Fisheries development in Majharia *maun* of Bihar through refinement of site-specific fisheries enhancement technology





ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata-700 120, West Bengal

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PREFACE

A significant portion of Bihar's population relies on the state's diverse fisheries resources for both livelihood and nutritional security. Bihar, the 13th largest state in India, spans an area of 94,163 km² and is geographically positioned between latitudes 24°20'10" N to 27°31'15" N and longitudes 83°19'50" E to 88°17'40" E. Situated along the Ganga River basin, the state comprises 38 districts, with 21 in North Bihar and 17 in South Bihar.

The plains of Bihar are nourished by the Ganges and its tributaries. In the north, these include the Gandak, Budhi Gandak, Koshi—originating from the Nepal Himalayas—and the Bagmati, which originates from the Kathmandu Valley and frequently causes seasonal flooding. In the south, the state is drained by tributaries such as the Son, Punpun, and Falgu rivers. Bihar is rich in aquatic resources, encompassing rivers, floodplain wetlands (such as oxbow lakes and seasonal floodplains), reservoirs, ponds, and tanks.

Despite having approximately 3,200 km of river systems, 200,000 hectares of floodplain wetlands (Chaurs), 9,000 hectares of oxbow lakes (*Maun*s), 26,303 hectares of reservoirs, and 93,296 hectares of ponds and tanks, the state faces a shortfall in fish production. Bihar's annual fish output stands at 7.62 lakh metric tons (MT), whereas the demand is 8.02 lakh MT, leaving a supply gap of 0.40 lakh MT.

To address this gap, strategic development and implementation of fisheries and aquaculture initiatives are crucial. Given Bihar's vast untapped potential, the expansion of open-water fisheries should be prioritized through collaboration among various organizations.

This document presents the outcomes of efforts led by the ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) to introduce and promote fish production technologies for inland open waters, particularly wetlands. The project, titled "Fisheries Development in Majharia *Maun* of Bihar – A Pilot Project," was funded by the National Fisheries Development Board (NFDB), Hyderabad, Telangana. The initiative was carried out in Majharia *Maun*, located in the Piprakothi block of Motihari district, Bihar, between 2018 and 2021. The project involved active participation from the Piprakothi Prakhand Matsyjeevi Sahyog Samiti Limited and received support from the State Fisheries Department, Government of Bihar.

The document provides an assessment of the fishery status in Majharia *Maun* before the project's implementation. It outlines the technologies and strategies adopted to overcome challenges, highlighting the success achieved in enhancing fish production. Additionally, it presents recommendations for further development of wetland fisheries in Bihar.

This publication aims to serve as a valuable resource for policymakers, planners, fisheries officials, researchers, and other stakeholders engaged in the advancement of Bihar's fisheries sector.

B. K. Das, Director, ICAR-CIFRI

Executive Summary

The ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore, conceived and implemented an innovative project under the Centrally Sponsored Scheme (CSS) Blue Revolution, with funding support from the National Fisheries Development Board (NFDB), Hyderabad. The project focused on integrated wetland management aimed at enhancing fish yield and improving the livelihoods of fishers, while also strengthening infrastructure, linkages, and institutional arrangements. The sanctioned project, titled "Fisheries Development in Majharia *Maun* of Bihar – A Pilot Project (2017–2021)," involved a range of key activities undertaken by ICAR-CIFRI. These included strengthening existing infrastructure, developing new facilities, upgrading the skills of local fishers, and augmenting fish production from Majharia *Maun* to ensure sustainable livelihoods for the community.

i. Infrastructure development for implementation of fisheries management technologies

ICAR-CIFRI developed key infrastructure including three earthen nursery ponds covering a total area of 1.5 hectares, a 0.8-hectare "CIFRI HDPE pen," six "CIFRI GI" cages, and water screen nets installed at the inlet and outlet of the wetland. These ponds and enclosure culture systems were successfully utilized for seed raising of Indian Major Carps and three exotic carp species—common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and Amur carp (*Cyprinus carpio haematopterus*)—as well as *Singhi* (*Heteropneustes fossilis*). This initiative ensured the availability of fish seed of the right size, quantity, and quality throughout the year, enabling timely stocking in open wetlands.

ii. Distribution of fishing implements and fish feed

The fishers were empowered through the distribution of one 12-foot FRP (Fibre-Reinforced Plastic) boat, two wooden boats, and 300 monofilament gill nets. These boats were used by community members for various common purposes, including cage and pen monitoring, security patrolling, and fishing activities within the wetlands. A total of 5.7 tons of "CIFRI CAGEGROW" floating commercial feed was provided for feeding fish in the ponds, pens, and cages.

iii. Fish seeds stocked for enhancement of fish yield

Fish seed stocking was carried out through both direct and indirect methods. A total of 5,024 kg of seed was stocked directly into the *maun*, while 829 kg of seed was stocked in ponds. The stocked species included Indian Major Carps (*Labeo catla*, *Labeo rohita*, and *Cirrhinus mrigala*), along with three exotic carp species—common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon*

idella), and Amur carp (*Cyprinus carpio haematopterus*). Additionally, Singhi (*Heteropneustes fossilis*, 25 kg) and Pangasius (27 kg) were stocked in ponds. A further 574 kg of carp seed was stocked in pens. These stocking efforts supported fish production in open wetlands, nursery ponds, cages, and pens.

iv. Implementation of Culture Based Fisheries and livelihood improvement

a. The integrated Culture-Based Fisheries (CBF) technology, standardized by ICAR-CIFRI, was implemented in the Majharia *Maun*. The adoption of this scientific CBF approach led to a significant increase in both fish yield and the number of fishing days. Under the fisheries enhancement programme, fish yield from stocked species improved steadily each year—from 62.0 kg/ha/year in the first year (2017–18) to 106 kg/ha/year in 2019–2020—along with a notable improvement in catch per unit effort (CPUE).

b. The number of fishing days based on stocked fish increased from 35 days in the first year to 78 days in the third and final year of the project.

v. Enabling fishers through capacity building and skill development

The developmental activities were implemented in a participatory mode, with a strong emphasis on capacity building of beneficiaries through awareness programs, exposure visits, demonstrations, and hands-on training. ICAR-CIFRI organized two workshop-cum-training programs and one specialized training on fisheries management in the wetlands of Bihar. Under this project, around 300 fishers benefited from these skill development and training initiatives.



Project Details

(June2018–March 2021)

I. Title of the scheme	**: Fisheries development in Majharia *maun* of Bihar through refinement of site-specific fisheries enhancement technology - An Innovative project**
II. Location	
· Name and address of the of the executing institute	**: ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata 700 120, WB**
· Name and address of the of the Head of the Institute	**: Dr. B. K. Das, Director, ICAR-CIFRI, Barrackpore, Kolkata-700 120, West Bengal**
· Project site	**: Majharia *maun*, Piprakothi, East Champaran**
III. The Scientists involved in the project	Dr. B. K. Das, Director & Chief Coordinator Dr. M. A. Hassan, Principal Investigator (PI) Mr. Ganesh Chandra (Co-PI) Dr. K. M. Sandhya (Co-PI) (till 10th July. 2018) Dr. Suman Kumari (Co-PI) Dr. Gunjan Karnatak (Co-PI) Dr. Raju Baitha (Co-PI) Mr. Mishal P (Co-PI) Dr. Lianthumluaia (Co-PI) Dr. Himanshu Sekhar Swain (Co-PI)
IV. Funding support	**: National Fisheries Development Board, Hyderabad, Telangana**
IV. Total sanctioned budget	**: Rs. 105.00 Lakhs only**
V. Duration	**: 3 years (April 2017-March 2020)**

1. Background

India ranks second globally in inland fish production, following China, but the disparity in production between the two countries remains vast. Over the past decade, India has experienced a significant surge in inland fish production, surpassing the growth of marine fisheries. As of 2020, the estimated fish yield from inland open water resources stands at 1.7 million metric tonnes (MMT), contributing approximately 17% to the total inland fish production (FAO, 2020).

Unlocking the full production potential of reservoirs and wetlands presents an opportunity to bridge the existing demand-supply gap. This can be achieved through the horizontal expansion of advanced technologies, the implementation of semi-intensive enclosure culture systems, capacity-building initiatives for skilled workforce development, and improved fisheries governance backed by policy support. Research-driven fisheries management strategies, particularly those developed by ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), have significantly enhanced the productivity of various wetland ecosystems through scientific stocking practices. The institute's extensive outreach initiatives—comprising training programs and workshops across India—have been instrumental in boosting wetland fish production, particularly in states like West Bengal and Assam.

However, these technological advancements are yet to make a significant impact in Bihar, despite the state's vast potential for fisheries development. Bihar's wetlands, which possess an ideal ecological setting for fisheries growth, continue to underperform, yielding an average of 500-700 kg/ha/year, which is below optimal levels. Prioritizing targeted interventions in this sector—such as infrastructure development, strengthening market linkages, and fostering training and capacity-building programs—can drive inclusive growth in wetland fisheries. The adoption of region-specific technologies and tailored management protocols can play a key role in increasing fish yield, supporting the Blue Revolution initiative in India.

The global demand for fish is steadily rising, particularly in developing nations, where it serves as a crucial source of nutrition and livelihood for millions of traditional fishers. India's fish production is projected to reach 22 MMT by 2024-2025, up from 14.16 MMT in 2019-2020, with 64% of this production coming from inland fisheries and 36% from marine sources. However, marine fish production has shown signs of stagnation, making it challenging to achieve substantial growth in this sector. Consequently, inland fisheries must play a more significant role, with increased focus on aquaculture and fisheries enhancement in open-water bodies, especially wetlands. Traditionally, inland aquaculture has been the backbone of fish production in India. However, in recent years, it has become increasingly capital-intensive and is facing growing environmental concerns. Meanwhile, fish production from natural ecosystems such as rivers, estuaries, and associated water bodies is on a decline due to human-induced pressures, including large-scale river modifications and habitat destruction. Given these challenges, restoring fisheries in these degraded ecosystems is a complex task.

To meet the growing fish demand, the focus must shift towards optimizing the underutilized and neglected aquatic ecosystems, particularly wetlands. Sustainable and rational exploitation of wetland fisheries can provide a viable solution to increasing fish production while addressing food security concerns. Implementing scientific management techniques, improved governance policies, and innovative aquaculture practices in wetlands will be instrumental in narrowing the existing demand-supply gap in India's fisheries sector.

By leveraging scientific advancements and policy-driven initiatives, India can significantly enhance its inland fisheries production, ensuring both economic and ecological sustainability for future generations.

2. Overview of open water fisheries resources in Bihar

Bihar, the 13th largest state in India, covers an area of 94,163 km² and is geographically situated between 24°20'10" N to 27°31'15" N latitude and 83°19'50" E to 88°17'40" E longitude. The state lies within the Ganga River basin, encompassing 38 districts, with 21 districts in North Bihar and 17 in South Bihar. Bihar is home to eight major river basins, namely Koshi, Gandak, Budhi Gandak, Adhwara Group, Kamla Balan, Bagmati, Mahananda, and Ganga Stem. The Ganges and its tributaries drain the Bihar plains, with northern tributaries such as the Gandak, Budhi Gandak, Koshi (originating from the Nepal Himalayas), and the Bagmati (from the Kathmandu Valley) frequently causing seasonal floods. The southern tributaries, including the Son, Punpun, and Falgu rivers, also contribute to the state's vast water network (https://fmis.bih.nic.in/Riverbasin.html)

The state is endowed with abundant natural water resources, including rivers, floodplain wetlands such as oxbow lakes, meanders, and seasonal floodplains, as well as reservoirs, ponds, and tanks. Among these, floodplain wetlands play a crucial role in supporting biodiversity, maintaining ecological balance, and sustaining livelihoods. These wetlands, which remain either temporarily or permanently submerged, vary significantly based on their formation, location, hydrology, and water chemistry. They are recognized as one of the most productive ecosystems, playing a significant role in the hydrological cycle by regulating floods, recharging groundwater, and maintaining water quality. Wetlands also serve as vital resources for local communities, offering benefits such as clean water supply, fish production, fiber and raw materials, flood control, and recreational opportunities.

According to the Millennium Ecosystem Assessment, wetlands cover approximately 7% of the Earth's surface yet contribute 45% of the world's natural productivity and ecosystem services. In Bihar, the Gandak River Basin in North Bihar contains a chain of oxbow lakes, which are crucial for local communities as sources of potable water, irrigation, fish protein, and nutritious aquatic fruits and vegetables. Despite their immense ecological and economic value, many of Bihar's wetlands remain underutilized. Sustainable management and conservation efforts are essential to maximizing their potential for fisheries development, biodiversity conservation, and livelihood enhancement. With proper policy support, scientific interventions, and infrastructure development, these water bodies can significantly contribute to Bihar's economy and environmental sustainability.

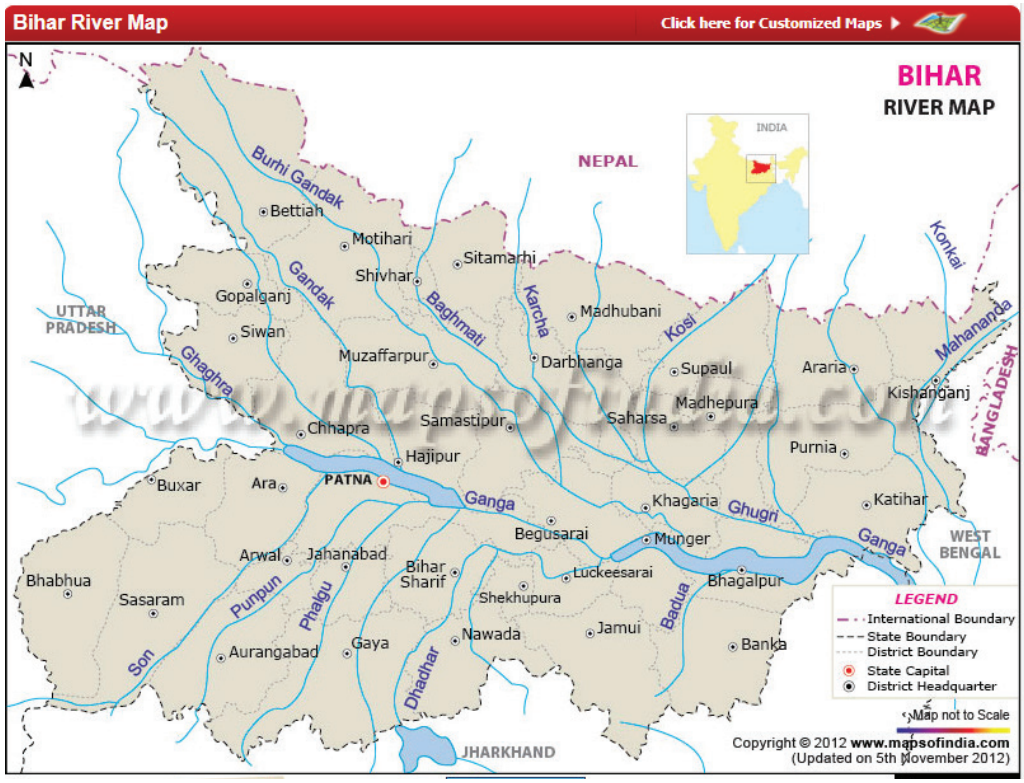


Fig.1 Riverine resources of Bihar (https://fmis.bih.nic.in/Riverbasin.html)

The State Bihar is situated at along the Ganga river basin, includes 38 district of which 21 districts in North Bihar and 17 districts in south Bihar. The state of Bihar is endowed with a variety of natural water resources viz. Rivers and associated water bodies like floodplain wetlands (Oxbow lake, meanders, seasonal floodplain), Reservoirs, Ponds and Tanks. Despite abundant aquatic resources in terms of about 2800 km of rivers, 43500 hectares chaurs and floodplain wetlands, 9,000 hectares of oxbow lakes or *maun*s, 7,200 hectares of reservoirs and 68,050 hectares of ponds and tanks, fish supply is short of demand in the State of Bihar. Apart from Ganga river system, 15 rivers and rivulets such as Koshi, Gandak, Budhi Gandak, Kareh, Kamla, Bagmati etc.

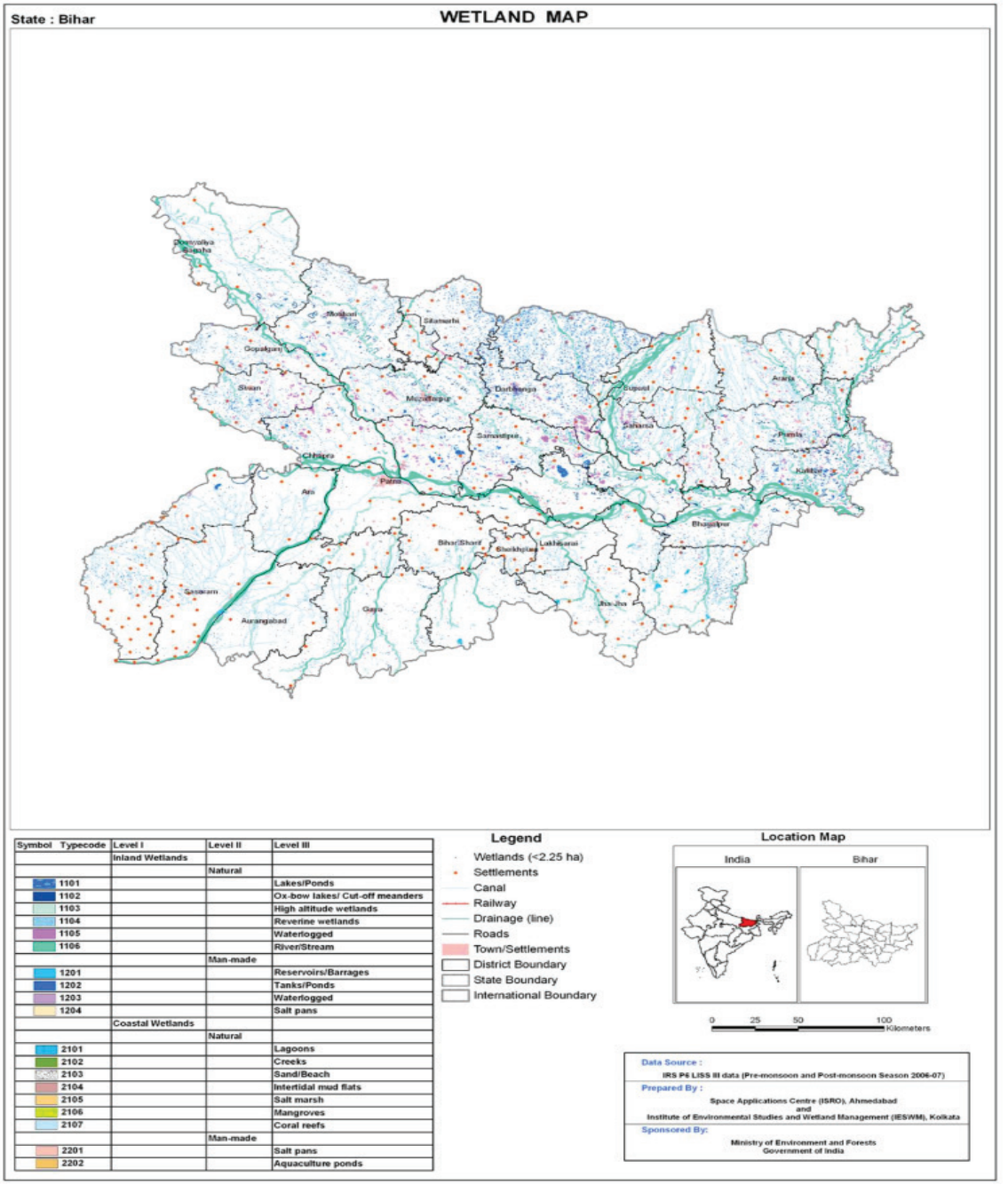
East Champaran District is functioning from 2 November 1972. The headquarter of district is at Motihari. It is situated at 26016' to 2701' North latitude and 84030' to 85016' East longitudes. The District comprises an area of 3968.0 sq km with 1344

villages having population of 50,82,868 as per 2011 census. The Administrative set up of the District is decentralized into 6 sub-division, 27 blocks, 27 Circles, 3 Nagar Parishads (Motihari, Raxaul and Dhaka), 6 Nagar Panchayats and 405 Panchayats. Majharia *maun* comes birchhapra panchayat of East Champara.

Gandak, Burhi Gandak and Baghmati are important rivers flowing through this region. The Gandak flows southeast 300 kilometres (190 mi) across the Gangetic plain of Bihar state through West Champaran, Gopalganj, Saran and Muzaffarpur districts. Burhi Gandak and Baghmati flows across the East Champaran region. The total wetland area of the district is 12477ha. The major wetland types are 28 oxbow lakes or *maun*s of 3030ha area, natural water logged area (1481), stream/river banks of 7000ha and rest are tanks and ponds.

Table.1 Water resources of Bihar

Sl. No.	Resource	Water area
1.	Ponds and tanks	90,050 ha
2.	Ox-bow lakes (*mauns*)	9,000 ha
3.	Chaurs	2,00,000 ha
4.	Reservoirs	25,000 ha
5.	Rivers	~3,200 km



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Fig. 2 Wetland map of Bihar (Panigrapgy et al., 2010)

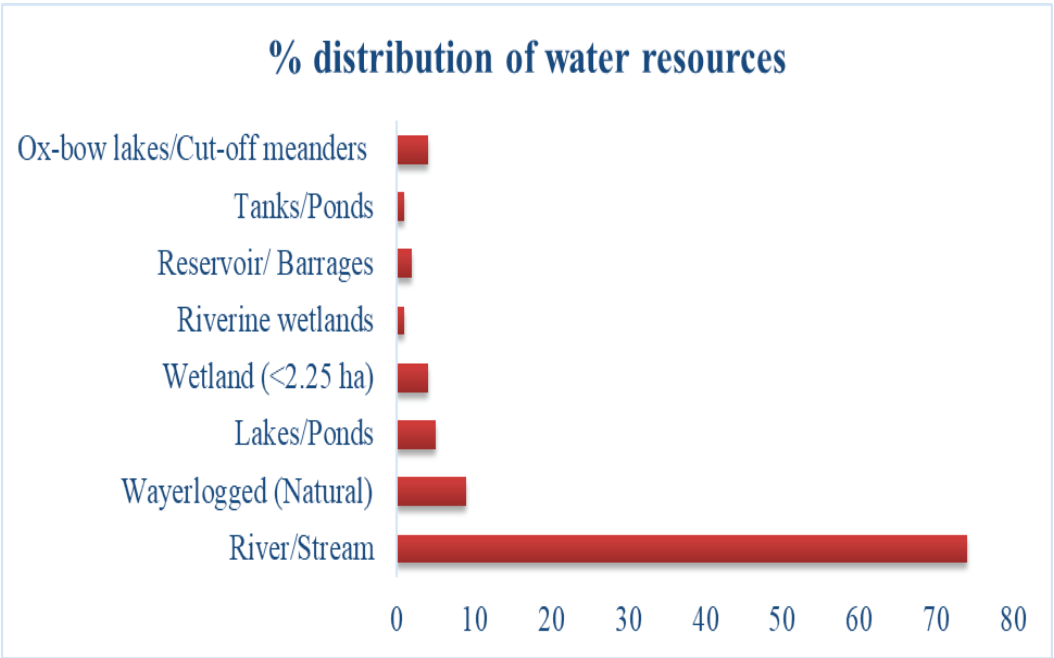


Fig. 3 Type-wise wetland distribution in Bihar (Panigrahy et al. 2010)

Bihar has 209,000 hectares of *Chaurs* and *Maun*s, primarily in the mountain-fed Gandak-Kosi River basin, which support rich aquatic biodiversity and sustain the livelihoods and nutritional needs of local communities. These wetlands serve as a vital source of protein and economic activity, making them essential for the region's well-being.

To meet the rising demand for fish, promoting Culture-Based Fisheries (CBF) in Bihar's wetlands, especially in *Chaurs* and *Maun*s, offers a viable solution. CBF is a low-cost, high-yield approach that enhances fish production through scientific stocking, habitat management, and controlled harvesting. Integrating CBF with existing fisheries management can significantly increase fish output, addressing the gap between supply and demand.

By 2022, Bihar's fish demand was projected to reach 8.02 lakh metric tonnes, while production in 2016-17 stood at 5.10 lakh metric tonnes, highlighting a substantial shortfall. Expanding CBF can bridge this gap by utilizing underused water resources, increasing productivity, and creating sustainable jobs for fishers. Strengthening infrastructure, training, and access to quality fish seed and feed will be key to its success. With strategic interventions, Bihar can boost its fisheries sector, enhance food security, and improve the livelihoods of millions dependent on inland fishing.

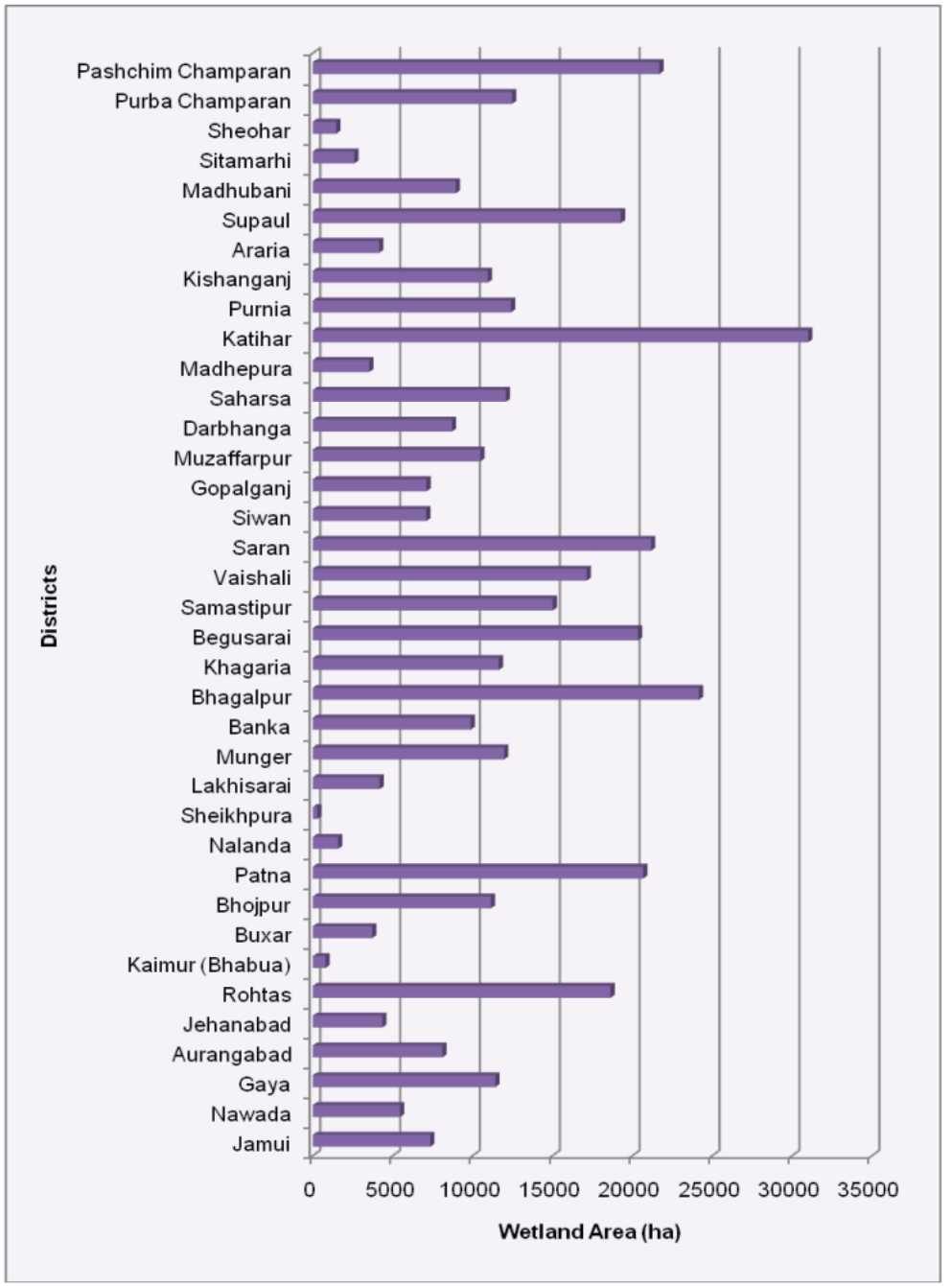


Fig. 4 District-wise wetland distribution in Bihar (Panigrahy et al. 2010)

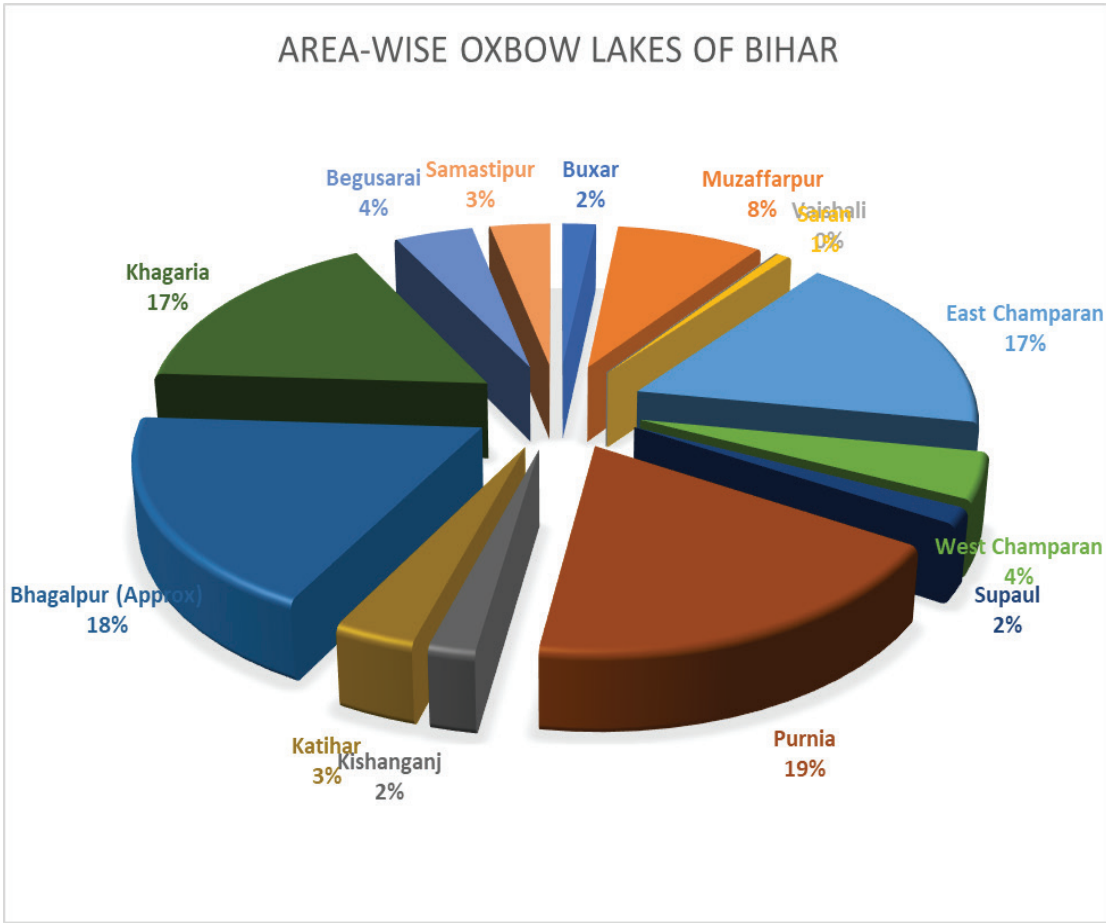


Fig. 5 District-wise oxbow lake resources of Bihar

2.1. Ecological Profile of Floodplain Wetlands

Bihar categorizes its floodplain wetlands into two types: oxbow lakes (*maun*s) and tectonic lakes (*chaurs*), each with distinct ecological characteristics. The formation of these lakes determines their hydrological patterns, which directly impact aquatic biodiversity and productivity. Additionally, human interventions significantly influence their ecological balance over time. Among the two, oxbow lakes (*maun*s) generally maintain a healthier ecological status compared to *chaurs*, which are more susceptible to environmental degradation and human-induced changes.

