduction of the expanse of KLWS was on the cards (Azeez et al., 2011). There was also a submission from the district collector to the government to remove the restriction on converting agriculture farms into aquaculture. Loans were given generously for aquaculture and for building ponds. To a very large extent, the original livelihood and occupation (rice farming) around Kolleru Lake gave way to semi-intensive carp culture farms (Ramakrishna, 2007).

The enterprising farmers of Andhra Pradesh evolved techniques for maximizing profits through developing stage-wise cultivation of carps (as shown in Table 3). With this approach, loss due to high mortality inherent in the system, which included culture of organisms from fingerling stage to marketable size, was greatly reduced. However, this split approach resulted in more area getting converted into aquaculture ponds.

Table 3: System of Stage-wise Carp Culture as Practised in Kolleru Lake

Stages	Process	Impacts
Stage 1	Stocking 2.5 cm fingerling which grows to provide input at Stage 2	Large areas converted into tanks/ponds in stage wise culture
Stage 2	Stocking 100-200 g fish which grows to provide input at Stage 3	Same as above
Stage 3a	Stocking 500 g fish which is grown to marketable size through intense feeding. This allows farmers to take two crops in a year.	Intensive farming, heavy use of fertilizers, feed; higher dependence on water resources etc.
Stage 3b	Stocking 500 g fish to be grown to 700-1000 g yearling to provide grow-out ponds which later grow them to marketable size through intense feeding.	Same as above

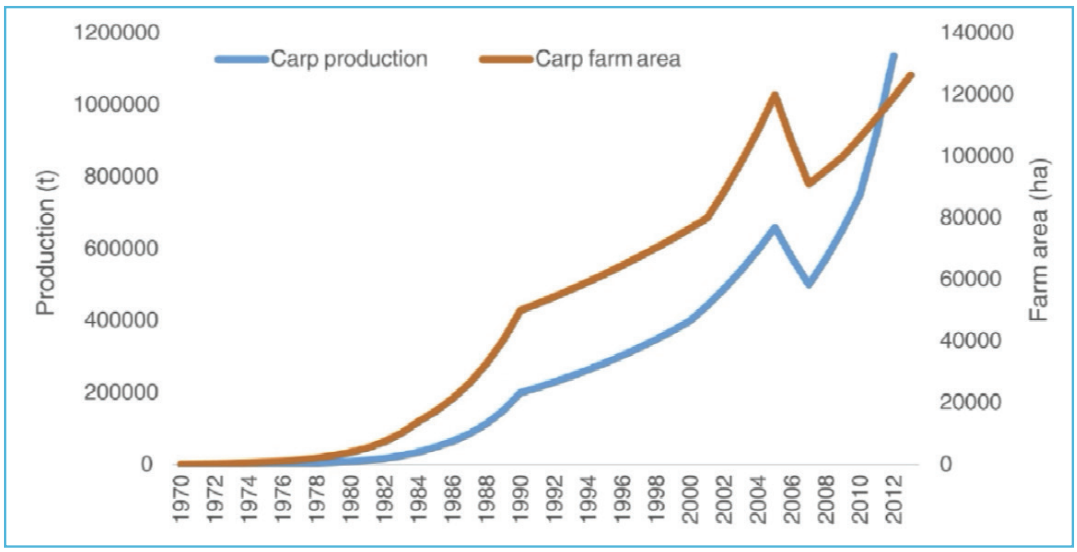
The unchecked conversion of lake and agriculture fields to aquaculture ponds along with indiscreet use of pesticides and fertilizers (to accelerate plankton production in the water body) not only affected its hydrology but also pumped the system with chemicals, creating havoc on its flora and fauna. Thus, Kolleru Lake, once a vibrant biodiverse area supporting myriad livelihoods namely fishing, cultivation of vegetables and water vegetables such as lotus and water chestnut, saw a

substantial reduction in the number of species, with associated reduction in livelihoods, nutrition and food security.

Witnessing the success of carp culture in Kolleru, it spread to other nearby districts of Andhra Pradesh (Nellore, Guntur, Prakasam, and East Godavari) albeit at a smaller scale (Muralidharan, 2019). While in Nellore carp culture is practised at a very low intensity, in East Godavari IMC polyculture includes *Macrobrachium rosenbergii* (giant freshwater prawn) or *Penaeus monodon* (black tiger shrimp). By 2010, there were more than 80,000 ha of carp aquaculture ponds in the whole of Andhra Pradesh (Ramakrishna, 2013) and, as shown in the graph below, it had risen further to 120,000 ha by 2012 (Belton et al, 2017). The Kolleru model has been adopted in other states of India such as Orissa, Madhya Pradesh, Haryana, Punjab etc.

The graph below (Figure 2) shows a dip in carp production in Andhra Pradesh in the years following 2004 till about 2008-09. This was due to "Operation Kolleru" which was undertaken following petitions against the uncontrolled proliferation of carp farms in and around Kolleru that were beginning to clog the natural flow of rivers into the lake. This, along with unprecedented rains such as those in 2005, devastated the nearby villages through floods. Operation Kolleru demolished aquaculture ponds leading to the area under carp aquaculture to shrink (Pattanaik, 2014). However, many of the services offered by the lake such as flood control are still not working properly due to the bunds of the earlier aquaponds still remaining, with new farms being illegally built (Azeez et al, 2011) - indicative of the inadequacy of protection measures in the absence of effective monitoring mechanisms in place.

Figure 2: Carp Production in Andhra Pradesh from 1970 - 2012



Source: Belton et al, 2017

4.1.2 Other Species in Freshwater Culture

According to the State of Fisheries and Aquaculture of the FAO (SOFIA, 2020), though there are many species that are cultured world over, the production systems focus on a few staples. Almost 67% of the inland aquaculture in India is contributed by three major carps - catla, rohu and mrigal (CEBPOL & NBA, 2018). Therefore, species diversification is seen as an area where work needs to be done in India. Most of the indigenous species (*Labeo calbasu*, *L. fimbriatus*, *L. gonius*, *L. bata, L. Ariza, Puntius sarana, Hypselobarbus pulchellus, H. Kolus, Amblypharyngodon mola,* etc.), though cultivable and highly marketable, fall terribly short with respect to the quality of the seed (indicated by high mortality) and lack of feed (both larval and grow-out) (Chakrabarthi et al, 2009). Success has also not been achieved due to the lack of development of hatchery technology or any feasible culture technology (NFDB, 2020). All these act as impediments for species diversification in freshwater aquaculture.

Genetically Improved Farmed Tilapia and *Pangasianodon hypophthalmus/Pangasius* catfish are the only two exotic finfish allowed for culture in India. They are slowly but surely substituting the traditional white fish market which is sought after by the North American, European and Japanese markets (SOFIA, 2020). Though tilapia was introduced in India at the half of the 20th century, it was not viewed favourably till recent years due to the prolific breeding nature of the species. This, as indicated by certain studies, led to the decrease of native species in the introduced waters, not only affecting the biodiversity but also impacting the livelihoods, food culture and the nutrition of the local community. Tilapia propagation was banned from 1959 due to this (NFDB, 2015). Though currently India produces only 18,000 tonnes/yr of tilapia, it is now being vigorously promoted for intensive cage culture in reservoirs and other open water bodies (evident from targeted seed production, increased number of hatcheries and nurseries etc).

Though not legally allowed, around 31 non-native species are now cultured in India (Laxmappa, 2016). These species currently contribute about 20-30% of the total production in India. Highly carnivorous *Piaractus brachypomus* (orange belly/pacu), though illegal, is sought after by farmers due to its high growth rate. In Andhra Pradesh itself, the production had reached 18,000 tonnes by the year 2012, only a couple of years after its introduction (Belton, 2017). Its reference in the *Guidelines for Declaration of Aquazones and for Zonation in the Coastal Districts of the State of Andhra Pradesh* is an indirect acknowledgement of the existing culture and an apparent nod for continuation of the same in the state. The impact of such a highly carnivorous species on native ones, and thereby on local food security and livelihoods when introduced into local waters can be catastrophic.

4.2 Brackishwater Shrimp Culture

While the IMC dominates freshwater aquaculture, it is shrimps that rule brackishwater aquaculture (NASO, FAO, visited in July 2020). Shrimp production through culture in India grew from 20 mmt annually in the 1970s to 40,000 mmt by 1991 (Vijayan & T Balasubramaniam, 2019).

According to MPEDA, three varieties dominate shrimp production in India and are of much interest to the export market. They are *Penaeus monodon, Litopenaeus vannamei* and *Macrobrachium rosenbergii*. The 2019-2020 statistics of MPEDA indicate that the current area under shrimp production (158,863 ha) is a 37% increase when compared to the figures for the period 2012-2013. Simultaneously, the current production of shrimp by quantity (747,694 tons) is a 176% increase when comparison for similar periods is made.

In the 1990s, brackishwater shrimp culture was synonymous with tiger shrimp *(Penaeus monodon)* culture. The *P. monodon* culture experienced a setback in the mid 1990s when the White Spot Syndrome Virus entirely wiped out many farms. However, with the advent of biosecure closed culture technology, semi-intensive culture system is again coming into prominence (Panigrahi et al, 2009). This is also accelerated by the legalisation (refer Chapter 3) of *L. vannamei* culture (the only exotic shrimp legally allowed to be cultured in India) by the Coastal Aquaculture Authority of India in 2009. Currently the tiger shrimp (62% reduction in area under tiger shrimp culture with a 44% reduction in quantity produced when values for the period 2001-02 are compared with 2017-18) is left far behind by the culture of the Pacific White leg Shrimp, *Litopenaeus vannamei*. The culture of *L. vannamei* contributes 63% of the total area under culture (AUC) for shrimp and 95% of the current shrimp production in the country (MPEDA, 2020).

The major contributor to the above jump is the state of Andhra Pradesh which showed a massive growth of 215% with respect to AUC and 284% with respect to estimated production (EP) of *L. vannamei*. While the state accounts for 40% of the total area under shrimp culture in India (with 64% of that under *L. vannamei* culture), it contributed about 69% of the total shrimp produced (and 73% of *L. vannamei* production) in India in 2019-2020 (MPEDA, 2021). Frozen shrimp led exports in the year 2017-18 by quantity (41.1%) and by value (68.46%) clocked an increase of 30.26% in quantity and 30.10% in value from the previous year (MPEDA, 2020). Export of *L. vannamei* increased from 0.3 mmt to 0.4 mmt, a 22.02% growth in quantity and 24.74% increase in value. Shrimp production was carried out through different systems of aquaculture namely – traditional, extensive, semi-intensive and intensive. A snapshot of different systems that are found in West Bengal is given in table 4 below:

Table 4: Shrimp Culture Systems in West Bengal

Parameters	Traditional	Extensive	Semi-Intensive	Intensive
Pond size (ha)	0.1-50	1-10	0.2-2	0.1-1
Stocking	Natural	Natural + Artificial	Artificial	Artificial
Stocking density (seed m^{-2})	Unregulated	2-6	6-20	20-50
Seed Source	Wild	Wild+Hatchery	Hatchery	Hatchery
Annual production (t ha^{-1} yr^{-1})	<0.6	0.6-1.5	2-6	7-15
Feed Source	Natural	Natural	Natural + Formulated	Formulated
Fertilizers	No	Yes	Yes	Yes
Water exchange	Tidal	Tidal + pumping	Pumping	Pumping
Aeration	No	No	Yes	Yes
Diversity of Crops	Polyculture	Monoculture, polyculture rarely	Monoculture	Monoculture
Disease Problems	Rare	Rare	Moderate to Frequent	Frequent
Employment (persons ha^{-1})	1-2	2-3	3-4	4-5

Source: Reproduced from Ghoshal et al, 2015

Though shrimps and carps are the major groups under inland aquaculture production in India, there are wide regional variations. Andhra Pradesh leads the states in aquaculture production by contributing 73% of the total *L. vannamei* production; 27% of Indian Major Carps production; catfish production of 0.43 mmt. West Bengal leads *P. monodon* production in India by contributing 85% to the total production (Handbook of Fisheries Statistics, 2018). Bihar is also an interesting state as it leads the country with regard to the production of minor carps (0.1 mmt). This is of importance as the state is one of the poorest in India and the assumption is that the production of these minor carps could be contributing to the protein intake of the poor. How much culture plays a part in this production needs to be further examined.

4.3 Inland Saline Aquaculture

The area of salt-affected soils in the country is estimated to be 6.73 mn ha (Sixth Draft NFP, 2020). The major states with such soils are Gujarat, UP, Maharashtra, West Bengal, Rajasthan, Punjab and Haryana. It is in this context that inland saline aquaculture has gained importance in policy documents in India. This is viewed not only as a sector that could substantially contribute towards total aquaculture production but also offer a solution to the livelihoods lost on those lands rendered non-arable by water logging and salt ingress due to indiscriminate agricultural practices. The National Fisheries Policy (Sixth Draft) 2020 has made it amply clear that inland saline aquaculture will receive increased attention in the coming years and has identified that only 12% of the available inland saline areas are utilised for aquaculture (1.2 mn ha have been marked as potential sites). The main states in focus are Haryana, Punjab and Rajasthan.

Haryana is a leading agriculture producing state witnessing an increase in production from 2.6 to 10.5 million tonnes since 1980s. With intensive agriculture and increased water mining for the same, the groundwater tables are rising in almost 50% of Haryana, making it waterlogged. This has also led to leaching of salt into water aquifers making the groundwater salty and land non-arable. Around 0.52 million ha of land has become salt-affected (saline, sodic or both). Agricultural production loss due to waterlogging and salinity in Haryana in 2000 was estimated at approximately US$22.5 million (Agarwal and Roest, 1996). The problems are exacerbated due to a topographical depression or basin that covers an area of 1.7 million ha in the centre of the state. Unless preventive measures are taken, a four-fold increase in salt-affected land is predicted by 2026 (Agarwal and Roest, 1996). Instead of preventing this degradation, salinisation and waterlogging was seen as an opportunity to further aquaculture.

Though Haryana is not a traditional aquaculture state, the continuous efforts by the Central Institute of Fisheries Education (CIFE) put the state on the map of freshwater aquaculture producers of India. The state's aquaculture has grown from 58 ha in 1966-67 to >21,000 ha in 2019-20 (DoF, Haryana 2020). The aim is to make Haryana the top state with respect to "per hectare fish production". Apart from utilising available ponds/tanks, new excavations are being carried out to bring more area under aquaculture. When the state plans to bring 2,500 ha of waterlogged area under aquaculture, around 400 ha of saline waterlogged agricultural land is to be brought under shrimp production. The state fisheries department has permitted the use of inland saline underground water with subsidy given to construction of shallow wells as well as deep bore wells. The use of waterlogged and saline areas for aquaculture though could be a boon to farmers who have lost employment and food security, the chances of such a move to be looked upon as an incentive to carry on business as usual is higher and could accelerate the further plunder of natural resources such as land and water.

The Haryana government is actively promoting saline water aquaculture with species such as *L. vannamei.* While SPF seeds are sourced from Tamil Nadu and Andhra Pradesh, feed factories are being encouraged to be set up in the state itself. The state plans to put up two large pellet feed plants as well as ten small feed mill plants. All these indicate the state's intent to intensify the culture of *L. vannamei.*

However, compared with coastal seawater, inland saline water differs in chemistry. Adjusting the chemistry or choosing species that are tolerant to these differences is one of the major challenges for expansion of inland saline aquaculture in the state. Culture of *P. indicus* is also being undertaken in Haryana on an experimental basis. Culture of *M. rosenbergii* happens well in Haryana. Earlier post larvae were brought from coastal areas but now CIFE has perfected its hatchery production using saline water.

Freshwater culture is also being promoted in the state. Species promoted earlier was the IMC, but now the focus is on the exotic Pangasius and Tilapia - both are candidates for intensive culture which puts further pressure on an already water stressed state. Haryana is a non-fish consuming state which could mean that unless there is a substantial shift in its food culture, all the produce will target external markets. This could mean less availability of food grains not only to the farmers but also to the local population, forcing them to buy essential cereals at a higher price from markets.