Ecological profile of ox-bow lake (*mauns*)

Most lakes in Bihar are undergoing a critical ecological transition, indicating an advanced stage of eutrophication. The excessive growth of aquatic weeds, ranging from 5 to 20 kg/m², has significantly impacted fish populations and overall fisheries productivity. Dissolved oxygen levels fluctuate from suboptimal to extreme supersaturation (16 mg/L and above), largely due to the unchecked proliferation of macrophytes. Additionally, seasonal variations in pH (7-10) and alkalinity (150-300 mg/L), along with high specific conductance (200-450 µmhos), highlight the unstable nature of these aquatic ecosystems. The carp fishery, once the main source of income for fishers, has declined drastically (by 4-10%), while forage fish now make up more than 60% of the total catch. This shift has led to an increase in predator dominance, further disrupting the carp population. The natural auto-stocking of quality fish seed has dwindled to almost negligible levels, primarily due to the loss of connectivity between rivers and wetlands. Data from ICAR-CIFRI indicate that fishermen now catch as little as 300 grams per day, primarily consisting of low-value fish with poor market acceptability. Reckless fishing practices, including the indiscriminate killing of brooders and juveniles, are rampant across these lakes. Additionally, the widespread use of fine-meshed mosquito nets, locally known as "Chattijal," has severely degraded these ecosystems, pushing them towards an ecological crisis.

Ecological profile of tectonic lakes (*Chaurs*)

In Bihar, *chaurs* have become highly degraded ecosystems due to excessive human intervention, significantly altering their ecological balance. One of the most visible impacts is the massive infestation of macrophytes, which thrive in the shallow waters of these wetlands. The loss of connectivity with rivers and other water sources has further accelerated their decline, reducing water exchange and affecting aquatic life. As a result, fish populations in chaurs are now dominated by smaller, low-value species and predators, rather than economically important fish varieties.

Most *chaurs* are in an advanced stage of eutrophication, rapidly transforming into swamps and leading to a colossal reduction in effective water areas that once supported fisheries and biodiversity. This degradation has also triggered a definite shift in fish diversity, with the disappearance of commercially valuable species and the proliferation of unwanted fish varieties. Additionally, increasing human interference has fueled the unchecked growth of undesirable biota, such as invasive macrophytes, further straining these fragile ecosystems.

The overall ecological integrity of chaurs has severely declined, directly impacting fish productivity and biodiversity. The ongoing degradation not only threatens local fisheries but also undermines the ecological functions of these wetlands, making urgent conservation and restoration efforts imperative to revive their health and sustainability.

2.2. Brief description of Majharia *maun* for fisheries development

The landscape of the lower Gangetic basin and Brahmaputra basin comprising eastern and northeastern Indian states such as Uttar Pradesh, Bihar, West Bengal and Assam is characterized by the abundance of various forms and types of wetlands locally called *beels*/*baors* and *mauns* offer scope for fisheries development. These states are considered potential for bringing blue revolution in the country.

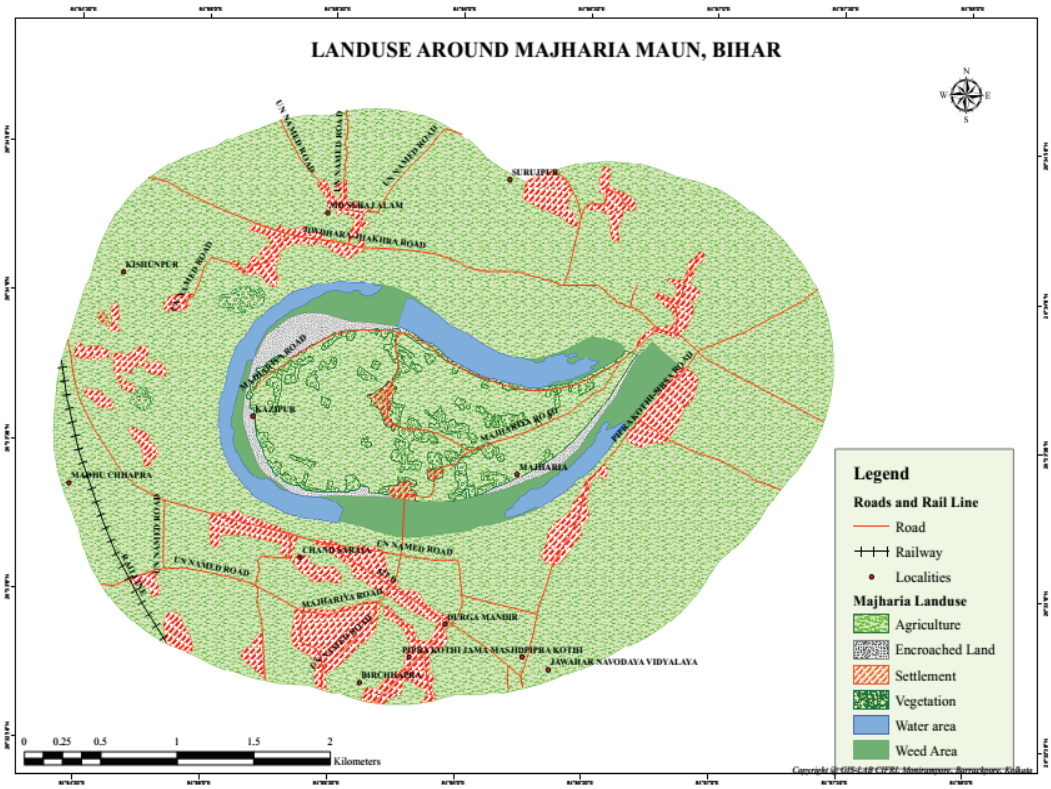


Fig. 6 Land use pattern of around Majharia *maun*

Majharia *maun* (26°40'59"N 84°50'44"E) is located 6 km South of Motihari town and is typically 'U' shaped in appearance. The *maun* has maximum water spread area of 120 ha and the depth ranged between 2-7 m. The lake is having connection with two rivers 'Dhanauti' and 'Sikarahna'. Approximately 40% of the lake is covered by macrophytes. Fishing in the water body carries out by 240 fishers living around the water body under the control of a cooperative society. The principle of Culture-Based Fisheries technology was being practiced but unscientifically, and with a low yield of 50-125 kg/ha/yr as per the social survey record



Majharia *maun*

3. Project Goal: Enhancement of inland fish production from wetlands for improving livelihood opportunities

The goal of the project was undertaken with below-mentioned objectives with successful implementation of fisheries enhancement technology to exploit the wetland for the enhanced fish production from current production level (2017-2018). The objective proposed and the mode and approach devised to achieve the goal of the project are mentioned below. Each objective with their achievement attended during 2018-2021.

4. Objectives

1) To develop wetland fisheries through institutionalizing stakeholders' participatory fisheries management model in a sustainable manner

2) To disseminate in-situ fish seed rearing and fisheries enhancement techniques(Stocking enhancement, enclosure cultures) for tapping the fish production potential of the wetlands.

3) To empower communities and stakeholders through improved livelihood opportunities and capacity building.

4) To refine site-specific fisheries enhancement technology for the development of wetland fisheries.

5. Modes and approaches of operation of the projects

1) Transfer of ecosystem-based fisheries enhancement technology for development and management of the wetland fisheries

2) Participatory/co-management regime in the management of wetland fisheries and strengthening of the fisheries cooperatives/SHGs

3) Financial and knowledge empowerment of communities and stakeholders through development of sustainability fund and capacity building

4) Reinforcing infrastructure and support services and habitat improvements

6. Rationale

Bihar possesses a vast expanse of wetlands spanning 7.98 lakh hectares, offering immense potential for boosting inland fish production through scientific fisheries management. Despite this, current fish yield from wetlands remains sub-optimal, averaging 200-800 kg/ha/yr across India. However, well-managed wetlands in West Bengal and Assam have demonstrated that sustainable fish production of over 800 kg/ha/yr is achievable. This indicates that Bihar's wetlands hold substantial untapped potential, which can be harnessed by adopting a culture-based capture fisheries management approach. Data from ICAR-CIFRI reveal that auto-stocking of Indian Major Carps (IMCs) is currently poor, highlighting the need for a rational stocking program to enhance production. To achieve this, a systematic and sustained stocking policy must be implemented while ensuring that biodiversity is preserved, allowing endemic fish populations to coexist with stocked species. Engaging local communities in fisheries management will also be crucial for improving livelihood opportunities while ensuring sustainable wetland utilization.

The key to maximizing fish production from Bihar's wetlands lies in stocking the right fish species, at the right size (>100 mm), and at the right time to effectively utilize available food niches. Although Bihar is largely self-sufficient in fish seed (spawn/fry) production for aquaculture ponds, there is a notable shortage of advanced fingerlings required for stocking in open waters. This shortfall significantly hampers efforts to improve wetland fisheries productivity. To address this challenge, it is essential to establish in situ seed production facilities within wetlands as an integral component of fisheries development. This approach will not only increase fish yield and biodiversity conservation but also support the livelihoods of local fishers, ultimately transforming Bihar's wetlands into a major contributor to inland fisheries production in India.

7. Methodologies

The enhancement of fish production in the selected wetland was pursued through an integrated approach that combined technological interventions, ecological assessments, community participation, and governance reinforcement. The key methodological components included:

1. Ecosystem Assessment and Stocking Strategy
   A thorough assessment of the wetland's ecosystem structure, trophic state, and fish species diversity was conducted to determine the seed requirement and stocking strategy. Stocking was carried out based on the trophic structure and potential productivity of the wetland (Lorenzen, 1976). This involved selecting the appropriate combination of fish species, ensuring the right seed size, and introducing them at optimal stocking periods to enhance fish yield.

2. Seed Production and Stocking Techniques
   To ensure the availability of quality fish seed, production was carried out through land-based nurseries and pen culture (ICAR-CIFRI, 2011). Advanced fingerlings were used to increase survival rates and maximize stocking efficiency. The harvesting strategy was designed based on optimal size at capture and harvesting frequency, ensuring sustainable fishery practices.

3. Macrophyte Management and Stock Loss Prevention
   Macrophyte management strategies were implemented to prevent excessive vegetation, which can hinder fish productivity. Additionally, preventive measures such as installing fish retention devices and protective structures were introduced to minimize stock loss, ensuring sustained fish populations and optimizing yield.

4. Community Participation and Capacity Building
   Active community involvement was promoted through capacity-building programs, where fishers were trained in scientific fisheries management, responsible harvesting practices, and conservation techniques. Infrastructure development and support services were reinforced to ensure the long-term sustainability of fisheries in the wetland.

5. Governance and Institutional Strengthening
   The project focused on strengthening institutional frameworks and reinforcing governance mechanisms to ensure proper implementation of fisheries policies and regulations. This included stakeholder collaboration and policy recommendations to facilitate sustainable wetland fisheries management.

6. Impact Assessment
   The effectiveness of the intervention was evaluated through impact analyses, using standard methodologies and the Impact Pathway Model (Chandra, 2010,

2013). The assessment focused on changes in fish production, biodiversity conservation, economic benefits to fishers, and ecological improvements in the wetland ecosystem.

By integrating these methodologies, the project aimed to enhance fish production, promote sustainable fisheries, and improve the livelihoods of wetland-dependent communities while maintaining the ecological integrity of the wetland ecosystem.

8. Operation module

The success of wetland fisheries development hinges on a synergistic collaboration between research institutions, fishery administrators, and the local fishing community. This multi-stakeholder approach ensures technological innovation, policy and infrastructure support, and active community participation, forming the foundation for a sustainable and inclusive fisheries management system.

In this proposed project, ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore, played a pivotal role as the core executing agency, providing technical expertise and overseeing the entire implementation process. The National Fisheries Development Board (NFDB), Hyderabad, extended financial support, while the Bihar state government and relevant line departments facilitated administrative coordination. The project was executed collaboratively, ensuring seamless integration of scientific advancements, policy implementation, and community-driven fisheries management.

Given that fisheries governance falls under state jurisdiction, the Bihar government actively facilitated the project's implementation, ensuring smooth coordination between stakeholders. A tripartite Memorandum of Understanding (MoU) was established between ICAR-CIFRI, the Bihar government, and a cooperative society, creating a structured framework for effective governance and execution. Additionally, local stakeholders, including Fishers' Cooperatives, Self-Help Groups (SHGs), and Panchayati Raj Institutions (PRIs), played an integral role by providing logistical support, overseeing security and surveillance, managing daily feeding, and ensuring routine maintenance of the fisheries infrastructure.

This holistic and collaborative model not only strengthens fisheries governance but also fosters community ownership, thereby enhancing the economic well-being of fishers while ensuring the long-term sustainability of Bihar's wetland fisheries.

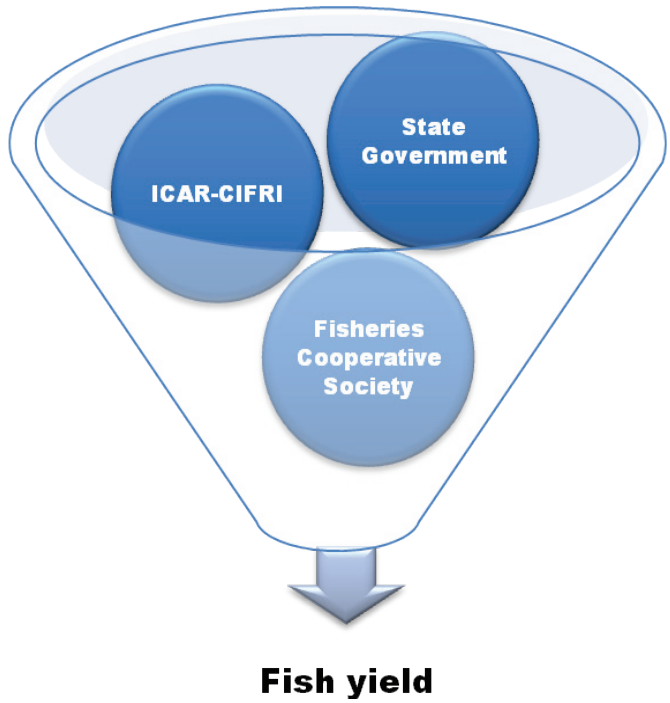


Fig. 7 Operational module for development of wetland fisheries

9. Technological intervention

The ecological characteristics, trophic status, and fish catch composition of the Majharia wetland were systematically assessed using standard methodologies and protocols to determine stocking requirements and develop a site-specific fisheries enhancement strategy. Given the absence of natural flood surges and connectivity, the natural recruitment of commercially significant fish species, such as major and minor carps, has drastically declined, making stocking support essential for maintaining productivity. While implementing the stocking process, special emphasis was placed on preserving and propagating native fish species to sustain the livelihoods of artisanal fishers, incorporating the principles of responsible fisheries management. To counteract environmental adversities and predatory threats, relatively larger fish seeds were introduced, ensuring higher survival rates and better contribution to overall yield. To maximize the benefits of the wetland's natural productivity, a staggered stocking approach was adopted, ensuring a continuous supply of suitable seeds over an extended period.

For effective fisheries management, hatchery-bred seeds of appropriate species and composition were procured from certified hatcheries and reared in land-based nurseries and enclosures (pens and cages) before being stocked in the open waters. A dedicated nursery facility was established near the wetland for fry rearing, followed by the development of advanced fingerlings in pens, cages, and land-based rearing units.

Additionally, mesh screen installations were introduced to facilitate water, nutrient, and germplasm exchange while preventing the escape of stocked fish. Selective harvesting techniques were employed, ensuring that predetermined size groups of fish were removed to reduce grazing pressure, thereby promoting the optimal growth of the remaining stock. To maintain growth and harvest records, all fishers brought their catch to a designated landing ghat, where data collection and auctioning were conducted. This systematic data recording played a crucial role in monitoring project outcomes. The sustainable enhancement of fish production was achieved through seed rearing from fry to fingerlings in nurseries and pens, where seed and feed were the primary inputs. The in situ seed rearing techniques developed by ICAR-CIFRI, involving land-based nurseries and enclosures, were implemented to replenish depleted carp stocks, ensuring feasibility, scalability, and adoption across different wetlands. Additionally, select exotic species were strategically stocked to utilize unexploited food niches, thereby enhancing productivity. This large-scale technological intervention, demonstrated through participatory engagement, is expected to increase adaptability, improve fish yields, and boost livelihood opportunities for wetland fishers across diverse geo-climatic regions.

10. Objectives

1. To develop wetland fisheries through institutionalizing stakeholders' participatory fisheries management model (Co-management) in a sustainable manner

10.1. Achievements

10.1.1. Baseline survey:

Majharia *maun* (N26˚33´23.8˝; E 84˚56´01.6˝) is located 6 km South of Motihari town and is typically 'U' shaped in appearance. The *maun* has maximum water spread area of 120 ha and the depth ranged between 2-7 m. The lake is having connection with two rivers 'Dhanauti' and 'Sikarahna'. Approximately 40% of the lake is covered by macrophytes. The flooding is the main source of replenishment of fish stocks every year, and hence the mainstay of fisheries-based income for society. The submerged and marginal weeds are present along the periphery and shallow part of the *maun,* covering 35-40% of the total area, varying with seasons, and water spread. Fishing in the water body carries out by 240 fishers living around the water body under the control of a cooperative society. The wetland is moderately productive and stocking of fish seeds is not observed in the true sense. The culture based fisheries technology is not being practiced with a low yield of 60 kg/ha/yr as recorded during the social survey.

10.1.2. Socio-economic status of fishers of Majharia *maun*

The development activities and its impact on the traditional fishers were not visible as per expectations due to multiple owners' nature of resource with multiple uses. Lack of information on socio-economic conditions of wetland fishers community may be one of the major constraints towards appropriate policy and planning for the development of wetland fisheries. Under socio-economic condition of fishers of Majharia *maun*, 66 fishers household were surveyed. The parameters covered were fishers household, family composition, housing, literacy rate, Employment, income status of fishers and expenditure profile of the fishers

10.1.3. Family composition of the respondent households

As part of the socio-economic status assessment, a comprehensive survey was conducted covering 66 beneficiary households associated with the project. In total, 441 individuals were documented, comprising 235 males and 206 females. This yielded an average family size of approximately 6.68 persons per household, reflecting the relatively large household structure common in rural communities. The male-to-female ratio in the surveyed population was calculated at 1.14, indicating a demographic composition where there were 114 males for every 100 females. This gender distribution provides important insights into household dynamics, labor availability, and potential participation in fisheries-related activities, which are essential for planning inclusive and effective livelihood interventions.

10.1.4. Housing of fishers

Housing type is a key indicator of the socio-economic status of fishing communities. Among the surveyed households, only 6% were found to reside in *pucca* houses—permanent structures made of concrete with one or more floors. A larger portion, about

38%, lived in *semi-pucca* houses, typically constructed with brick walls and roofs made of asbestos or tin sheets. The majority, 56% of the households, were found to be living in *kachha* houses, such as thatched huts or dwellings with tin roofs. This distribution clearly reflects the economic vulnerability and limited access to durable housing among the fishing community.

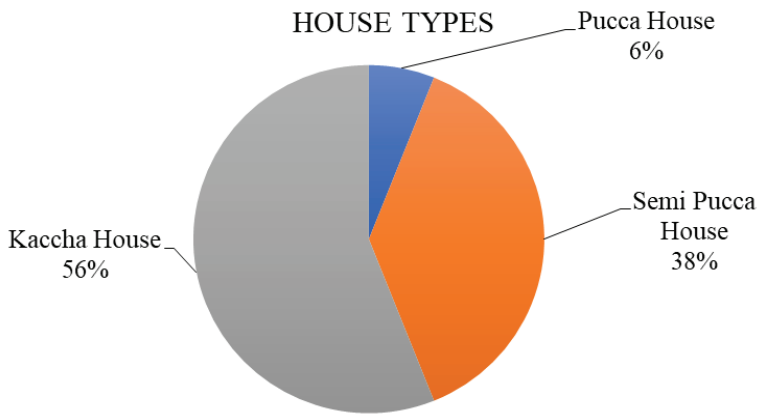


Fig 8. Housing Type of fishers household

10.1.5. Literacy status of respondent households

In India, under the literacy status survey, persons above the age of seven years and more are only covered. The literacy status of the respondent households was analyzed through the literacy level and educational status. The illiterate indicates the fishers without having any formal education and those who doesn't even read and write. The literate indicated persons who can read and sign. The literacy status includes the level of education as indicated by primary, secondary and collegiate level of education. The general literacy rate of India as a whole was 74.52 per cent as per the last Census 2011. The study indicated literacy rate of the respondent households are only 25 percent. Out of the 392 persons above the age of seven only 98 are literate showing very poor literacy rate among the fisher families of Majharia *maun*.

The male literacy rate is 27.88 while the female literacy is only 21.74, showing among the literate population of the respondent household 56 percent are male and 44 percent female. Among the respondent household, not a single person have graduate degree, and only six have passed matriculation examination. More than seventy percent literate population have education up to primary level and thirty percent up to middle level.

The results indicated comparatively poor literacy rate among the fishers. The overall scenario may be attributed to poverty, involvement of children in domestic and household economic activities from childhood, ignorance of parents about child education etc.

10.1.6. Employment

The primary livelihood activity or employment of the respondent household is fisheries while the secondary household activities are agriculture, daily wage earning. 84 percent household have indicated fisheries as their main employment activity including wage earning from fisheries activities. On an average 2 persons are engaged in fishing from each family having average household having 6.68 members.

Migration for wage earning and minor labour job to other states were not reported by the respondent households. Though some of the household members are going for fishing contract job.

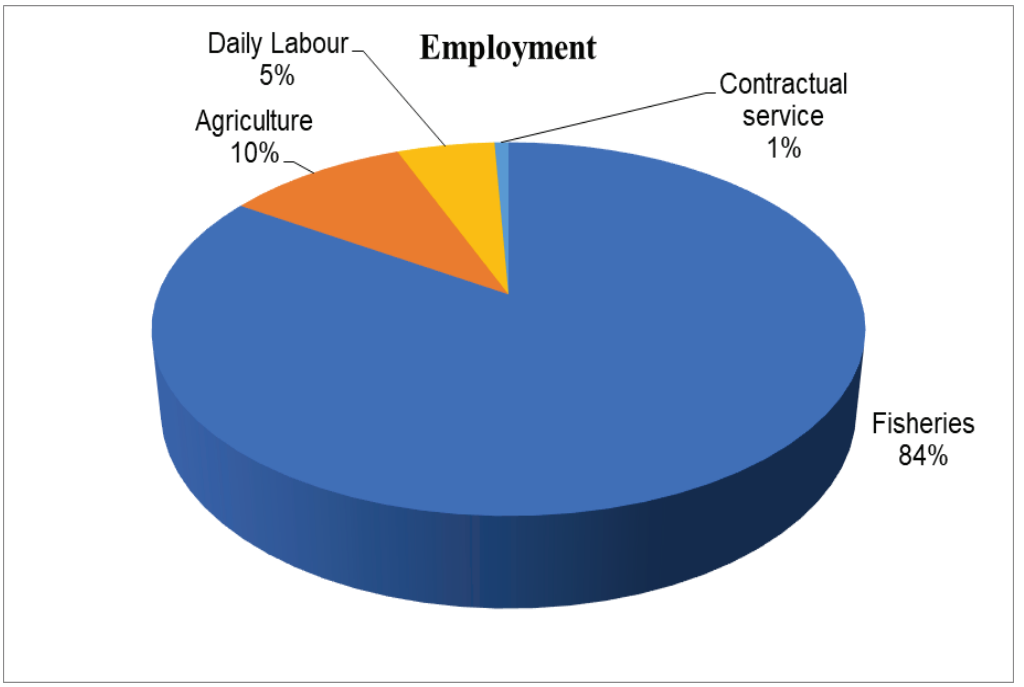


Fig 9. Employment profile of fishers household

Throughout the project period the fishing days have increased significantly due to culture based fisheries management in Majharia *maun*. But during non-fishing period, the respondent household reported farming (60%), Wage earning through fishing labour job (20%), Daily wage earning (11%) and remaining one percent in contractual service.

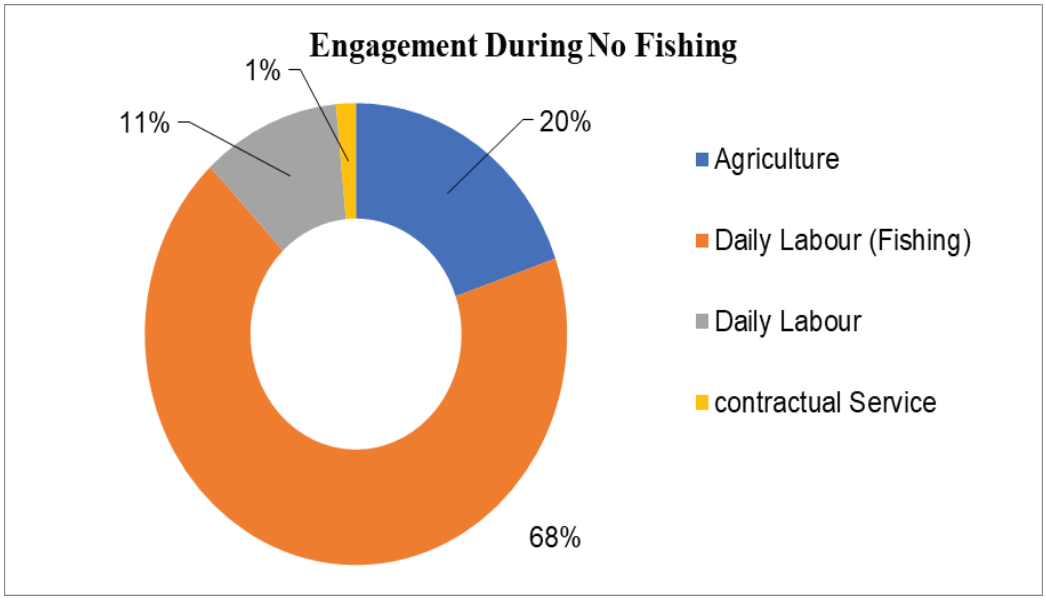


Fig 10. Engangement during non fishing days of fishers household

10.1.7. Income profile of the fishers' household

Fisheries from *maun*, agriculture or farming and labour wage earning were the major income sources of the respondent households. Income from fisheries operation was the most important income contributing 59.7 percent of the annual income fishers while other activities including agriculture and wage earning contribute 40.3 percent of total annual income. The average annualincome of the respondent household was Rs. 38878.

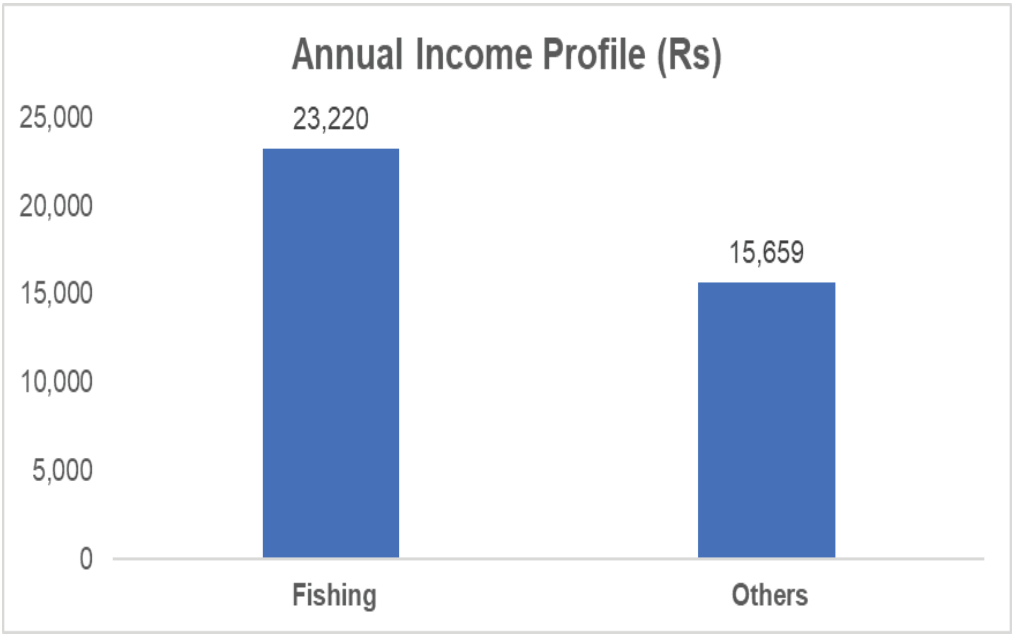


Fig 11. Income profile of fishers household of Majharia *maun*

10.1.8. Expenditure profile of fishers' household

The monthly expenditure of the respondent household revealed that the maximum expenditure was going towards food (75%) followed by clothing (9%). Personal (5%) and expenditure towards medical treatment were at 6% of the total expenditure. Education of children costs 3% of the total expenditure of the household. This shows that expenditure towards food covers three fourth of the total expenditure.

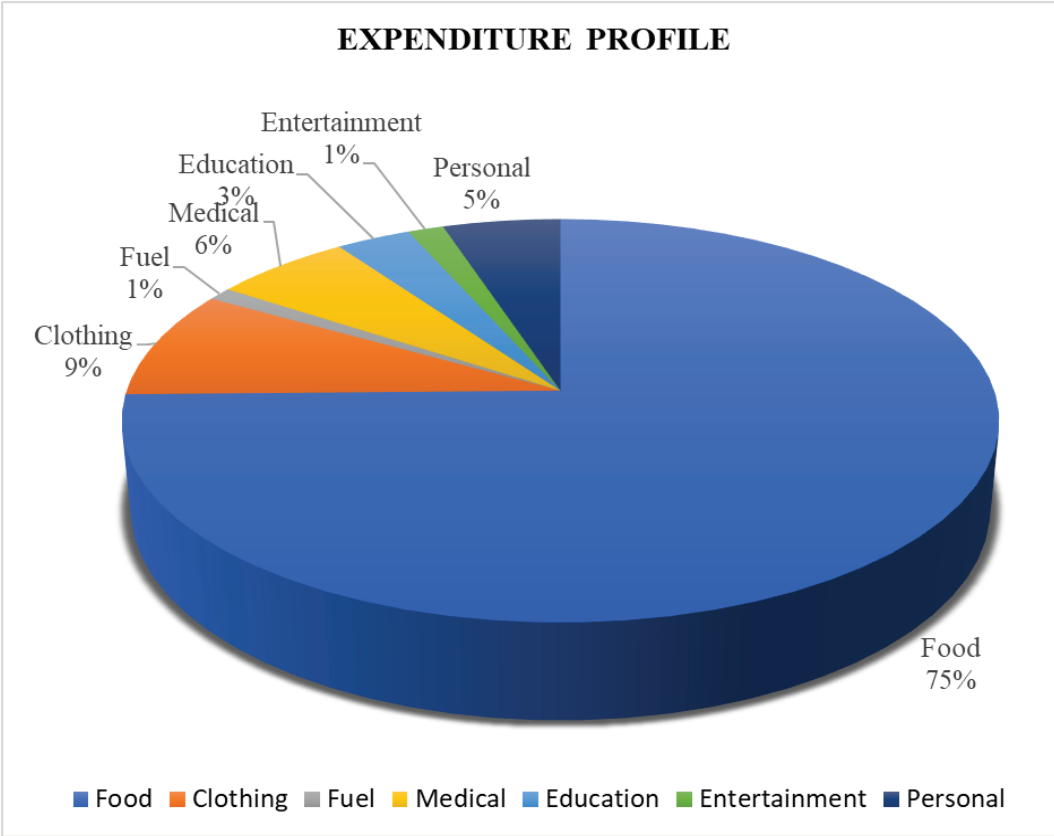


Fig 12. Expenditure profile of the respondents household of Majharia *maun*

10.1.9. Access to resources

Fisheries comes under the state list of Indian constitution and state acts are governing fisheries in India. In Bihar, Bihar Jalkar Act 2006 governs the fisheries in the state. The access to fishers is governed by leasing policy and property rights regime applicable in the state. The property rights are the fundamental institutions of allocation and access. These property rights are wide and vary from the highly controlled exclusive properties to open access water bodies like rivers with almost no control.

The inland water bodies are managed for various objectives like economic benefit, livelihood security; sustainability, equity, conservation of biodiversity, maintenance of the ecosystem etc. are the determining variables for the nature of property rights (Chandra, 2011; Chandra and Das 2019). Establishing property rights to fisheries creates stable expectations among users and managers. It provides owners with an incentive for long-term sustainability. The government retains the responsibility to conserve fishery resources for the public, who is involved through the management process.

Leasing or tenurial right is the transfer of use rights by the owner (Govt/lesser) to the lessee for a specified duration or tenure on the payment of specified amount which is determined by the highest bidder under the auction process or through negotiation or as per the law established. The access to the fisheries is predominantly governed by the lease holders but the traditional rights of access are also been integrated in the property rights. Generally fishing to the large fishes are determined by the lease holders where as small fishes are mostly open or regulated access to the specific group of the fishers.

In Bihar, the lease of wetlands given only to traditional fishers. They defined traditional fishers as

- Those person or group who engaged in fishing activity alone or in a group or cooperative in the inland open waters resources
- The person, who directly undertakes the trade such as marketing of fresh fishes, preserved fishes, *etc*.
- Members of primary fisherman cooperative society

The fishing rights of wetlands in Bihar are given only to traditional fishermen, fisher's self-help groups and fishermen cooperative societies as per Bihar Jalkar act 2006 for five years. Majharia *maun* is presently under the ownership of the Department of Fisheries, Govt. of Bihar under the Bihar Jalkar Act 2006. The fishing right of all the government waterbodies of the Majharia block were leased out to Majharia Prakhand Matsyajeevi Sahyog Samiti Limited for a period of five years. The cooperative society has a membership of 285more than 300 members of fisherman community of Majharia block. The secretary allocates different waterbodies to members of cooperative society for fishing.

10.1.10. Management regime

Majharia *maun* is governed under Cooperative Management regime by the Majharia Prakhand Matsyajeevi Sahyog Samiti limited. As per the statutory requirement, in any primary fisherman cooperative society eighty percent of the members must be from fishermen community. Primary fisherman Cooperative society or fishers have got exclusivity in allocation of fishing license in waterbodies.

In Cooperative management the management of fisheries operations is done by the members of the cooperative society as per the rules prescribed by the society. Here the access of property is governed by the membership of the cooperative society. The routine activity of the cooperative society is managed through an executive committee under the command of the President, Secretary and executive committee.

Fishing is mainly carried out using a drag net and gill net with traditional dingy boat.

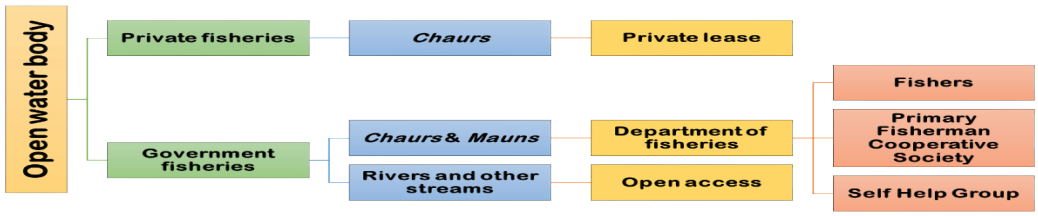


Fig.13 Formation and Transfer of fishing right in open waters of Bihar

10.1.11. Sharing arrangement

Two types of sharing arrangements are recorded at Majharia *maun*. For stocked fishes the ratio of sharing is 55-60% of the catch by cooperative society and 40-45 % by the fishers. For indigenous or non stocked fishes 65:35 sharing with 65% to the fishers and 35% to the cooperative society.

10.1.12. Physico-chemical characteristics of water

Physico-chemical characteristics of water are of prime importance that favours the diversity and abundance of the flora and fauna of the aquatic ecosystem that leading to defining the type of productivity of the wetland, which supports the fish production.Water samples was collected across the wetland from different sampling zones to evaluate the quality of the water. Physico-chemical parameters of water like Water Temperature (WT), pH, electrical conductivity (EC), dissolved Oxygen (DO) and Total dissolved solids (TDS) were measured *in-situ* with a portable using digital Multiparameter Water Quality Instrument (YSI Professional Plus). Transparency was measured by using standard Secchi disk of 30 cm diameter with black and white quarters. The ecological data collected from Majharia *maun* are presented below.

Table. 2 Physico-chemical characteristics of Majharia wetland

Parameters	**Range**
Temperature (˚C)	20.7-32
Depth (cm)	121-275
Transparency (cm)	31-92
DO (mg/l)	6-11.6
pH	8.03-8.8
Conductivity (µS/cm)	255-302
TDS (mg/l)	215-181
Alkalinity (mg/l)	106-120
Nitrate (mg/l)	0.12-0.175
Phosphate (mg/l)	0.013-0.022

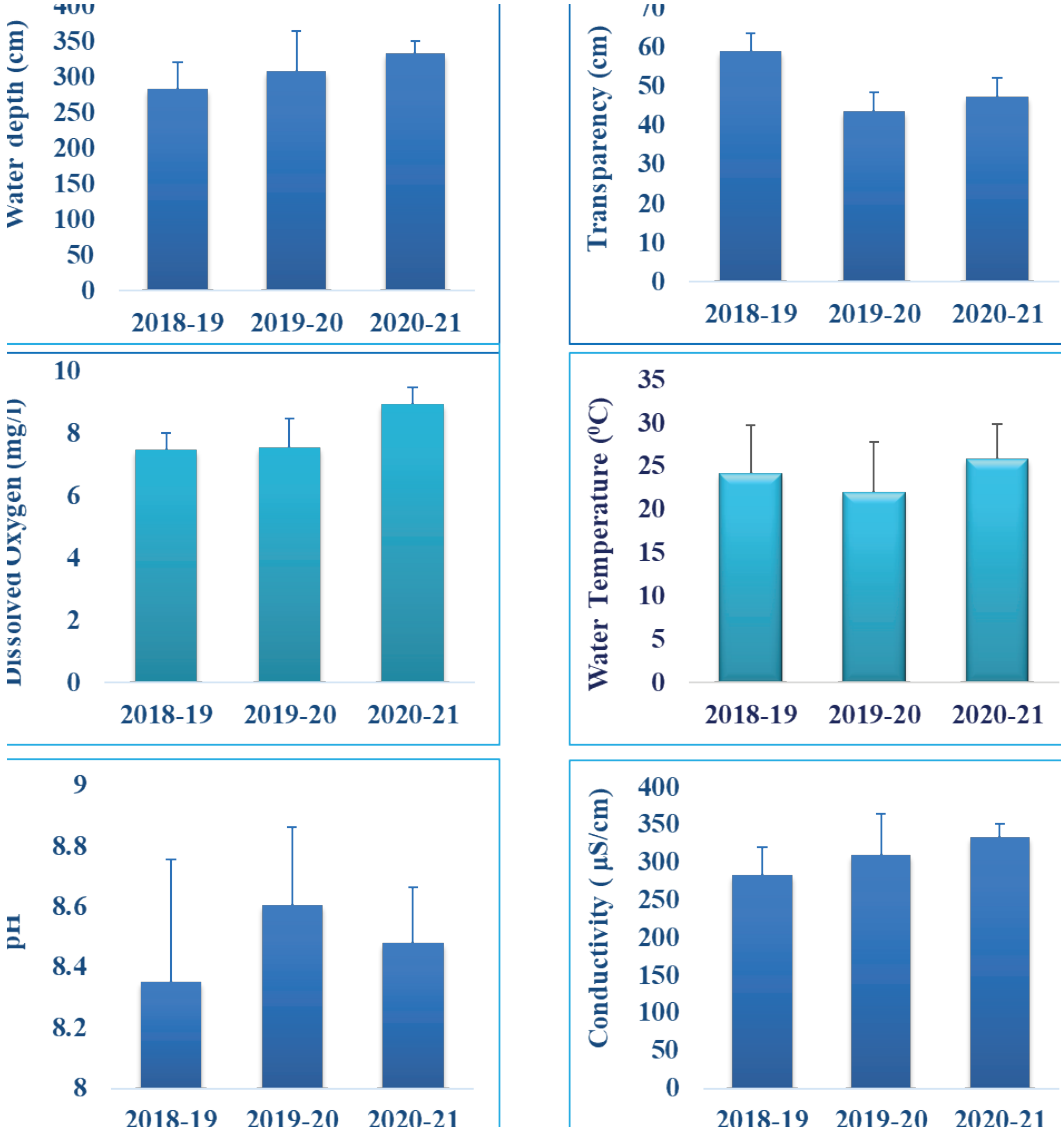


Fig. 14. Annual changes in physico-chemical of majharia *maun*



Fig. 15. Routine monitoring of ecological parameters of the Majharia *maun*, Assessment of water quality using multi parameter probe and documentation of ecological parameters

10.1.13. Plankton community of Majharia *maun*

The plankton community is a heterogeneous group of microscopic organisms inhabit wide range of aquatic ecosystem from ocean to freshwater. Plankton is pelagic organism, suspended in the water and have limited mobility often less than that of water which carries (Declince, 1992). They are basically microscopic and not visible through naked eye in aquatic ecosystem, but play very important role in the ecology and fisheries of aquatic ecosystem. These wetlands harbour important fishery resources and subjected to culture based fisheries management practices. Plankton is divided into photosynthetic organisms (phytoplankton) and heterotrophic organisms (zooplankton). Plankton has an essential role in the fluctuations happening in the naturalistic survival rates of fish juvenile and larvae and the consequent effects on the adult fish stock. Plankton is an integral part of wetland biodiversity and plays a vital role in the function of wetlands. Diversity patterns of plankton in wetlands and factors structuring its community composition are poorly understood.

10.1.13.1 Phytoplankton

Phytoplankton are the foundation of the aquatic food web, the primary producers, in aquatic ecosystems and play an important role in overall wetland productivity, while zooplankton are recognized as the main primary consumers. Small fish and invertebrates also graze on the plant-like organisms, and then those smaller animals are eaten by bigger ones. As the base of the aquatic food web, phytoplankton plays a fundamental role in setting the productivity of the entire aquatic ecosystem. Specific phytoplankton groups also play key roles in the biogeochemical functioning of the wetlands such as nitrogen fixing and oxygenation of aquatic ecosystem. Due to their short life cycle of plankton and thus potentially rapid response to anthropogenic disturbance and environmental changes, planktonic organisms are also regarded as ideal bioindicators for assessing the environmental status of wetland.

Freshwater phytoplankton (algae) is a very diverse group of organism, embraces large number of phyla such as Chlorophyceae (green algae), Bacillariophyceae (diatoms) and Cyanophyceae (blue green algae) with different form of Chlorophyll considered as major player of the ecosystem. Qualitative and quantitative assessment of phytoplankton sample collection, preservation, qualitative and quantitative analysis was done following APHA (2012), Bellinger & Sigee (2010). We investigated seasonal fluctuation of diversity and abundance of plankton in Majharia wetland of East Chmparan, Bihar.

Majharia is one of the rich diverse wetland comprises a total number of 46 genera/ species of phytoplankton *viz.,* Bacillariophyceae (12; *Cyclotella, Navicula, Nitzschia, Synedra, Aulecosira, Cymbella, Gomphonema, Amphipleura, Pinnularia* and *Fragillaria,*), Chlorophyceae (21; *Chlorella, Actinastrum, Spirulina, Coalastrum , Ankistrodesmus, Selenastrum, Kirchneriella, Gleocystis, Oocystis, Tetraedron, Mougeota, Chlamydomonas, Rhopalodia, Pediastrum, Tetraedron, Scenedesmus, Maougeotia, Spirogyra, Staurastrum, and Spirogyra*), Cyanophyceae (7;

Aphanocapsa, Microcystis, Merismopedia, Phormidium, Anabaena, Lyngbya and *Oscillatoria*), Euglenophyceae (*Euglena*, *Phacus* and *Trachelomonas*) and Dinophyceae (1; *Peridinium*) was observed during study period. There were significant changes in seasonal fluctuation of phytoplankton. Highest abundance and/or biomass of phytoplankton were observed during monsoon season (June-September) Common genera of phytoplankton have been recorded during study period.

Chlorophyceae was more diverse group but Cyanophyceae was more abundant group in Kararia wetland. During premonsoon of second year (2019) Cyanophyceae was found to be most dominant group and genera *Microcystis* followed by *Oscillatoria* sp. while in second year (2019) followed by Bacillariophyceae (genera *Cyclotella*) in post monsoon. The seasonal change in phytoplankton abundance, number of cell per unit volume was recorded maximum in the monsoon season in 2018 and premonsoon in 2019. However, annual abundance of phytoplankton was higher in the 2018 compare to 2019. Phytoplankton diversity decrease seasonally during 2019 but 2018 increased from monsoon to post-monsoon.

Diatoms mostly dominate in clear water with high-pH. Genus Cyclotella is closely associated with dry season and high pH, generally in premonsoon season. *Diatoms*, shifts in genus-level composition corresponded with seasonal shifts with favorable *environmental* conditions. Throughout the year cellular abundance of phytoplankton was observed. Among these most dominant was *Microcystis.* Abundance of phytoplankton was observed highest during monsoon 628140 cellsL^{-1} and 236640 cellsL^{-1} in 2018 and 2019 respectively and lowest during premonsoon 30140 cellsL^{-1} in first year (2018). Generally, phytoplankton population explosion-blooms occur when sunlight and nutrients are readily available to the plants, and they grow and reproduce to a point where they are so dense that their presence changes the color of the water in which they live. The plankton abundance and diversity both have decreased from first year to second year, may be due to grazing by stocked fish as a part of culture based fisheries management plan.

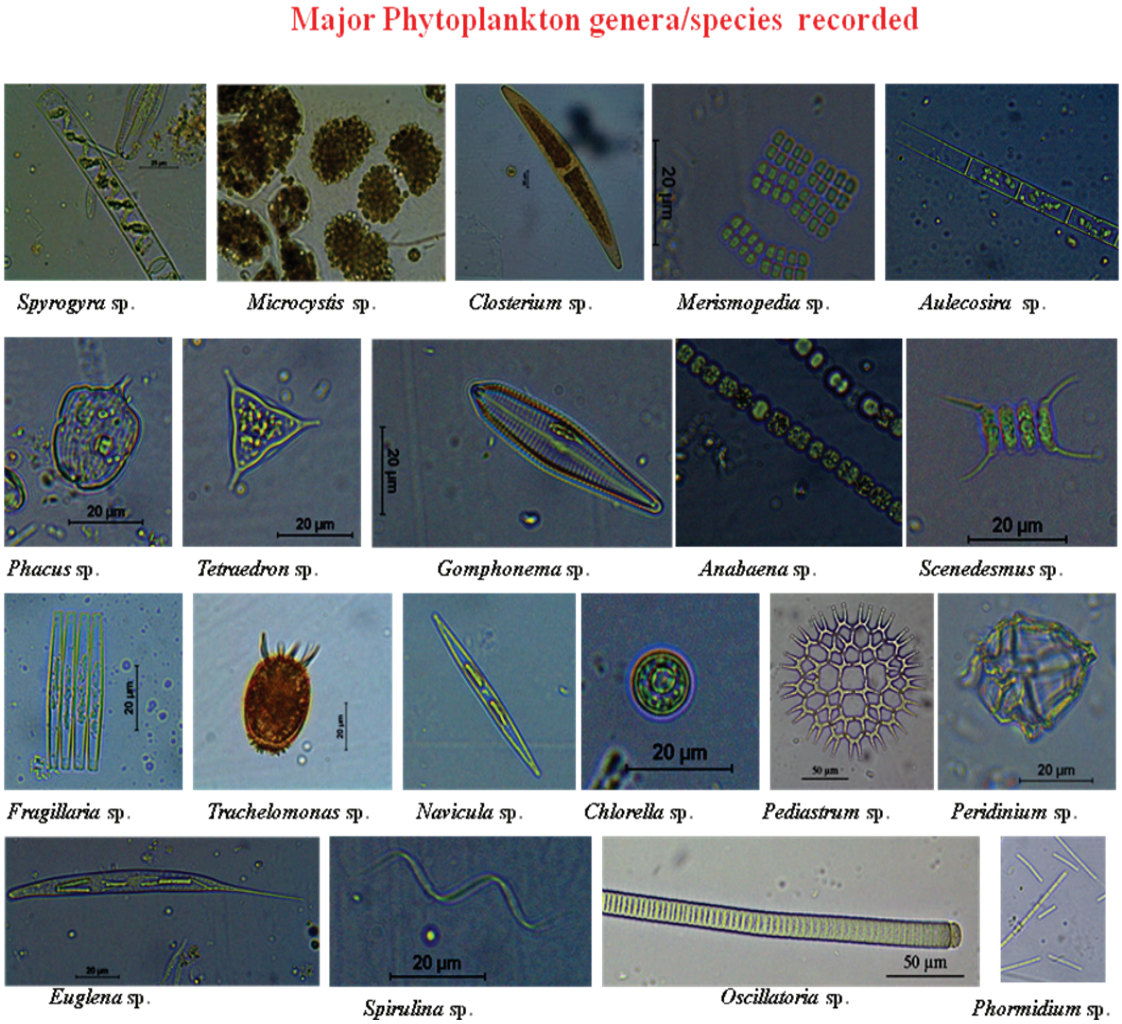


Fig. 16 Common genera/taxa of phytoplankton recorded during study period of wetland of East Champaran

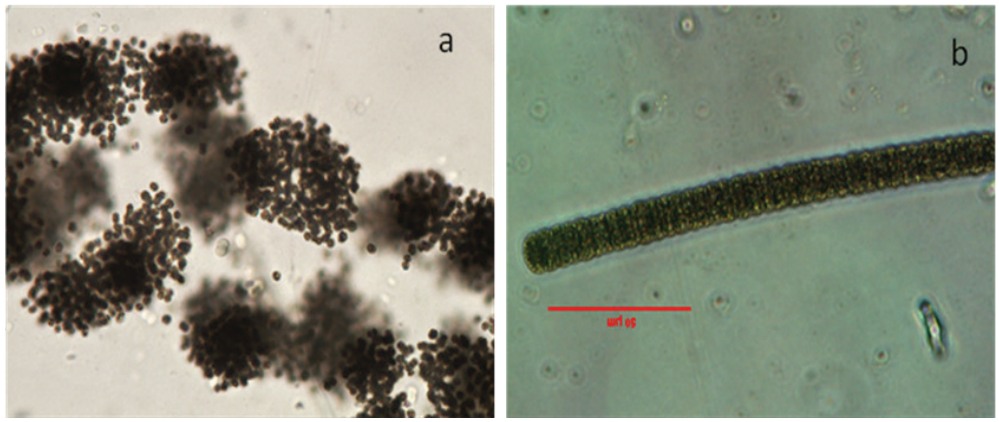


Figure 17 (a). *Microcystis aeruginosa*; a colonial bloom forming cyanobacteria (b). *Oscillatoria* sp. unbranched filamentours blue green algae cyanobacteria

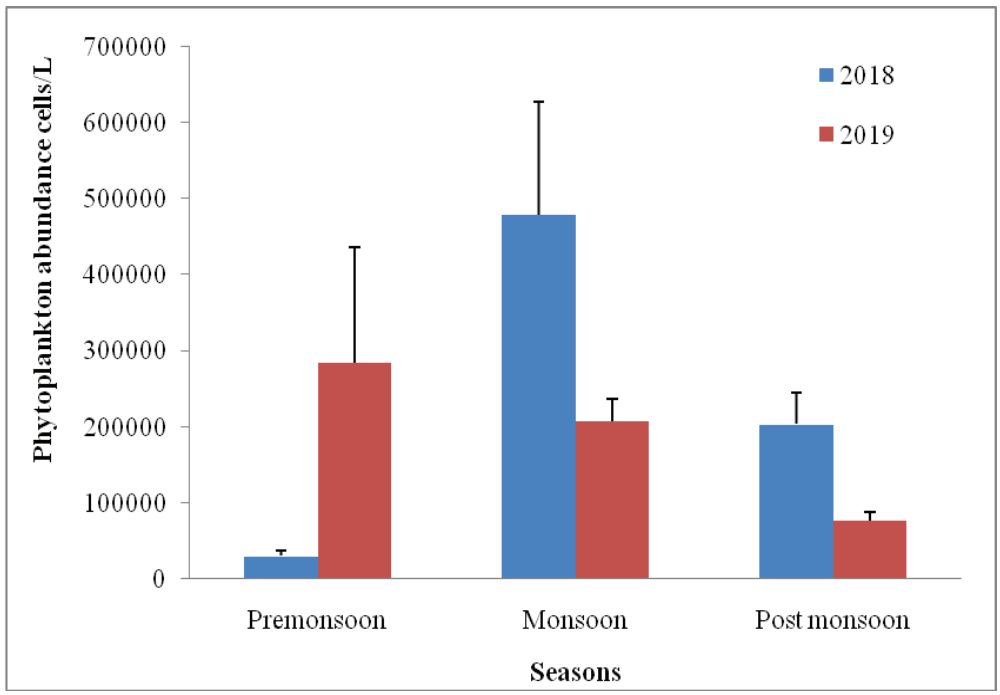


Fig. 18 Seasonal change in phytoplankton abundance in two subsequent years during 2018-2019

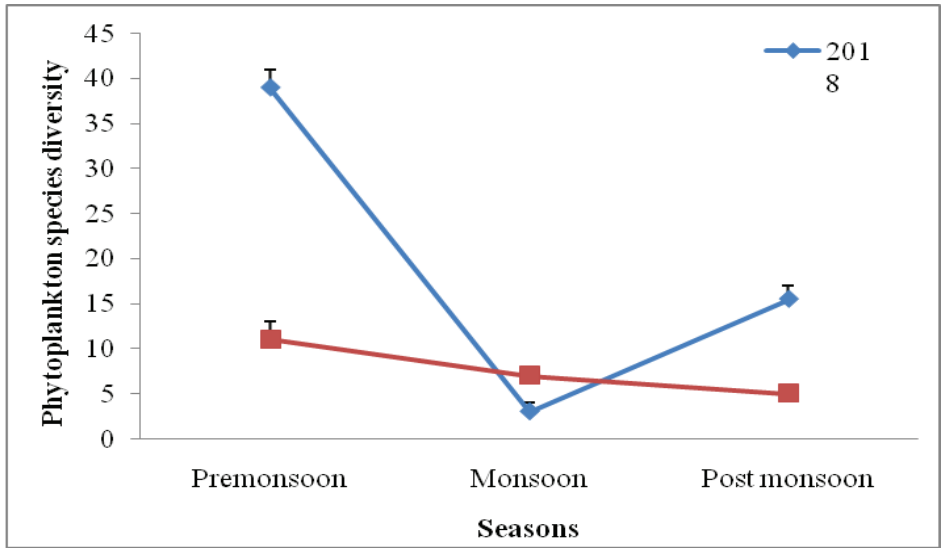


Fig 19. Phytoplankton species diversity in Majharia wetlands of East Champaran during 2018-2019

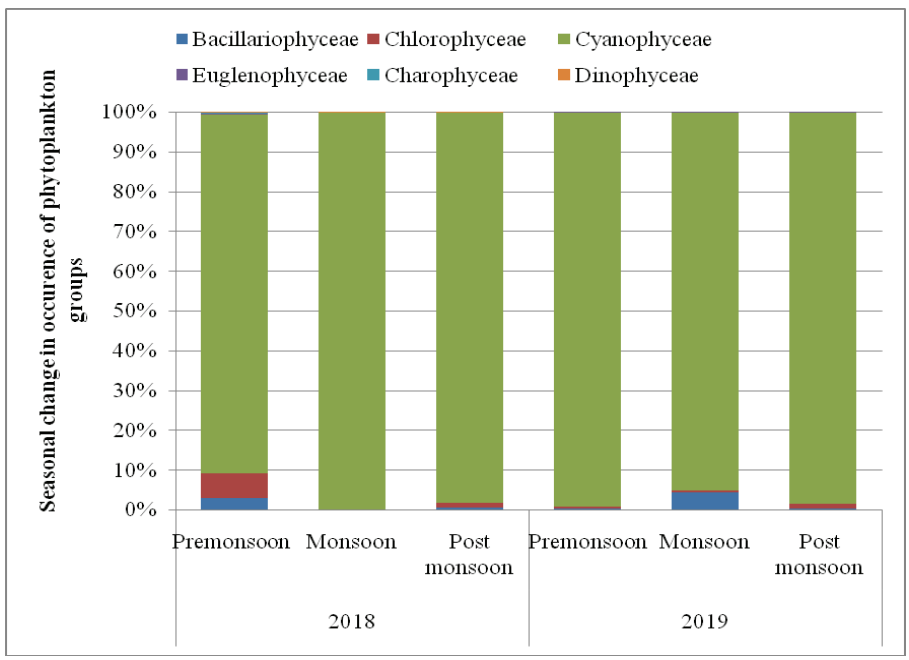


Fig.20 Group-wise seasonal occurrence of phytoplankton in abundance

10.1.13.2 Zooplankton

Zooplankton is considered as most important live food organism in larval stages of fish just after absorption of yolk sac in an aquatic ecosystem. Most of the small indigenous fish (SIF) in aquatic ecosystem depend on zooplankton for their survival. Many scientists attributed the ability of a fish population to outdistance through the larval period without vast mortality as one of the primary factors determining the size of the resulting year class and hypothesized that competition for food during the larval time might be a major factor affecting survival and subsequent year class strength.