Given the profit earned from the system, the conversion of agriculture fields to aquaculture ponds is set to rise (refer case study below). The increase in use of water will make the land more waterlogged and increase the salt content of surface as well as ground water - impacting drinking water availability to the local communities. The state fisheries department encourages the conversion of saline and waterlogged agricultural lands for aquaculture through subsidies. This, with no cap on the land that can be converted, is a dangerous trend.

Case Study of a Shrimp Farmer and Feed Mill Owner in Haryana

Vinod is a traditional farmer (one of the 22-member joint family) with a job in the Indian Air Force. About six years ago, he heard of a training program on prawn farming on saline agricultural lands by the Central Institute of Fisheries Education, at Lali village in Haryana. His profit from agriculture being on a decline, he decided to convert one acre of his land to an aquaculture pond. He dug a pond of dimension 128 ft x 22ft with 6 1/2 ft depth and set up four aeration systems (at a cost of INR 40,000 per system). He also dug a 40 ft borewell fitted with a 7.5 hp pump exclusively for the pond at an expense of INR 0.1 mn. (Ground water needs to be pumped daily during the initial years of the pond and subsequently the frequency reduces to once or twice a week). Two to four check trays are also installed, usually at each corner of the pond. The organism is checked four to five times daily (during feeding) for its health and growth, and to adjust the feed.

An average production is around 3-5 tonnes/acre/crop cycle, with an average net profit between INR 0.5-0.6 mn per acre/crop cycle (it has even given a net profit of INR 1mn/crop cycle). Two cycles of crops are done - from end of March to July end and end of July to end of November. The pond is left fallow from November end to March beginning.

Currently 50% of Vinod's agricultural fields have been turned into aquaculture ponds for *L vannamei*. He is of the opinion that even if only 20% of his farm survives and gives produce, due to any unforeseen circumstance destroying the rest, he should be able to recover the production cost. Though some of the farms will be retained as agriculture lands, the profit provided by shrimp farms is far bigger (almost 15 to 20 times more), forcing farmers to convert maximum area into aquaculture ponds. While an acre of agricultural land gives a net profit of INR 0.05 mn/cycle, it gives a maximum net profit of up to INR 0.7-1mn/cycle as an aquaculture pond.

It was also shared by Vinod that at the end of November, the water from the aqua farms is used to irrigate the neighbouring agriculture farms, especially cotton and pearl millet (bajra). The productivity of fields irrigated with this

water was found to increase by 1.5 times as the effluent water has feed waste along with the waste of the cultured organism. This water has a high demand and is given for free to the neighbouring farms.

Labour

The labour in Vinod's farm is mostly from Jharkhand. Only two workers are required per seven acre of aquaculture pond – the one during the day provides feed four to five times, and the other at night is responsible for aeration, watch and ward. Their duties are rotated. The labour is given a remuneration of INR 12,000 per month with stay and accommodation provided on site at the owner's expense. There is a supervisor (one of the members of the joint family) who is given training to inspect shrimps, especially during feeding with the help of the check tray.

Disease

There was one incidence of WSSV disease which came to the farm management's notice as soon as it set in. This was made possible by proper management using the check trays. This batch was harvested and sold in the market. The produce is sold to the markets of the nearby city of Delhi or Ghazipur in Uttar Pradesh where shrimp is in great demand.

Seed

Around 65-70% of the input cost of shrimp aquaculture is seed and feed. The seed is procured from Tamil Nadu and Andhra Pradesh in polystyrene boxes of dimension 1.5 ft x 3 ft, with 1-5 packets of seeds. Each packet will have 3,000 fingerlings (totalling to 15,000 fingerlings). This is airlifted to Delhi and then carried to Bhiwani, Haryana by road. The survival rate of the seed is 100% with proper aeration. There has been no incidence of fingerling mortality. The high cost of such an elaborate procurement process needs to be further probed and weighed against its benefits.

Feed

It is said that the feed cost has been on the rise with the introduction of *L. vannamei* culture. Initially feed was procured from various companies such as Avanti, Cargill, Grovel etc. at a cost of around INR 75-85/kg. This along with transportation cost was making *L. vannamei* culture unfeasible. The introduction of a new technology by CIBA, wherein fishmeal is added with other vitamins, brought the cost down to around INR 55-60/kg. Vinod started the first feedmill in Northern India with CIBA technology and procured fishmeal, the main ingredient of the feed, from Gujarat at a price of INR 90-120/kg. The feedmill runs for eight months from March to December in tandem with the culture cycle. The feed is made on demand with an average output of 15 tonnes/day. Vinod has employed five labourers in the feedmill with the same wage as indicated above and sells his feed within Haryana and to other states such as Gujarat, Punjab and Rajasthan.

COVID-19

It was while Vinod was preparing the pond for *L. vannamei* culture that COVID-19 started to spread. Flights were cancelled which in turn affected the transportation of the seed consignment, stalling the first shrimp cycle. However, during this time, the produce from agriculture was harvested. To the question of the danger of converting more agriculture fields into aquaculture and in the event of any such future incidents, Vinod replied that aquaculture provides profit unseen in agriculture till date, and this one fact tips everyone in favour of converting their fields to aquaculture. Currently there are more than 1000 ha of land converted to *L. vannamei* culture in Haryana.

4.4 Mariculture Development in India

Mariculture is still in its infancy in India, although efforts have been on from 1970 and many technologies on breeding and rearing of aquaculture species have been developed by ICAR institutes such as CMFRI. While coastal aquaculture (including coastal tanks/ponds - currently included under brackishwater aquaculture) was largely focused on shrimp culture, mariculture almost always included culture of seaweeds and bivalves (Gopakumar, 2010). Finfish culture is attempted commercially only on land-based structures while the same for marine areas is still under experimental stages (refer Table 5).

Table 5: Mariculture Farming Systems Prevalent in India

	Resource	Location	Type of Farming	Farming Status	Status regarding lease
1	Shrimps *Penaeus monodon* *P.indicus, P.semisulcatus,* *Metapenaeus dobsoni,* *M.monoceros*	Intertidal/subtidal	Land based (ponds)	Commercial	Lease policies exists in some maritime states guided by rules framed by AAI
2	Oysters *Crassostrea madrasensis*	Intertidal/subtidal Open Waters	Off-bottom (Rack and ren)	Commercial in Kerala	None
3	Mussels *Perna viridis*	Intertidal/subtidal Open Waters	On-bottom, off-bottom (Racks, lines, rafts)	Commercial in Kerala	None
4	Pearl Oysters *Pinctada fucata* *P.margaritefera*	Bay/Lagoons/ Oceanic Open Waters	Off-bottom (Rafts, cages)	Experimental (Commercialization - Transition phase)	None
5	Clams *(Paphia malabaraica* *Villorita cyprinoides)*	Intertidal/subtidal Open Waters	On-bottom	Semi-commercial in Kerala, Karnataka	None
6	Crabs *Scylla serrata*	Intertidal/subtidal	Cages/Land based	Commercial fattening	None
7	Lobsters *Panulirus homarus,* *Thenus orientalis*	Near shore	Land based (Ponds/cages)	Commercial fattening/ Experimental	None
8	Finfishes	Open sea	Sea cages	Experimental	None
		Coastal	Land based ponds, fixed cages	Commercial, Experimental	Lease policies exist in some maritime states

Source: Excerpted from Mohammed & Kripa, 2010

Mariculture did not take off due to the lack of any policy attracting investments into the sector (Bhat & Vinod, 2008), besides the environment is hostile. Bhat & Vinod (2008) also point out the want of standardization of technologies which hindered its commercialisation. The sector has received renewed interest with the Sixth Draft of the National Fisheries Policy 2020, suggesting it should be developed with urgency, especially in the face of decreasing production from marine capture fisheries (termed as one of the most dangerous occupations in the world (FAO, 2020)). It highlights the need to develop suitable sites/areas with a leasing policy following a Marine Spatial Planning approach. The Neel Kranti Mission 2016 (Blue Revolution) under the Marine Fisheries

Infrastructure and Post Harvest Operations, supports and promotes mariculture through open cage culture (namely finfish culture), seaweed culture, bivalve culture, and pearl culture.

The guidelines for sea cage farming in India (2018) developed by NFDB indicate that if 1% of the coastal waters is utilised for mariculture through cage farming, around 8,20,000 cages can be installed, increasing production to the targeted level of 4-8 mmt (NFDB, 2020). Though the technology of cage culture was experimented earlier on, it failed to garner much attention till late 2000. Development of the feed industry had an immense impact on the evolution of cage farming in India. The first feed mill producing floating pelleted feed was established in 2008 and in the following years, some species (Vietnam catfish, pacu–orange belly, etc) and technologies such as cage farming received increased attention and application (Anand, 2019). Successful sea cage farming is now carried out in Kanyakumari, Chennai and Mandapam (Tamil Nadu), Vizhinjam (Kerala), Mangalore and Karwar (Karnataka), and Balasore (Odisha).

MPEDA (2020) on its website also indicates the favourable species for mariculture/sea cage farming with an eye on export. These include, the Asian Sea bass *(Lates calcarifer)*, a euryhaline species which is highly sought after in Indo-Pacific countries for its high export value and considered a right candidate for intensive cage culture; the Cobia *(Rachycentron canadum)* with its qualities of being brackish and marine tolerant, fast growth rate and high adaptability to culture conditions, with an economically viable cage culture model already in place, topped with high demand in both domestic and international markets (especially in Taiwan and Japan), makes it the ideal candidate for culture. It is greatly sought after in brackishwater culture systems and used as a rotational crop in increasingly disease laden *L vannamei* culture farms. Cobia is also furthered as a species that can be cultured from November to April as well as during the fishing ban season that lasts for three months (Gopakumar, 2015).

Fattening of Spiny Lobster in cages is done in Vizhinjam, Veraval and Mandapam (Gopakumar, 2010). CMFRI (2020) provided cages and technical guidance to the Siddi tribes cooperative society in Veraval (the largest commercial seafarm in India) to carry out rotational cropping of cobia and spiny lobster fattening. All species mentioned above for mariculture are highly feed dependent, therefore their culture increases demand on fishmeal and fish oil-based fish feed for optimum growth. As indicated in the case study below, the most sought after open sea cage culture species such as cobia relies heavily on regular supply of fresh trash fish. Thus a “no/low-value” or “trash” commodity brings in income. This incentivises indiscriminate fishing practices resulting in landing of more such fish. This will be a blow to the biodiversity of coastal waters affecting recruitment and future fish catch.

The Sixth Draft of the National Fisheries Policy (2020) indicates that mariculture will be developed with states drawing up their own leasing policy based on the Model Leasing Policy prepared by the Union Government. CMFRI has submitted to DAHDF a "Policy Framework for Aquaculture Development in India". Mariculture, which was to be commercialised after proper leasing guidelines were drawn out, is already furthered in many areas (refer Table 5). This is a cause of concern as focus on its development could blindside the community and negatively impact the environment.

Discussion with a Scientist, CMFRI

Open Sea Cage Culture (OSCC) is the technology to be adopted in mariculture but there are some worrying trends seen in its policy guidelines. The pace at which OSCC is progressing is similar to the unplanned developments that happened during the brackishwater shrimp farming of the 1990s. The focus in the guidelines document is only on production while the well-being of coastal communities/fishing communities, their livelihoods, coastal environment etc., makes only a nominal appearance. There are no definite guidelines on the carrying capacity, the social or environmental impacts – displacement caused by the cages, financial implications; number of cages to be put in an area; the amount of nitrate or phosphate that will be expelled to the environment, etc. A holistic study needs to be conducted in the field of OSCC. A thorough environment impact assessment and social impact assessment needs to be conducted before cage culture is commercialised. There is also a question here of this technology converting fishers from hunter gatherers to culturists; from a continuous daily income to an income of once in six months – a change on these lines could take time for fishing communities to adapt to. This delay could see the handing over of this technology to private companies thereby branding fishers as laggards with respect to adopting new innovations.

Cage farming is envisaged in a space which is traditionally the physical areas of work and life of fishers and it should be ideally designed with detailed prior consultation with coastal communities. Not only has this not happened but also this space has become easier for outside investors to grab. The cage farming guidelines talk about the need for an integrated approach to make the initiative successful. This integration could lead to corporatisation and convert the coastal communities to mere spectators to the alienation of their traditional productive resources. However, this can be turned into an opportunity where most of the coastal and fisher communities (especially the youth) can be absorbed through right training, subsidies and continuous hand holding (by organizations such as CMFRI) provided for at least five years. OSCC is an opportunity as well as a threat. For it to be an opportunity, the focus should be on employment generation among coastal youth - involving fishers and coastal communities in all stages of the integrated model where one activity

forms the raw material for the next. Even inland ponds can be utilised for such an activity, also allowing the consumers to get more fresh fish.

The species encouraged for culture are cobia, sea bass etc., which are heavily feed dependent. This translates into a higher proportion of fishmeal and fish oil which in turn places heavy demand on trash fish (raw material) and justifies the diversion of food species to the FMFO industry as it earns higher returns with lower investments. A regular sea cage (6 m diameter HDPE) costs INR 0.5 mn, a heavy investment for small-scale fishers. Uncontrolled proliferation of cages needs to be monitored. Siting of the cage is considered the prime factor which determines the success of cage farming. The guidelines on sea cage farming in India (2018) indicate that it should be put in a sheltered area - mostly these areas will also be havens for fish and other marine organisms, making it a sought after fishing ground. With the installation of cages, culturists could come in conflict with fishers. With increasing frequency of bad weather due to climate change, the increased mooring of cages to the shore could be a reality which will be a cause of space crunch in the coastal areas. How will this be solved when the fishing communities are already experiencing shortage of common spaces used for recreation and leisure due to other projects in coastal areas?

Cage farming is currently practised only for a few species while many other species can be tried out. The many juveniles caught in the nets during fishing can be dropped in these cages, allowed to fatten and then sold at higher prices. Such practices can stop mindless throwing away of juvenile fish as trash and can be converted into an avenue for making better incomes, and also contribute to preserving the biodiversity of the area. Such experiments are being successfully carried out in Kovalam near Chennai.

Care needs to be taken to train the youth of the fishing community into cage culture. Disenchanted with the current earnings from capture fisheries, they are trying to migrate to other places to earn a better living. This could be stopped if gainful employment in OSCC is proved. Each OSCC could employ up to ten fishers in the beginning and reduce to five as the culture evolves (making it economically more beneficial). However, with the advent of private companies into this sector, they could have a battery of cages manned by a lesser number of people, thus taking away the employment opportunity of the coastal communities.

Sea Cage Farmer in Rameshwaram

Abhi is a youth from the fishing community of Rameshwaram, a traditional fishing village in the district of Ramanathapuram which has many fishing hamlets dotting its coast. Rameshwaram, at some places, is only a couple of kilometers away from the International Maritime Boundary Line between India and Srilanka which the fishers cross knowingly and unknowingly in pursuit of fish for their daily earning. There have been many instances where Indian fishers have been caught by the Sri Lankan Coast Guard and at times even shot at. Cage culture was introduced in Rameshwaram with the objective of weaning the new generation from marine capture fisheries to marine culture fisheries to avoid such conflict as well as a means of gainful employment. The youth are organised in groups, and Abhi is a member of a 13-member group named the Catamaran Aquaculture Association that is given training by CMFRI on cage farming for 10-15 days, and also provided with cages on a 100% subsidy. Currently they have seven cages for the culture of either cobia or sea bass. In six months, cobia grows to a size of 4-5 kg. However, it is said that, unlike sea bass, cobia is not cultured regularly as the seeds are not available on a regular basis. The cage is mostly made of galvanised iron (GI cage) which is half the price (INR 0.15 mn) of the recommended HDPE cages. Cobia and sea bass grow well on fresh trash fish procured from the nearby trawler boats. Sea cage culture involves a lot of work like checking the nets for biofouling, changing the nets for cleaning, feeding of fish, regular grading of fish, calculation of feed based on the size of the fish (feed conversion ratio is 1:7), watch and ward etc., and the number of workers is far lesser than in capture fisheries. Currently there are 50-70 cages in Rameshwaram. One of the problems enlisted by the farmers is the non-acceptability of cage farming by elders and active fishers from the fishing community. Usually, the space for the installation of a cage needs to be arrived at through consultation. This could be farther from the ideal site for aquaculture which could make watch and ward of the installation difficult and see increased incidence of theft. Overfeeding is not viewed as a problem in cage culture as this is supposed to get dispersed in the sea. However, this attitude could be dangerous especially where there is a high concentration of cages, and where the tidal action is low, allowing the feed to settle below the cage. The guidelines suggest regular shifting of cages from one place to another to escape this accumulation of feed at the bottom.