Zooplankton abundance and their diversity were assessed during the study period. A total of 26species/texa of four taxonomical groups viz. Rotifer (17 species/texa), Cladocera (4 species/texa), Copepoda (2 groups) and Protozoa (3 species/texa) was recorded. Among the rotifer most dominant genera *Brachiouns* followed by *Keratella* indicates nutrient rich aquatic environment. In Cladocera, most abundance species/texa recorded was *Ceriodaphnia* sp. followed by *Bosmina*. Among Copepoda both group of copepod cyclopoid and calanoid was equally abundant with different life forms. The Common zooplanktons recorded during the study period have been given below.

Majharia wetland was comparatively more diverse as well as abundance than the other similar suited wetlands of the same region. Highest abundance of zooplankton 5350 ind./L in premonsoon (2019) followed by 3680 ind./L monsoon (2019) where as lowest abundance 435 ind./L in premonsoon (2018). Zooplankton diversity was recorded maximum during monsoon season (2019).

The occurrence of Rotifer was observed throughout the study period in both the year. Dominance of copepod including larval stages (in count) was recorded during premonsoon (2019) followed by postmonsoon (2019). Whereas, Cladocerans were dominant during monsoon (2019) followed by monsoon (2019).

The plankton (phytoplankton and zooplankton) abundance was recorded very high and highly suitable of stocking of planktivorous fish especially *Hypophthalmichthys molitrix* (silver carp) based on ecology and plankton dynamics.

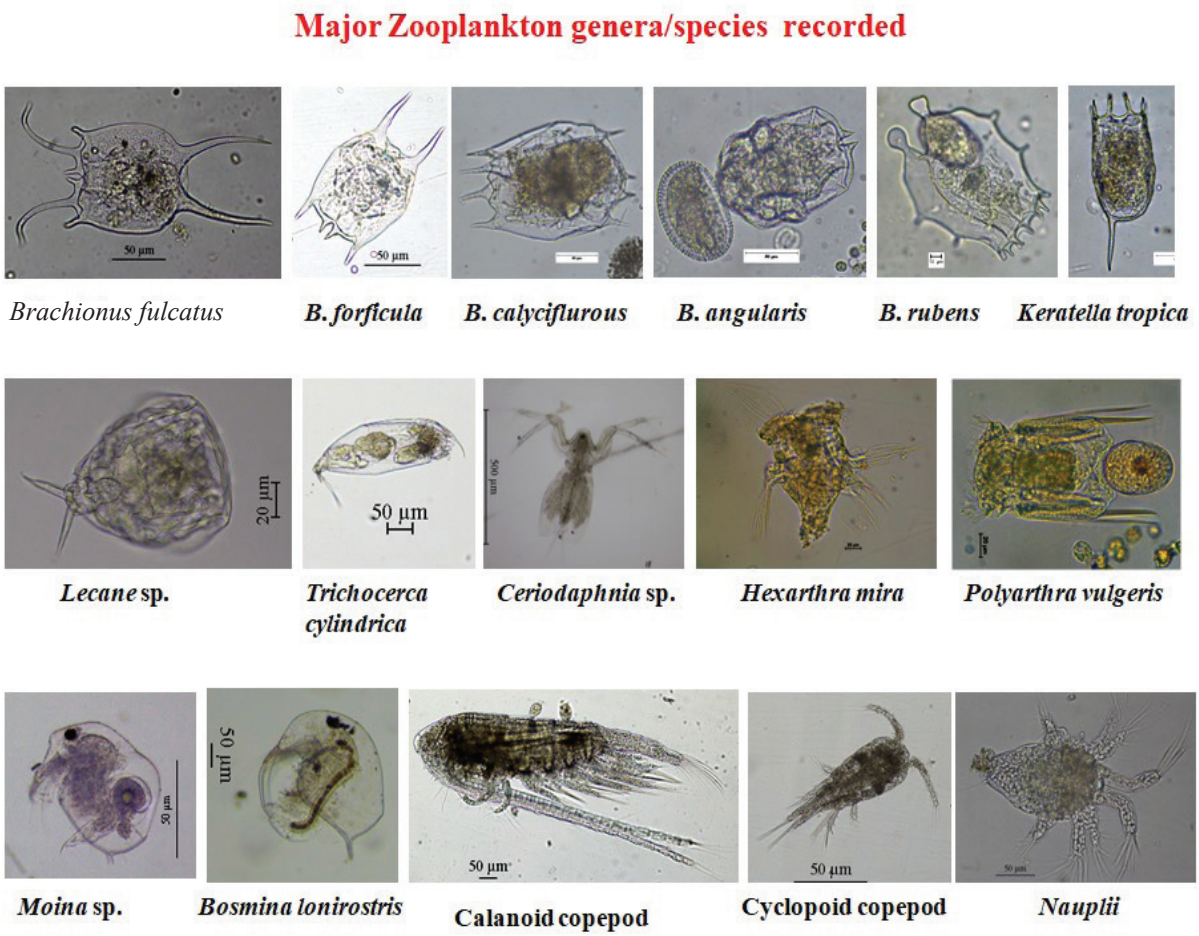


Fig. 21 Common genera/taxa of zooplankton recorded during study period of wetland of East Champaran

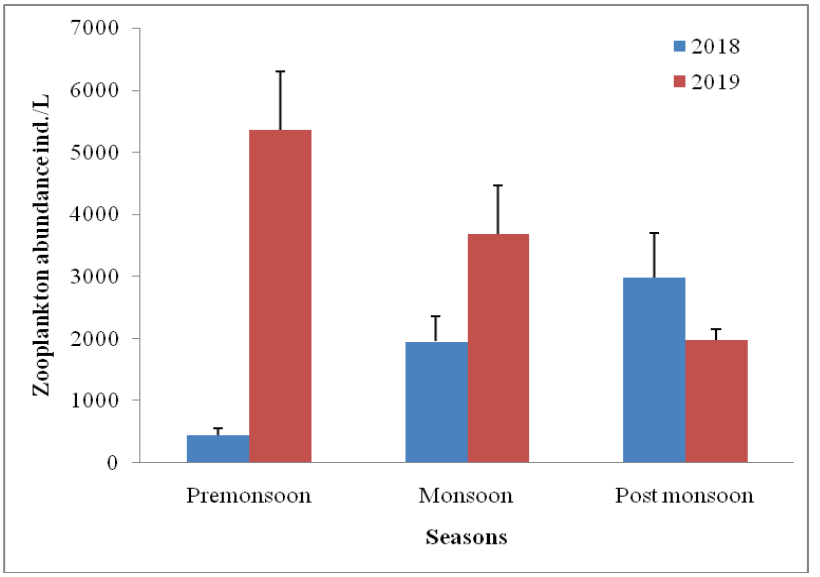


Fig. 22 Seasonal change in zooplankton abundance in two subsequent years during 2018-2019

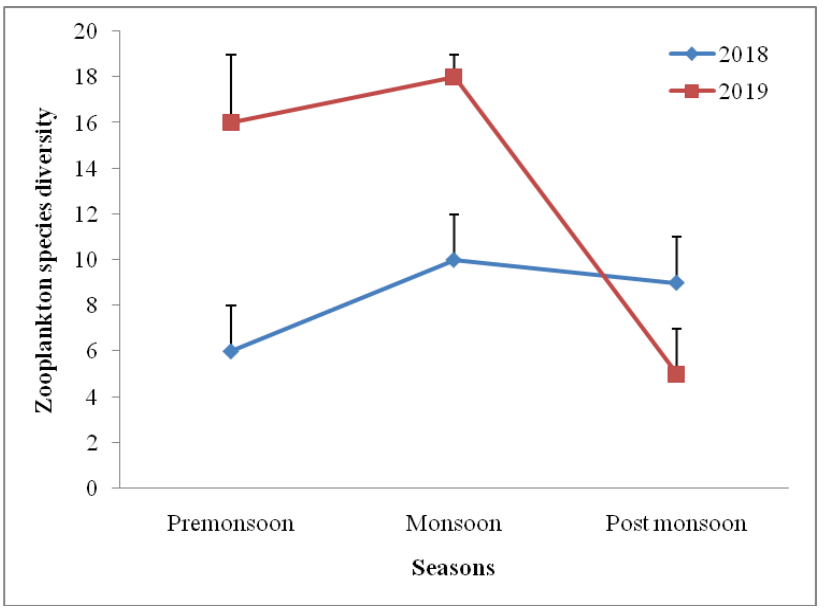


Fig. 23 Zooplankton species diversity in Kararia wetlands of East Champaran during 2018-2019

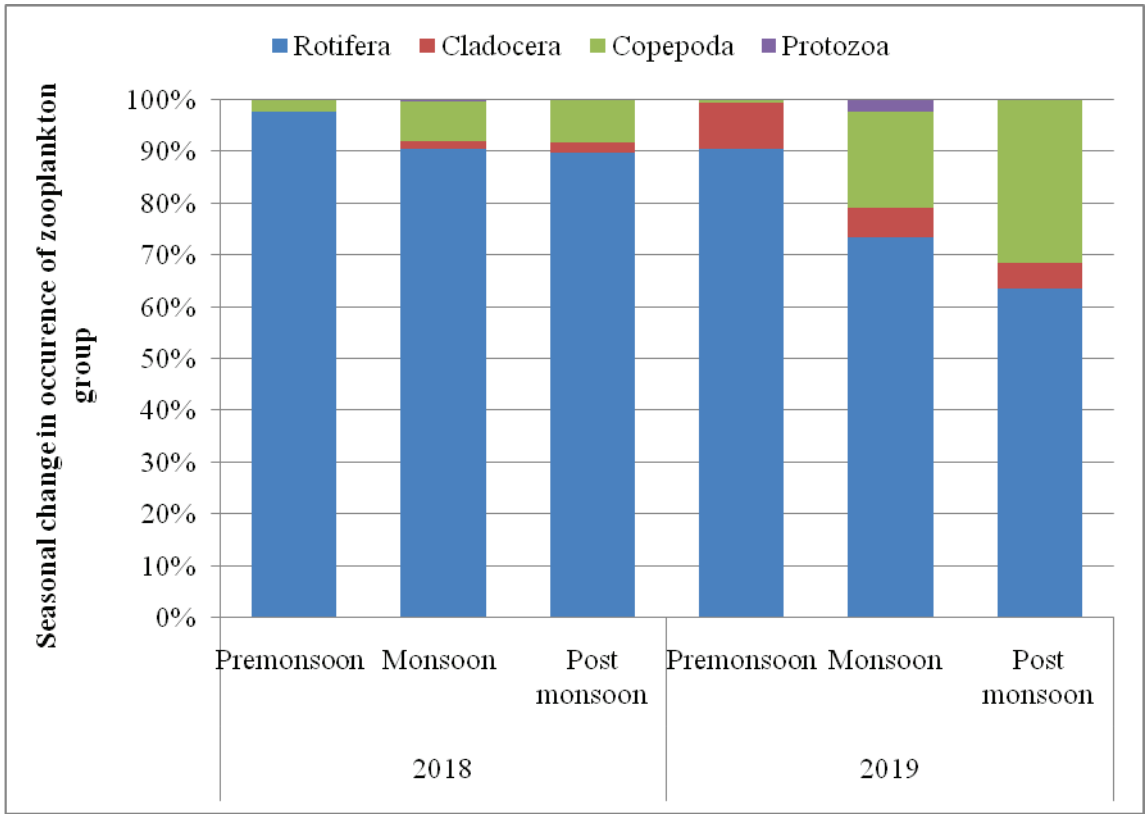


Fig. 24. Seasonal changes in group-wise occurrence of zooplankton in abundance

10.1.14. Assessment of fish diversity

Wetlands are among the most productive ecosystems on Earth, rivaling the richness of rainforests and coral reefs. These dynamic environments provide essential ecosystem goods and services that sustain millions of people worldwide (Finlayson et al. 2005). Among their many ecological roles, wetlands serve as crucial reservoirs of aquatic biodiversity, particularly for freshwater fish species. They offer shelter, food, breeding grounds, and nursery habitats, ensuring the survival and propagation of diverse fish populations. Studies indicate that around 90 fish species from 33 families have been recorded in India's floodplain wetlands (Suresh and Chitranshi 2011; Sandhya et al. 2015). The diversity of fish species in these wetlands is influenced by their hydrological connectivity to rivers and their habitat conditions. Notably, oxbow lakes, enriched with nutrients from extensive catchments, present ideal conditions for enhancing fish production through both capture and culture-based fisheries.

Majharia *Maun*, an oxbow lake in Bihar's East Champaran district, exemplifies the significance of wetlands in supporting aquatic biodiversity. Seasonally linked to the Budhi Gandak River through a channel, this lake provides a habitat for more than 50 indigenous fish species. The richness of its fish diversity reflects the ecological importance of such wetlands in maintaining freshwater fish populations. A detailed analysis of the fish species found in Majharia *Maun*, along with their conservation status as per the International Union for Conservation of Nature (IUCN) Red List, is presented in the accompanying table. This data highlights the crucial role of wetland conservation in safeguarding the genetic resources of freshwater fish and sustaining local fisheries.

1. ***Ailia coila*** **(Hamilton, 1822)**

The Gangetic ailia, a species of the class Actinopterygii and order Siluriformes, belongs to the family Ailiidae. It is native to South Asia, with its distribution spanning India, Bangladesh, Nepal, and Pakistan. This fish inhabits surface to mid-water levels and is found in both freshwater and brackish water environments. Carnivorous by nature, it primarily feeds on smaller aquatic organisms but occasionally consumes algae, plant material, and debris. During the breeding season, distinct pairing behavior is observed; the species is oviparous and does not exhibit parental care, with fecundity ranging from 600 to 1,300 eggs. Classified as Near Threatened (NT) on the IUCN Red List, the Gangetic ailia holds commercial value as a food fish.



2. ***Botia lohachata*** **Chaudhuri, 1912**

The Reticulate loach, classified under the class Actinopterygii, order Cypriniformes, and family Botidae, is found across India, Pakistan, Bangladesh, and Nepal. It is a freshwater species typically inhabiting creeks with rocky and gravelly bottoms in hilly areas, although it has also been reported in plains during the monsoon season. Omnivorous by diet, the Reticulate loach prefers live food. Breeding occurs during the monsoon in various floodplains and rivers, with the species being oviparous and often displaying distinct pairing behavior. While its conservation status has not yet been evaluated by the IUCN Red List, the Reticulate loach is valued commercially as an ornamental fish.



3. ***Amblypharyngodon mola*** **(Hamilton, 1822)**

The Mola carplet, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is found across India, Afghanistan, Pakistan, Bangladesh, and Myanmar. This freshwater benthopelagic species thrives in various slow-moving bodies of water such as ponds, canals, beels, nullahs, and paddy fields, where adults are commonly found. Herbivorous in nature, the Mola carplet primarily feeds on plankton. Its breeding biology is characterized by asynchronous oocyte development, making it a fractional spawner, with fecundity ranging from 1,600 to 16,000 eggs. The species is classified as Least Concern (LC) on the IUCN Red List and holds commercial value as a food fish.



4. ***Setipinna brevifilis*** **(Valenciennes, 1848)**

The short-hairfin anchovy, classified under the class Actinopterygii, order Clupeiformes, and family Engraulidae, is found in India, particularly in its tributary and distributary rivers. It is a freshwater pelagic species known for its potamodromous migration, moving within freshwater systems. Omnivorous by nature, it primarily prefers plankton as its food source. Although specific details about its breeding biology are lacking, the species is currently listed as Data Deficient (DD) on the IUCN Red List. The short-hairfin anchovy holds commercial importance as a food fish.



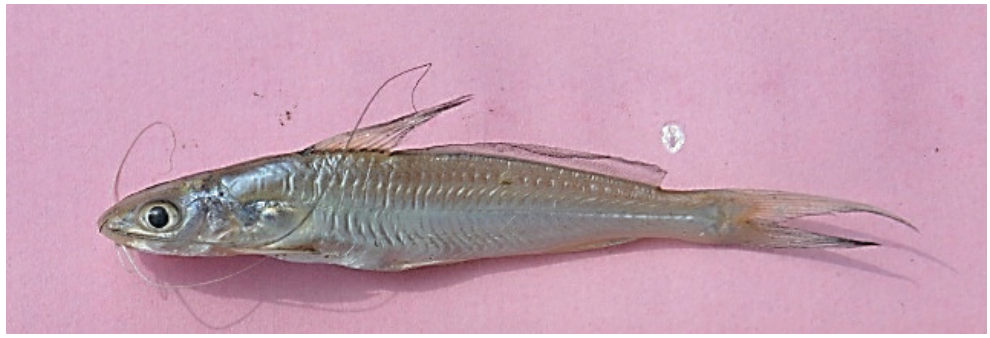
5. ***Aspidoparia/Cabdio morar*** **(Hamilton, 1822)**

The commononly known Morari fish, belonging to the class Actinopterygii, order Cypriniformes, and family Danionidae, is widely distributed across India, Pakistan, Bangladesh, Myanmar, Nepal, Iran, and Thailand. It inhabits benthopelagic zones in freshwater environments and is commonly found in streams and ponds located in both plains and mountainous regions. Omnivorous by nature, the Morari primarily prefers plankton as its food source. Reproductively, it is an oviparous species. Classified as Least Concern (LC) on the IUCN Red List, the Morari holds commercial value as a food fish.



6. ***Mystus cavasius*** **(Hamilton, 1882)**

The Gangetic mystus, classified under the class Actinopterygii, order Siluriformes, and family Bagridae, is distributed across India, Pakistan, Sri Lanka, Myanmar, Nepal, and Thailand. It is a demersal fish that inhabits both freshwater and brackishwater environments. Its feeding behaviour shows a wide range of food referred to as eury-omnivore. The fish is oviparous, having a fecundity of 3,000–63,000 eggs. It is currently listed as Least Concern (LC) on the IUCN Red List and holds commercial value as a food fish.



7. *Devario devario* (Hamilton, 1822)

The Sind Danio, belonging to the class Actinopterygii, order Cypriniformes, and family Danionidae, is geographically distributed across India, Pakistan, Bangladesh, Nepal, and Afghanistan. It inhabits benthopelagic zones in freshwater environments and is commonly found in streams and ponds located in both plains and mountainous regions. The fish has a carnivorous feeding habit, feeding on worms, small crustaceans, and insects. It is an oviparous species with a fecundity ranging from 3,700 to 23,000 eggs. Classified as Least Concerned (LC) on the IUCN Red List, the Sind Danio is valued commercially as an ornamental fish.



8. *Clupiosoma garua* (Hamilton, 1822)

The Garua bachcha, classified under the class Actinopterygii, order Siluriformes, and family Aillidae, is mainly distributed across India, Pakistan, Bangladesh, and Nepal. It is a demersal fish found in both freshwater and brackish water, inhabiting large freshwater and tidal rivers, and exhibits potamodromous migration. The species feeds on insects, shrimps, other crustaceans, and small fish. It is an oviparous fish that does not guard its eggs, with fecundity ranging from 6,000 to 22,000 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the Garua bachcha holds commercial value as a food fish.



9. ***Ompok bimaculatus*** **(Bloch, 1794)**

The butter catfish, belonging to the class Actinopterygii, order Siluriformes, and family Aillidae, is native to several Asian countries including India, Pakistan, Bangladesh, Myanmar, and Sri Lanka. It is a demersal species inhabiting both freshwater and brackish water environments. Adults are typically found in quiet, shallow waters (0.5–1.5 meters deep), often muddy, in sandy streams, rivers, and tanks, and are also present in canals, beels, and inundated fields. Omnivorous in nature, the butter catfish feeds on both vegetable matter and fish. Reproductively, it is an oviparous species with a fecundity of 151–257 eggs per gram of body weight. It is listed as Near Threatened (NT) on the IUCN Red List and holds commercial importance as a food fish.



10. ***Systomus sarana*** **(Hamilton, 1822)**

The Olive barb, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is native to a wide range of countries including India, Pakistan, Afghanistan, Bangladesh, Bhutan, Sri Lanka, Myanmar, Nepal, and Thailand. It is a benthopelagic species found in both freshwater and brackish water environments. Adults inhabit rivers, streams, lakes, and backwaters, often forming schools ranging from small groups of four or five to several dozen individuals. Their diet includes aquatic insects, fish, algae, and shrimps. They spawn in running waters among submerged boulders and vegetation, with fecundity ranging from 12,000 to 225,000 eggs. The Olive barb is listed as Least Concerned (LC) on the IUCN Red List and holds commercial value as a food fish.



11. ***Pethia conchonius*** **(Hamilton, 1822)**

The Rosy barb, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is widely distributed across India, Pakistan, Bangladesh, Nepal, Myanmar, and Afghanistan. It is a freshwater benthopelagic species, with adults typically inhabiting lakes and fast-flowing hill streams. The Rosy barb feeds on worms, crustaceans, insects, and plant matter. It is known for being a prolific spawner, capable of tolerating low water temperatures, with fecundity ranging from 154 to 7,202 eggs. Classified as Least Concerned (LC) on the IUCN Red List, the Rosy barb holds commercial value both as a food fish and as an ornamental species.



12. ***Eutropiichthys murius*** **(Hamilton, 1822)**

The Murius vacha, classified under the class Actinopterygii, order Siluriformes, and family Schilbeidae, is geographically distributed across India, Bangladesh, and Nepal. This species is found in rivers, streams, and canals within demersal habitats. Omnivorous in nature, the Murius vacha feeds on a variety of organic material. It is an oviparous fish, with fecundity ranging from 4,800 to 77,976 eggs, though it does not guard its eggs. The species is classified as Least Concerned (LC) on the IUCN Red List and holds commercial value as a food fish.



13. *Nandus nandus* (Hamilton, 1822)

The Gangetic leaffish, classified under the class Actinopterygii, order Perciformes, and family Nandidae, is native to several Asian countries, including India, Pakistan, Bangladesh, Nepal, Myanmar, and Bhutan. It is a benthopelagic species found in both freshwater and brackish water environments. Adults are commonly found in ditches and inundated fields, and they are particularly abundant during the summer months when they are collected from dried-up beds of tanks, beels, bheries, and other similar habitats. The Gangetic leaffish is typically found in standing or sluggish waters of lakes, reservoirs, and canals. As a carnivorous fish, it feeds on aquatic insects and smaller fish. It is an oviparous species, with fecundity reaching up to 300 eggs per gram of body weight. Classified as Least Concerned (LC) on the IUCN Red List, the Gangetic leaffish holds commercial value both as a food fish and as an ornamental fish.



14. *Gudusia chapra* (Hamilton, 1822)

The Indian River shad, classified under the class Actinopterygii, order Clupeiformes, and family Clupeidae, is primarily distributed across India, Pakistan, Bangladesh, and Nepal. It is a pelagic fish found in both freshwater and brackish water, with adults typically occurring in the middle and upper reaches of rivers. The species is also found in ponds, beels, ditches, and inundated fields, and exhibits potamodromous migration. Omnivorous by nature, the Indian River shad feeds on plankton and detritus. It is an oviparous species, with fecundity ranging from 10,000 to 36,000 eggs. The Indian River shad is classified as Least Concerned (LC) on the IUCN Red List and holds commercial value as a food fish.



15. *Chanda nama* Hamilton, 1822

The Elongate glass-perchlet, classified under the class Actinopterygii, order Perciformes, and family Ambassidae, is primarily distributed across India, Pakistan, Bangladesh, Myanmar, and Nepal. This benthopelagic fish inhabits both freshwater and brackish water environments. It is commonly found in standing and running waters, such as clear streams, canals, beels, ponds, and inundated paddy fields, and is particularly abundant during the rainy season. The species exhibits potamodromous migration. While predominantly carnivorous, the Elongate glass-perchlet's diet also includes insect parts, fish scales, and pieces of higher aquatic plants. It is an oviparous species with fecundity ranging from 2,518 ± 917.95 eggs. Classified as Least Concerned (LC) on the IUCN Red List, the Elongate glass-perchlet holds commercial value as a food fish.



***16. Parambassis ranga* (Hamilton, 1822)**

The Indian glassy fish, classified under the class Actinopterygii, order Perciformes, and family Ambassidae, is native to India, Pakistan, Bangladesh, Myanmar, Nepal, Malaysia, and Thailand. This demersal species inhabits both freshwater and brackish water environments, typically found in sluggish and standing waters. It is a common species that thrives in impoundments, being most abundant during the rainy season. The Indian glassy fish feeds on invertebrates, worms, and crustaceans. It breeds during the rainy season, building nests and guarding its young. The species has a fecundity of up to 500 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the Indian glassy fish holds commercial value as a food fish.



17. ***Laubuca laubuca*** **(Hamilton, 1822)**

The Indian glass barb, classified under the class Actinopterygii, order Cypriniformes, and family Danionidae, is native to India, Pakistan, Indonesia, Bangladesh, the Malay Peninsula, Sri Lanka, Myanmar, Nepal, and China. It inhabits both freshwater and brackish water environments, primarily in the middle-depth areas of streams, ponds, and tanks. The species is found in shallow and relatively deep areas of streams, thriving in both still and moderately fast-flowing waters. Indian glass barbs typically form shoals consisting of 15 to 30 individuals. Omnivorous in nature, they primarily feed on insects but also consume plants. They spawn at dusk or dawn in shallow waters, with around 30 eggs scattered at a time, which hatch within 24 hours. Listed as Least Concerned (LC) on the IUCN Red List, the Indian glass barb is commercially valued as an ornamental fish.



18. Labeo calbasu **(Hamilton, 1822)**

The Orangefin labeo, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is found in India, Pakistan, Bangladesh, Thailand, Myanmar, Nepal, and China. This demersal species inhabits both freshwater and brackish water environments, exhibiting potamodromous migration. Adults are commonly found in slow-moving waters of rivers and ponds, where they feed on plants, filamentous algae, and diatoms. The Orangefin labeo is a seasonal breeder, spawning during the monsoon months. The fecundity of two specimens measuring between 38.8 to 40.5 cm ranged from 193,000 to 238,000 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the Orangefin labeo holds commercial value as a food fish.



19. Labeo gonius (Hamilton, 1822)

The Orangefin labeo, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is found in India, Pakistan, Bangladesh, Thailand, Myanmar, Nepal, and China. This demersal species inhabits both freshwater and brackish water environments, exhibiting potamodromous migration. Adults are commonly found in slow-moving waters of rivers and ponds, where they feed on plants, filamentous algae, and diatoms. The Orangefin labeo is a seasonal breeder, spawning during the monsoon months. The fecundity of two specimens measuring between 38.8 to 40.5 cm ranged from 193,000 to 238,000 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the Orangefin labeo holds commercial value as a food fish.



20. *Sicamugil cascasia* (Hamilton, 1822)

The yellow-tail mullet, classified under the class Actinopterygii, order Mugiliformes, and family Mugilidae, is geographically distributed across India, Pakistan, Sri Lanka, Myanmar, Nepal, and Bangladesh, particularly in the upper reaches of the Ganga, Yamuna, and Brahmaputra river systems. This demersal freshwater species exhibits potamodromous migration, moving within streams and rivers. Omnivorous by nature, yellow-tail mullets primarily feed on detritus. They are oviparous, producing non-adhesive pelagic eggs. Listed as Least Concerned (LC) on the IUCN Red List, the yellow-tail mullet holds commercial value as a food fish.



21. *Puntius chola* (Hamilton, 1822)

The swamp barb, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is geographically distributed across India, Pakistan, Bangladesh, Myanmar, Sri Lanka, Nepal, and Bhutan. This freshwater species inhabits streams, rivers, canals, beels, haors, ponds, and inundated fields, primarily occurring in shallow waters. Omnivorous in nature, the swamp barb feeds on worms, crustaceans, insects, and plant matter. It is an oviparous fish, with a fecundity of 1,184 ± 1,117.35 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the swamp barb holds commercial value both as a food fish and as an ornamental species.



22. *Puntius sophore* (Hamilton, 1822)

The pool barb, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is native to India, Pakistan, Bangladesh, Myanmar, China, Bhutan, Afghanistan, and Nepal. This species is found in benthopelagic habitats in both freshwater and brackish water and exhibits amphidromous migration. Adults typically inhabit rivers, streams, and ponds in plains and submontane regions, often found in large rivers with high turbid monsoon flow and diverse substrates such as sand, mud, gravel, pebbles, cobbles, and boulders. The pool barb is a shoaling fish and an omnivore, with a preference for plankton. It spawns during the pre-monsoon and monsoon seasons, from March to July, with fecundity ranging from 7,951 to 23,053 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the pool barb holds commercial value both as a food fish and as an ornamental species.



23. Labeo rohita (Hamilton, 1822)

The rohu, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is primarily distributed in India, Pakistan, Bangladesh, Myanmar, and Nepal. It is a benthopelagic species found in both fresh and brackish waters. Rohu is a diurnal, usually solitary fish that occasionally burrows and feeds primarily on plants. Its spawning season generally coincides with the southwest monsoon, occurring in flooded rivers, reservoirs, and bundh-type tanks. Spawning takes place in the middle reaches of rivers, where floodwaters spread over fertile flats, well above tidal zones, in more or less limpid shallows. The fecundity of rohu ranges from 226,000 to 2,794,000 eggs, depending on the fish's length, weight, and ovary condition. Listed as Least Concerned (LC) on the IUCN Red List, rohu holds significant commercial value as a food fish.



24. *Cirrhinus mrigala* Linnaeus, 1758

The pool barb, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is geographically distributed across India, Pakistan, Bangladesh, and Nepal. This species is found in freshwater, demersal habitats. Pool barbs are omnivorous by nature. They spawn during the southwest monsoon, with the main spawning period occurring from June to August. In hatcheries, the same fish can spawn two to three times early in the season. They are oviparous, with fecundity ranging from 100,000 to 150,000 eggs per kilogram of body weight. Listed as Least Concerned (LC) on the IUCN Red List, pool barbs are valued commercially as a food fish.



25. ***Ompok pabda*** **(Hamilton, 1822)**

The pabdah catfish, classified under the class Actinopterygii, order Siluriformes, and family Siluridae, is found in India, Pakistan, Bangladesh, Myanmar, Bhutan, and Afghanistan. These freshwater demersal fish exhibit potamodromous migration and are commonly found in both clear and muddy rivers, streams, ponds, and lakes. Pabdah catfish are highly carnivorous and opportunistic cannibals. They are annual breeders, typically spawning during the monsoon period, and are oviparous with fecundity ranging from 300 to 1,020 eggs. Listed as Near Threatened (NT) on the IUCN Red List, pabdah catfish have commercial value as a food fish.



26. ***Cirrhinus reba*** **(Hamilton, 1822)**

The reba carp, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is found in India, Pakistan, Bangladesh, Myanmar, and Nepal. This freshwater benthopelagic species inhabits large streams and rivers, and is also found in tanks, canals, ponds, beels, and inundated fields. Reba carp primarily feed on plankton and detritus, although they may also consume mud, vegetables, crustaceans, and insect larvae. They breed during the monsoon season, with spawning occurring between June and September, peaking in August. Listed as Least Concerned (LC) on the IUCN Red List, reba carp are commercially valuable as food fish.



27. Eutropiichthys vacha (Hamilton, 1822)

The bachwa vacha, classified under the class Actinopterygii, order Siluriformes, and family Schilbeidae, is distributed across India, Pakistan, Bangladesh, Myanmar, Thailand, and Nepal. This pelagic fish inhabits both freshwater and brackish water and exhibits potamodromous migration. It is commonly found in rivers, canals, and tidal waters. Bachwa vacha primarily feeds on small fish and insects. It is an oviparous species, with a fecundity ranging from 4,800 to 77,976 eggs, and does not guard its eggs. Listed as Least Concerned (LC) on the IUCN Red List, the bachwa vacha has commercial value as a food fish.



28. *Xenentodon cancila* (Hamilton, 1822)

The freshwater garfish, classified under Actinopterygii, Beloniformes, and Belonidae, is mainly distributed in India and Sri Lanka. This pelagic-neritic fish inhabits both fresh and brackish waters and exhibits amphidromous migration. It is predominantly carnivorous, feeding on smaller fish and invertebrates. During the breeding season, the male pursues the female, engaging in a side-to-side shuddering motion while oriented parallel to her. They position themselves near submerged vegetation, and the male assumes a slight head-down position to release a single large egg. Each female produces about a dozen eggs per day, and the eggs hatch within a week. The species is oviparous and has a fecundity ranging from 750 to 2,852 eggs. They do not exhibit parental care. Listed as Least Concerned (LC) on the IUCN Red List, the freshwater garfish is valued as a food fish.



29. Channa striatus (Bloch, 1793)

The striped snakehead, classified under Actinopterygii, Perciformes, and Channidae, is native to several Asian countries, including India, Pakistan, Bangladesh, Nepal, Myanmar, Bhutan, Thailand, and South China. This benthopelagic fish inhabits both freshwater and brackish waters, preferring stagnant and muddy environments in ponds, streams, and rivers, especially in swamps and lowland rivers. It is commonly found in relatively deep (1-2 m) still waters such as medium to large rivers, brooks, flooded fields, and sluggish canals. Striped snakeheads can survive the dry season by burrowing into the bottom mud of lakes, canals, and swamps, using their skin and air-breathing apparatus to remain moist while subsisting on stored fat. They are primarily carnivorous and breed in ditches, ponds, and flooded paddy fields, laying between 2,843 and 23,230 eggs. The young snakeheads shoal at the surface and are guarded by the male parent, who hides beneath the water's surface. Listed as Least Concerned (LC) on the IUCN Red List, the striped snakehead holds commercial value as a food fish.



30. Channa marulius (Hamilton, 1822)

The great snakehead, classified under Actinopterygii, Perciformes, and Channidae, is native to India, Pakistan, Bangladesh, Myanmar, Thailand, and Nepal. Adults are typically found in sluggish or standing waters such as canals, lakes, and swamps, often in areas with submerged aquatic vegetation. They inhabit deep pools in rivers and occasionally enter flooded forests. The great snakehead is carnivorous, feeding on a variety of prey, including fish, frogs, snakes, insects, earthworms, and tadpoles. There are also reports of this species preying on water birds, snakes, and rodents. Males are territorial and build floating nests made of weeds and leaves, where the orange-yellow eggs are laid. The eggs hatch within 36 to 48 hours, and the fry stay in the nest for about 10 days after hatching. The parents guard the young for about a month. The species has a fecundity range of 2,116 to 11,332 eggs per kilogram of body weight. The great snakehead is classified as Least Concerned (LC) on the IUCN Red List and holds commercial value as a food fish.



31. Channa punctatus (Bloch, 1793)

The spotted snakehead, classified under Actinopterygii, Perciformes, and Channidae, is native to India, Pakistan, Bangladesh, Myanmar, Sri Lanka, Nepal, Afghanistan, and China. It inhabits both freshwater and brackish water in the benthopelagic region, preferring stagnant, muddy streams. The species is carnivorous, feeding on worms, insects, and small fish. Breeding occurs year-round, typically at night, in shallow, silty waters. Spawning involves the female laying eggs in nests that resemble vertical water columns, floating within vegetated tunnels. During spawning, the male entwines the female, releasing and fertilizing the eggs as they ascend. One or both parents provide care for the eggs, which hatch within a day. The fecundity of the spotted snakehead ranges from 2,423 to 6,466 eggs. Classified as Least Concerned (LC) on the IUCN Red List, the spotted snakehead is commercially valued as a food fish.



32. Heteropneustes fossilis (Bloch, 1794)

The Singhi, or Asian stinging catfish, classified under Actinopterygii, Siluriformes, and Schilbeidae, is distributed across India, Bangladesh, Pakistan, Nepal, Sri Lanka, Thailand, Myanmar, and Bhutan. It is a demersal fish found in both freshwater and brackish water, primarily inhabiting ponds, ditches, swamps, and marshes, though it can sometimes be found in muddy rivers. Omnivorous by nature, the Singhi feeds on a variety of food sources. During the monsoon months, it breeds in confined waters, though it can also breed in ponds, derelict ponds, and ditches when rainwater accumulates. The species is oviparous, and distinct pairing is observed, with parents guarding the eggs. The fecundity ranges from 1,730 to 23,870 eggs. Classified as Least Concerned (LC) on the IUCN Red List, the Singhi is commercially valued as a food fish.



33. *Glossogobius giuris* (Hamilton, 1822)

The Tank goby, classified under Actinopterygii, Perciformes, and Gobiidae, is globally distributed from Africa and Madagascar to India and southern China. This benthopelagic species inhabits freshwater, brackish water, and marine environments, with individuals growing larger in brackish water compared to freshwater. Tank gobies feed on small insects, crustaceans, and small fish. Spawning typically occurs in freshwater, with eggs and larvae subsequently carried by river currents into the sea. The species is oviparous, with a fecundity range of 5,118 to 100,003 eggs per female. Listed as Least Concerned (LC) on the IUCN Red List, the Tank goby is commercially valued as a food fish.



***34. Gagata cenia* (Hamilton, 1822)**

Sisorid catfishes, classified under Actinopterygii, Siluriformes, and Sisoridae, are found across India, particularly in the Ganges basin, the Indus River system, and the Mahanadi River, as well as in Myanmar and Thailand. These demersal fish inhabit both freshwater and brackish environments, growing significantly larger in brackish water. As carnivorous species, they exhibit cannibalistic behavior, feeding on small insects, crustaceans, and fish. Spawning takes place in freshwater, after which the eggs and larvae are carried downstream by river currents into the sea. Sisorid catfishes are oviparous, and they are listed as Least Concerned (LC) on the IUCN Red List. They are commercially valued as food fish.



35. ***Pachypterus antherinoides*** **(Bloch, 1794)**

Schilbid catfishes, also known as Indian potasi, belong to Actinopterygii, Siluriformes, and Schilbidae. They are found across India, Pakistan, Bangladesh, Myanmar, and Nepal. These demersal fish inhabit both freshwater and brackish environments and exhibit amphidromous migration. Known for their carnivorous-omnivorous feeding habits, they primarily prefer zooplankton. Schilbid catfishes are oviparous, with distinct pairing behaviors observed during reproduction, and parents guard their eggs. They are listed as Least Concerned (LC) on the IUCN Red List and hold commercial value as food fish.



36. ***Salmostoma bacaila*** **(Hamilton, 1822)**

The large razorbelly minnow, classified under Actinopterygii, Cypriformes, and Danionidae, is found in India, Pakistan, Bangladesh, Nepal, and Afghanistan. These fish thrive in both freshwater and brackishwater environments, typically inhabiting slow-running streams, rivers, ponds, beels, and inundated fields. As surface feeders, they primarily consume larvae and adult insects. They are oviparous, with fecundity ranging from 9,873 to 29,960 eggs. Listed as Least Concerned (LC) on the IUCN Red List, the large razorbelly minnow holds commercial value as a food fish.



37. Labeo boga (Hamilton, 1822)

Sisorid catfishes, belonging to the class Actinoptergii, order Cypriniformes, and family Cyprinidae, are primarily found in India, Pakistan, Bangladesh, Nepal, and Myanmar. These freshwater species are known for their potamodromous migratory behavior. As bottom-dwelling fish, they primarily feed on plankton. Sisorid catfishes are oviparous, spawning in flooded rivers, with fecundity ranging from 23,484 to 81,648 eggs. According to the IUCN Red List, they are classified as Least Concern. Additionally, they hold commercial value as food fish.



38. *Mystus vittatus* (Bloch, 1794)

The striped dwarf catfish, classified under the class Actinopterygii, order Siluriformes, and family Bagridae, is mainly distributed across India, Pakistan, Sri Lanka, Bangladesh, Myanmar, and Nepal. This demersal species inhabits both freshwater and brackish environments, typically residing in standing and flowing waters. Adults are often found among marginal vegetation in lakes and swamps with muddy substrates. Their diet includes plants, shrimps, insects, mollusks, and other fish. Reproductively, they are oviparous, exhibiting distinct pairing behavior similar to other species in the Bagridae family, and are known to produce sounds during spawning. Their fecundity ranges from 3,256 to 22,549 eggs. According to the IUCN Red List, they are classified as Least Concern and are valued commercially as food fish.



39. ***Sparata seenghala*** **(Sykes, 1839)**

The giant river catfish, belonging to the class Actinopterygii, order Siluriformes, and family Sisoridae, is native to India, Pakistan, Bangladesh, Nepal, Thailand, Afghanistan, and China. This demersal species inhabits both freshwater and brackish environments. Known for their strength, adult giant river catfish are also valued for sport fishing. They are carnivorous in nature, feeding on a variety of animal matter. Breeding typically occurs before the onset of the monsoon season. These fish are oviparous and may exhibit distinct pairing behavior similar to other members of the same genus. Their fecundity ranges from 131,820 to 428,376 eggs. Listed as Least Concern on the IUCN Red List, they also hold commercial importance as a food fish.



40. Sparata aor **(Hamilton, 1822)**

The long-whiskered catfish, classified under the class Actinopterygii, order Siluriformes, and family Bagridae, is distributed across India, Pakistan, Bangladesh, Nepal, and Myanmar. This freshwater species is benthopelagic in nature, occupying habitats near the bottom and midwater zones. Carnivorous and predatory, adult individuals primarily feed on small fish and worms. Reproductively, they are oviparous and may display distinct pairing behavior similar to other members of their genus. Their fecundity ranges from 59,255 to 70,586 eggs. According to the IUCN Red List, the species is categorized as Least Concern and is commercially valued as a food fish.



41. *Trichogaster fasciata* Bloch & Schneider, 1801

The banded gourami, belonging to the class Actinopterygii, order Anabantiformes, and family Osphronemidae, is widely distributed across India, Pakistan, Bangladesh, Nepal, and Myanmar. This freshwater benthopelagic species inhabits a variety of environments, including large rivers, estuaries, ditches, ponds, and lakes, typically favoring areas with dense aquatic vegetation. An omnivorous feeder, the banded gourami consumes algae, decaying organic matter, zooplankton, insects, and mosquito larvae, with a significant portion of its diet consisting of plant material. Reproductively, the male constructs and defends a bubble nest, with the female laying around 500–600 eggs. The species is listed as Least Concern on the IUCN Red List and holds commercial value as a food fish.



42. *Trichogaster lalius* (Hamilton, 1822)

The dwarf gourami, classified under the class Actinopterygii, order Anabantiformes, and family Osphronemidae, is widely distributed across India, Pakistan, Bangladesh, Nepal, and Myanmar. This freshwater benthopelagic species primarily feeds on small insects, crustaceans, and tiny fish, making it largely carnivorous. During breeding, the male constructs and guards a floating bubble nest where the female lays around 600 eggs. The eggs hatch within 12 to 24 hours, and the male continues to protect the nest until the larvae become free-swimming, typically about three days after hatching. Listed as Least Concern on the IUCN Red List, the dwarf gourami also has commercial importance as a food fish.



43. ***Mystus bleekeri*** **(Day, 1877)**

Day's mystus, belonging to the class Actinopterygii, order Siluriformes, and family Bagridae, is distributed across India, Pakistan, Bangladesh, Nepal, Bhutan, Indonesia, and Myanmar. This freshwater demersal fish exhibits potamodromous migration, moving within river systems for spawning. It has an omnivorous diet, feeding on a variety of plant and animal matter. Reproductively, Day's mystus is oviparous, with fecundity ranging from 1,120 to 14,790 eggs. The species is listed as Least Concern on the IUCN Red List and holds commercial value as a food fish.



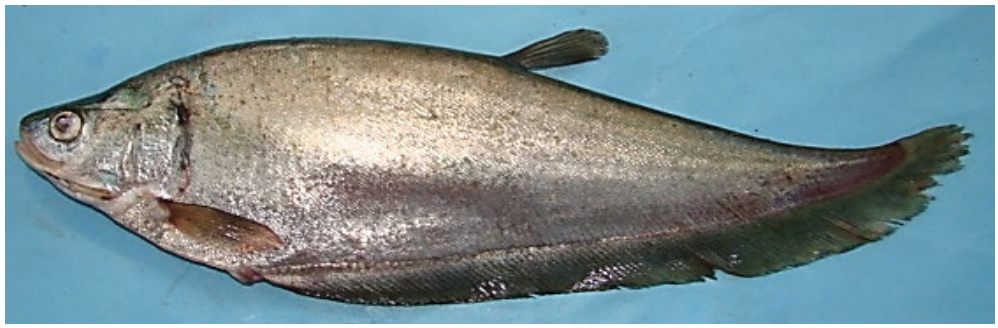
44. ***Acanthocobitis botia*** **(Hamilton, 1822)**

The mottled loach, classified under the class Actinopterygii, order Cypriniformes, and family Nemacheilidae, is geographically distributed across India, Pakistan, Bangladesh, Nepal, Thailand, and China. This benthopelagic freshwater species typically inhabits clear, fast-flowing streams with rocky, pebbly, and sandy substrates. Although omnivorous, it prefers live feed in its diet. Reproductively, the mottled loach is oviparous, with a fecundity ranging from 100 to 150 eggs. It is listed as Least Concern on the IUCN Red List and is commercially valued as an ornamental fish.



45. ***Notopterus notopterus*** **(Pallas, 1769)**

The bronze featherback, belonging to the class Actinopterygii, order Osteoglossiformes, and family Notopteridae, is native to India—particularly in the Indus, Ganges-Brahmaputra, Mahanadi, Krishna, and Cauvery river basins—as well as Thailand, Malaysia, and Vietnam. This demersal species inhabits both freshwater and brackish environments and exhibits potamodromous migration. Adults are commonly found in standing or sluggish waters such as lakes, floodplains, canals, and ponds. They feed on insects, fish, crustaceans, and occasionally young roots of aquatic plants. Breeding occurs seasonally during the rainy season, often in stagnant or running waters, with eggs laid in small clumps on submerged vegetation. A female measuring 21–25 cm can lay between 1,200 and 3,000 eggs. The bronze featherback is listed as Least Concern on the IUCN Red List and is valued both as a food and ornamental fish.



46. ***Rasbora daniconius*** **(Hamilton, 1822)**

The slender rasbora, classified under the class Actinopterygii, order Cypriniformes, and family Danionidae, is native to the Mekong, Chao Phraya, and Salween river basins, the northern Malay Peninsula, and extends westward to the Indus region and Sri Lanka. It inhabits benthopelagic zones in both freshwater and brackish environments. Although primarily carnivorous, it shows a preference for detritus and often forms large schools. Its diet mainly consists of aquatic insects and surface detritus. Spawning typically occurs in rivers and ponds, likely during the rainy season, with individual fecundity ranging from 580 to 11,040 eggs. Listed as Least Concern on the IUCN Red List, the slender rasbora is also commercially valued as an ornamental fish.



47. ***Channa orientalis* Bloch & Schneider, 1801**

The walking snakehead, classified under the class Actinopterygii, order Anabantiformes, and family Channidae, is native to regions from Afghanistan and Baluchistan southward to Sri Lanka and eastward to Indonesia. It inhabits both freshwater and brackish water in the benthopelagic zone, typically seeking shelter under marginal roots and bogwood. This species is commonly found in quiet, shaded, clear-flowing waters with silt or gravel substrates, but it is also highly tolerant of stagnant, poorly oxygenated, turbid, and even foul water. Its diet primarily consists of insects and crustaceans. The walking snakehead exhibits mouth brooding, with eggs hatching in the male's mouth; after hatching, either parent may continue to guard the brood orally. Interestingly, fry have been observed feeding on subsequent batches of eggs laid by the female. Fecundity ranges from 2,843 to 23,230 eggs. It is currently listed as Vulnerable on the IUCN Red List and holds commercial significance as a food fish.



48. ***Tariqilabeo latius* (Hamilton, 1822)**

The stone roller, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is primarily distributed across India, Bangladesh, Myanmar, and China. This benthopelagic species is found in both freshwater and brackish water and exhibits potamodromous migration. Adults typically inhabit streams and rivers, often residing over the gravel and stony bottoms of mountain streams. The stone roller primarily feeds on plankton. Its breeding season occurs from June to mid-July, during which it spawns in vegetation in slow-moving streams and canals. An oviparous species, its fecundity ranges from 20,660 to 79,630 eggs. Listed as Least Concern on the IUCN Red List, the stone roller is commercially valued as a food fish.



49. ***Mastacembelus armatus*** **(Lacepède, 1800)**

The stone roller, classified under the class Actinopterygii, order Cypriniformes, and family Cyprinidae, is primarily distributed across India, Bangladesh, Myanmar, and China. This benthopelagic species is found in both freshwater and brackish water and exhibits potamodromous migration. Adults typically inhabit streams and rivers, often residing over the gravel and stony bottoms of mountain streams. The stone roller primarily feeds on plankton. Its breeding season occurs from June to mid-July, during which it spawns in vegetation in slow-moving streams and canals. An oviparous species, its fecundity ranges from 20,660 to 79,630 eggs. Listed as Least Concern on the IUCN Red List, the stone roller is commercially valued as a food fish.



50. Macrognathus aral **(Bloch & Schneider, 1801)**

The one-stripe spiny eel, classified under the class Actinopterygii, order Synbranchiformes, and family Mastacembelidae, is primarily distributed across India, Pakistan, Bangladesh, Nepal, Sri Lanka, and Myanmar. This benthopelagic species inhabits both freshwater and brackish water, occurring in both running and stagnant waters. It is commonly found in the deltas of large rivers and is particularly abundant in ponds, slow-flowing rivers, and areas with abundant vegetation in plains. The species prefers still waters with silt or mud substrates. As a carnivorous and nocturnal feeder, the one-stripe spiny eel primarily preys on smaller animals. Breeding takes place during the months of August and September, coinciding with the southwest monsoon, and it is an oviparous species with a fecundity range of 1,065 to 4,961 eggs. Listed as Least Concern on the IUCN Red List, the one-stripe spiny eel is commercially valued both as a food and ornamental fish.



51. ***Macrognathus puncalus*** **Hamilton, 1822**

The barred spiny eel, classified under the class Actinopterygii, order Synbranchiformes, and family Mastacembelidae, is primarily found in India, Pakistan, Bangladesh, and Nepal. This benthopelagic species inhabits both freshwater and brackish water, commonly residing in slow, shallow waters of rivers, estuaries, canals, streams, beels, ponds, and inundated fields in the plains. As a carnivorous, nocturnal feeder, the barred spiny eel preys on smaller animals. Breeding occurs between February and September, with peak spawning periods in February/March and July/August. The species is oviparous, with fecundity ranging from 227 to 8,310 eggs. Listed as Least Concern on the IUCN Red List, the barred spiny eel is commercially valued as both a food and ornamental fish.



52. Wallago attu **(Bloch & Schneider, 1801)**

Sisorid catfishes, classified under the class Actinopterygii, order Siluriformes, and family Siluridae, are native to regions including India, Pakistan, Bangladesh, Afghanistan, Nepal, Myanmar, Indonesia, and Thailand. These large, predatory catfish are typically found in areas with grassy margins, often hiding in holes in riverbanks and canals. They thrive in deep, slow-flowing or still waters with a muddy or silty substrate, where they remain sluggish on the bottom in search of food. Juvenile sisorid catfish primarily feed on insects, while adults consume smaller fish, crustaceans, and mollusks. The species is oviparous, with distinct pairing possibly resembling other members of the same family. Abundant during the warm season, they are pre-monsoon summer breeders, with fecundity ranging from 16,565 to 29,883 eggs. Listed as Vulnerable on the IUCN Red List, sisorid catfish hold commercial value as a food fish.



10.1.15. Assessment of fish productivity

Based on the semi-structured interview of the fishers, morpho-hydrographic features and ecological assessment of the wetland. The fisheries status have been determined for Majharia *maun* .

Table. 3 Summerized profile of the Majharia *maun*

GPS coordinate	Area (ha)	Depth range (m)	No. of dependent fishers	Potential yield (kg/ha/yr)	Present yield (kg/ha/ yr)	Expected yield (kg/ha/yr)
N $26^0$33`23.8``, E $84^0$56`01.6``	120	2-7	300	800-1000	50-125	300-500

10.1.16 Participation of fishermen and stakeholders in sustainable fisheries management

Wetland resources of Bihar render multiple goods and services to the ecosystem and society providing food, fodder, fuel and microclimate regulation, benefitting the local community. Fish being one of the major ecosystem goods ensures nutrition and livelihood; their scientific management for development and sustainability needs coordinated intervention by government and social agencies. Despite having the immense scope and potential for fish production, realization remains inadequate due to insufficient access to scientific knowledge and technological interventions, poor fisheries infrastructure, weak financial capacity, lack of cooperative approach, the poor linkage between line department and user groups and unorganized institutional arrangements pose challenges in achieving the potential. Hence, the realization of sustainable production potential necessitates broader and better approaches.

Isssues and challenges :

These wetlands provide numerous ecological goods and services but are under tremendous stress due to rapid urbanization, flood, encroachment and agricultural intensification, manifested by the shrinkage in their areal extent, and decline in the hydrological, economic and ecological functions they perform. Urbanization, flood and land use changes exerted tremendous pressure on wetlands and flood plain areas for meeting water and food demand of growing population. Apart from these problems low fish fish production are attributed from unorganized Institutional arrangement, habitate degradation, decline in fish stock, climate change, poor adoption of technology, insufficient infrastructure, lack of skilled manpower, weak financial capacity, poor linkage and lack of cooperative approach.

Challenges observed

1. Lack of awareness of ecological and economic importance of the wetland
2. Lack of appropriate Institutional arrangement:
3. Inadequate governance of wetland management systems
4. Policy failures
5. Lack of availability of Baseline Information on wetlands
6. Wetland lease tenure and ownership arrangement
7. Inadequate funding for wetland conservation and management
8. Inadequate community participation
9. Lack of Wetland Management Plans
10. Political goodwill
11. Variability of climatic conditions
12. Lack of knowledge of technology for fisheries enhancement
13. Lack of management of predatory fishes
14. In sufficient infrastructure
15. Macrophyte management
16. Migration of fishers
17. Lack of Sustainable Fisheries management plan
18. Lack of skill for fisheries management

Opportunities

Understanding the above mentioned threats and challenges, there exists a great need for technological interventions, skill development, governance, financial support for the management of the wetlands. ICAR-CIFRI have intervention in the five wetlands of East Chamaparan based on the principle of Ecosystem Approach to Fisheries Management model with the above mentioned challenges.