Premising on the information shared above, the following section provides a snapshot of how aquaculture has developed in some of the leading aquaculture states of India. Much concentration is given to Andhra Pradesh and West Bengal as these two states top the list of producers with respect to inland production.

5. Prominent Aquaculture States of India

Aquaculture growth in India shows a clear regional pattern. Though the traditional aquaculture states were on the western seaboard of India, with the exception of West Bengal, the newly emerged leaders are all from the eastern seaboard. The states of Andhra Pradesh, Odisha, West Bengal, etc. top the list of aquaculture producers of the country, both with respect to freshwater and brackishwater production. The states of Punjab, Haryana and Rajasthan require special mention as they lead in inland fisheries production from saline/alkaline lands. Table 6 gives the inland fisheries production of these states in 2011-12 and 2017-18, and clearly shows that production has doubled over the course of six years in most of these states. Premising on this data, the study will attempt to review some of these states' policies which made this growth possible and look at the different aspects of this development from the point of view of environmental and social implications.

Table 6: State-wise Inland Fish Production for the Year 2011-12 & 2017-18

States	2011-12 (mmt)	2017-18 (mmt)
Andhra Pradesh	1.17	2.85
Bihar	0.344	0.59
Odisha	0.27	0.53
Uttar Pradesh	0.43	0.63
West Bengal	1.3	1.6
Punjab	0.098	0.14
Haryana	0.11	0.19

Source: Compiled from Handbook of Fisheries Statistics 2018, 2020

5.1 Andhra Pradesh: Aquaculture Development Through its Policy and Other Documents

Andhra Pradesh, the current top aquaculture producer, does not appear in any literature which deals with traditional fish culture in India. However, it has made a transition from a “no show” state to being termed as the “fishbowl”of India (Ramakrishna, 2007; Azeez et al, 2011). Andhra Pradesh became an aquaculture hotspot by converting most of the agriculture farms and its allied facilities such as irrigation channels (that came up in the 19th century as part of commercialisation of the agriculture sector with 49% coverage), into aquaculture facilities (Belton, 2017). Currently 80% of the carp production from Andhra Pradesh comes from in and around Lake Kolleru in the districts of Krishna and Godavari (Nandeesha and Gopal Rao, 1989 as cited in Ramakrishna et al, 2013). Although not a traditional shrimp producing state, its culture was initiated in Andhra Pradesh by

the Marine Products Export Development Agency in the early 1980s (Muralidharan, 2000, 2015). Though the initial shrimp farms were scientifically established and properly sited, their success attracted many into the sector, bringing a lot of area under shrimp culture without any sound scientific management or measures in place (Muralidharan, 2015).

Other species were also introduced in this area such as *Pangasianodon hypophthalmus* (Vietnam catfish), *Clarias gariepinus* (African catfish), and *Piaractus brachypomus* (pacu) (Muralidharan, 2015). Vietnam catfish saw a boom and a bust in Andhra Pradesh (Belton et al, 2017). The culture of non-native species happens clandestinely as it is illegal. This is rapidly increasing, causing much concern to biodiversity experts as no policies regarding their culture are in place and there is an absence of biosecure measures (Muralidharan, 2015). However, these species form the local protein source of the poor as it is sold at a low price (Laxmappa, 2016).

According to the Andhra Pradesh Department of Fisheries (APDoF), the state contributes more than 20% of fish and 70% of shrimp produced by India (APDoF, 2018). It is said that the share of the state in seafood exports increased from 20% in 2009-2010 to 40% in 2013-14. A commendable increase from 1.7 mn to 2.8 mmt in inland fish production is witnessed during the period 2011 to 2017, of which around 90% can be safely assumed as contributed by inland aquaculture. According to the Handbook of Fisheries Statistics (2020), in the year 2019-20, in Andhra Pradesh, the Indian Major Carps (IMCs - catla, rohu and mrigal) constituted ~55% of production which together with exotic carps constituted ~61%, catfishes including pangasius constituted ~6% while other fishes together constituted ~33%. The shrimp production from Andhra Pradesh is dealt with in the previous section of aquaculture development in India which indicated a huge jump in the area under shrimp culture and its production.

The Andhra Pradesh Fisheries Policy 2015 acknowledges fisheries and aquaculture as an engine of growth and wants to push the state to be the Aqua hub of India. It aims to achieve a production of 42 mn tonnes as well as double the export earnings to INR 160 bn (Fisheries Policy, APDoF 2015).

5.1.1 Andhra Pradesh Fisheries Policy 2015-2020

The policy emphasises on sustainable fisheries and aquaculture ensuring ecological integrity and biodiversity. It indicates that assistance will be provided for the development of the domestic market and stresses on promoting high value fishery, modernising through imported foreign technology, and encouraging public private partnership etc. The new policy also talks about promoting many species in culture; closing down of sub-standard hatcheries; preventing collection of seeds from the wild and restricting the introduction of exotics.

With respect to inland fisheries, the policy talks about formulating a comprehensive leasing policy in which minor irrigation and panchayat tanks will be reserved for genuine fisher societies or in the absence of fishers to women SHGs. With regard to reservoir fishery management, it is indicated that cage/pen culture is to be promoted at all possible water bodies. For pond culture, though registration is mandated as compulsory (which fails in the absence of monitoring), lifting of land ceiling up to an area of 100 ha is a worrying trend that skews the legal environment in favour of aquaculture. With regard to brackishwater culture, the state is promoting sustainable aquaculture systems and contemplating restructuring of the land lease policy and making the allotment policy transparent. It goes on to say that the government owned brackishwater areas which are suitable for coastal aquaculture will be leased to fishing cooperatives, self-help groups for a period of up to nine years and renewable for another two years.

The policy encourages public private partnership in aquaculture with a cluster development approach inclusive of cold chain, processing, value addition etc. The policy states that as they are 100% export oriented, Special Economic Zones (SEZs) with similar state support should be accorded to such PPPs. It mentions in no uncertain terms its readiness to involve big companies such as Walmart, Spencers, More, Big Bazaar etc., in PPPs, and also indicates developing sea cage culture using technologies imported from tried and tested countries with a produce buy-back agreement. These are all reflective of the tangential aquaculture development that will take Andhra Pradesh forward in its effort to become an *Aquahub* of the world.

5.1.2 Guidelines for Declaration of Aquazones and for Zonation in the Coastal Districts of Andhra Pradesh (2018)

These guidelines are premised on the observation that lack of zonation was the main reason for the uncontrolled expansion of aquaculture of the 1990s in the state which adversely impacted its environment, leading to a social and economic outfall. The objective of these guidelines states regulation and prohibition of unauthorized conversion of fertile agriculture land to aquaculture ponds. It also aims to demarcate areas fit for aquaculture (especially low-lying waterlogged areas and agriculturally unproductive lands). The guidelines also indicate the species that can be grown, including highly carnivorous exotic species such as Piaractus or Pacu (orange belly) which is not legalized at the national level. However, the suggestion is indirectly legalising its culture and production.

Some of the other government documents that could determine aquaculture development of the state include the regulation of freshwater aquaculture as indicated in the **Government Order No. 7** (2013) which states that while using common property resources like creeks, canals, etc., the

traditional rights of local communities should not be adversely affected. Dykes or dams should not be constructed over common property resources to the detriment of the interests of local communities or farmers. The G.O clearly indicates the minimum distance any freshwater farm should observe with respect to a drinking water source, agricultural land, burial ground, places of worship etc., and goes on to say that water spread is not to exceed 80% of the farm area. The order mandates a seepage canal surrounding an aquaculture farm. Though it prohibits the use of bore well water to fill aquaculture ponds, it allows for supplementing evaporation and seepage loss through bore wells; though it prevents direct pumping from canals, rivers and reservoirs, it allows the use of indirect and harmless methods. What those methods are lacks mention in the order. This has been amended in **G.O. MS. No. 48**, where direct pumping is not allowed in natural mangrove areas, spawning and breeding grounds, ecologically sensitive areas etc. In cases where there are "no" such areas i.e., in up-land areas, direct pumping is allowed after meeting the drinking and irrigation water needs. There is no ceiling on the amount of water that can be pumped out or the power of the pump that can be installed for the same, thus making the efficacy of such measures questionable.

Though the order indicates that registration of ponds needs to be carried out, it is noted that there is a never-ending extension of the last date for registration, allowing more and more farms to mushroom in the area irrespective of the carrying capacity of the environment. The District Level Committee is authorised with monitoring of aquaculture ponds to inspect whether ponds adhere to norms. The DLC may arrange for inspections by dividing themselves into individuals or teams. If done on an individual basis, the approval of ponds for registration will solely depend on the integrity of the visiting officer, with a higher probability of corruption.

5.2 West Bengal: Aquaculture Development Through its Policy and Other Documents

West Bengal, one of the few traditional aquaculture practising states of India, is the second largest fish producer in India with a production of 1.72mmt in 2019-20 (MoFAHD, 2020). The state is home to rich inland water resources with 18% of the brackishwater resources in the country (Handbook of Fisheries Statistics, 2018), that are distributed among the districts of Sundarbans – the South and North 24-Parganas and Purba Medinipur. Although trailing only to Odisha (37%) and Kerala (20%) with respect to brackishwater resources, it is the top most producer of the shrimp *P. monodon*. West Bengal produces 0.049 mmt, contributing 80% of India's total production of this high value species (MPEDA, 2020). *L. vannamei* was introduced in West Bengal in 2012 under an ICAR-CIBA experiment in Kakdwip (Ghoshal et al, 2015) which is slowly but surely replacing *P. monodon*. Currently frozen shrimp and live crab, both fed species and requiring fish

meal and oil in their diets, are the main export items from brackishwater aquaculture in Sundarbans (Ghoshal et al, 2015). Around 0.21 mn ha of additional potential brackishwater areas have been identified in the two districts of Sundarbans that can be converted to shrimp farming (Ghoshal et al, 2015; West Bengal Fisheries Policy, 2015). West Bengal also produces an annual carp seed of 20 bn and shrimp seed of 12 bn. Though the state produced 1.72 mmt of fish in 2019-20, the projected production potential is 3.1 mnt (West Bengal Fisheries Policy, 2015).

5.2.1. West Bengal Fisheries Policy, 2015

The objective of the West Bengal Fisheries Policy (WBFP 2015) is to ensure fish for all and fish culture in all water bodies *("Sabar Jonyo Maach 0 Sab Jalasaye Chash")*. Though push for private investment is sought in the document, it also mentions judicious harnessing, livelihood security, small-scale fish farmers, etc. The policy also underscores the importance of extending the same finance and insurance products offered to agriculture to small-scale fish farmers. This would be without collateral security and the government would pay 50% of the premium. The policy can be easily termed as local nutrition sensitive, evident in the many measures taken in that direction such as promoting rice-fish culture wherever possible along with locally preferred species such as catla, rohu, chital (a popular carnivorous and cannibalistic fish), besides the locally preferred air breathing species such as clarias, channa etc. Even with respect to fish seed production, emphasis is given to local indigenous varieties. The policy also talks about developing backyard and household ponds - a welcome change from other policies which do not even name these critical income and nutrition sources for rural families of the flood plain regions of India. The WBFP 2015 encourages culture of small indigenous fish species such as *morula, puntius, gobids, colisha, nados, koi* etc. in seasonal, small-sized ponds.

The policy emphasises on preferential rights with respect to leasing to be given to Primary Fisher Cooperative Societies (PFCS) and SHGs. Long term leases of surplus waste lands are to be given to the poorer sections of the society for developing fish farms. With respect to brackishwater aquaculture, the policy talks about restructuring land lease policy (this needs to be studied in detail). Though the policy talks of allocation of land use rights for shrimp culture, it mentions safeguarding the rights of traditional communities. The WBFP is a little wary when it comes to mariculture and emphasises the need to carefully evaluate the same especially in terms of instituting a sound management framework and having an implementable policy and legal framework in place before mariculture is promoted.

With respect to women, the policy not only encourages them in all aspects of aquaculture, but also stresses on the need to ensure equity in access, tenure, participation and sharing of benefits. This is

a heartening step especially when other policy documents are mostly silent on the role of women. As to environmental concerns, the policy talks about setting up binding minimum standards for environmental protection.

5.2.2 West Bengal Land & Land Reforms Manual (WBLLRM), 1991

West Bengal Land & Land Reforms Manual, 1991, places restrictions on change in land use. For any application for conversion to be approved, the Collector needs to ensure that the said change does not cause any environmental damage; that no sharecroppers *(bargadars)* or their interests are negatively impacted; that no industry adds noxious effluents to the surrounding environment or adversely impacts the nearby agriculture, etc. The WBLLRM, 1991 notes that it is not proper to give private lease for fishery thereby excluding the rights of the public (in common property resources). The West Bengal Fisheries Act, 1984 and West Bengal Fisheries Rules in no uncertain terms support aquaculture and penalise any person/s who level any depression that can be used for tank fishery. This is true for privately/collectively or state owned water bodies.

5.3 Odisha: Aquaculture Development Through its Policy and Other Documents

5.3.1 Odisha Fisheries Policy 2015

Odisha's Vision 2020 as indicated in the Odisha Fisheries Policy, 2015 is to become a pioneer in aquaculture development and fisheries extension. Fish production in Odisha has more than doubled in 2017-2018 in comparison to 2011-12, with the inland production trebled during this time period. It is noted that the area under shrimp culture increased from 8,120 ha producing 8,960 tonnes (2001-02) to 11,486 ha (with 8,862 ha under *L. vannamei*) producing 42,735 tonnes (with 37,229 tonnes of *L. vannamei*) (2017-2018). The state of Odisha contributes 2.5% of India's marine exports in quantity while contributing 4.8% in value. The aim is to increase the export earnings to INR 200 bn through vertical and horizontal expansion. The state is striving to achieve a production of 6 mmt/ha/year through sustainable intensification of freshwater and brackishwater aquaculture. The inland fishery resources will be assessed through Remote Sensing and Geographical Information System and medium irrigation projects, tanks, reservoirs etc., will be brought under pen/cage culture. About 25% of the reservoirs of the fisheries department as well as those mismanaged by PFCS (conditions are not specified) will be auctioned out to private entrepreneurs.

A refreshing change in this policy is that it highlights the importance of small-scale aquaculture (though not qualified) as well as indicates the employment that each suggested measure for aquaculture improvement could generate.

Similar to the state of West Bengal, mariculture is treated with caution by the Odisha state. It insists that minimum standards that are binding for environmental protection should be followed in Odisha when it comes to mariculture. The policy mentions supplementary nutrition and plans to introduce social fishery which could encourage farming of small indigenous freshwater fish species along with carp, especially in small-sized seasonal and perennial water bodies such as backyard ponds/waterlogged rice fields.

5.3.2 Odisha State Reservoir Policy 2012

This is one of the few policies that talks about gainful employment of fishing communities as well as project displaced people, apart from inviting private entrepreneurs. The fishing rights of ponds above 40 ha will be with the Fisheries and Aquatic Resource Development Department while those up to 40 ha will be given to PFCS (registered under OCSA 1962).