Ecosystem Approach to Fisheries Management: It described as a strategy framework that promotes conservation, sustainable use and equitable sharing of ecosystem resources. It involves a transition from traditional fragmented planning and decision making to a more holistic approach to natural resource management. It addresses both the human and ecological dimensions of sustainability, it is participatory, and takes all key factors into consideration and encourages the use of the best available knowledge in decision-making. Basic principle of Ecosystem Approach to Fisheries Management

- Need to have the right knowledge about the system to be managed
- Maintain ecosystem integrity
- Improve human well-being and equity
- Apply the precautionary approach
- Develop participatory an adaptive management systems
- Ensure compatibility of management measures
- Broaden stakeholder participation and
- Improve research to better understand ecosystems in all components

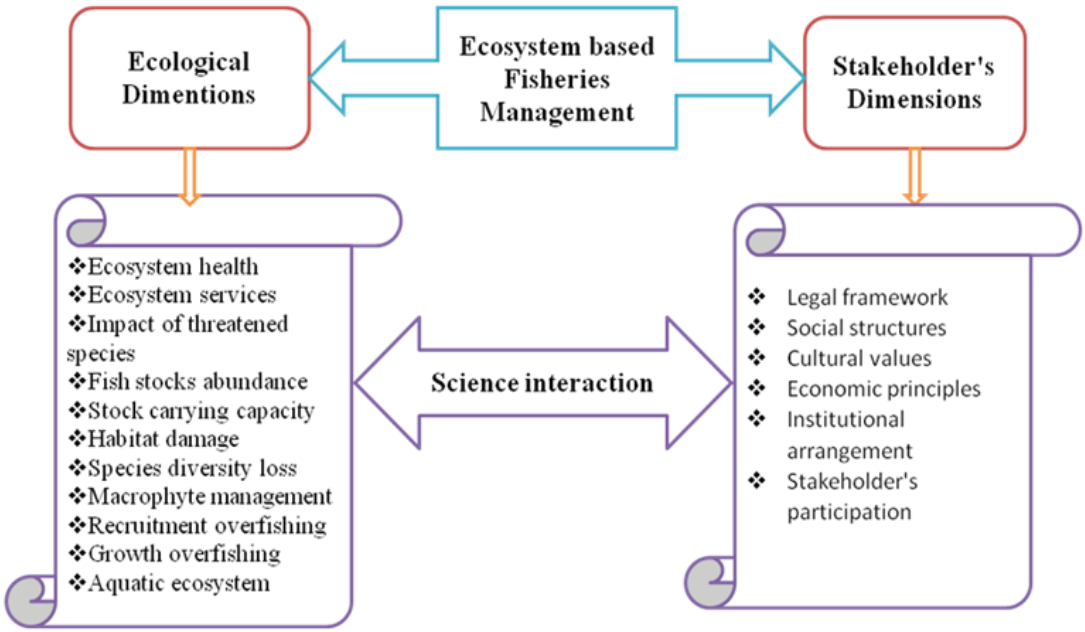


Fig 25. Implementation of Ecosystem Approach to Fisheries Management



Fig 26. Flow chart of Approach for realizing fish production potential from Majharia *maun*



Fig 27. Ecosystem Approach to Fisheries Management Model for Majharia wetlands

10.1.17 Community sensitization, mobilization and orientation

The success and sustainability of community development projects depend heavily on active community participation. Engaging the community helps raise awareness, build essential skills, and foster self-reliance. Therefore, establishing a strong rapport between the project-executing agency and the local community is a critical first step.

Recognizing the importance of rapport and trust-building, particularly between fishers and scientists, several interactive meetings, brainstorming sessions, and sensitization programs were conducted at the project sites. These initiatives involved the funding agency (NFDB), the Department of Fisheries, and other key stakeholders.

Before implementing scientific interventions, it was essential to mobilize and orient the fisher community. This was achieved through camps, awareness programs, and especially through personalized door-to-door visits. Active society members, especially secretaries, were identified and empowered as front-line workers. They

played a key role in communicating the project's objectives and building trust within the community. These project activities were strategically designed not only to meet the targeted fish yield but also to ensure the sustainable improvement of the community's livelihood.

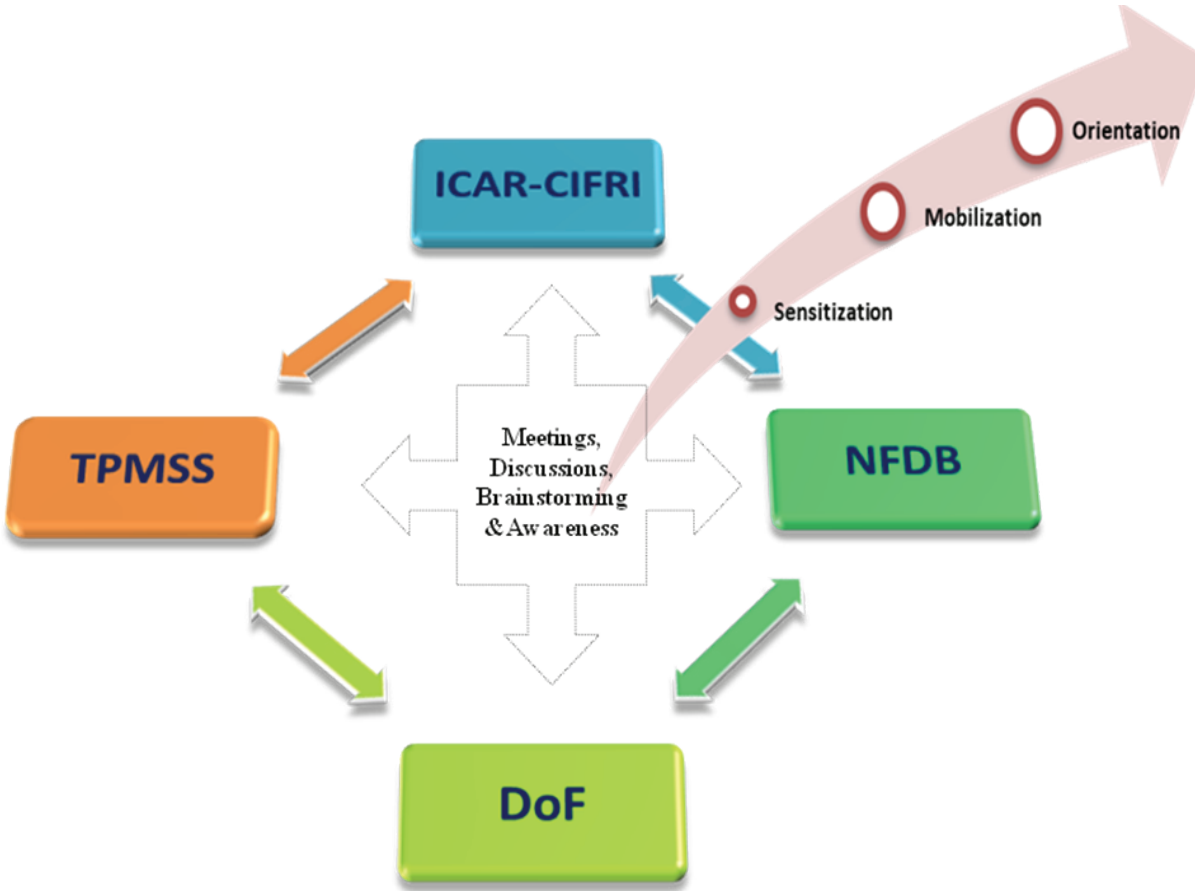


Fig. 28 Flow chart to depict the process of community sensitization, mobilization and orientation for sustainable fisheries management

10.1.18. Development of infrastructure/fisheries resources

ICAR-CIFRI has developed and established infrastructure to promote participatory fisheries management. This includes the creation of a 1.5-hectare earthen nursery pond, divided into three sections of 0.5 hectares each; a 0.8-hectare CIFRI HDPE pen; six CIFRI GI cages; and water screen nets installed at the inlet and outlet of the wetland. Additional provisions include one FRP boat, two wooden boats, and 300 gill nets, along with the installation of a submersible pump. Members and stakeholders were actively motivated to engage in learning and contributing to the process of establishing land-based nursery ponds and implementing infrastructure such as pens, cages, and water-screen nets. This initiative encourages stakeholders to collaborate, fostering unity and a shared commitment toward long-term fisheries management and sustainability.

Table. 4 Fish seeds rearing facilities created at Majharia *maun*

S.N.	Particulars	Unit (nos)/Area (ha)
1	Pond	1.5 ha
2	Cage	06
3	Pen	0.8 ha
4	FRP Boat	1
5	Wooden boat	2
6	Gill net	300
7	Submersible pump	1



Fig. 29 Community participation in creation of wetland fisheries development infrastructure, Installation of submersible pump (A), Installation of Pen culture system (B) Establishment of land based fish seed rearing facility (Pond-C); Clearence of weed (D), Intallation of cage (E-F).

10.1.19. Management of Culture Based Fisheries through community participation

Culture-based fisheries involve utilizing natural aquatic bodies like freshwater wetlands for fish production, where fish seeds are stocked and later harvested once they attain a marketable size. This process is a strategic approach to sustainable fish farming and involves a series of activities conducted systematically between the stocking and harvesting phases.

The sequence begins with an ecological assessment of the aquatic body, which helps determine its suitability for fish farming and assesses the availability of resources such as water quality, nutrient levels, and vegetation. Based on these findings, the selection of fish species and their composition for the stocking program are determined. Fish species are carefully chosen to maximize production while maintaining ecological balance.

Next, sourcing of fish seeds is carried out to ensure that healthy and high-quality seeds are obtained from reliable hatcheries or natural sources. This is followed by decisions on stocking size and time, where fish seeds are introduced into the wetland at an optimum size and during favorable seasons to ensure their survival and growth. Once stocked, stock monitoring is conducted to regularly observe the health, growth rates, and overall progress of the fish population.

Harvesting protocols come into play when the fish reach marketable size. This step involves selecting appropriate fishing gears, imposing restrictions on fishing periods to avoid overfishing, regulating mesh sizes to ensure only fish of desired size are caught, and applying techniques like periodical and selective fishing, particularly when predatory fish pressure exists. Additionally, fencing may be installed if the wetland has seasonal or perennial connections to rivers to prevent the escape of stocked fish into larger water systems.

Documentation of each activity, including stocking details, ecological assessments, monitoring results, and harvesting data, is carried out meticulously to maintain records and refine future processes. Community participation plays a pivotal role throughout this endeavor. Stakeholders and local community members are actively involved and educated about the importance and significance of each step, ensuring their engagement and long-term contribution to sustainable fisheries management. Through this collaborative approach, culture-based fisheries can thrive, benefiting both the environment and local livelihoods.

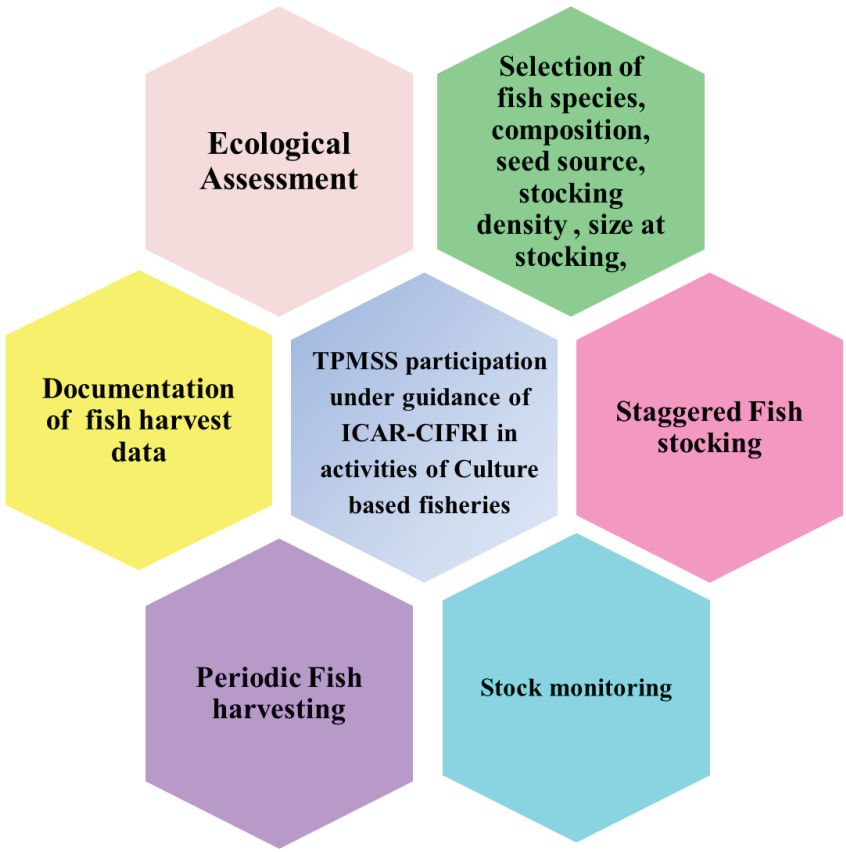


Fig 30. Management of Culture Based Fisheries through community participation

10.1.20. Upscaling of community skill and capacity through their participation

The management regimes of open water fisheries in Bihar, based on property rights and access, are classified into four distinct categories: private management involving individuals or groups; fishers' cooperative management or self-help group (SHG)-based management for floodplain wetlands; and open-access systems without formal management for rivers, rivulets, and streams. Ownership of water bodies resides with the Department of Fisheries, and management rights for wetlands

are typically leased to the highest bidder, often a Fishermen Cooperative Society or Fishers' SHG, who generally operate in an extractive mode. Over time, the natural replenishment and rejuvenation of wetland fisheries have significantly declined due to factors such as stock depletion of riverine fisheries, overexploitation, loss of connecting channels, and the impacts of climate change. This decline has adversely affected fish catch and, consequently, the livelihoods of fishers, underscoring the urgent need for technological interventions, dissemination of knowledge, and skill development to enable more sustainable management practices. Addressing these challenges, skill and capacity-building initiatives were implemented for the fishers of Kothia *Maun* through formal classroom teachings, workshops, field demonstrations, and active participation in visits to various establishments, organizations, fora, and events (mela), aiming to enhance their expertise and prepare them for improved management of wetland fisheries in the long term.



Fig. 31. Community skill and capacity development program for Fishers

11. Objective 2

To disseminate in situ fish seed rearing and fisheries enhancement techniques (stocking enhancement, enclosure cultures) for tapping fish production potential of wetlands

11.1 Achievements

11.1.1 Installation of "CIFRI HDPE Pen"

Pen culture is a semi-intensive fish farming technique developed and refined by the ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), designed to optimize fish production in inland water bodies, especially in environments otherwise unsuitable for traditional aquaculture practices. A *pen*, in this context, refers to a defined area within a water body that is enclosed by fencing or netting to confine and culture fish. These enclosures are engineered to suit diverse water body conditions, particularly in *beels* (floodplain wetlands), lakes, and other shallow aquatic systems.

According to the ICAR-CIFRI design principles, pens are generally constructed along the margins of a lake or wetland, with three sides enclosed using fencing materials like bamboo screens or HDPE nets, while the fourth side remains open and contiguous with the land to facilitate management operations. In certain conditions, pens may also be built entirely away from the shore, in which case all four sides are securely fenced to create an isolated aquatic zone.

The primary objective of pen culture is to convert underutilized, shallow, weed-infested, and derelict water bodies into productive fish farming zones. These areas typically pose challenges for conventional capture fisheries due to difficult access, poor water exchange, and dense vegetation. Pen culture overcomes these limitations by creating manageable aquatic environments where fish stocks can be reared effectively.

ICAR-CIFRI recommends an ideal pen size of 0.1 to 0.2 hectares, which is optimal for ease of operation, maintenance, and resource allocation. Multiple pen units, known as a *battery*, can be installed within a single water body, depending on its total area and the production targets. This modular approach allows scalability and site-specific customization.

One of the key applications of pen culture is the rearing of fish fingerlings, particularly carps, for further stocking in open waters. In a typical 0.1–0.2 ha pen, farmers can raise up to 500 kg of carp fingerlings (averaging 10g or 100mm in size) over a rearing cycle of approximately three months. This is achieved by initially stocking 50,000 to 75,000 fry of 15–30 mm size, with an expected survival rate of around 80%, under proper management conditions.

The ICAR-CIFRI pen culture system is not only eco-friendly but also cost-effective. It requires minimal inputs, with the primary expenditures related to supplementary feeding and basic fish health management practices. The open nature of the pen allows for natural productivity and water exchange, reducing the environmental footprint and maintaining water quality.

Overall, pen culture represents a viable livelihood enhancement strategy for rural fishers and small-scale aquaculture practitioners. By employing this innovative technology, water bodies once deemed unproductive can be transformed into vibrant centers of inland fish production, contributing to food security, employment, and sustainable aquaculture development.



Fig. 32. Community participation in creation of wetland fisheries development infrastructure, Cleaning of macrophyte for pen installation (A-B), Installation of pen (C-D), Stocking of fish in pen (E) and fish harvest from pen culture (F)

To ensure a continuous and sustainable supply of fish seed for stocking in the *maun*, a pre-fabricated "CIFRI HDPE pen" (covering an area of 0.5 hectares) was procured and strategically installed in a scientifically selected marginal zone of Majharia *Maun*. This installation was aimed specifically at producing advanced fingerlings from available fry-stage fish seeds during the monsoon period (July to September), thereby ensuring year-round availability of stocking material for culture-based fisheries in the wetland.

In July 2018, during the monsoon when the wetland was in a flooded state, the pens (0.5 ha effective rearing area) were stocked with two exotic carp species: grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*), in a stocking density of 20 individuals per square meter, following a stocking ratio of 1:1.5 (grass carp:common carp). CIFRI Cage Grow feed was administered to the fish at a rate of 2–3% of their body weight per day to promote optimal growth. The total stocking density was maintained at 100,000 fry per hectare.

The rearing of seeds in the pen proved to be a highly effective approach for fingerling production in this wetland ecosystem. Among the species cultured, grass carp demonstrated notably high growth performance, indicating its suitability and potential for pen-based aquaculture systems in floodplain wetlands.

In a trial conducted in 2018, 100 kg of fry-stage seeds were stocked into the pens, and within 20 days, 274 kg of fingerlings were harvested—highlighting rapid growth and high survival rates under controlled pen conditions. These advanced fingerlings were subsequently released into the open *maun* to serve as robust stocking material, thereby mitigating the risk of winterkill and optimizing fish production.

Encouraged by the success of the initial trial, another batch of 100 kg of fry was stocked into the pen system in early 2019. After a three-month culture period, a total of 289 kg of fingerlings were harvested and released into the open waterbody.

However, during the 2019–2020 cycle, the pen infrastructure faced setbacks due to storm damage and heavy rainfall. Despite these challenges, the damaged installations were recovered, dried, and stored properly for reuse in subsequent cycles. Fingerling production resumed thereafter, and a total of 187 kg of fingerlings were harvested after a four-month rearing period during the same cycle.

Overall, the pen-based seed rearing system in Majharia *Maun* successfully produced a total of 750 kg of advanced fingerlings between 2018 and 2020, validating this approach as a sustainable and replicable model for enhancing fish seed availability and supporting culture-based fisheries in floodplain wetlands.

Table 5: Growth parameters of carps in Pen culture at Majharia *maun*

	C. idella	*C. carpio*
Initial Weight (g)	4.48	1.63
Final Weight (g)	73.5	24.4
Weight gain (%)	1541	1397
Survival (%)	74	82
Specific growth rate	0.040	0.039
Culture duration (days)	70	70
Stocking (Kg)	574	176

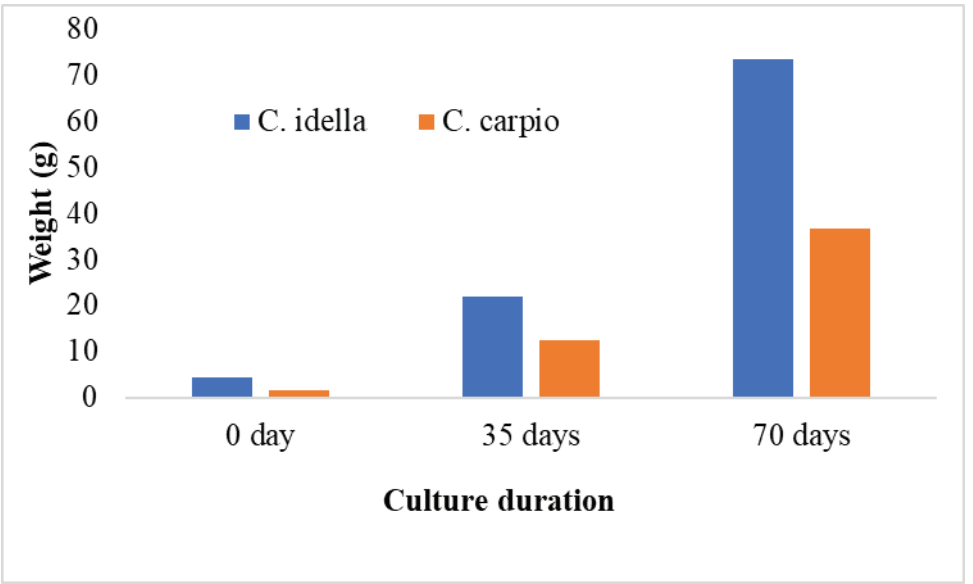


Fig 33. Growth trend of carps in pen at Majharia jheel

11.1.2. Installation of CIFRI GI Cage

Cage aquaculture, although relatively new to India's inland aquaculture sector, has rapidly emerged as a transformative technology, offering new opportunities to optimize fish production from underutilized water bodies such as reservoirs, lakes, wetlands, and beels. Spearheaded by institutions like the ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), cage culture has not only enhanced the productivity of inland fisheries but has also developed vital new skills among fishers and entrepreneurs, contributing significantly to their income and livelihood resilience.

In essence, a cage in aquaculture refers to an enclosed structure deployed in natural water bodies, allowing a free exchange of water while confining the cultured organisms within a specific space. Typically, cages are enclosed on all sides with durable netting, leaving an open top for operational tasks like feeding and stock management. These cages can be strategically placed along different levels of the water column—bottom, mid-water, or surface—with floating cages being the most popular due to their ease of installation, management, and maintenance.

Cage culture serves two critical purposes in inland fisheries: the rearing of fry to fingerling stages for seed stocking in culture-based fisheries, and the grow-out of fingerlings to table-size fish for direct market sale. This dual application makes cage farming particularly adaptable for optimizing fishery outputs in different aquatic ecosystems, including shallow wetlands and deeper beels.

The design of cages varies, typically including round, square, and rectangular shapes. While round cages are extensively used in marine cage farming, for inland waters—especially in reservoirs and deeper wetlands—rectangular and square-shaped cages have proven to be more practical and effective. From a production perspective, both shapes are equally efficient. However, logistical considerations such as ease of installation, maintenance, and harvesting often favor square and rectangular designs in inland water bodies.

One of the most notable innovations by ICAR-CIFRI has been the development and promotion of the "CIFRI GI Cage," a square-shaped, galvanized iron-framed cage tailored specifically for inland aquaculture. These cages have gained immense popularity due to their robustness, adaptability, and cost-effectiveness in Indian reservoirs and wetland ecosystems. A significant initiative was undertaken in 2018 at Majharia *Maun*, a wetland where six units of CIFRI GI Cages were installed at carefully selected sites with a minimum water depth of ≥5 meters. The standard frame dimensions of these cages were retained, while modifications were made to the netting (hapa) to better suit the ecological dynamics of wetland environments.

The CIFRI GI Cage comes in two standard productive volumes: 87.5 m^3 for table-size fish production and 25 m^3 for fingerling rearing. These cage units have demonstrated impressive production capacities. For instance, an 87.5 m^3 cage can yield up to 4

tonnes of *Pangasius hypophthalmus* (a fast-growing, high-demand species), while a 25 m^3 cage can produce between 2,500 to 4,000 high-quality fingerlings (primarily *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*) of approximately 100 mm size, suitable for stocking in culture-based fisheries.

This initiative has not only augmented fish production in traditionally underutilized wetlands but also provided an alternative, sustainable livelihood model for local fishing communities. The success of cage culture in these inland waters, led by research and demonstrations from ICAR-CIFRI, is paving the way for its wider adoption across India, heralding a new era of scientific and sustainable inland aquaculture development.In the present project, major carp seeds were stocked in cages as a measure of a contingent source of stocking material in the open wetland during post flood situations.

The CIFRI GI cages were installed in the wetland to raise stocking material (advanced fingerlings of carps) during flooding period and to grow table size pangasius for providing compensatory income during fishing ban. Fingerlings of *Labeo rohita* and *Labeo catla* were stocked in cages at the rate of 15 per cubic meter in a ratio of 1:2.5::Catla:Rohu and cultured for a period of 110 days from June 2018 to October 2018. The fishes were fed with CIFRI cage grow feed at the rate of 2-3% body weight. The advanced fingerlings of over 100g were harvested and released in the wetland for enhancing culture-based fisheries.



Fig. 34. Installation and monitoring of CIFRI GI Cage at Majharia *Maun*



Fig. 35. Table size fish Harvest of CIFRI GI Cage at Majharia *Maun*

Table 6 Growth parameters of carps in cages at Majharia *maun*

Particulars	***Labeo rohita***	***Labeo catla***
Initial Weight (g)	10.31	18.87
Final Weight (g)	118	168
Weight gain (%)	1044.5	790.3
Survival (%)	81	74
Specific growth rate	0.022	0.020
Culture duration (days)	110	110

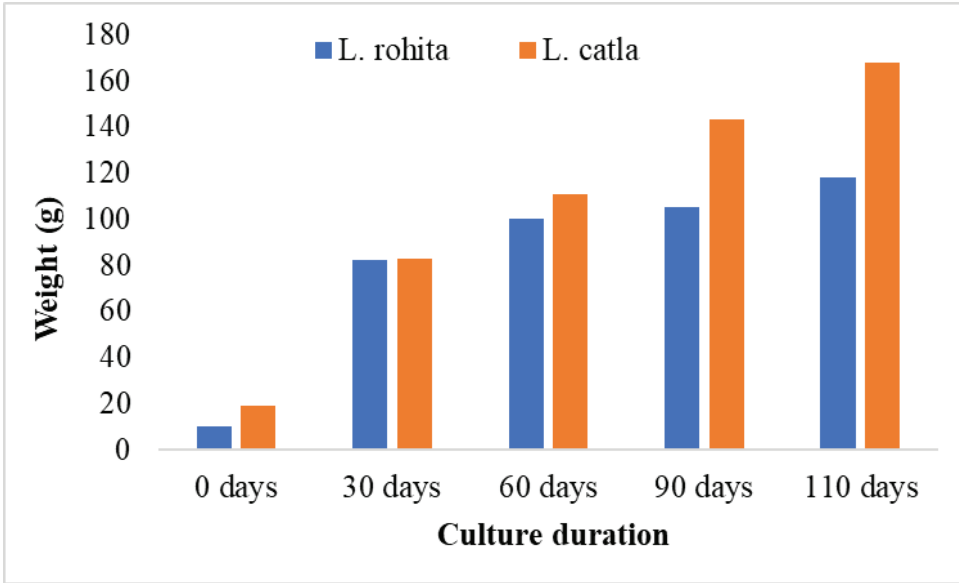


Fig. 36. Comparative groth of *Labeo rohita* and *L. catla* in cages of Majharia *Maun*

During 2018–2021, cage culture trials for Catla (*Labeo catla*) and Rohu (*Labeo rohita*) were conducted in six CIFRI GI cages installed in a wetland ecosystem, aimed at optimizing fish production and validating the adaptability of inland cage aquaculture during the winter season. A total of 40 kg of Catla and 30 kg of Rohu fingerlings were stocked following best aquaculture practices, with a strong focus on health management and scientific feeding protocols. Fish were fed twice daily with "CIFRI Cage Grow," a specially formulated feed developed by ICAR-CIFRI to meet the nutritional demands during colder months. The trials resulted in encouraging survival rates, with Catla achieving 74% and Rohu reaching 81%, reflecting the effectiveness of health and environmental management in cage systems. Over a culture period of 110 days, Rohu exhibited remarkable growth, with the initial average weight increasing from 10.31 grams to 118 grams—approximately a tenfold weight gain—while Catla grew from an initial average weight of 18.87 grams to 168 grams, recording nearly an eight to ninefold increase. These results not only demonstrated the suitability of cage culture technology for enhancing fish productivity in wetlands during challenging winter conditions but also highlighted the potential of customized feeding regimes and robust cage management practices to significantly boost fish survival, growth, and overall production efficiency in inland open waters.

Pangasianodon hypophthalmus (Pangasius) was cultured as an additional livelihood during the closed fishing season after rearing of carp seed for culture-based fisheries. Six cages (5mx5mx2.5m each) were stocked with pangasius seed of average weight: 7.1g at the rate of 10 nos. /m^3in the month of April 2019. The fishes were fed minimally at the rate of 2-3% of body weight. After 120 days, pangas of average size 248g were harvestedwith survival rate of 85%. The fish was sold live at the site at the rate of 100Rs/kg.