5.3.3 Principles for Lease of Brackishwater Areas in Odisha (FARD 2015)

With regard to the principles for lease of brackishwater aquaculture in Odisha (FARD 2015), the persons and parties are divided into two categories. Category I is further divided into sub-categories A and B, with Category A consisting of beneficiaries of anti poverty programmes; persons below poverty line (BPL); fishers by profession or by caste; landless persons with an annual income not more than INR 40,000; marginal farmers, etc., while Category B includes SHGs, PFCS, unemployed youth etc. DLC will identify and record brackishwater resources suitable for pisciculture, of which 50% will be earmarked for Category I and 50% for Category II. It is said that the leased land should not go beyond the identified area due to environmental concerns. While leasing out areas to individuals, preference will be given to existing farmers, technically qualified persons, trained and experienced persons, etc. Any individual beneficiary under sub category A of Category I will not receive lease beyond one hectare while those under sub category B can go up to five hectares (in the 2012 version of the principles it is indicated that the land should not be leased out to outsiders as this will have detrimental effects on land utilisation. This line has been removed in the 2015 version). The lease (for an amount INR 2500/ha/year for category I with ground rent of one percent of the lease amount and INR 10000/ha/yr for category II) is to be given for a period not less than 15 years and if not utilised for shrimp farming, the land is to be resumed. Shrimp culture can be carried out from 0.5 to 2 km from HTL if permitted by CAA. However, cultivation of *L. vannamei* can be carried out between 2-5 km from HTL. If an area is identified beyond two kilometers, it should be part of cluster development, have clearance from the hydrology department and have consensus of the local population. Sea bass is to be promoted for rotational culture with shrimps. Odisha Fisheries Department also envisages funding construction of new ponds for

brackishwater aquaculture. However, this is purely export oriented with a targeted nine fold increase of export earnings (from INR 30 bn to INR 200 bn). Due to lack of areas that could be converted to brackishwater ponds, it is estimated to increase shrimp production to 6 mmt/ha/year (through vertical intensification). The farmer beneficiary will be chosen based on the Blue Revolution guidelines.

5.3.4 Matsya Pokhari Yojana (extended to 2020-21)

The state introduced the Matsya Pokhari Yojana of Odisha with a budget provision of INR 960 mn for two years (2017-18 and 2018-19), specifically earmarked for the intensification of inland farming systems (focus will be on extending farming into new areas and production of advanced fingerlings). Along with the aim to increase inland production by 4150mmt/year, it aims to increase employment through this Scheme which will be monitored yearly. There is also a special scheme to increase women's involvement in pisciculture through input assistance given to women SHGs in gram panchayat ponds.

5.3.5 Odisha WorldFish Project

Through this project, small and medium cage culture will be promoted for local entrepreneurs, fisher cooperatives, etc. Genetically Improved Farm Tilapia (GIFT) multiplication is to be taken up in Odisha and technical support for the same to be given to 100 small and marginal farmers from ten priority districts. The Odisha fisheries department aims to increase nutrition security by promoting carp-mola polyculture in backyard ponds through this project, with focus given from brood stock development to fingerlings production. For promoting nutrition, mola will be included in the mid-day-meal programme of 100 Anganwadis (targeting the diet of 20,000 children and 5,000 mothers).

6. Impacts of Aquaculture

Though highly rewarding, the unregulated intensification of aquaculture can cause immense negative social, ecological and economic impacts - as exemplified by shrimp aquaculture of the 1990s that resulted in large-scale changes in land use pattern due to massive destruction of natural resources, denudation of mangrove forests, conversion of coastal agriculture areas to aquaculture ponds, indiscriminate dumping of aquaculture effluent causing land and water contamination, coastal land grabbing, etc. This was also the time when the coastal communities of India were galvanising against the trawler onslaught for the pink gold rush under the fishworkers movement, fighting for their right to life, coastal space, livelihoods and to well-being. Brackishwater aquaculture was usurping the coastal spaces through its expansion. This could be the reason why such impacts got highlighted only from the brackishwater culture though there were similar impacts witnessed in freshwater aquaculture, especially in and around Kolleru Lake, Andhra Pradesh.

6.1 Land Use Changes

When aquaculture proliferates in an area, a multi-use, multi-species, multi-service providing ecosystem gets converted into a private, single-user, single-species ecosystem (Bailey, 1988). This was witnessed when mangroves were converted into aquaculture ponds in the late 1980s-early 1990s by the shrimp industry that cashed in on the readily available flat coastal lands provided by mangroves (Hein, 2000). The valuable services provided by these mangroves - as nurseries for coastal fauna; as natural coastal protectors against tidal surges due to cyclones, tsunamis, etc; as a rich economic and livelihood resource for coastal gleaners who were mostly women, children or elders of the community who could provide the much required protein or an additional income - were overlooked in this race for foreign exchange. Shrimp farms have replaced about 38% of mangroves globally (Environmental Justice Foundation (EJF), 2003) due to factors such as (i) easy access to saline water for culture; (ii) usually undeveloped with its custodianship vested with the government making it cheap and easily available (Poernomo, 1990 as cited in Barg, 1992); (iii) availability of large contiguous land, etc. In fact, shrimp farms developed at the expense of other agriculture, aquaculture, forest uses and fisheries that were better suited in many places for meeting local food and employment requirements. These requirements were hardly met by intensive and semi-intensive types of shrimp production. The current proliferation of shrimp farms could be no different as it is expanding at a rate unheard of in the aquaculture history of the country. Approximately around 60% of agricultural lands were converted in a village in East Medinipur, West Bengal for the culture of *L. vannamei* in the last half a decade (personal communication, Debashish Syamal, 2021).

The important mangrove areas of India were in Sundarbans in West Bengal and Krishna/Godavari delta in Andhra Pradesh. Hein (2000) indicates that Godavari lost 80% of its mangroves to shrimp farming and an aggravation of the same is witnessed between 1997-1999, even though the Environment Protection Act (1986) or the Coastal Regulation Zone Notification (1991) were very much in place then. Poernomo (1990) indicates that mangroves (virgin or secondary) had very low productivity; high cost with respect to pond construction and required soil reclamation work as it could become acidic, and over the course of time less suitable for aquaculture leading to its abandonment. There were large tracts of thus reclaimed mangrove land abandoned due to low productivity, and they do not appear in worldwide estimates of areas used for shrimp farming. In 1993 about 962,600 hectares were abandoned globally of which 847,000 hectares were in Asia. By December 1994 these areas were estimated to have increased worldwide to 1,147,500 with 1,017,000 hectares in Asia (Rosenberry, 1993 and 1994). *Globally, areas affected by the industry's practices over the last decade are probably at least one third larger, or even more if the total infrastructures surrounding the ponds are taken into account.*

The supratidal zones of agricultural fields, coconut plantations etc., exhibit high productivity and could be used directly for shrimp culture, even intensive culture (Poernomo,1990 in Barg, 1992). This together with high cost of production in agriculture, and the success as witnessed by some agriculture farmers on conversion to aquaculture ponds, coupled with heavy subsidies and extensions provided by the Departments of Fisheries in various states, have catalysed many farmers to turn their land into aquaculture farms. This is proven by the research presented by Jayanthi et al (2018) where the data indicates that the conversion of agriculture to aquaculture (1998-2013) was far greater than the conversion of mangroves to aquaculture in the studied states (see Table 7). An interesting observation in the paper mentioned above is that about 50% of the newly formed aquaculture area was through the conversion of mudflats, crucial in supporting the lives and livelihoods of local communities and providing various ecosystem services.

Table 7: Land Use Changes from 1998-2013 (in ha)

States	Ag to Aq	Ma to Aq	Mf to Aq	Aq to Aq
Andhra Pradesh	5166	836	6818	123
West Bengal	1515	779	1435	1032
Tamil Nadu	809	13	1813	16
Gujarat	136	135	6547	0
Odisha	2915	131	2762	2327

Ag= Agriculture; Aq= Aquaculture; Ma= Mangroves; Mf = Mudflats

Source: Jayanthi et al, 2018

A significant observation in the states of West Bengal and Odisha is that there is substantial conversion of one type of aquaculture area to another type of aquaculture area, 1032 ha and 2327 ha respectively. It is interesting to compare these notes with the findings of the study done by Dutta et al (2016) which indicate the conversion of a large number of freshwater ponds into brackishwater ponds for *P. monodon* culture in the Contai II block (the block nearer to the coastline) of Purba Medinipur, West Bengal.

These conversions continue unabated, mainly due to the high profit from shrimp culture which is almost 12 times that of high yielding varieties of rice (Shang et al, 1998 as quoted in Ojha and Chakrabarty, 2018). In some cases, more than profits, the culture of *L. vannamei* shrimp which tolerates salinity range of 0-45ppt, has allowed an earning from fallow lands which were low/unproductive due to factors such as salinity (Jayanthi et al, 2018). In the Contai II block of Purba Medinipur, the paddy fields with vegetables grown on the sides, gave way to brackishwater shrimp culture (Ojha and Chakrabarthy, 2018). This is a pattern seen in many areas where aquaculture is growing in an unregulated manner with the cultivation of staples of the region giving way to monoculture of a high profit species. This creates a gap in supply of essential commodities in the community leading to price hikes, and at times even resulting in a collapse of the local food culture. This is reported by Nayak (2014) from Odisha where the food culture of rice and fish has collapsed due to changes in land use due to shrimp farming. Alagarsami (1995) has also indicated that the huge conversion of agricultural fields to carp culture ponds witnessed in Kolleru Lake in Andhra Pradesh, Punjab and the Cauvery delta (especially tail end regions of Tamil Nadu) has also caused huge concern within governments over the loss of production of areas under cereal production. These are the staples of the community, and their decreasing production adversely affects them as a whole with the poorest as the most severely impacted group.

Table 8: Land Use Changes Seen in Purba Medinipur District of West Bengal

Block Name	2008			2012			2016		
	Bwtp		Ag	Bwtp		Ag	Bwtp		Ag
	No	Area (ha)	Area (ha)	No	Area (ha)	Area (ha)	No	Area (ha)	Area (ha)
Contai - I	664	287.54	10239.20	808	326.44	10195.01	1631	450.91	9974.5
Desopran	6417	922.02	10958.27	8325	1206.01	10631.82	12736	1965.00	9804.51
Contai - III	1295	200.14	11285.90	1491	235.20	11224.57	2914	471.95	10973.73
Ramnagar - I	1050	937.20	6464.02	1348	998.69	6413.09	1438	1007.27	6382.31
Ramnagar - II	1790	1887.24	9043.17	2019	1953.51	8995.69	2385	2000.27	8910.19

Source: Reproduced from Dutta & Kundu, 2016; Bwtp – Brackishwater Tank Pond; Ag – Agriculture

According to the Directorate of Economics and Statistics, the productivity of rice in Andhra Pradesh for the year 2019-20 was in the tune of 3.7 mt/ha. However, in the case of carp production from Andhra Pradesh, though an average production hovers around 3mt/ha (NFDB, 2021), the Kolleru model has shown productivity close to 7-12 mt/ha (Ramakrishna, 2007). Thus, productivity from aquaculture far outweighs that of rice. The price of the produce from agriculture, especially food grains (which is the major proportion of agricultural production) in comparison to aquaculture produce is a point of interest. When a maximum market price for a kilogram of rice (for basmati) is around USD 1.06, the minimum farm-gate price of fish is around USD 1.33, which can go up to USD 3.33 (NFDB, 2021) in the case of Indian Major Carps, yielding an assured greater income per hectare in comparison to agriculture. Agriculture includes activities which are labour intensive - such as transplanting, weeding, harvesting, etc. The share of cost of cultivation spent on labour is about 35% for paddy (DES, GoI 2016-17 cited in Shweta et al, 2020) and the daily wage average for general field labour (male) in India is ~USD 4.64 (MoAFW, 2021). In aquaculture capital investment is most in land, fish and very low for labour (K Sushama Krishna Sri et al, 2019). In a study conducted in 2002 across 10 districts of Tamil Nadu, it was found that aquaculture farms with an expanse of 4,268 ha provided employment of 455,414 man-days while paddy cultivation of the same area provided 759,024 man-days of work (Jesurathinam, 2007). This, along with the increasing shortage of agricultural labour and increased agricultural labour wages, tips the farmers' favour towards aquaculture production wherever the conditions are conducive.

6.2 Salinisation of Soil and Salinity Ingress

When agricultural lands are converted to aquaculture ponds, the danger is not only posed by land use change but also by seepage of polluted or highly saline water from the nearby aquaculture ponds (Hein, 2000). According to the Hossain et al model, salinity has a positive correlation with the soil pH, soil temperature, total content of phosphorus, exchangeable potassium, exchangeable magnesium, and has a negative correlation with organic matter and nitrogen content (two components required for the productivity of the soil). Thus, salinity also decreases the fertility of the soil. Expert Committee Report on Impact of Shrimp Farms Along The Coast of Tamil Nadu and Pondicherry by Justice Suresh (as cited in SC Judgement of S Jagannath v/s Union of India and ORS, 11 December 1996) noted that even palmyrah trees (considered to be sturdy trees) dried up after the setting up of aquaculture farms, and the few left have stopped yielding fruit.

Currently there is high land use conversion for *L. vannamei* culture (see the data of AP, Odisha etc). Though *L. vannamei* is promoted as a shrimp with a very high range of salinity tolerance, advisories by certain governments indicate otherwise. The Andhra Pradesh G.O Ms No 15, advising farmers on increasing production cautions against *L. vannamei* culture in 0 ppt, indicating that the success

rate will be low and suggests precautions such as using PL15 seeds if the culture is carried out in 0 ppt (which escalates cost of production) if some success is to be achieved. This indicates that it is always prudent to use water with moderate salinity which makes pumping of saline water into ponds a necessity - a process that has its own set of problems such as salt leaching into aquifers, salinity ingress, seepage into neighbouring agriculture fields, conversion of potable water into nonpotable water, etc.

6.3 Water Mining for Aquaculture

Pumping of water is a common phenomenon both in freshwater and brackishwater aquaculture. It is said that in the Krishna basin, one of the high intensity freshwater aquaculture areas, the farmers (both agriculture and freshwater aquaculture) started tapping the ground water to a tune of 19,000 wells in 2001 (twice in comparison to the figures of 1987). This water mining resulted in the water table to fall by one to two meters in ten years resulting in progressive salinisation (GoAP 2003 as cited in Venot et al, 2008). The salinisation happened due to two processes - the falling of the water table and the surfacing of fossil saline aquifers (GoAP 2003 cited in Venot et al, 2008). In nearby coastal areas where water mining for aquaculture depleted the ground water table, it led to seawater intrusion. This was also one of the observations of a study conducted in East Godavari where salt water intrusion was found to be very high in villages namely Antarvedi, Antarvedi Kara, Kesavadasupalem, Gondi, Mutyalapalem, Turpupalem, Mori, Srungavarappadu and Karavaka. These villages are in close proximity to the estuary and the Bay of Bengal as well as surrounded by aquaculture farms (Penmetsa, 2013). The salinisation due to salt water from deep aquifers and intrusion from the tidal waters permanently damaged the quality of groundwater (Venot et al, 2008) and most of the wells in the vicinity became useless for domestic use. Protection of ground water sources may be viewed as a non-tradeable capital, as once contaminated, they may prove impossible to rehabilitate (Mark Eyvarard, 1994).

Non-availability of potable water affects the quality of living of the communities who depend on these aquifers and wells. Rao et al (2006) indicate that the community surrounding Kolleru used lake water for drinking in the 1980s but the advent of aquaculture and the change in quality of water resulted in them having to bring water from sources as far as six kilometers from their villages. It is more often than not that women bear the major brunt of these changes. The change in water table and salt water intrusion etc., force women (who are usually the water bearers) to walk considerable distances in search of potable water. The long hours spent in sourcing water decreases their available free time which could be used for other (socially or economically) gainful engagements.

6.4 Water Pollution

The return flows from aquaculture facilities loaded with chemical and organic waste into the nearby water bodies poses a major environmental problem. The intensification of aquaculture (both freshwater and brackishwater) has led to an increase in the use of artificial inputs (Pathak et al, 2000) which include aquaculture feed, water/soil treatment products, disinfectants, piscicides, herbicides, organic fertilizers, inorganic fertilizers, feed additives, therapeutants and anesthetics. Though most of the therapeutics used in the culture are absorbed by fish tissues, they also leach into the natural habitat, modifying even the bacterial population, resulting in emergent antibiotic resistant strains. Agricultural farms located in the vicinity of aqua farms (1–3 km) are more influenced by the increase in chemical contents than those located at a distance (5 km) (Kagoo & Rajalakshmi, 2002). Pathak et al (2000) in their paper states that the dosage, administration, duration of exposure to fish, effects on non-target species, efficacy in treating a disease is still not clearly understood.

Higher nutrient inputs increase the nutrient load in nearby waters. For every ton of fish, aquaculture operations generate between 42 to 66 kg of nitrogen waste and 7.2 to 10.5 kilograms of phosphorus waste (Penmetsa et al, 2013). Kagoo & Rajalakshmi (2002) refer to the estimate put out by NEERI (in Jagannathan vs Union of India Ruling in 1996) which studied the environmental cost of shrimps produced and exported. In no uncertain terms, the report indicates that the socio-environmental cost of aquaculture far exceeds the earnings from coastal aquaculture activities. It also indicates that for a moderate 3 t/ha yield of shrimp, 4-6 t/ha feed is applied, while to achieve an additional tonne per hectare production the amount of feed required is 15 t/ha. This could also be the case for freshwater aquaculture where increasingly even herbivorous fish are being fed using fish feed and a production of 6 mmt/ha is aimed at, according to the guidelines for intensive inland aquaculture. The magnitude of organic matter from this increased input is enormous and therefore this should be avoided as it is highly polluting (Mackintosh. D.J. INFOFISH. International 6/92. 38/41). The intent of the Odisha Fisheries Policy 2015 to produce 6 mmt/ha/year of shrimp (the reason being given as lack of available water bodies for culture) can be viewed from this perspective. The NEERI report goes on to say that feed waste is more toxic than sewage. In Andhra Pradesh, the estimated annual earnings from shrimp aquaculture was INR 15 bn achieved at an environmental damage worth INR 63 bn. While the same figures for the state of Tamil Nadu were INR 2.8 bn and INR 4.3 bn respectively (Kagoo & Rajalakshmi, 2002).

The compulsory installation of effluent treatment plants (ETPs) is now specified for at least intensive systems of aquaculture. However, this raises the cost of production by another bar, leading

to many producers failing to install ETPs, ignoring environmental and social concerns (Ghosh et al, 2015). The increased capital inputs preempts small aquaculture farmers into venturing into shrimp culture which is mostly undertaken in semi-intensive *(P. monodon)* or intensive culture *(L. vannamei)* systems, making space for larger players to fill the void.

6.5 Loss of Biodiversity

One of the top most casualties of aquaculture is biodiversity. It not only impacts aquatic but also terrestrial biodiversity. The land use changes witnessed due to aquaculture expansion have altered the dynamic ecosystems capable of protecting itself and the life within, turning the multi-service provider into a vulnerable single use system. The negative highlight of aquaculture is usually exemplified by shrimp/brackishwater aquaculture. Ayyappan and Jena's paper (1999) indicates that freshwater aquaculture also has large impacts on biodiversity, causes environmental pollution, feed and fertilizer-related issues, water management issues, import of exotic fish and shellfish species, issues of human pathogens associated with fish cultured in wastewaters, fish marketing and hygiene, etc. Most of the problems indicated above are exemplified by Kolleru carp culture. This has impacted floral and faunal, aquatic, and terrestrial biodiversity. Once a haven for migratory birds, rich with 120 species of fish and 12 species of shrimps; with water vegetables (lotus and water chestnut) as well as home to almost 45,000 dependent fishers, it has been reduced to a waste dump due to change in land use; accumulation of waste from aquaculture ponds; drainage blocks caused by aquaculture structures etc (Reddy, 2014). With regard to other freshwater ecosystems, Sugunan (1995) indicates that the indigenous species which were already under stress due to the reservoir formation were subjected to further pressure when gangetic carps were introduced into these ecosystems, leading to near decimation of indigenous species. Though many species were introduced other than the gangetic carps, it is tilapia, common carp and silver carp which are shown to be deleterious for the native fish population, the mainstay of nutrition for local communities (refer Table 9).

Table 9: Impact of Introduced Species on Indigenous Species

Introduced Species	Characteristics	Impacts
Oreochromis mossambicus Introduced in 1952	Prolific breeder, voracious feeding habits; establishes itself in all water bodies	Reduction of carp in polyculture; eliminated Gangetic carps from reservoirs; reduction in average weight of carp production; posed threat to native mahaseers (*Tor tor*; *T putitora* which are already on the verge of extinction); in some reservoirs it has caused extinction of indigenous varieties.
Silver carp Introduced in 1959	Does not establish in water bodies other than where it is introduced	Established a breeding population; caused reduction in carps; native catla and *T putitora* (which formed 20.62% of the capture before the silver carp introduction in 1974-75 which reduced to 2% in 1984-85)
Common carp		Jeopardized the snow trout population; led to extinction of *Osteobrama belangeri* in Loktak Lake
Mirror carp		Dubious distinction of jeopardizing the existence of many native species

Source: Pillai & Katiha, 2004; Sugunan V V, 1995

6.6 Impact of Aquafeed Industry

Feed contributes to 75% of variable expense in aquaculture (Naylor et al, 2009). Indicative of the increasing dependence on aquaculture feed is the declining global trend of the non-fed species in aquaculture from 43.9% (in 2000) to 30.5% in 2018 (SOFIA, 2020). Aquaculture production has grown at 11% with industrial compounded aquafeed production tripling between 1995 and 2008 (Tacon, 2011). Just 9 of the 200 fed species cultured in the world contribute to 62.2% of the fed aquaculture production. The major fed species include grass carp, common carp, nile tilapia, catla, white leg shrimp, crucian carp, Atlantic salmon, pangasius catfish and rohu (FAO 2010a in Tacon et al, 2011). 85.5% of fed fish aquaculture happens in Asia. Of the total fed species cultured in the world, 80.8% consists of freshwater species with the biggest group being the carp which has shown an increasing dependence on commercial feed (20 to 48% from 1995-2008). It is the Pacific White shrimp that utilises the lion's share of shrimp feed produced followed by tiger prawn. In the period between 2000-2008, the species which showed the biggest growth with regard to fed finfish aquaculture was catfish. Out of the total feed produced in the world, 31.3% was consumed by carps; 17.3% by crustaceans; followed by tilapia (13.5%) and catfishes (10%) (Tacon et al, 2011).

India fares 15th in the list of top feed producers. The major aquaculture output from India (quantity wise) is the Indian Major Carps and the low offtake of feed is indicative that they are still produced in an extensive or semi-extensive mode, fed with low-cost farm-made feed (traditionally prepared by women). This is considered to be comparatively environment friendly and low on waste aquaculture, though Kolleru model is an intensive, environmentally damaging one.

There is a push towards uptake of pellet feed in the culture of carps as it is argued that it is less polluting in comparison to traditional mash feed which increases organic load in water. It requires 3-4 kg of wet mash feed to produce 1 kg of fish while for pelleted feed it is usually 1-1.5 per kg of fish as it is better assimilated by fish species. This has a direct correlation with organic pollution of pond water. Pelleted feed is promoted for increasing resource efficiency while increasing production. About 33% of the carp farmers in Andhra Pradesh have shifted to pelleted feed (Ramakrishhna et al, 2013). Advent of improved feed such as pelleted feed or floating pelleted feed were instrumental in species as well as technological diversification (such as cage culture) (Anand, 2019).

The National Fisheries Policy (Sixth Draft) 2020 emphasises the importance of diversification of species in aquaculture. The Handbook of Fisheries Statistics (2018) (also indicated by MPEDA) indicates that the culture of sea bass, cobia, pompano, tilapia, mudcrabs, pangasius, etc., are on the rise. In India, there is an increasing trend in the production of tilapia, catfish, shrimp (white leg and tiger shrimps). All of them are fed species. Thus, the demand for commercial aquaculture feed is

steadily on the rise in the country. Though India produces only 0.247 mmt of fish feed, it imports from other countries around 25-50% of the feed ingredients used in compound feed. Research and Market Report (2019) indicates that the demand for shrimp feed itself will cross 1.8 mmt by 2024 in India, with the greatest market share led by Andhra Pradesh, West Bengal, Tamil Nadu, Orissa, Gujarat, Maharashtra etc. Greater the emphasis on export species, greater the thrust on import of protein ingredients such as fishmeal, soybean meal, fish oil etc. As fish has very low capacity to digest carbohydrates, it is important that the feed contains concentrated fats and protein for achieving optimal growth (Terpstra, 2015). SOFIA (2020) also agrees to the fact that fish meal and fish oil are the most nutritious and digestible ingredient in fish feed. It takes 4-5 kg of fish to make one kilogram of fishmeal (Greenpeace, 2019). According to SOFIA 2020, about 18 mmt (88% of the non-food use of capture fish production) is reduced to fishmeal and fish oil. When 68% of fishmeal is consumed as aquafeed, the sector consumes 88% of fish oil produced. The share of fish used for reduction to fish meal and fish oil is the largest in Latin America followed by Asia and Europe.

The ideal fish for FMFO (fish meal and fish oil) industry are the small pelagics. Although in small numbers (in comparison), the FMFO industries of Western and Eastern Africa are creating havoc for the biodiversity, livelihood and income of local communities besides impacting the consumption and food culture of as many as 40 million people in Africa (Greenpeace, 2019). Though the FMFO industry was established very early on in Latin America, the scaling up in Asia and Africa is a fairly new phenomenon.

Rich fishery of small pelagics such as the oil sardine is seen along the western seaboard of India. A staple for coastal communities of the western states namely Kerala, Karnataka, Goa, Maharashtra, it is also highly sought after and prized by the FMFO industry (CMF, 2020). During the glut of small pelagics, which usually happens together with the upwelling phenomenon common on the west coast of India, the surplus fish after being sold in local markets used to be cured by women through drying and salting. This activity was instrumental in providing additional income and/or food security during lean seasons. Only the excess fish, neither sold in the local market for consumption or cured, was used for extracting oil. This surplus catch witnessed in the southwestern coast of India resulted in traditional fish oil extractors, ruins of which can still be seen along the Indian west coast. These have now been replaced by FMFO industries, encouraging targeted fishery for reduction where any quality and quantity of catch could fetch a price in the market (CMF, 2015). Though fish meal and fish oil are increasingly being sourced from processed waste, fish fit for human consumption are also diverted to the reduction industry (SOFIA, 2020). This is increasingly witnessed especially in the western seaboard of India, and Western and Eastern Africa.

The CMF (2020) report says that a foreign company, Skretting through a joint venture with the local West Coast Group, is trying to establish a fish feed industry in India. Such ventures can survive only if there are dedicated large volume suppliers of fish for the reduction fishery, and if such companies offer very high returns for the supply. Currently the Indian feed mill industry is valued at USD 1.2 bn (CMF, 2020). The first feed mill was installed in 2008 and 30 feed mills were established by 2018 with an installed capacity of 2 mmt (Anand, 2019).

The small pelagics, high in nutrient content namely calcium, minerals, omega-3 fatty acids etc., are highly perishable and it takes effort and money to make them (a low-value species) available fresh and palatable to the customers who are usually local/domestic. In comparison, it takes far less effort (time and money) if the same catch becomes raw material for the FMFO industry, thus making the economics work in favour of FMFO (Wijkström, 2009). This diversion also impacts employment as fish processing for human consumption employs more than when fish is directed for reduction (Wijkström, 2009). Therefore, the establishment of FMFO has resulted in rapid depletion of fish stocks (it not only affects current fish stocks but also future recruitment due to indiscreet fishing, unmindful of size or species), thereby affecting biodiversity; loss of gainful occupation of women (in drying/salting etc.) due to unavailability of fish; impact on local nutritional security due to unavailability of fish for consumption/processing (physical - since fish caught are redirected to FMFO, and financial as the species which were affordable become prized due to competition with FMFO industry).

The biggest consumer of aquafeed in India is Andhra Pradesh, the number one state in India with respect to aquaculture (Greenpeace, 2019). Apart from carp culture, Andhra Pradesh leads in the production of tilapia, *pangasius, L. vannamei,* even *pacu* or the orange belly. All of these are heavily fed species.

National Fishworkers' Forum (NFF, a network of fishworkers' unions) demanded that the government of Kerala (a state on the western seaboard of India) bans illegal and indiscriminate light fishing and trawling, and also seizes the catch which does not adhere to the legal mesh size as approved by the Kerala government. NFF indicated that catch from illegal fishing went to the FMFO factories in the northern part of Kerala as well as the Karnataka Coast. NFF also demanded that these industries be stopped, and heavy fines be imposed on boats/trawlers which did not adhere to the minimum legal size (applied to 50 species as advised by CMFRI) (TNIE, 2020). It is also indicated in various other reports that such FMFO factories are mushrooming in various parts of India. In West Bengal, the leading tiger prawn (another voracious feed consumer) producer of India, many FMFO factories are sprouting in North and South 24 Parganas and East Medinipur,

and food species are being increasingly diverted for processing as fishmeal and fish oil (Youthkiawaaz, 2020).

The dependence of aquaculture on FMFO has been reducing over the years (down from 30 mmt in 1990s to 18 mmt in 2018) as it is being replaced by plant-based products. The usual protein replacers are soybean oil or other plant-based oil, though their efficacy is still debated with evidence suggesting onset of diseases in cultured species (Naylor et al, 2000). Aquaculture's increasing dependence on plant based products is also worrisome as this may cause diversion of plant based-protein for making aquafeed. Protein for the poor versus protein for fish culture will again ensue with problems shifted but not dealt with.

A comprehensive study on the impact of aquaculture on driving the feed mill industries in India and its impact on the local livelihood, income, biodiversity, nutritional security, on women, working conditions, social security of workers etc., needs to be further probed. This is especially important given the tangential aquaculture is about to embark upon.

6.7 Climate Change Impacts on Aquaculture

Aquaculture, like most other production sectors, is under the threat of climate change. While it is seawater temperature, ocean acidification, parasite infestations etc., for mariculture, the freshwater and brackishwater culture systems will not only face high temperature variations but also salinity variations, higher dependence on freshwater (due to increased evaporation), unpredictable climatic conditions including unpredictable floods and cyclonic events, prolonged drought periods, higher incidences of diseases etc. It is said that climate change impacts will be more pronounced in Asian countries. Lebel et al (2018) indicate in their paper that the freshwater culture systems of Viet Nam, Bangladesh, Laos and China are to be the most affected, and countries with major impacts on their brackishwater aquaculture will include Viet Nam, Thailand, Egypt and Ecuador. With respect to mariculture, though Norway and Chile stand at the forefront, Asian countries such as China, Viet Nam and the Philippines are not far behind.

The impact of climate change is very much pronounced in the Indian subcontinent. Though this is an area that is less explored, it holds immense importance to the aquaculture industry of India. The increased incidences of cyclones impact coastal ponds and its culture; the unpredictable rainy seasons (with far lesser rainy days but with higher recorded rainfalls per day) lead to flash floods that heavily impact inland culture systems. This leads to direct economic fallouts through loss of cultured animals, infrastructure, livelihoods etc. It is said that the aquaculture industry of West Bengal suffered a loss of 138 mn USD during cyclone *Yaas*. The intensification of cyclone *Yaas* from

a mere disturbance in the Bay of Bengal to a very severe cyclonic storm happened in an interval of four days and the farmers were left without any time to harvest the market ready crop, thus accounting for a humongous loss. The figure cited above accounts only for the loss of farmed animals and does not consider the loss of infrastructure, jobs etc. It is said that during cyclone *Yaas*, around 1,100 villages of West Bengal bordering Bangladesh were severely affected (Mutter, 2021). Were the land use changes and the subsequent loss of green cover, the culprits of this increased path of impact of cyclone *Yaas*? Or can this be attributed to the unfortunate coincidence of a very severe cyclone making landfall during high tide (Relief Web, 2021)? Any curative steps towards reducing the impacts of a cyclone will be meaningful only if the cumulative impacts of the cyclone aggravated by uncontrolled expansion of aquaculture are taken into consideration. Such cyclones have been an annual affair for the east as well as the west coast of India.