Table 7: Growth parameters of Pangasianodon hypophthalmus in cages

Parameter	Value
Initial weight (g)	7.1
Final Weight (g)	248
Weight gain (%)	2912
Survival (%)	88.50
Specific growth rate	0.034
Feed Conversion Ratio	1.5

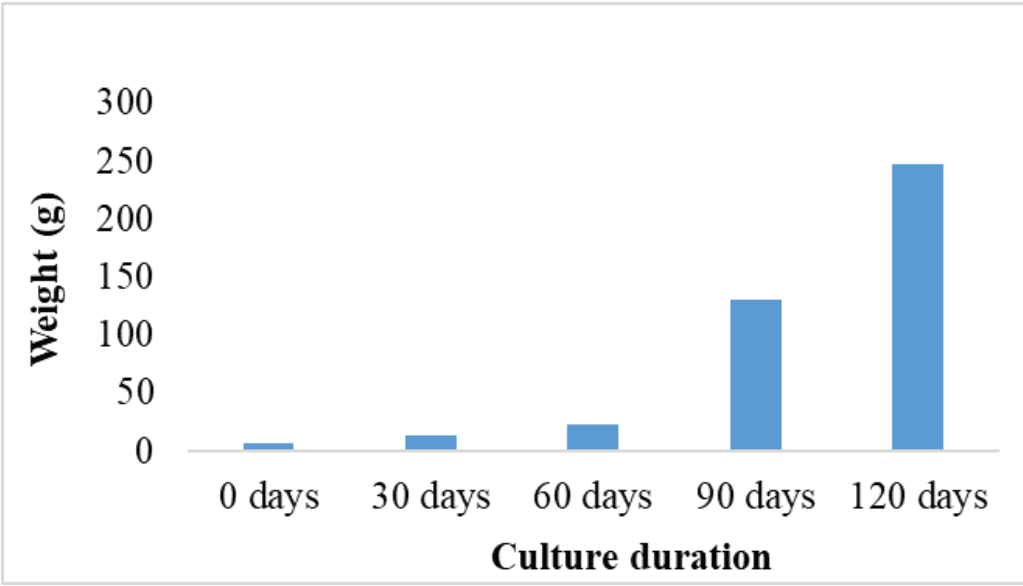


Fig 37. Growth trend of *Pangasianodon hypophthalmus* in cages







Fig 38. *Pangasianodon hypophthalmus* harvest from Majharia *maun* cages

11.1.3. Establishment of nursery ponds

At the global level, two major strategies have been increasingly adopted to boost fish production from open waters: the massive stocking of nursery-reared fingerlings and the large-scale expansion of fish culture operations. In line with these international trends, technological interventions aimed at maximizing the productive potential of wetlands emphasize the use of large-size fingerlings for open water stocking, which is crucial to minimize losses caused by harsh environmental conditions and natural predators such as planktonic carnivores, insects, amphibians, reptiles, birds, and predatory fish.

To support this approach, beneficiaries associated with the Majharia *Maun* wetland were provided with exposure visits and hands-on training in hatchery operations, ensuring that they developed the necessary technical skills. In addition, a comprehensive land-based nursery facility was established near the Majharia *Maun* to facilitate the rearing of fry into advanced fingerlings, both in nursery ponds and through the use of pens and cages. As part of this infrastructure development, four nursery ponds, each measuring 0.5 hectares, were excavated, and pre-stocking pond preparation is currently underway. Once operational, these ponds are expected to produce a substantial quantity of advanced carp fingerlings for stocking into the open *maun*, with fry stocking targeted at a density of 30,000 per hectare.

Nursery ponds (0.5 ha) were constructed beside the wetland as they are integral part of CBF in oxbow lakes provision of nursery was made to ensure timely availability of seed with cost effectiveness and better survival. Carps (*Labeo rohita* and *Cyprinus carpio*) were overwintered in ponds to ensure availability of stocking material in February, 2019.

Table 8: Growth parameters of carps in ponds

Particulars	***L. rohita***	***C. carpio***
Initial Weight (g)	1.8	4.92
Final Weight (g)	7.9	14.8
Weight gain (%)	339	201
Survival (%)	55	60
Specific growth rate	0.021	0.016
Culture duration (days)	70	70

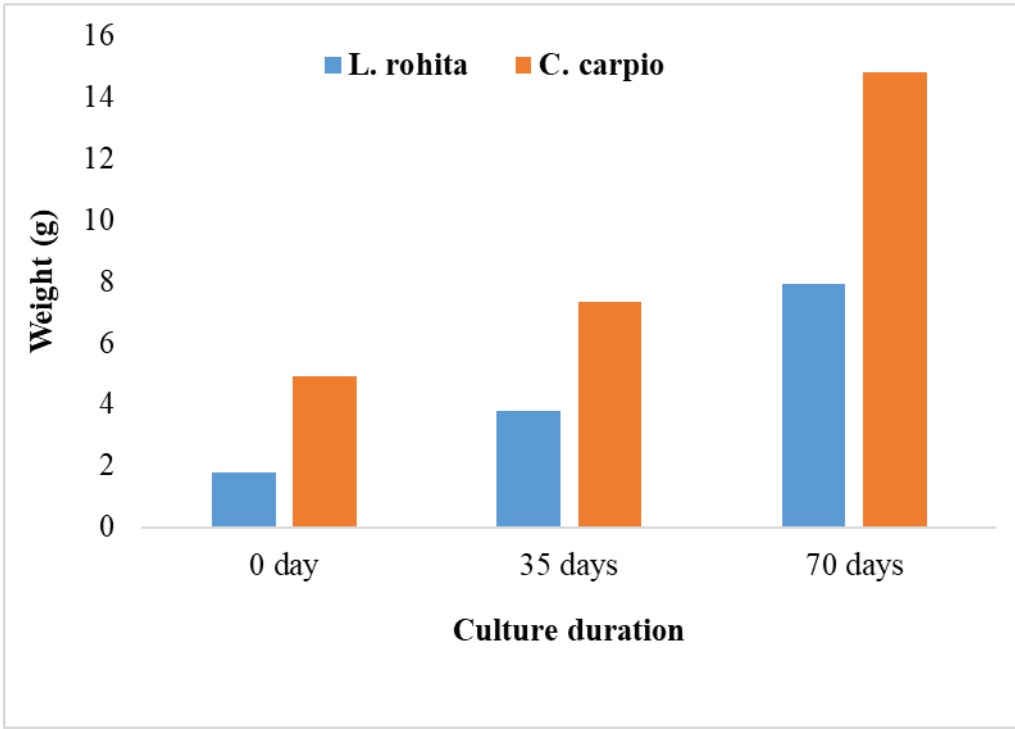


Fig 39. Growth trend of carps in ponds during overwintering

The ponds were also utilized for the culture of highly priced native fish, Singhi during the fallow period providing additional income to the fishers. The infrastructure created will contribute to fishers income through sale of surplus seeds besides meeting their own requirement for wetland fisheries. the nursery ponds have been equipped with submersible pumps to ensure water availability in lean season. Biosecurity fencing have also been provided to prevent stock escape during flooding.

Table 9: Growth parameters of Amur carp and *Heteropneustes fossilis* in ponds

Particulars	***Cyprinus carpio haematopterus***	***Heteropneustes fossilis***
Initial Weight (g)	1.93	5.6
Final Weight (g)	7.13	35.4
Weight gain (%)	369	533
Survival (%)	58	62
Specific growth rate	0.021	0.012
Culture duration (days)	70	150

During the period from 2018 to 2020, three dedicated nursery ponds were systematically utilized for the monoculture rearing of four commercially important fish species — Rohu (*Labeo rohita*), Common Carp (*Cyprinus carpio*), Amur Carp (*Cyprinus carpio haematopterus*), and Singhi (*Heteropneustes fossilis*). Each pond was stocked at an approximate density of 20,000 fry per species, ensuring optimal growth conditions tailored to the biological needs of each species. Over two culture cycles, rigorous and systematic management practices were implemented to optimize survival rates and promote uniform growth among the cultured species. These practices encompassed regular and balanced feeding, continuous monitoring of water quality parameters, and timely health care interventions.

Periodic intermediate harvests yielded a total of 829 kilograms of fish, comprising Rohu (*Labeo rohita*) with 486 kilograms (averaging 541 individuals per kilogram), Common Carp (*Cyprinus carpio*) with 275 kilograms (averaging 203 individuals per kilogram), Amur Carp (*Cyprinus carpio haematopterus*) with 43 kilograms (averaging 700 individuals per kilogram), and Singhi (*Heteropneustes fossilis*) with 25 kilograms (averaging 237 individuals per kilogram).

After approximately three months of culture for each cycle, the final cumulative harvests recorded significant production: Rohu accounted for 1221 kilograms, Common Carp for 536 kilograms, Amur Carp for 103 kilograms, and Singhi for 116 kilograms. Collectively, the nursery ponds achieved a total fish biomass of 1976 kilograms.

These results clearly demonstrate the efficiency and effectiveness of the integrated nursery-rearing system, establishing its potential to produce large numbers of vigorous and healthy fingerlings. Such outputs are highly suitable for augmenting open-water fishery enhancement programs and strengthening the productivity of culture-based fisheries.



Fig. 40. Majharia nursery rearing pond and harvest of carp



Fig. 41. Amur Carp (*Cyprinus carpio haematopterus*), and Singhi (*Heteropneustes fossilis*) harvest from Majhariya nursery rearing pond

12. Objective. 3

To empower communities and stakeholders through improved livelihood opportunity and capacity building

12.1. Achievement

Fish production from floodplain wetlands can be substantially increased by adopting scientifically developed management strategies formulated by ICAR-CIFRI. Multiple options exist for enhancing fisheries in wetlands, with the choice of intervention dependent on the specific objectives and prevailing ecological conditions of a given system. Among the eco-friendly options available for augmenting fish production are a range of enhancement measures. According to the Food and Agriculture Organization (FAO, 1997), enhancements are defined as technical interventions in existing aquatic resource systems that significantly alter the environmental, institutional, and economic attributes of the system. Enhancement involves achieving both qualitative and quantitative improvements in water bodies through the application of targeted management interventions.

One of the most widely adopted and successful management strategies in inland water bodies of India is Culture-Based Fishery (CBF), which holds considerable potential to enhance fish yields from floodplain wetlands. Key areas of intervention within CBF include stock enhancement, species enhancement, management improvement, and the integration of peripheral land-based rearing systems, along with cage and pen culture techniques.

In Bihar, two distinct types of floodplain wetlands exist: oxbow lakes (locally known as *mauns*) and tectonic lakes (*chaurs*). The state possesses an estimated chaur area exceeding 200,000 hectares, while the oxbow lakes are represented by approximately 215 water bodies covering around 9,000 hectares. The oxbow lakes are primarily concentrated in the districts of East Champaran, West Champaran, Muzaffarpur, Samastipur, Begusarai, and Darbhanga. Among these, East Champaran has the largest water area, encompassing 1,566.24 hectares. Notably, the Majharia *Maun*, located in the Piprakothi block of East Champaran, spans an area of 60 hectares and serves as a critical source of full-time or part-time livelihood for approximately 250 to 300 families.

The enhancement of fish production in Majharia *Maun* was achieved through an integrated approach involving multiple technological interventions. These included the scientific determination of seed requirements and stocking strategies through ecosystem structure assessments, trophic state evaluations, macrophyte management, and analysis of the prevailing fish species spectrum. Additional measures involved the production of quality seed through land-based nurseries and the implementation of cage and pen culture systems. Collectively, these interventions led to a significant increase in fish yields from the wetland, resulting in the sustainable and successful improvement of the livelihoods of the dependent fishing communities.

Further, specific strategies were implemented to strengthen the livelihoods of fishers. These included empowerment through infrastructure and resource development, distribution of fisheries implements, equitable sharing of fish harvests among community members, and enhancement of their knowledge, skills, and financial capacities.



Fig 42. Majharia *maun* after partial removal of floating macrophyte

12.1.1. Infrastructure development and dissemination of fisheries management technologies

The "CIFRI GI Cage," a square-shaped galvanized iron structure, has gained significant popularity in inland cage farming practices across India. In 2018, for the first time, six units of the "CIFRI GI Cage" were installed in the Majharia *Maun* at a strategically selected site where the water depth was consistently greater than or equal to 5 meters. To adapt to the wetland ecosystem, the dimensions of the *hapas* within the cages were suitably modified. These cages were introduced as a contingency measure to ensure the availability of advanced fingerlings during the post-flood season (September–October). The cages were successfully utilized for seed raising of Indian Major Carps as well as for the production of table fish, particularly *Pangasianodon hypophthalmus* (commonly known as pangas).

12.1.2. Demonstrated & trained fishers on fish seed raising and table fish production in Cages

As part of a fish species diversification program for cage culture, *Labeo rohita* (rohu) was experimented with to assess its suitability and growth performance in cage conditions during June 2018. In the first experimental trial, rohu were stocked in each cage at a biomass of 13.3 kilograms (with individual weights ranging between 90 and 110 grams) and were fed twice daily with "CIFRI Cage Grow" fish feed throughout the winter period from June 2018 to November 2018. This experiment was conducted

in three cages. Over the five-month culture period, the stocked rohu exhibited an impressive weight gain, achieving nearly a tenfold increase to reach an average weight of 118 grams. The total fish biomass harvested amounted to 382.3 kilograms, with an encouraging survival rate of approximately 81%.

In the second experimental trial, *Labeo catla* (catla) were stocked in another set of three cages, each receiving 10 kilograms of seed, corresponding to approximately 52 individuals per kilogram, with an initial average body weight of 18.87 grams. The fish were similarly fed twice daily with "CIFRI Cage Grow" fish feed during the summer period from June 2018 to October 2018. Over the four-month culture period, the catla exhibited an average weight gain of approximately 8.9 times, reaching an average weight of 168 grams. The total fish biomass harvested from this trial was 186.96 kilograms, with a survival rate of around 74%.

The third experimental trial involved the culture of *Pangasianodon hypophthalmus* in another set of three cages. Each cage received 9 kilograms of seed stock, corresponding to approximately 140 individuals per kilogram, with an initial average body weight of 7.1 grams. The fish were fed twice daily with "CIFRI Cage Grow" fish feed during the summer period starting in April 2019. Over a four-month culture period, the pangas demonstrated remarkable growth, achieving an average weight gain of approximately 34.9 times, reaching an average individual weight of 248 grams. The total fish biomass harvested in this trial was 838 kilograms, with a high survival rate of approximately 88.5%.

In the fourth experimental trial, *Pangasianodon hypophthalmus* were once again stocked in three cages. Each cage received 8.3 kilograms of seed, corresponding to approximately 144 individuals per kilogram, with an initial average body weight of 7.5 grams. Feeding practices remained consistent, with fish fed twice daily using "CIFRI Cage Grow" feed during the summer period commencing in April 2019. After four months of culture, the pangas exhibited an average weight gain of about 32.0 times, reaching an average weight of 240 grams. The total fish biomass harvested from this trial was 700 kilograms, with a survival rate of approximately 89%.

These experimental trials collectively demonstrated the significant potential of the "CIFRI GI Cage" technology for enhancing fish production and diversifying species composition in floodplain wetlands like Majharia *Maun*. The successful outcomes highlight the value of cage culture as an effective tool for boosting fish yields, ensuring livelihood security, and promoting sustainable aquaculture practices in wetland ecosystems.

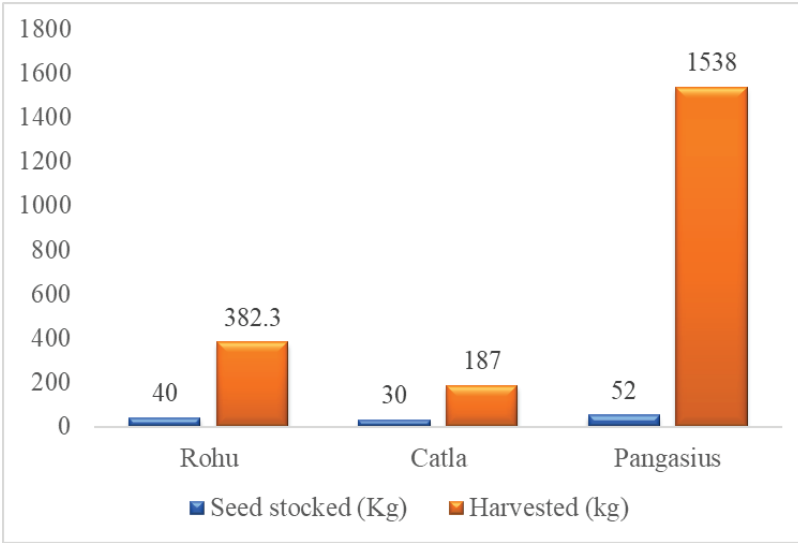


Fig 43. Production performance of Catla, Rohu and Pangas in cage culture system of Majharia *maun*

12.1.3. Demonstrated and trained fishers on *in-situ* fish seed raising in Pens

A pre-fabricated "CIFRI Pen HDPE" structure was installed in the marginal area of Majharia *Maun*, covering approximately 0.5 hectares, as part of a contingency plan to raise stocking material. The pen was stocked with the seed of two exotic carp species: Grass Carp (*Ctenopharyngodon idella*) and Amur Carp (*Cyprinus carpio haematopterus*). Very encouraging growth performance was observed in the pen culture system, with the recommended size of advanced fingerlings (≥100 mm) being achieved within a period of 20 to 120 days.

The local fisher community actively participated in the pen culture activities and gained firsthand experience of the advantages offered by the new HDPE pen material, notably its ease of installation. Motivated by the success of the initial demonstration, in the following years, the fishers organized themselves into groups, independently installed additional HDPE pens, and began producing advanced fingerlings on their own initiative.

The fishers found the "CIFRI Pen HDPE" technology to be a highly practical and efficient tool for seed production, owing to its simple installation, easy uninstallation, convenient storage, and user-friendly operation. The ability to produce fish seed flexibly at suitable locations and times within the wetland environment proved to be highly beneficial. Moreover, seed production through pen culture emerged as a reliable technology to support staggered stocking regimes in wetlands, thereby enhancing fishery management and productivity.

Among the various species stocked, Grass Carp exhibited particularly outstanding growth performance, further validating the effectiveness of pen-based seed raising in wetland conditions.



Fig. 44. Production performance of grass carps in pen culture system of Majharia

12.1.4. Land based nursery ponds and production of advanced fingerling

Nursery ponds are considered as an integral part of culture based fisheries for natural resource management such as oxbow lakes/wetlands. Provision of nursery pond near lakes will ensure timely availability of cost effective quality seed supply of the desired size. Seed produced in these nurseries will ensure better survival. Nursery ponds have been constructed in Majharia *maun* (four no, each of 0.5 ha) for the production of advanced fingerlings for stocking in the wetlands.

The ponds were stocked with the seed of both Indian major carp and three exotic carp species namely common carp, grass carp, and Amur carp. The seeds produced were stocked in open *maun* and cages for the production of table size fishes. The infrastructure created will contribute to fisher's income through the sale of surplus seeds besides meeting their own requirement.The production of fish fingerlings of carps from fry stages increased successively over the years. It has ensured the right size, quantity, quality and timely availability of fish seeds for stocking in open wetlands throughout the year.



Fig 45. Newly constructed land based nursery pond at Majharia *maun*

12.1.5. Distribution of fishing implements and fish feed

The fishers were enabled through the distribution of one FRP boat (12 ft OAL) and water screen net at the inlet and outlet of the wetland, 30 numbers of monofilament gill nets were distributed. The boat was used by the members for common purposes such as cage, pen monitoring, security patrolling and for fishing the members of the wetlands. Total of 21.2 tons of CIFRI CAGEGROW floating and commercial feed was provided for feeding fishes in ponds, pens and cages.



Fig 46. Distribution of fishing implements and fish seed, water screen nets ; FRP boat & Cleaning of macrophyte

Clearing of macrophytes

12.1.6. Demonstrated and trained fishers about Culture Based Fisheries in open wetland

The wetlands of Bihar are currently facing a significant decline in fish yield, primarily due to the disruption of natural recruitment and auto-stocking processes. This failure is largely attributed to the depletion of riverine fish stocks and the degradation or complete loss of connecting channels between rivers and wetlands, which traditionally facilitated the natural migration and replenishment of fish populations. The resulting yield gap has become a major concern for sustainable fisheries in the region. Compounding this issue is the high abundance of large carnivorous fish species such as *Wallago attu* and *Channa marulius*, which are prevalent in these wetlands. These predatory species exert intense pressure on juvenile stages—particularly fries and fingerlings—of commercially important carps. Their predation significantly reduces the survival rate of stocked or naturally spawned young fish, further contributing to the overall decline in fish productivity.



Fig 47. Predatory fish recorded from Majharia *maun*

Large predatory fish

To bridge the yield gap, the CBF technology standardized by ICAR-CIFRI was implemented in the Majharia wetland. Based on primary data collected on the ecology and fisheries of the wetland, species enhancement and stocking strategies were formulated. The selection of species and their stocking was based on the ecosystem characteristics. Stocking enhancement activity with advanced fingerlings was undertaken in a staggered manner. The annual fish seed stocked in the open wetland is mentioned below. The implementation of scientific CBF led to an increase in fish yield and fishing days from the wetland and hence, improvement in their livelihood.

12.1.7. Cumulative fish seeds stocked for enhancement of fish yield

Indian major carp (*Labeo catla, Labeo rohita* and *Cirrhinus mrigala*) and three exotic carp species namely common carp, *Cyprinus carpio*, grass carp, *Ctenopharyngodon idella* and Amur carp, *Cyprinius carpio haematopterus* was was based on the ecosystem characteristics of the Majharia *maun*. The Majharia *maun* is primarily submerged macrophytes infested wetland, and hence, herbivorous fish (common carp and grass carp) were stocked. Amur carp and singhi was selected to produce table size fish in ponds.

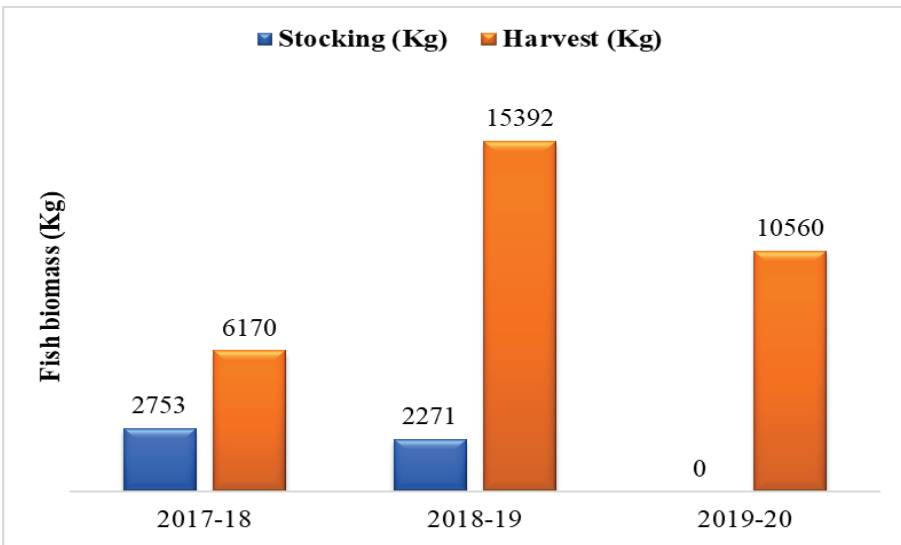


Fig 48. Trends of annual fish seeds stocked and total biomass harvest from open Majharia *maun* under integrated CBF

12.1.8. Implementation of CBF and fish yield

The wetlands of Bihar, including Majharia *Maun*, have been experiencing a steady decline in fish yield due to a combination of ecological and anthropogenic factors. One of the primary reasons for this decline is the failure of natural fish recruitment

and auto-stocking processes, largely caused by the depletion of riverine fish stocks in rivers such as the Budhi Gandak. Additionally, the shrinkage or complete loss of river-wetland link channels has disrupted the migratory routes of fish, preventing the natural replenishment of fish populations in these wetlands. Overfishing has further intensified the pressure on existing fish stocks, leading to a significant yield gap. A major ecological concern within Majharia *Maun* is the oligotrophic nature of the wetland, characterized by low nutrient availability, which limits the primary productivity essential for supporting high fish biomass. Compounding the problem is the dominance of large predatory fish species such as *Wallago attu* and *Channa marulius*, which were frequently observed in the catch in substantial sizes (12–14 kg and 6–8 kg respectively). These carnivores prey heavily on smaller carp species, especially fries and fingerlings, drastically reducing the survival rates of stocked and naturally occurring juvenile fish.

To address this multifaceted issue, ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) introduced its standardized Culture-Based Fisheries (CBF) technology in Majharia *Maun*. The approach began with detailed ecological and fisheries assessments to understand the productivity potential, species composition, and ecological constraints of the wetland. Based on this primary data, a species enhancement and stocking strategy was developed, aligning the selection of fish species with the ecosystem's carrying capacity and water quality parameters. The stocking strategy involved the use of advanced fingerlings (weighing 25–80 g and measuring 12–23 cm in length) which are less vulnerable to predation and environmental stress compared to younger fry stages. Stocking was carried out in a staggered manner to optimize the use of ecological niches and minimize intra-species competition. Over a three-year period, this intervention led to a marked improvement in fish yield. In the first year (2017–18), fish production was recorded at 62 kg/ha/year. This yield more than doubled in the second year (2018–19) to 154 kg/ha/year following a second round of stocking. In the third year (2019–20), no new stocking was undertaken, yet the fish yield remained relatively high at 106 kg/ha/year, suggesting enhanced fish retention and improved catch per unit effort (CPUE). However, despite these gains, the expected yield based on primary productivity (estimated at 300–500 kg/ha/year) was not fully realized, mainly due to the persistent presence of large predatory species and other ecological constraints. Nevertheless, the successful implementation of CBF technology in Majharia *Maun* underscores its potential for bridging the yield gap in floodplain wetlands and highlights the importance of ecosystem-based management strategies, species selection, and scientific stocking in improving inland fishery resources.

Fishing effort, measured in terms of the number of fishing days, also showed a significant upward trend following the implementation of CIFRI's culture-based fisheries (CBF) interventions in Majharia *Maun*. Prior to the initiation of the project, the average number of effective fishing days per year ranged between only 28 to 31 days, reflecting the low availability of harvestable fish biomass and the limited

economic viability of sustained fishing operations. However, with the introduction of scientifically planned stocking of advanced fingerlings and subsequent enhancement of fish standing crop, fishing activities increased both in frequency and duration over the project period.

In the first year of implementation (2017–18), fishing days increased to 35, corresponding with the initial boost in fish biomass resulting from the first cycle of stocking. Encouraged by the success of this early intervention, and with continued ecological monitoring and species management, the second year (2018–19) saw a substantial rise in fishing effort, with a total of 62 fishing days recorded. This increase directly reflected improved fish availability and the growing confidence of local fishers in the productivity of the wetland.

By the third and final year of the project (2019–20), even in the absence of additional stocking, the number of fishing days further increased to 78. This indicates that the residual fish populations from previous stocking cycles, coupled with better management practices and improved ecosystem conditions, sustained a longer fishing season. The comparative year-wise trend in fishing days thus clearly demonstrates the effectiveness of the CBF approach not only in enhancing fish yield but also in extending the fishing calendar, thereby improving livelihood opportunities for the fisher community dependent on Majharia *Maun*.

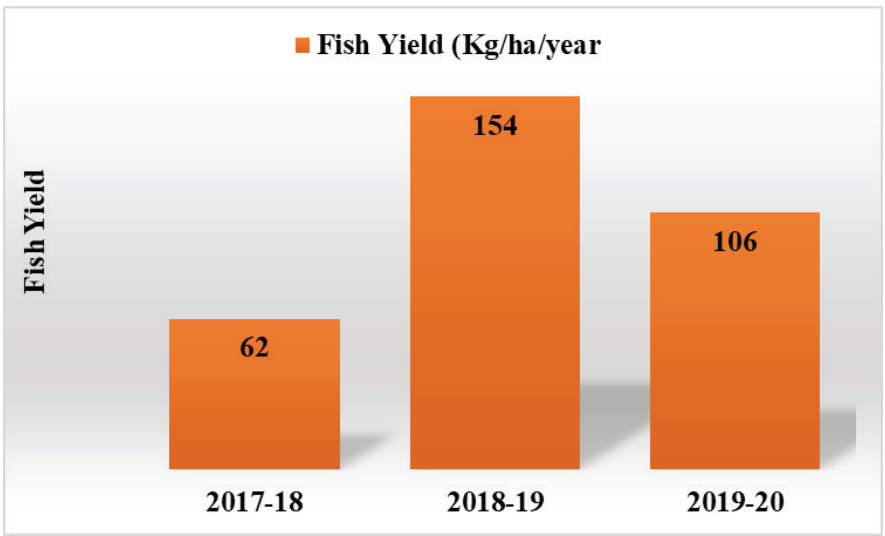


Fig 49. Year-wise fish yield trends from Majharia *maun*

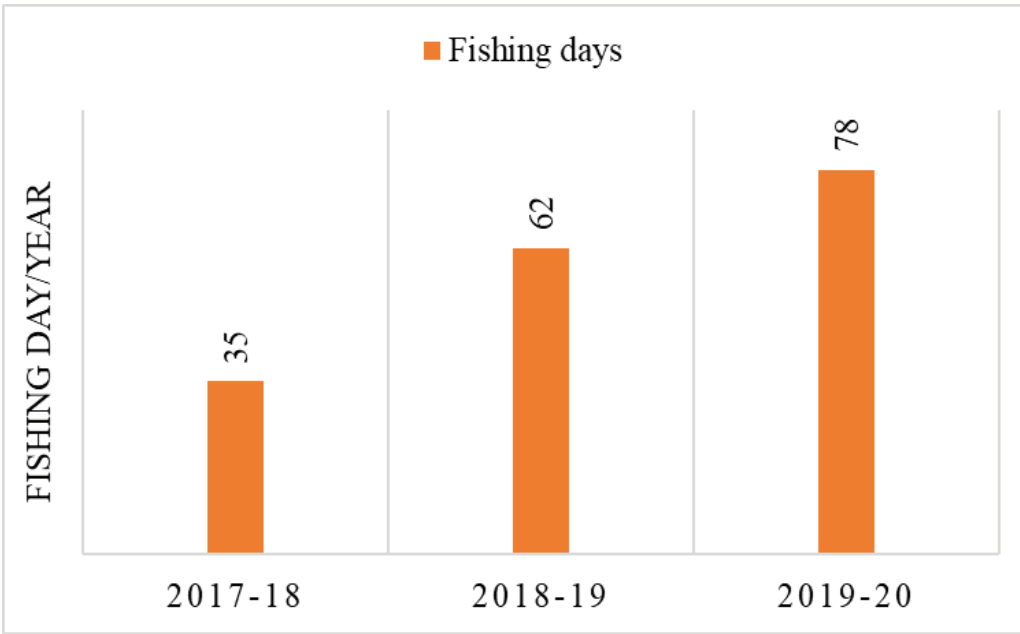


Fig 50. Year-wise fishing days trends from Majharia *maun*

12.1.9. Enabling fishers through capacity building and skill development

The implementation of developmental projects in a participatory mode places significant emphasis on the capacity building of beneficiaries. This is achieved through a combination of awareness programs, exposure visits, on-site demonstrations, and hands-on training sessions. Such initiatives have been instrumental in positively influencing the attitudes and behaviors of local stakeholders, particularly by fostering a sense of collective responsibility and cooperation aimed at enhancing fish yield in wetland-based fisheries. As part of this effort, ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) organized a series of capacity-building activities under its project interventions in Bihar. Specifically, two workshop-cum-training programs and one specialized training on fisheries management were conducted, focusing on the unique ecological and operational challenges of wetland fisheries in the region. These training programs included a blend of theoretical lectures, practical demonstrations, and field exposure visits to reinforce learning and ensure practical understanding.