The impact of floods on freshwater aquaculture was studied by Rutkayová et al (2018) in Czech Republic and indicated that on an average, 44% of the farmed animals were lost due to floods. The report goes on to say that there could be variations in loss with regard to pond size, the size of farmed animals, the species (carps suffer less loss in comparison to other species), age of species - whether juveniles (more loss reported) or adults, etc. It is also indicated by the report that greater loss is witnessed by owners of small farms than those with large areas. The fish escaped during floods, if exotic, could cause havoc to native species and the environment. These are all direct impacts of climate vagaries.

Increased exposure of pond water to sun/increased ambient temperature increases the temperature of the pond water which in turn increases its evaporation, necessitating water replenishment. Adhikari et al (2018) indicate that increased water temperature is dealt by farmers by pumping water from wells to both replenish their ponds as well as reduce the temperature of the water. This is practised more by farmers in Andhra Pradesh and West Bengal. Although some papers indicate a positive correlation between carp production and temperature, many papers indicate a negative correlation between dissolved oxygen and temperature which impacts production of many other species.

This increased dependency on water could force farmers to look for species which can be cultivated at a shorter time with lesser depth of water and which are more tolerant to varying water temperatures. Adhikari et al (2018) report that carp farmers in Karnataka are opting for polyculture of *pangasius* and *pacu* (orange belly – the major component in the culture). These species require less water depth (1-2 m) in comparison to carps (3-4 m); they are more heat tolerant and fast growing, requiring water only for six months in comparison to a year of water with adequate depth

for carps. In this transition of species used in aquaculture, especially as given above, the locally preferred species (namely Indian Major Carps) give way to ones that are more robust exotic carnivorous formulated-feed-dependent species, cultivated for external markets (for example *pangasius*, sought after for its white flesh with no intramuscular bones), further impacting local availability of fish protein. This not only has socio-economic but also severe environmental impacts.

According to some reports, the tissue permeability, oxygen demand, metabolic rate etc., of the fish increases with rise in temperature increasing the accumulation of toxins in the flesh and also making the farm animals more vulnerable to even decreased levels of toxic substances (Fondriest Environment Foundation, 2021). In one study done on *Labeo bata* it was seen that 50% of lethal concentration of zinc at 15°C more than halved at 30°C.

All the above emphasises the importance of the quality of water used for culture which will become more and more pronounced in the future. Good quality water, a requirement (especially) for freshwater aquaculture, a precious resource now will face extreme shortage in the near future, compounded by longer periods of drought and shorter periods of intense rainfall, causing floods and preventing water from percolating into the soil. Aquaculture will face shortage of water not only due to lower water reserves but also due to the intense competition from other water-dependent production sectors and due to the massive horizontal expansion envisaged for the sector itself. This automatically increases the cost of water, thereby alienating the less resourceful and poor farmers from the sector.

6.8 Changes in Property Rights in Aquaculture Areas

Uncontrolled aquaculture development aimed at attaining projected production and foreign exchange has had many unintended impacts. Although it has been a gamechanger for all and has positively impacted many, the adverse effects were felt mostly by the community at the aquaculture site while the positive impacts were most often largely enjoyed by the investor community. Though in most cases of leasing of ponds, preferential rights were given to traditional fishing communities and to traditional aquaculturists, it was observed that wherever the profits were high, there was a gradual takeover by business interests who sub-leased the pond from the rightful owners by giving them rent. The ownership of the ponds/tanks eventually came into the hands of the moneyed.

Though the above was witnessed to a severe extent in brackishwater areas, freshwater areas also observed a similar pattern. In most of the states where aquaculture was not known to be traditionally practised, namely Gujarat, Haryana, Uttar Pradesh etc, the increased preference to use village ponds/water bodies for aquaculture was witnessed. These bodies were common property

resources for the village (Ghosh, 2020). In the case of Gujarat, Ghosh (2020) indicates that the lease policy has changed from being protective to competitive. In Haryana, the increased demand of aquaculture started a domino effect of increased lease amount leading to alienation of poor households/individuals from sources earlier used for common purposes. With increase in profits there were cases of nepotism leading to collusion of contractors with *panchayat* leaders, with the original aquaculture farmers and people dependent on the water resource losing out.

In the East Champaran area of Bihar where *mullah*s are the main fishing caste who traditionally practised aquaculture, there is an unwritten rule that the lease for aquaculture ponds will usually be given to the cooperative societies of *mullahs* and not to any outsiders. However, it is increasingly being operationalised by members of the upper castes and the decision making wrests on a single or a couple of powerful members. This is also the case in Odisha (Ghosh, 2020).

Table 10 gives the different property regimes in different states. It is seen that about 41.9% of the village water bodies in these states are multi use common village ponds while the rest 59.10% are private water bodies. Around 71% of the ponds in the villages are leased out. When 42% of the private ponds are leased out, only 23% and 28% of panchayat and FFDA ponds are leased out. Almost 83% of the total lessees were private parties while only 14% of the lessees were cooperatives or SHGs. This proves that common sources of water have gone to private parties who would naturally restrict its use by the community members in fear of contaminating the pond. This could have limited the communities and forced them to pay in cash for services which were otherwise free.

Table 10: Property Rights Regimes of Water Bodies in Various States

	Property regime type			Lessor type				Lessee type		
	% of multi use common village pond	% of private ponds	% of leased ponds	% lessor as panchayat	% lessor as FFDA/Govt dept	% lessor as pvt party	% lessor as others	% lessee as Co-op or SHG	% lessee as Pvt party	% lessee as others
Orissa	64.29	35.71	75.00	76.19	0.00	9.52	14.29	0.00	100.00	0.00
W. Bengal	12.50	87.50	90.00	0.00	8.82	85.29	5.88	8.33	86.11	5.56
Assam	6.52	93.48	30.43	0.00	0.00	78.57	21.43	14.29	85.71	0.00
Jharkhand	6.67	93.33	6.67	0.00	33.33	66.67	0.00	0.00	100.00	0.00
Bihar	82.14	17.86	100.00	0.00	82.14	17.86	0.00	82.14	17.86	0.00
J & K	20.00	80.00	100.00	0.00	20.00	80.00	0.00	0.00	100.00	0.00
Kerala	14.58	85.42	29.17	0.00	0.00	87.50	12.50	50.00	50.00	0.00
UP	82.35	17.65	100.00	50.00	20.00	20.00	10.00	0.00	100.00	0.00
AP	52.94	47.06	100.00	23.53	29.41	11.76	35.29	17.65	47.06	35.29
Gujarat	98.00	2.00	94.00	41.30	56.52	2.17	0.00	0.00	100.00	0.00
Haryana	86.67	13.33	100.00	92.86	0.00	7.14	0.00	0.00	93.33	6.67
Total	41.90	59.10	71.50	23.40	27.92	42.26	6.42	14.02	82.66	3.32

Source: Reproduced from Ghosh, 2020

Roy (2013) lists out the impact of shrimp aquaculture development on the coastal region of Tamil Nadu, Odisha and Andhra Pradesh. Halim (2004), Kagoo and Rajalakshmi (2002), Naganathan et al (1995) and Mukul (1994) as referenced in Roy (2013) reported from all three states that the loss of right to agriculture lands (productive assets) resulted in increasing landlessness among farmers and eviction of tenants from these lands resulted in loss of sharecropping (loss of labour; loss of income; alienation from the known environs). The increased pollution in nearby land and water sources due to aquaculture has led to poorer farmers selling their land to big aquaculture farmers due to the decreasing returns from agriculture. These lands mostly fell in the hands of a few business houses, politicians, bureaucrats, and marine product merchants. Naganathan et al, (1995) in Roy (2013) say that these were acquired through treacherous and insidious methods by large companies engaged in brackishwater prawn farming by giving false promises of employment, provision of infrastructure facilities etc. Naganathan et al (1995) indicate that all such changes almost always happened with the backing of the state that adopted measures (direct or indirect such as discarding of the land ceiling act). Samal (2002) argued that around 14,000 acres of land was leased out through the lease policy of the Government of Odisha to non-fishers in the Chilika Lake area by 2002. Such changes also resulted in increasing incidences of violence for tenurial rights (Pattanaik (2006) in Roy 2013).

Changes in property regimes were also studied in Chilika Lagoon by Nayak in 2014. The fishing rights which were caste based till the 19th century were converted to a leasing system in the 1950s, with a gradual increase in the lease amount over the years. A strong aquaculture lobby evolved by the 1990s which worked to influence the Odisha government to reduce the lease years given to the fishers from three years to one year, by which time aquaculture ceased to be profitable for them. With the introduction of a new policy, which not only introduced lease rights for aquaculture apart from fishing rights, the lease amount saw a 27% increase. In 2001, under the Odisha Fishing in Chilika (Regulation) Bill, 30% of the lagoon fishing area was reserved for non-fishers. This was a way of legalising aquaculture encroachers and reversing the aquaculture ban brought in by the S.Jagannath vs Union of India & Ors on 11 December, 1996 which sought to re-establish the customary rights of fishers. By the year 2004-05 most of the original fishers lost their lease, fishing rights and even access to customary fishing grounds, forcing them to migrate out of the area.

Another interesting case study is offered by Roy (2013) from Tentultala village, Purba Medinipur district, West Bengal where the land reform policy together with the decentralisation process and redistribution of land resulted in poor securing rights on land (Mishra and Rawal, 2002; Dasgupta, 1995; Khasnabis, 2008, Majumdar, 2003, Banerjee et al, 2002, Lieten, 1990 and Dutt, 1981 as cited in Roy 2013). Majority of land in Tentultala was small with marginal holdings. However, the advent of intensive shrimp culture that provided year round employment and higher income than agriculture (providing only seasonal employment and low income) changed the pattern of land holding. While the land ownership remained in the name of the small and marginal farmers, the operational rights went to the big farmers who invested in aquaculture (they owned only 8.9% of land but had 69.6% of the operational holdings). About 75% of the households in the village were wage labourers or with small land holdings that they leased out to bigger farmers for prawn farming. This case study also underscored the importance of access to water channels which determined the operational holding. If the small farms were located away from the creek or the canal which had tidal water, then their only resort was to hand over the operational holding to farmers who had the money and means for the same. With only 11.2% of sharecroppers *(bargadars)* practising shrimp farming, the remaining sharecroppers (illegally) sub-leased their land to big farmers.

According to Kagoo and Rajalakshmi (2002), the changes in ownership pattern seen in Andhra Pradesh and Tamil Nadu can be due to different reasons. When 20% of the coastal landholdings were sold due to their small size (less than one ha), 40% were sold due to high price offered by those having big aquaculture business; 30% sold their property due to decreasing income from agriculture and inability to invest in aquaculture, while 10% of land was sold due to the shortage of labour that immensely impacted agriculture work.

7. Employment in Aquaculture

SOFIA 2018 states that in Asia employment is more in aquaculture than in capture fisheries. However, most figures of aquaculture statistics in India are with respect to production, with employment being only an estimate at the national or state level. The Central Marine Fisheries Research Institute puts out a fair estimate of the fishers involved in marine fishing and the population of the coastal community through the marine fisheries census. The latest census came out in 2010. However, a similar one is wanted in the inland or the aquaculture sector. This is not particular to India but also to most other countries (Hishamunda et al, 2014). SOFIA 2020 puts out a figure of 20.5 mn employed in aquaculture in 2018, of which 19.6 mn were from Asia, contributing to 96% of the total aquaculture workers in the world. For every worker involved in the primary sector, there are 4 employed in support services such as fish processing, marketing, service providers such as accountants, researchers etc. This puts the employment at 36 mn, which together with their families, adds up to 100 mn (Hishamunda, 2014). Most of the research papers on aquaculture in India are technical in nature with very few giving an account of its impact on the environment, with negligible (almost nil) papers giving a glimpse of the social dimensions such as labour in aquaculture – types of labour, number of people involved, labour conditions etc. Table 11 below makes an effort to compile information obtained from multiple research papers with respect to labour provided by aquaculture in India.

Table 11: Studies Referring to Employment in Aquaculture in India

Publication	Focus of the Study	Labour Requirement/Conditions			
Gopakumar, G. 2010. Mariculture Technology for Augmenting Marine Resources. In Coastal Fishery Resources of India - Conservation and Sustainable Utilisation.	General	Employment in aquaculture (inland and marine) has been increasing and account for 25% of the total employment in fisheries and aquaculture (GoI, 2001)			
M. Krishnan & P. S. Birthal. 2002. Aquaculture development in India: an economic overview with special reference to coastal aquaculture in Aquaculture Economics and Management 6(1/2) 2002	The study gives a glimpse of the employment and its type once shrimp aquaculture sets in the district of Nellore in Andhra Pradesh	In addition to direct on-farm employment, ancillary industries have provided employment opportunities for both skilled and unskilled workers. It is estimated that the 33 seed hatcheries employ approximately 1650 workers; the 14 feed mills employ approximately 840 workers; the 8 processing plants employ approximately 1200 workers, and the 16 new ice plants employ approximately 400 workers in total. It is clear that there are strong direct and indirect employment opportunities associated with the development of ancillary industries to aquaculture.			
Ghoshal et al, 2015. Brackishwater Aquaculture: Opportunities and Challenges for Meeting Livelihood Demand in Indian Sundarbans. ICAR	The study is on West Bengal Brackishwater Aquaculture	The paper talks about the number of people employed per ha in different brackishwater shrimp aquaculture practised in the state			
		Traditional = 1-2 person/ha	Extensive = 2-3 persons/ha	Semi-intensive = 3-4 persons/ha	Intensive = 4-5 persons/ha

Publication	Focus of the Study	Labour Requirement/Conditions
Pradeep K. Katiha; J. K. Jena; N. G. K. Pillai; Chinmoy Chakraborty; M. M. Dey. 2005. Inland Aquaculture in India: Past trend, present status, and future prospects. Aquaculture Economics & Management, 9: 1, 237 - 264	The paper compares employment in coastal aquaculture vis-a-vis agriculture	The brackishwater aquaculture sector provides greater employment opportunities than agriculture in coastal areas Shrimp farming requires 600 mandays/crop/ha as compared to 180 mandays/crop/ha in agriculture (Rao & Ravichandran, 2001). Shrimp farming takes two crops while agriculture usually in coastal areas are only one crop (during the rains as in summer the soil salinity increases). This also increases earnings in aquaculture which is INR 12,000 as compared to INR 7,500 in agriculture. The skilled manpower requirement for the next two decades is estimated at 0.2–0.25 million.
Hishamunda et al, 2014. Improving governance in aquaculture employment: a global assessment. FAO Fisheries and Aquaculture Technical Paper No. 575. Rome, FAO. 48 pp	Provides a glimpse into employment in aquaculture and gives figures for different countries, including India.	This is based on a sample size of 342 respondents who practise aquaculture in India Most of the workers in Indian aquaculture are semi-skilled or unskilled – mostly contract labourers who are actually indirect workers whose labour can be got with no commitment on labour rights. Therefore, the working conditions of contract labourers in India are exploitative in nature (also may be due to higher supply to demand). Higher proportion of women are found in processing industry. The proportion of women in Asian aquaculture is much more than (about 74%) other regions such as Africa and Americas. About 84.5% of aquaculture workers in India are labourers. The proportion of workers on farms consists of 56% permanent; 23% contract; 5% casual; 16% seasonal.
National Aquaculture Sector Overview – India (of the FAO)		In the brackish water sector, hatcheries and feed mills are providing employment opportunities; it is estimated that over 300,000 jobs have been generated in the main and supporting sectors of the shrimp aquaculture sector in rural areas.
Ramakrishna, R. 2007. Kolleru carp culture in India: An aquaplosion and an explosion. Aquaculture Asia Magazine. October-December 2007	This paper talks about Kolleru carp culture	The paper indicates that carp culture is a direct source of livelihood for about 8,000 farmer families. It provides indirect employment to about a million people, especially in the rural areas, including women, engaged in supporting industries or activities namely - production and supply of seed, supplementary feed, organic and inorganic fertilizers, water and soil quality amendments, fish health management chemicals, and also pond (farm) management, harvesting, ice manufacture, packing, processing and transport.
Venkatesh, S. 2006. Trends in poverty and livelihoods in coastal fishing communities of Orissa State, India. FAO Fisheries Technical Paper. No. 490. Rome, FAO. 2006. 111p.	Talks about the migrant labourers employed in aquaculture ponds	Owner operator aquaculture farms employed people from the surrounding fishing and agricultural communities while the owners who are outsiders usually employ people from inland areas (usually tribals, agricultural workers, etc.) for manual work. These labourers are from poorer households and are given a place to stay on the banks of the ponds. The families tend to be relatively isolated and are actively discouraged to associate with neighbouring communities. 'Watch-and-ward' work is usually given to the villagers.

Employment has not got any prominence in aquaculture till date and no existent statistics regarding the same is available from any major aquaculture producer nation. As a sector which is expected to provide multiple and varied livelihoods, it is important to have the statistics on a segregated basis - who and how many people do what, the gender of the employees for a particular job/gender preferences for particular work, is there pay parity; the working conditions in each of the different jobs/ancillary jobs in aquaculture (even enlisting the different kinds of jobs involved - specific to types of aquaculture practice, etc). Without this data, the people employed in the sector will remain invisible and policies to safeguard them will be hard to come by. It is time that statistics on this are made available so that more people inclusive policies with regard to aquaculture are formulated. In the absence of such statistics from the government, it is important that studies which highlight these voids are carried out to give a picture of labour and labour conditions in aquaculture.

7.1 Aquaculture in the Times of COVID-19

COVID-19 has left no sector untouched. Aquaculture, like agriculture and fisheries, saw disruptions both in production cycles and supply chains (FAO and CELAC, 2020). Government measures that declared aquaculture along with fisheries as essential sectors and allowed its functioning while adhering to Covid-19 protocols have been of help. Some of the states such as Andhra Pradesh took steps like declaring a minimum price for aquaculture products and capped the price for seeds etc. (Kumaran et al, 2021). However, it applied only to species such as shrimps which were targeted for export markets. This could be a step to ensure that farmers do not stop producing shrimps which could impact future prospects of shrimp exports, a prominent foreign exchange earner. The practitioners of freshwater culture and dependents were left without similar solutions. But even the steps taken for shrimp culture had only a limited impact as the shrimps harvested were not up to the mark in quality, making traders hesitant to buy at the minimum price put forth by the government. A study in Malaysia, which also holds true for all aquaculture producing countries including India, found that market demand and logistics bottlenecks were the worst for aquaculture (Azra et al, 2021). This compounded the problem of saleability of the early harvested inferior quality shrimp (not only due to its small size but also spoilage caused by mishandling due to the unavailability of skilled labour post the nationwide return migration witnessed) (Kumaran, 2021).

With the aquaculture sector supporting 36 million direct employment, with at least three times as many in allied sectors, the human impact of an event such as Covid-19 is humongous (FAO, 2021). One of the coping mechanisms exhibited by farmers during the pandemic was to retain fish for longer periods of time in ponds, thereby considerably increasing the production cost (OECD, 2020). Most of the cultured animals are preferred within a size category and this holds more true for freshwater culture. For instance, the preferred weight of *rohu* by consumers is usually between 1-2 kg, thus affecting the uptake of these from the market and eventually the price. This depression of price for commodities produced at a higher cost (due to longer duration of culture) is a double whammy for farmers. However, with regard to shrimps, bigger is always better. But the economic downturn that followed the pandemic reduced the accessibility to markets as well as the purchasing power of the consumers. Thus, the export oriented shrimps were sold at very low prices in local markets. Such variability in price and the pressure of greater cost of production has led farm owners to adopt many measures to cut cost.

The general approach to reducing cost in any production system is to save labour cost. Reflection of this can also be seen in the guidelines for sea cage farming brought out by the NFDB. The optimum size of cages used for culture is fixed at 6m diameter as it employs less labour and is thus economically preferable. Thus, the first casualties in the sector were labourers, especially those who

were casually employed (Sara, 2021). Around 30-40% of labour in the Indian aquaculture sector lost their jobs (Kumaran et al, 2020). This also had repercussions on the retained labour who were burdened with additional work without commensurate increase in compensation. Basic job retention itself was considered as a grace during these tough times. No salary assurance; no subsistence allowance; no social security measures etc. even for full time labour became extremely challenging especially during these times (Kumaran et al, 2020). Azra et al's study (2021) indicates that people in large and medium farms were replaced easily with technology wherever possible in comparison to small and micro farms where labour was local or employed in their own farms. The study also goes on to say that the labour recovery in aquaculture was slow and indicated a U curve while the other sectors exhibited a V-shaped recovery. The worst affected were women during the pandemic and among them the worst hit were the casual labourers similar to men in the sector (Sara et al, 2021). The study states that businesses employing women took a harder hit than those employing men. This further dims the prospects of women getting employed in the future. The only positive trend that is seen in post-covid times is the pay parity observed in the sector. However, this could imply that only skilled women were retained in the sector while the unskilled and women employed as lower wage casual labour lost their livelihoods.

To help aquaculture labour to tide over future scenarios like Covid-19, the sector should implement social security measures; minimum wages, health cover, life insurance etc., at least for full time labour (Kumaran et al, 2021). However, to realise this, the casually employed labour has to be replaced with formal contractual labour. This will also help put a figure to the number of people employed in the aquaculture sector.

In the policy response to the Coronavirus by the OECD in 2020, it is said that fishers/farmers who sold directly to consumers faced less difficulty in selling their products. There was a surge in online marketing platforms during Covid-19, especially targeting the higher economic class (Azra et al, 2021). However, how many farmers were able to use these platforms to bring their produce to the consumer needs to be analysed. It may be safely assumed that the numbers will be low. Though the consumer needs to be analysed. It may be safely assumed that the numbers will be low. Though the OECD paper implied that those who sold their products directly to supermarkets/consumers were able to survive, it holds true even for small-scale family-owned aquaculture markets in India where the produce is consumed by the farmers' family or by the local community. Such farmers would also have benefited from the market situation during the pandemic as they faced lesser competition from the outside, thereby getting a higher price for their produce (BBC News: Afrique, 2020 in FAO, 2021). One of the recommendations given by OECD in its policy response to corona, is to tide over similar situations in the future by pushing for local produce consumption.

Covid-19 and the situation thereafter has initiated a trend to replace long duration species (such as carp) with shorter life span species such as shrimps and pangasius in freshwater fin fish culture (FAO, 2021). Due to limitation of available hatchery technologies, this would also concentrate production to a limited number of species. However, farmers who adopted the integrated multi-trophic aquaculture systems had lesser impact due to Covid-19 and held up better despite multiple stressors (Sara et al, 2021). This underlines the importance of adopting multispecies culture techniques in aquaculture compared to single species intensive culture.

Due to massive migrations (internal displacements) witnessed in many parts of the world especially in countries like India, Bangladesh etc, the trader community also saw a shift from being dominated by members of the outside community to the local community members who returned from cities due to pan India lockdowns. This indicates that aquaculture has the capacity to provide jobs to members of the local community when favourable situations arise.

8. Women in Aquaculture

Women's work in any sector requires effort to be highlighted as most of the productive sector is seen as man's work, and more so in fisheries and aquaculture. When workers in aquaculture itself are unaccounted for, one can only guess at what the place of women in such statistics would be. This is at a time when the proportion of women in the world aquaculture work force (19%) is more than that in fisheries (12%) (SOFIA, 2020).

Women did aquaculture in their backyard ponds as an extension of their household duties, especially in the flood plain regions of India, namely West Bengal, Odisha, Bihar, etc. Shanthi et al (2012) say that women's involvement in India varies from place to place, and even within that, it varies amongst castes, religions, and positions in the family hierarchy. Women usually take part in aquaculture to support the work of men in the family. Through the case studies given by Shanti et al (2012), it is evident that women take up traditional roles in aquaculture, and when they are organized and strengthened under structures such as self help groups, even complex tasks are taken up. This is more visible and functional in areas where temporary women-headed households are higher in number due to migration of men to other places in search of work. However, it is seen in cases where farms are at a distance from home, women are not allowed to stay at the pond site during the night due to reasons of physical safety. Nevertheless, it requires her to shuttle between the house and the pond site, adding burden to her time and energy (Shaleesha & Stanley, 2000).

In freshwater and brackishwater aquaculture, women are involved in various activities such as carp breeding, nursery raising, carp polyculture, breeding of catfish, freshwater prawns, in backyard hatcheries, ornamental fish culture (both breeding and culture), and feed preparation for carps and prawns (Shaleesha & Stanley, 2000). They also earn supplemental income, for example in 0.1 ha of pond, they raise 150,000 fry in about 15-20 days and earn around INR 5,000. Their role in culture is also high with respect to the culture of seaweeds, mussels, oysters, pearls etc. Activities such as ornamental fish hatchery provide women with a continuous income when compared to agriculture labour. However, there is also resistance in employing women in aquaculture in contrast to that of agriculture. Therefore, the conversion of agricultural land to aquaculture heavily impacts women's meagre income.

Observations of a ten-state study done by Nandeesha (2011) indicates that women participation in aquaculture varies from state to state as given in Table 12 below:

Table 12: Women in Aquaculture

State	Women Participation	Activities	Trend
Andhra Pradesh	Women Participation very low		
Manipur, Assam, Tripura and West Bengal	Greater involvement. However, more participation of women seen in animal rearing	Pond fertilization; nursery rearing; fish feeding and harvesting	Increasing participation especially due to the involvement of SHGs. It is seen that there is considerable increase in production (15.19%) when women get involved
Punjab and UP	Negligible presence of women in aquaculture	Community ponds are leased out to labourers from Bihar and UP	Non-participation of women in aquaculture in northern states is due to the lack of knowledge, the traditional beliefs and taboos
Orissa	Greater participation of women in aquaculture among weaker sections of the community	31% of work force in aquaculture comprise of women	
Jharkhand	Women participation negligible		
Manipur	Highest participation of women in aquaculture. There is no social taboo or social stigma in getting involved in aquaculture across class	Participation of women is more visible in nursery rearing, feed preparation, marketing (exclusively); participation is high in integrated aquaculture as well as small-scale aquaculture.	

Source: Compiled from Nandeesha (2011)

Women became part of the aquaculture industry early on as shrimp seed collectors, even from the 1990s and 2000s. However, their engagement varies according to the type and scale of aquaculture, for e.g., women are more involved in freshwater culture than mariculture. It is often noted by studies that women get excluded when the culture systems progress from being extensive to intensive systems (Brugere and Williams, 2017). Women are also the most impacted groups due to aquaculture. For instance, salinisation of water sources due to brackishwater aquaculture farms; or depletion of water due to water mining for freshwater culture has increased the drudgery of women who are the main water bearers in rural families. They are forced to travel long distances to provide water for the family, taking away much of their free time which could be used for other (socially or economically) gainful engagements. Contamination of land and water has also taken away employment (such as agricultural work) from people in many areas which has resulted in migration to other places in search of work. Usually, it is the men who migrate, leaving their family behind, with the women left to tend to the household chores, the children and the elders, resulting in a kind of physical, emotional and mental bondage.

Aquaculture aimed at profits includes only a few marketable species. With increasing spread of aquaculture and more water bodies coming under culture, indigenous varieties of fish are often slowly wiped out from the local markets, ecosystems, and diet. These are usually small indigenous fish species which are an important source of food security and nutrition (and micro-nutrition as they are a rich source of vitamins and fatty acids) and their loss impacts the dietary culture of the

local population. Moreover, the availability of fish in the diet, especially for rural women, stands a higher chance when smaller fish is cooked in comparison to bigger fish (usually served first to men followed by children, with women served last or often left with only the gravy of the dish (ICSF, 2010). Thus, with advancements in aquaculture, women could stand to not only lose out on employment and financial independence but also on food and nutrition security.

9. Conclusion and Recommendations

Without doubt, aquaculture in India is poised for further exponential growth. However, the sector's development so far has been heavily production oriented through improving technologies and culture systems to increase production per hectare, labour productivity etc. The 33rd session of the Committee on Fisheries (COFI) recognized the increasing importance of the sector not only to total fish production but also to improved livelihoods, increased income, poverty alleviation, in ensuring food and nutrition security; and thereby, its undeniable potential in contributing towards realising many sustainable development goals such as -- no poverty (1), zero hunger (2), good health and wellbeing (3), gender equality (5), decent work and economic growth (8); reduced inequalities (10); sustainable consumption and production (12); climate action (13); life below water (14) and life on land (15).

While India contributes only 8% to total aquaculture production in the world, it is home to 4.2 million aquafarmers - the second largest aquafarmer population in the world. China's figures for the above are 57.9% and 4.7 mn respectively, proving that even now, aquaculture in India is heavily labour dependent. The objectives of many aquaculture related national and state policies are drawn with the hope that the measures recommended could increase monetary returns that could trickle down to the local community and increase their well-being. However, if the above mentioned SDGs are to be achieved by 2030, it is imperative that aquaculture is streamlined towards an environmentally sustainable, socially just model, with the various policies taking into their fold the dependent population (directly and indirectly) and addressing their concerns through a human rights-based approach.

9.1 Aquaculture Development with a Human Face

Though the scientific community, policy makers etc., may be well aware of the environmental and social impacts of aquaculture (especially intensive), they may not fully acknowledge its extent. This is reflected in the fact that the available literature on aquaculture is mostly production and system oriented, with a few dealing with environmental aspects. Any paper on human concerns of the sector is hard to come by. With further expansion of the sector, a commensurate increase in the number of workers is inevitable. The intensification and the subsequent rush to profiteering, would invariably raise concerns over access to decent work, fair wages, pay parity, safe-secure-and-hygienic working conditions, access to adequate resting hours and resting conditions, freedom of movement and association, etc. Therefore, to acknowledge the human dimensions of aquaculture, the human face of aquaculture needs to be made visible.

According to ILO (2021), inclusive growth and decent work are non-negotiable for attaining sustainable development. Statistics play a major role if inclusive growth is to happen. India is one of the few countries with a sound system of recording land holdings with detailed data. The agriculture census collects data on agricultural holdings, tabulated based on different size classes (marginal, small, semi-medium, medium and large), and also the different social groups. The Government of India website on Agriculture Census indicates that the above said disaggregated data collection is crucial towards formulating developmental plans, socio-economic policies, and establishment of national priorities. Government of India through the Central Marine Fisheries Research Institute also provides disaggregated census data on marine fisheries up to the fishing hamlet level; on the degree of mechanisation; active/inactive fishers - based on age, sex, literacy, engagement with the sector (direct/indirect) etc. Though the aquaculture sector is projected as the future of fish production, it is bereft of any data on the types of work and the humans dependent on them. The last set of disaggregated (full time/part time) data on aquafarmers was given by the 17th Livestock Census of 2003. The National Fisheries Policy (NFP Sixth Draft) 2020 talks about regular census of fisheries resources and operations but a clear mention of inland fisheries and aquaculture census, as indicated in the earlier draft of this policy (the National Inland Fisheries and Aquaculture Policy, 2019) is lacking. It is of utmost importance that this necessary action is put back into the current NFP.

Further, COVID-19 has brought to the fore the requirement of formalising the workforce in aquaculture. It highlighted the lack of fairness of employing casual labour where during emergencies such as the pandemic, labourers were left without any means of survival in terms of wages, sustenance allowance, social security etc. The non-committal nature of the job has forced labour to leave at the first instance of the threat of a lockdown and the prospect of being without a job outside their state/village. Though this hurt the labourers the most, it also impacted the standing crops as well as the farmers who employed them. The fallouts of Covid-19 will be felt in the future as both downstream and upstream industry were impacted by the closing down of farming activity. This is where the recommendations suggested by Kumaran et al (2021) to implement social security measures, minimum wages, health cover, life insurance etc., at least for full time labour, hold water. The situation underscored the requirement of accounting the unaccounted, thus the emphasis on proper statistics and policies that safeguard work and ensure fairness at workplace for those employed by the aquaculture sector. For this to be achieved, a census providing disaggregated data of work is a mandatory requirement.

As is the case in most of the developing countries that are aquaculture leaders, the sector in India too is predominantly characterised by small-scale aquaculture farms. Aquaculture Big Number

(FAO, 2016) indicates that small-scale aquaculture and value chains oriented around them are estimated to provide more employment in comparison to medium and large farms. It is witnessed that these farms display more equitable distribution of wealth; where local and worker food security is more possible; which have been least affected by the three-year pandemic ravaging the world; which are more biodiversity friendly and have less of an ecological footprint; and moreover, as the sector that absorbs the maximum of labour, a major aspiration for any government in power. Aquaculture has more representation of women (19% of the total farmers) compared to 12% of fishers, and within that, small-scale and medium-scale aquaculture sees more women representation globally. But over the years, their representation has decreased with increased intensification and modernisation of the sector, making them dispossessed in varying magnitudes. These issues are easily visible and taken note of (especially its magnitude) when it is quantified.

In addition to raw statistics, studies to bring out the human aspects of aquaculture need to be undertaken and widely disseminated. This will encourage the scientific community, researchers, policy makers, NGOs etc. to take a more focused outlook towards applying a human rights-based framework to aquaculture. Thus, the major recommendation of the study is to increase visibility of the human face of aquaculture by ensuring that the humans in aquaculture and those impacted by the sector are counted and accounted for in planning, policies, schemes, social welfare measures etc.

9.2 Develop and Implement a National Aquaculture Legislation based on a Human Rights-based Framework

The uncontrolled proliferation of aquaculture and the commensurate increased land use changes --

- could alienate the local community from their traditional livelihoods (conversion of agricultural lands, as seen in Andhra Pradesh, Punjab, Haryana, Odisha etc. - making even cereals, otherwise available from their own agricultural land into a priced commodity to be sourced from the market);
- could lead to conversion of lakes to aquaculture ponds (as seen in Kolleru Lake where capture fisheries and cultivation of water vegetables thrived before the introduction of aquaculture ponds); conversion of mangroves/mudflats (which were food mines for local communities providing food/income supplements especially during lean seasons) into aquaculture ponds; conversion of freshwater aquaculture ponds to brackishwater aquaculture ponds (as seen in Sundarban area of West Bengal where brackishwater culture is more capital intensive than freshwater, and has nudged the economically lesser privileged out of the sector, where renting out of land or selling the land to bigger farmers seems more profitable than culture);
- could cut off access to traditional fish food especially by the economically weaker section and

impact their food culture (due to hiked price encouraged by the unavailability of species caused by habitat change/eradicating native species to make way for high value culture/preference to sell fish to FMFO industries rather than local markets etc.);

- could hinder local communities from free usage of common property resources available for several activities (water for irrigation, potable water or other household activities, watering holes for animals); curtail access to traditionally used living and livelihood spaces (this is a concern with regard to cage culture that is promoted in coastal waters and inland open water bodies).

This brings up the question of a legislation for aquaculture in India (the requisite for a rule of law as indicated in the guiding principles of the SSF Guidelines. Despite being the second largest producer of aquaculture in the world, India does not have a dedicated policy covering all forms of aquaculture till date. The existing Coastal Aquaculture Authority Acts & Rules of 2005 is applicable only to the coastal, brackishwater and saline water aquaculture systems and not to freshwater systems. An effort towards this was taken in the form of the National Inland Fisheries and Aquaculture Policy (NIFAP Draft) 2019, and National Policy on Mariculture (NPM, 2018). However, both these draft policies were subsumed by the formation of the National Fisheries Policy (NFP, draft) 2020 which does talk about aquaculture in detail but has dropped many socially and environmentally sensitive points of its earlier drafts. Though NIFAP 2019 had indicated that aquaculture development will be in alignment with relevant national and international agreements such as the SSF guidelines, the NFP has taken off the mandatory tone and indicated that all efforts will be made to implement the provisions of the SSF guidelines in small-scale fishing. A few guidelines and policies developed by the Centre as well as individual states have certain dimensions of a rights-based approach. These could be viewed as initial steps towards a human rights-based framework for aquaculture development.

Guidelines for Fisheries Development in Reservoirs emphasise the need to ensure that benefits of such efforts accrue to the poorest of the poor. Guidelines for Cage Culture in Inland Open Water Bodies of India acknowledge - the tenurial rights on cages and right to fish as the primary rights of local fisher communities; advises against augmenting fish production by negatively impacting the livelihood of traditional/local fishing community; the need to ensure aquaculture growth to be sustainable and inclusive; underlines the importance of being in harmony with the principles of ecological integrity, natural resource conservation without conflict with other users of water and land; and suggests a precautionary approach while dealing with data deficient systems. The guidelines further emphasise putting in place safety at work for farmers and workers of cage culture

systems, and that the main achievable from any intervention in aquaculture should be an improved standard of living for the weakest of the society rather than just achieving production goals. The Guidelines for Adoption of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) acknowledge aquaculture ponds as a social protection measure to help small and marginal farmers. The focus on small farmers is clear with support provided through Mission Fingerling Programme where ponds with shorter water retention are encouraged to take up fingerling rearing. Some state policies also stand out with regard to social and ecological commitments. For example, the Kerala Inland Fisheries and Aquaculture Act 2010 specifies the need to consult local self-government bodies before any public water body is to be notified for aquaculture. The legal provisions offered through the West Bengal Land and Land Reforms Manual 1991 is a step in this direction as it prohibits the granting of private lease to fishery that excludes the rights of the public on the water body. The Kerala Fisheries Policy 2019 has an eye towards better conservation of biodiversity as well as providing a continuous source of income, livelihoods, and food security; and encourages rotational cropping systems for aquaculture where finfish crop is cultivated after shrimp crop. The policy also promotes organic aquaculture and traditional methods of culture such as those seen in *pokkali, kol* and *kaippad* areas. The policy looks at any measure suggested as a way to improve social security provisions for fish farmers and underlines the importance of conservation through people's participation. Thus, this policy acknowledges and promotes small-scale aquaculture and underlines the need for it to be environmentally sustainable, socially sensitive, inclusive and equitable (gender wise as well).

With respect to aquaculture, where the labour and human involvement is not adequately clear, one can only guess at the status of women in the sector. Women always lack proper mention in sectors even when their contribution is evident and considered to be an important link in the whole activity. This is where the Kerala Inland Fisheries and Aquaculture Policy gains importance when it acknowledges that 66% of workers in aquaculture in the state are women. This, the policy emphasises, necessitates a targeted approach and measures for their upliftment and empowerment. Similarly, the West Bengal Fisheries Policy 2015 not only underscores the need to encourage women in all aspects of aquaculture but also lays stress on the need to ensure equity in access, tenure, participation and sharing of benefits. Though the National Policy on Mariculture (2018) recognised the active role of coastal women in mariculture systems, especially of bivalves and seaweeds, and how it led to increased household income/social empowerment etc and underscored the requirement of providing financial and technical support to these women, the new (Draft) NFP fails to mention any of these targeted measures and adopts the usual generalised approach of gender mainstreaming. However, NFP does underline the importance of a congenial workplace, including providing amenities and working conditions (though these are not further qualified).

The Odisha Fisheries Policy 2015 and the West Bengal Fisheries Policy (WBFP) 2015 talk about encouraging small-scale fish farmers; integrated fish farming; rice-fish farming; backyard/household ponds; adoption of good aquaculture practices (GAP); promoting organic aquaculture; encouraging small indigenous freshwater fish species (SIFFS) wherever feasible. These states also lay emphasis on the inclusion of SIFFS in the mid-day meal scheme of children and expectant mothers. The Odisha Fisheries Policy is also unique in that each measure it adopts also indicates the amount of employment it creates. Though this could be a measure thought out in general by the government to increase employment generation, it is a welcome step as it acknowledges the labour dimensions of the sector. The West Bengal Fisheries Policy 2015 stands out in being environmentally sensitive and lays stress on putting up a binding minimum with regard to environmental protection. OFP 2015, and especially WBFP 2015, caution towards a thoughtful implementation of mariculture activities and emphasise on putting in place a sound implementable legal and management framework before mariculture is promoted.

Though the key principles laid out in most of the above mentioned documents exhibit glimpses of a human rights-based framework, the aims and objectives follow the traditional route of increasing production and exports. For instance, though the NFP sounds encouraging given its cardinal principles of equity and equality; people centric, participatory approach; striving to achieve ecologically healthy, economically viable and socially inclusive sector contributing to the economic prosperity and well-being of the fishers and fish farmers etc., when it comes to its aims and objectives, the focus shifts towards achieving an increase in production (through vertical and horizontal expansion), doubling exports etc. It applies a benefactor/beneficiary approach when schemes/measures are talked about. The policy identifies low input and low investment as a hurdle for the sector to embark on an ambitious growth tangent, indirectly hinting at increasing investment and inputs for achieving higher production. This increased focus on hiking the tonnage/ha can have severe environmental repercussions leading to immense social and human impacts. The Odisha Fisheries Policy indicates that since there is no availability of land for horizontal expansion of aquaculture, intensification of existing aquaculture ponds is the way forward. It talks about increasing tonnage/ha to six from the current two to three through sustainable intensification (though what that entails is not spelt out). According to the NEERI study, for an increase beyond 3t/ha yield for shrimp (requiring 4-6t/ha feed), the farm would require feed input in the magnitude of 15t/ha for any additional tonne/ha. This will increase the organic load on pond water and cause subsequent effluent pollution (feed pollution being more toxic than sewage waste). What the impact of such a measure will be on nearby water bodies, agricultural land etc., cannot be fathomed.

This throws light on the fact that though most of the policies talk about people's participation, equity, sustainable development, environmental concerns etc., they fall short of these considerations when it comes to application. Most of the aquaculture farmers in India are small-scale, many of them traditional aquaculture dependents (part-time or full-time). The emphasis on increase in investments and inputs could alienate these farmers from the sector, especially those from the lowest rung of the economic ladder. This allows outside investors to fill the void and their advent could commence a chain reaction of labour struggles and conflicts. As noted by Salagrama (2006), the outsiders who are owners but not operators mostly aim at maximising profits and therefore bring their own cheap labour from far off areas, impacting the local labour force and hence their bargaining ability for better wages. This could result in violence as well as violation of labour rights.

The Odisha Fisheries Policy (OFP) 2015 and the Kerala Fisheries Policy (KFP) 2019 stand out among other policies as they underline the importance of people's participation. OFP 2015 indicates the lack of the above as one of the key issues and challenges facing the sector and emphasises the importance of community participation for ensuring better livelihoods, food, nutritional and social security to the fishers. KFP 2019 also indicates that conservation is better achieved through people's participation.

Though some measures advised seem encouraging, they could be detrimental if applied without much thought. For instance, one of the objectives of Pradhan Mantri Matsya Sampada Yojana (PMMSY) is to increase the bargaining power of fishers and fish farmers through collectivisation - similar to the efforts by the fishworkers unions in the marine fishing realm. Currently, the aquaculture sector lacks collective action or position or a unified front, and as observed by PMMSY, which if present will better their lives and livelihoods by increasing their bargaining power. However, PMMSY envisages this shift through the Fish Farmers Producer Organisation (FFPO) which raises two problems – firstly it negates the already present extant system of FFDAs and BFDAs. Instead of instituting new structures, it should concentrate on making the structures already in place more effective and efficient. OFP 2015 shows the way when it says that new FFPOs will not be allowed and the capacities of existing FFDAs and BFDAs will be strengthened. Secondly, even the current FFDAs and BFDAs are mostly used as a benefactors' portal for disbursement of goods and services and fail to work towards making farmers (especially small-scale farmers) politically aware. They do not function as platforms for putting forth their demands and concerns. This can be achieved only through collectivisation within the aquaculture sector.

India being the second largest aquaculture producer in the world, with most of its aquaculture farms being small/medium type (with respect to size and production tonnage); with considerable

absorption of labour, one should demand for drafting of a National Aquaculture Policy and a National Aquaculture Leasing Policy (with specific guidelines for each type of system) based on a human rights-based framework. This can be inspired by the various human rights elements as seen in the documents discussed above and also draw from the principles of the SSF Guidelines. All the guiding principles of SSF Guidelines fit well for the aquaculture sector as they ensure human rights and dignity; respect of cultures; non-discrimination; equity and equality (including gender); consultation and participation; rule of law; transparency; accountability; economic, social and environmental sustainability; holistic and integrated approaches; social responsibility; feasibility and social and economic viability etc.

It is timely that a demand for such a legal provision is made as the Food and Agriculture Organization of the UN is calling for sustainable intensification; prepares for the drafting of the Guidelines for Sustainable Aquaculture; prepares for the International Year of Artisanal Fisheries and Aquaculture where well-being; social-inclusion; equitable development etc., is discussed; in a scenario where the countries are striving to attain sustainable development goals; as a sector which could contribute to various SDGs as indicated at the start of the chapter. India is a land of good and well thought out legislation. However, any aquaculture legislation could be made good on the ground with proper monitoring and controls that help avoid indiscriminate intensification of aquaculture that could lead to large-scale environmental and social impacts.

9.3 Recommendations of the Study

The study recommends the following:

- Putting in place systems to develop an aquaculture census similar to the agriculture census in India and ensure periodic conduction of the same. Different types/categories of work in aquaculture is documented and disaggregated data on labour in these categories of work such as men/women; part-time/seasonal/full-time; etc., is arrived at. This would help count the uncounted and lead to formulation of fair and effective policies with respect to aquaculture. The census will also help implement social security measures; minimum wages, health cover, life insurance etc., for all aquaculture labour (irrespective of formal/informal; part-time/full-time); which ensures the wellbeing of the dependent population and thereby a dignified life.
- Progressively formalise work in aquaculture irrespective of them being men/women; full time/part-time/seasonal; migrant/local etc.
- Develop, adopt and implement a national aquaculture policy and an aquaculture leasing policy adapted to specific culture systems; ensure that these instruments are firmly based on a human rights-based framework.

- Further small-scale aquaculture, the salient features of which among others include greater employment opportunities; equitable distribution of wealth; improved food security and nutrition; greater involvement of women; conservation and sustainable use of biodiversity.
- Ensure that multitrophic multispecies approach in aquaculture is preferred to single species culture, especially in rural areas where this kind of culture offers continuous employment rather than in pulses. This multitrophic approach also held good during the pandemic where one or the other species helped seek out multiple markets ensuring income for the practising family; single species approach often leads to intensification for the market, catalysing vertical integration leading to replacement of labour with technology; multitrophic species also leave a lesser ecological footprint in comparison to single species intensive culture system.
- Adopt measures that ensure women's involvement and employment in aquaculture. This would help in equitable distribution of wealth within the family and also ensure the well-being of the family. This is possible by supporting small-scale family-owned aquaculture wherever possible, especially in rural areas. Various research indicates that as aquaculture intensifies and responds more and more to the market, where its role transforms from a multiple service provider (towards food, livelihoods, employment, income etc.) to a single service provider (mainly grown as cash crop) with respect to the family, women face dispossession of various magnitudes – economic, stature within the family and community etc.
- Conduct and disseminate more studies from a human rights perspective of aquaculture to bring out facets of the sector that are currently unknown or ignored.

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A Case for a Human Rights-based Approach to Indian Aquaculture Systems

Aquaculture is the new sunrise sector with respect to fish production. Developing countries of Asia are the world leaders, with a large population dependent on the sector. Though a plethora of literature is available on aquaculture, there is a lacuna with regards to specific studies on the human rights aspects of the same. This study is an effort to bring focus on this void and the facets that need to be examined if aquaculture is to become sustainable and is able to contribute towards various sustainable development goals as envisaged. As the human dependence on the sector is very high, the study emphasises the need and importance of placing a human rights-based framework at the centre stage of future growth of aquaculture in India. This will steer the development towards an environmentally sound and socially just path, a prerequisite for the sector. The objective of the study is to understand the strengths of legislation, guidelines, schemes and other government documents with regard to the defence of human rights; review and analyse the environmental and social impacts of aquaculture systems as seen in the literature review; and to suggest a set of recommendations that could help fill the gaps in the current systems as identified by this study. The monograph will be of use to researchers, scientists, fishworker organisations, environmentalists and anyone interested in aquaculture development in India.

International Collective in Support of Fishworkers (ICSF) Trust

The International Collective in Support of Fishworkers (ICSF) Trust works towards the establishment of equitable, gender-just, self-reliant and sustainable fisheries, particularly in the small-scale, artisanal sector.