In addition, two structured exposure visits were organized to ICAR-CIFRI headquarters at Barrackpore, West Bengal. These visits took place from 27th to 30th April 2019 and 18th to 22nd June 2019. During each visit, participants attended both theoretical

sessions and practical classes led by subject matter experts, providing them with in-depth insights into advanced fisheries management practices, pen culture, and sustainable aquaculture technologies. To support continued learning and as a quick reference tool, training manuals in Hindi were also distributed to all trainees. These manuals served as ready reckoners for the participants, enabling them to apply the acquired knowledge in their respective local contexts effectively.

A skill development programme titled "Bihar ke Chaur aur *Maun* me Matsyiki Prabandhan" (Fisheries Management in Chaurs and *Maun*s of Bihar) was conducted from 6th to 8th October 2017 at Krishi Vigyan Kendra (KVK), Piprakothi, Motihari, Bihar. The programme was sponsored by the National Fisheries Development Board (NFDB) and aimed at equipping fishers with scientific knowledge and practical skills to enhance fisheries productivity and contribute to the goal of doubling farmers' income.

A total of 50 fishers from Majharia *Maun* participated in the training, which focused on sustainable fisheries management practices suited to the ecological characteristics of chaurs and *maun*s. The training sessions included expert lectures, practical demonstrations, and interactive discussions designed to improve participants' understanding of resource management, species selection, and culture-based fisheries techniques.

The valedictory function of the programme was graced by Shri Radha Mohan Singh, the then Union Minister of Agriculture and Farmers' Welfare, Government of India. During the closing ceremony, Shri Singh addressed the participants, commending their enthusiasm and urging them to adopt scientific approaches for increased fish production. He also distributed certificates of participation to the trainees, acknowledging their successful completion of the programme and encouraging them to serve as ambassadors of sustainable fishery practices within their communities.



Fig 51. Skill development and capacity-building training programmes for fishers of Majharia *Maun*, sponsored by NFDB, were conducted at ICAR-CIFRI, Barrackpore, Kolkata, during 27–30 April 2019 and 18–22 June 2019



Fig 52. Skill development Training programme on wetland fisheries development was organized at KVK, Piprakothi

ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) organized a two-day workshop-cum-training programme on *"Wetland Fisheries Development for Fishers of East Champaran, Bihar"* from 22nd to 23rd March 2021 at Krishi Vigyan Kendra (KVK), Dr. Rajendra Prasad Central Agricultural University (DRPCAU), Piprakothi, East Champaran. The objective of the event was to build the capacity of fishers through awareness and skill development in sustainable wetland fisheries management, with a particular focus on the adoption of culture-based fisheries (CBF) technologies. The programme was inaugurated in the presence of Shri Pramod Kumar, Hon'ble Minister of Sugarcane Industries and Law Department, Government of Bihar, who attended as the Chief Guest. Secretaries of Fishermen Cooperative society were guests of honor and 600 fishers of oxbow lakes of East Champaran attended training programs. The event commenced with a virtual welcome address by Dr. B. K. Das, Director of ICAR-CIFRI, who emphasized the institute's dedicated work over the past four years across five wetlands in Bihar. He highlighted the collaborative efforts with line departments aimed at doubling the income of wetland fishers through the introduction of scientific fishery practices. Dr. M. A. Hassan, Head of the Fisheries Enhancement and Management Division, addressed the participants on the potential of CBF, including technologies such as cage culture, pen culture, and in situ nursery systems, as effective tools for enhancing fish production and livelihood security in floodplain wetlands. The workshop also witnessed the presence of several prominent guests, including Shri Prakash Asthana, Member, Board of Management, RPCAU, Pusa; Shri Ravindra Sahani, Mukhiya of Piprakothi and President of the Piprakothi Fishermen Cooperative Society; Shri Sanat Kumar Singh, Divisional Forest Officer (DFO), East Champaran; and Shri Arvind Kumar Singh, Head of KVK, Piprakothi. These dignitaries acknowledged the significant contributions of ICAR-CIFRI in transforming wetland fisheries and appreciated the institute's successful implementation of the project, which has played a vital role in strengthening the livelihoods of the local fisher communities through participatory and scientific approaches.



Fig 53. Two-day workshop-cum-training programme on “Wetland Fisheries Development for Fishers of East Champaran, Bihar” from 22nd to 23rd March 2021 at Krishi Vigyan Kendra (KVK), Dr. Rajendra Prasad Central Agricultural University (DRPCAU), Piprakothi, East Champaran

The fishers were trained in scientific wetland fisheries management to earn their livelihood. Books/training manual, brochure and policy paper were released which has been developed for fishers, researchers, academicians and policymakers. The books had written based on the ICAR-CIFRI working experiences in wetland fisheries management in Bihar.



Fig 54. Resource/training kit as ready reckoner for fishers and stakeholders. List of publications, (A) Stride in Fish Yield through Participatory Technological Interventions inOxbow Lakes of Bihar (06), (B) Roadmap for Fisheries Development in *Maun*s and Chaurs of Bihar, Policy Paper & (C& D) Bihar ke Man aur Chaur ka Matsyiki Vikas evam Prabandhan (Hindi)

One day workshop cum training programme was organized at the Bihar Veterinary College, Patna by ICARCIFRI, Barrackpore, Kolkata in collaboration with Bihar Animal Science University, Patna on 20th November 2019. Dr. Prem Kumar, honorable

minister of Agriculture, Animal and Fisheries Resources, Government of Bihar was the chief guest of the programme. Faculty members of Bihar Animal Science University, Patna, officials of state fisheries department, Scientist and technical officer of ICAR-CIFRI, Barrackpore and ICAR-RCER, Patna along with one hundred fishers of East Champran participated in the workshop. The fishers were taught by subject matter experts of these mentioned organizations and a session on fishers-Scientist was also organized to solve their queries related fish farming.



Fig 55. On-site meeting and consultation with fishers and local communities by the Director and Scientist of ICAR-CIFRI



Fig. 56 ICAR-CIFRI scientist and fishers were interacting with Minister of Agriculture & Farmers Welfare, Government of India, Sri Radha Mohan Singh, Honourable Deputy Chief Minister, Bihar, Dr. J. K. Jena, Deputy Director Journal Fisheries and other stakeholders in 2018; Field training at Majharia *maun* and Stalls of ICAR-CIFRI at Maha Kumbh mela.

During the event, emphasis was also laid on key management strategies such as macrophyte control and measures to prevent fish escape through link channels during flooding. In 2018, several dignitaries, including Shri Radha Mohan Singh, then Union Minister of Agriculture and Farmers' Welfare, Government of India; Shri Sushil Kumar Modi, Hon'ble Deputy Chief Minister of Bihar; and Shri Pramod Kumar, Hon'ble Tourism Minister of Bihar, visited the exhibition stall and appreciated the ongoing fisheries development activities at Majharia *Maun*.

Additionally, twenty-five fishers from Majharia *Maun* were part of a larger contingent of 84 fishers who participated in the *World Fisheries Day* celebrations held at Gyan Bhavan, Patna, on 22 October 2018. The event aimed to enhance their awareness and facilitate interaction with fisheries experts involved in nationally and internationally recognized aquaculture and inland fisheries programs.

During the Krishi Mela held at East Champaran, from 13th to 15th April 2018, a group of 25 fishers from Majharia *Maun* participated as part of a larger contingent of 84 fishers. Organized to showcase advancements in agriculture and allied sectors, the mela provided a significant opportunity for wetland fishers to gain exposure to the latest developments in inland fisheries and aquaculture. The fishers interacted with leading scientists and officials, including Dr. B. K. Das, Director of ICAR-CIFRI, and Dr. J. K. Jena, Deputy Director General (Fisheries), ICAR, who engaged in discussions on sustainable fishery practices and the importance of adopting scientific interventions in wetland management. The event also featured stalls and exhibits highlighting the success stories and ongoing activities under the ICAR-CIFRI project at Majharia *Maun*. The dignitaries appreciated the participatory approach adopted by ICAR-CIFRI and lauded the capacity-building efforts aimed at improving fishers' livelihoods through culture-based fisheries.



Fig 57. Stakeholder's meet Dr. J. K. Jena, Depury Director Gerenal fisheries, Dr. B. K. Das, Director ICAR-CIFRI, Barrckporee, NFDB officials , Scientist ICAR-CIFRI and Fishers have discussed various issue regarding institutional arrangement and benefit sharing of fishers and other stakholders



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मछुआरों का तीन दिवसीय प्रशिक्षण शुरू

भास्कर न्यूज | तेतरिया

प्रखंड क्षेत्र के कोठिया मन के समीप राष्ट्रीय मात्स्यिकी विकास बोर्ड के तत्वावधान में भाकृ अनुप केंद्रीय अंतः स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर, कोलकाता की टीम मछुआरों को प्रशिक्षण दे रही है। तीन दिवसीय मछुआरों का प्रशिक्षण शिविर का उद्घाटन प्रखंड विकास पदाधिकारी चंद्र भूषण कुमार ने किया। शिविर में 50 मछुआरों को प्रशिक्षित किया जा रहा है। प्रशिक्षण में पहले दिन प्रशिक्षक राजू बैठा, सुमन कुमारी, एमए हसन एवं गणेश चंद्र ने मछुआरों को केज कल्चर एवं पेन कल्चर का प्रशिक्षण दिया। इस प्रशिक्षण का लाभ उठाकर मछुआरे अपनी आमदनी बढ़ा सकते हैं। मौके पर मत्स्यजीवी संघ के प्रखंड अध्यक्ष राम नारायण सहनी, शिवबालक सहनी, कृष्ण देव सहनी, परमहंस निषाद, उपेंद्र सहनी, जय किशोर सहनी आदि मौजूद थे।

मछुआरों को प्रशिक्षण देते अधिकारी।

पांच लाख हेक्टेयर में मछली पालन संभव

बोले कृषि मंत्री

पटना | हिन्दुस्तान ब्यूरो

कृषि व पशुपालन मंत्री प्रेम कुमार ने कहा है कि बिहार में लगभग 9 लाख 41 हजार हेक्टेयर आर्द्रभूमि (नमी वाली जमीं) है। इसमें से पांच लाख हेक्टेयर जलक्षेत्र (मन, चौर) हैं। वे राज्य के सबसे महत्वपूर्ण मत्स्य संसाधन क्षेत्र हैं और यहां मछली उत्पादन की असीम संभावनाएं हैं। इस क्षेत्र का विकास राज्य सरकार की प्राथमिकता में है। इससे मछुआरों की आमदनी भी बढ़ेगी और उत्पादन भी। इसके लिए कृषि रोड मैप में व्यापक प्रावधान किए गए हैं।

मंत्री ने ये बातें बुधवार को 'बिहार के आर्द्र भूमि मात्स्यिकी प्रबंधन' विषय पर आयोजित कार्यशाला सह प्रशिक्षण कार्यक्रम में कही। आयोजन बिहार पशु विज्ञान विश्वविद्यालय ने किया था। कहा कि कृषि रोड मैप में 3000 हेक्टेयर के नमी वाली जमीन (वेटलैंड) को विकसित करने का लक्ष्य रखा गया है। इसके लिए 75 करोड़ का प्रावधान किया गया है। राज्य सरकार ने 2021-22 के अंत तक मछली उत्पादन का लक्ष्य 8.02 लाख मीट्रिक टन रखा है। अभी राज्य के मन एवं चौर में वर्तमान में उत्पादकता क्रमशः 220 एवं 50 किलो प्रति हेक्टेयर है। वैज्ञानिक आधार पर यहां मत्स्य पालन कर क्रमशः 1500 एवं 750 किलो प्रति हेक्टेयर की उपज ली जा सकती है। पशुपालन सचिव एन. विजयलक्ष्मी ने कहा कि राज्य में मांग के अनुरूप मछली का उत्पादन हो रहा है। 1100 हेक्टेयर में मछली पालन का लक्ष्य है। महिलाओं को इस क्षेत्र से जुड़ने की जरूरत है, ताकि वे भी स्वावलंबी बन सकें। पशु विज्ञान विवि के कुलपति रामेश्वर सिंह संयुक्त निदेशक निशात अहमद भी मौजूद थे।

पशु विज्ञान विवि में बुधवार को आयोजित कार्यशाला सह प्रशिक्षण कार्यक्रम में कृषि व पशुपालन मंत्री प्रेम कुमार, पशुपालन सचिव एन. विजयलक्ष्मी व अन्य।

मत्स्यपालन पर दिया गया जोर

फुलवारीशरीफ. बिहार के मन (तालाब) एवं चौर में मात्स्यिकी विकास के उद्देश्य से केंद्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर, कोलकाता, पश्चिम बंगाल एवं बिहार पशु विज्ञान विश्वविद्यालय, पटना के संयुक्त तत्वावधान में बिहार वेटनरी कॉलेज प्रांगण में बिहार के आर्द्रभूमि मात्स्यिकी प्रबंधन पर एक दिवसीय कार्यशाला सह प्रशिक्षण कार्यक्रम का आयोजन किया गया. उद्घाटन कृषि-सह-पशुपालन एवं मत्स्य संसाधन मंत्री डॉ प्रेम कुमार ने किया. डॉ प्रेम कुमार ने कहा कि किसानों की आमदनी बढ़ाने के लिए खेती के साथ-साथ अन्य विकल्पों पर भी कार्य किये जा रहे हैं. इसमें मत्स्यपालन पर विशेष ध्यान दिया जा रहा है. बिहार राज्य आर्द्रभूमि मन एवं चौर, टैंक, तालाब, और नदियों के रूप में विशाल जलीय संपदा से संपन्न है. बिहार में लगभग पांच लाख हेक्टेयर बाढ़ कृत जलक्षेत्र (मन, चौर) राज्य के सबसे महत्वपूर्ण मत्स्य संसाधन है. इनमें मत्स्य उत्पादन की असीम संभावनाएं हैं जिसका विकास राज्य सरकार की प्राथमिकता है. कृषि रोड मैप में 3000 हेक्टेयर की आर्द्रभूमि को विकसित करने का लक्ष्य रखा गया है. इसके लिए 75 करोड़ का प्रावधान किया गया है. सचिव, पशुपालन एवं मत्स्य संसाधन विभाग डॉ एन विजयालक्ष्मी ने कहा, पीएम पैकेज के तहत मत्स्य संसाधन ने 1100 हेक्टेयर में मछलीपालन का टारगेट लिया है. उन्होंने आगे कहा कि किसान सरकार की योजनाओं को समझें और आवेदन देकर योजनाओं का लाभ उठाएं.

आज | पटना सिटी-दानापुर-फुलवारी

राज्य में मत्स्य उत्पादन की असीम संभावनाएं

आर्द्रभूमि मात्स्यिकी प्रबंधन पर कार्यशाला सह प्रशिक्षण

प्रति हेक्टेयर 1500 किलो मछली उत्पादन का लक्ष्य

राज्य ब्यूरो, पटना : कृषि एवं पशुपालन मंत्री प्रेम कुमार ने कहा कि अभी राज्य में मछली की उत्पादकता अधिकतम 220 किलो प्रति हेक्टेयर है। नई तकनीक के जरिए इसे बढ़ाकर 1500 किलो प्रति हेक्टेयर तक किया जा सकता है। राज्य सरकार ने 2021-22 तक मछली उत्पादन का लक्ष्य 8.02 लाख मीट्रिक टन रखा है। पशु विज्ञान विश्वविद्यालय में बुधवार को डॉ. प्रेम कुमार 'बिहार की आर्द्र भूमि में मात्स्यिकी प्रबंधन विषय पर आयोजित कार्यशाला सह प्रशिक्षण कार्यक्रम को संबोधित कर रहे थे।

उन्होंने कहा कि बिहार में नौ लाख 41 हजार हेक्टेयर आर्द्रभूमि है। इसमें पांच लाख हेक्टेयर जलक्षेत्र है, जहां नई तकनीक से अगर मछली पालन किया जाए तो बिहार बड़ा मछली निर्यातक राज्य बन सकता है। मछली पालन के लिहाज से जल क्षेत्र का विकास राज्य सरकार की प्राथमिकता में है। इसके लिए कृषि रोडमैप में भी प्रावधान है। पशुपालन मंत्री ने कहा कि कृषि रोडमैप में तीन हजार हेक्टेयर की नमी वाली जमीन (वेटलैंड) को विकसित करने का लक्ष्य रखा गया है। इसके लिए 75 करोड़ का प्रावधान है। प्रधानमंत्री विशेष पैकेज में भी इसके लिए योजनाएं ली गई हैं। हरियाली मिशन के तहत 10 करोड़ स्वीकृत किया गया है।

पशुपालन सचिव एन. विजयलक्ष्मी ने कहा कि राज्य में मांग के अनुरूप मछली का उत्पादन हो रहा है। आधी आबादी को स्वावलंबी बनाने के लिए इस क्षेत्र से जुड़ने की जरूरत है। पशु विज्ञान विवि के कुलपति रामेश्वर सिंह ने औद्योगीकरण को जलीय जीवों के लिए सबसे ज्यादा खतरा बताया। संयुक्त निदेशक निशात अहमद ने भी संबोधित किया।

पटना आसपास

वर्कशॉप • आर्द्रभूमि मात्स्यिकी प्रबंधन पर कार्यशाला में पशु एवं मत्स्य संसाधन मंत्री प्रेम कुमार ने कहा

मछलीपालन के लिए 90 फीसदी अनुदान

पॉलिटिक्स रिपोर्टर | पटना

पशु एवं मत्स्य संसाधन मंत्री डॉ. प्रेम कुमार ने कहा कि मछुआरा सहित अतिपिछड़ा, अनुसूचित जाति एवं जनजाति के लोगों को मछलीपालन के लिए सरकार 90 प्रतिशत अनुदान दे रही है। राज्य में 9.41 लाख हेक्टेयर आर्द्रभूमि है। कृषि रोडमैप में मछली उत्पादन बढ़ाने की योजना से राज्य मछली उत्पादन बढ़ा है। आगे वाले दिनों में अधिक मछली उत्पादन कर दूसरे राज्यों को भेजी जाएगी। तालाबों का जीरोटेस टैगिंग की जा रही है। वे बुधवार को बिहार पशु विज्ञान विवि में आर्द्रभूमि मात्स्यिकी प्रबंधन पर एक दिवसीय कार्यशाला सह प्रशिक्षण कार्यक्रम को संबोधित कर रहे थे।

उन्होंने कहा कि मछली उत्पादन के विकास के लिए 75 करोड़ की राशि का प्रावधान किया गया है। पीएम पैकेज के तहत 1100 हेक्टेयर में मछलीपालन का टारगेट लिया है। कार्यक्रम को केंद्रीय अंतःस्थलीय मात्स्यिकी अनुसंधान संस्थान के निदेशक डॉ. वसंत कुमार दास, संयुक्त निदेशक मत्स्य निशात अहमद, बिहार पशु विज्ञान विवि के कुलपति डॉ. रामेश्वर सिंह ने भी संबोधित किया। मौके पर डॉ. रमण कुमार सिकेरी, डॉ. केजे मंडल आदि मौजूद थे।

आर्द्रभूमि मात्स्यिकी प्रबंधन पर कार्यशाला में पशु एवं मत्स्य संसाधन मंत्री प्रेम कुमार, सचिव डॉ. एन विजयलक्ष्मी व अन्य।

योजनाओं की जानकारी देने के लिए चौपाल

बाकपुर | किसानों की केंद्र एवं राज्य सरकार की अति महत्वाकांक्षी कृषि योजनाओं की जानकारी देने के लिए दानापुर प्रखंड के जमालपुरदीनपुर पंचायत स्थित गोरागांव गांव में बुधवार को रबी मौसम का किसान चौपाल शुरू किया गया। इसका उद्घाटन राज्य के कृषि मंत्री डा प्रेम कुमार ने किया। मंत्री ने कहा कि किसान चौपाल के माध्यम से कृषि से संबंधित विभिन्न योजनाओं की जानकारी पर उतारा जायेगा। किसानों से सीधे संवाद स्थापित कर कृषि की नवीनतम तकनीक के बारे में भी बताया जायेगा। कृषि से आय बढ़ाने के लिए लगाव को कम करने के लिए बताये जायेंगे। कृषि वैज्ञानिक फसलों का चुनाव और मिट्टी का स्वास्थ्य बनाये रखने से संबंधित जानकारी देंगे। मौसम के बदलते परिवेश के साथ कृषि में बदलाव पर चर्चा की जाएगी। छोटे एवं मंझोले किसानों को समेकित कृषि प्रणाली जैसे मछलीपालन, पुष्पीपालन, मशरूम उत्पादन, मधुमक्खी पालन आदि को अपनाते हुए आय बढ़ाने के लिए प्रोत्साहित किया जायेगा। कृषि विभाग द्वारा राज्य के सभी पंचायतों के चयनित गांवों में अलग अलग तिथियों पर किसान चौपाल लगाये जाने की योजना है। विधायक आशा सिन्हा ने उनके क्षेत्र में इस अवसेलन के लिए मंत्री के प्रति आभार प्रकट किया। कृषि विभाग के सचिव डॉ एन सरवण कुमार, पटना प्रमंडल के संयुक्त निदेशक उमेश प्रसाद मंडल, बागेती के निदेशक डॉ निर्मेंद्र प्रसाद, उपनिदेशक भगवीर चौडेय, जिला परियोजना निदेशक आरबी सिंह, मुखिया अरुणा देवी आदि मौजूद थे।

• विश्व जल दिवस के अवसर पर मत्स्य पालकों के लिए प्रशिक्षण कार्यक्रम

जिले के पांच मन होंगे विकसित

पीपरकोठी | एक संवाददाता

जिले के मुख्य पांच मनों के विकसित होने के बाद मत्स्य पालन के क्षेत्र में क्रांति आयेगी। उनके विकास की विभिन्न परियोजना इस माह के अंत तक पूरा कर लिया जाएगा। उक्त बातें बिहार सरकार के गन्ना मंत्री प्रमोद कुमार ने कृषि विज्ञान केंद्र के सभागार में सोमवार को विश्व जल दिवस के अवसर पर मत्स्य पालकों के दो दिवसीय प्रशिक्षण आयोजन के दौरान कही। कार्यक्रम की अध्यक्षता केविके प्रमुख डा अरविंद कुमार सिंह ने किया। इसके पूर्व मंत्री ने कार्यक्रम का उद्घाटन दीप प्रज्वलित कर किया। कहा कि मछली उत्पादन के मामले में आज बिहार देश के पांचवे स्थान पर है। मन विकास परियोजना के तहत इस जिले में कररिया, मझारिया, रुलही, सिरसा, कोठियां सहित पांच परियोजना का शुभारंभ वर्ष 2017-18 में पूर्व केंद्रीय कृषि मंत्री राधामोहन सिंह द्वारा किया गया। यह परियोजना 31 मार्च को पूर्ण हो रही है।

इसी अवसर पर दो दिवसीय मछुआरों के लिए मत्स्यिकी विकास हेतु प्रशिक्षण कार्यक्रम आयोजित है। पिछले तीन वर्षों में कररिया मन का उत्पादन प्रति हेक्टेयर 300 किलोग्राम से बढ़कर 700 किलोग्राम हो गया है। वहीं स्थिति अन्य मन का हुआ है जो औसतन दोगुना से ज्यादा है। इस परियोजना के माध्यम से दो हजार से ज्यादा मत्स्यजीवी आत्मनिर्भर हुए हैं।

इस अवसर पर मंत्री ने निदेशक से इस परियोजना को अगले पांच वर्ष के लिए विस्तारित करने की मांग की। ताकि छूटे हुए शेष मन को विकसित करने के मछुआरों को रोजगार से जोड़ा जा सके। परियोजना का नेतृत्व सिफरी के निदेशक डॉ. बीके दास ने किया। जबकि सहयोगी के रूप में प्रधान वैज्ञानिक डॉ.एमए हसन, वरिष्ठ वैज्ञानिक डॉ. गणेश चंद्रा, केविके प्रमुख डॉ अरविंद कुमार सिंह, डा नीलम कुमारी, नेहा पारीक सहित अन्य उपस्थित थे।

दो दिन होगा प्रशिक्षण

- केविके में मछली प्रशिक्षण का किया शुभारंभ
- विश्व जल दिवस के अवसर पर हुआ आयोजन

Fig 58. Electronic media coverage of the workshop cum training programme and project activities on "Management of Wetland Fisheries of Bihar

The project site at Majharia *Maun* received visits from several distinguished dignitaries and senior administrators who reviewed project activities and engaged in direct interactions with fishers and ICAR-CIFRI scientists. Among the notable visitors were Shri Radha Mohan Singh, former Union Minister of Agriculture & Farmers Welfare, Government of India; Shri Sushil Kumar Modi, former Deputy Chief Minister of Bihar; Shri Pramod Kumar, former Tourism Minister of Bihar; and Dr. Prem Kumar, former Minister of Agriculture, Animal and Fisheries Resources, Government of Bihar. Senior officials from the Department of Fisheries, Bihar, including Shri Nishad Ahmad, Director, and Shri Suman Kumar, Joint Director, also visited the site, along with the Block Development Officer of Piprakothi, East Champaran, and members of the print and electronic media. In addition, the Vice-Chancellor and faculty members of Bihar Animal Sciences University, Patna, and Dr. Bimal Chand, Executive Director of the National Fisheries Development Board (NFDB), Hyderabad, were present at various key events. These visits not only reinforced institutional support for the project but also provided valuable opportunities for the stakeholders to discuss the progress, impact, and future scope of sustainable fisheries development initiatives being implemented at Majharia *Maun* under the guidance of ICAR-CIFRI.



Fig 59. Distinguished dignitaries and senior administrators reviewing project activities

13. Objective. 4

To refine site-specific fisheries enhancement technology for the development of wetland fisheries

13.1. Achievements

In contrast to aquaculture, which involves the commercial cultivation of aquatic organisms in controlled environments where most of the species' life cycle is managed under regulated conditions, culture-based fisheries (CBF) operate by enhancing fish production in natural or semi-natural water bodies. CBF achieves this by intervening in only part of the species' life cycle—typically by releasing hatchery-produced seed (fry or fingerlings) into open waters such as lakes, reservoirs, rivers, floodplains, or coastal lagoons. These juveniles then grow using natural food sources until they reach harvestable size (Honma, 1980; Thorpe, 1980).

Unlike aquaculture, CBF does not require the construction or simulation of artificial ecosystems and is therefore not constrained by land availability, high input costs, or population pressures (Liao, 1988). The natural ecosystem serves as the rearing ground, and hence, production costs are typically lower. However, a major limitation of CBF is the unpredictability of harvests and returns, as environmental conditions and other biological factors in natural systems remain largely uncontrollable.

Despite these challenges, culture-based fisheries are gaining recognition as a sustainable and cost-effective approach to enhancing fish production, especially in water bodies where natural fish populations have declined due to overfishing, habitat degradation, or loss of connectivity with breeding grounds. CBF is increasingly being adopted globally as a strategy to replenish depleted stocks and to maximize the productivity of underutilized aquatic ecosystems. According to ADCP (1989a), scaling up CBF interventions has been identified as a developmental priority in many regions worldwide.

The main types of culture-based fisheries include: (i) sea or ocean ranching, where marine species are released into open waters; (ii) coastal lagoon farming; (iii) stocking and restocking of freshwater lakes and reservoirs; and (iv) managed fisheries in floodplain systems. Each of these approaches leverages the natural environment to boost fish production with minimal ecological disruption, making CBF a valuable tool in sustainable inland and coastal fisheries management.

13.2. Stocking management of fish seeds

Majharia *maun* wetland is seasonally connected to River Budhi Gandak, typically, 'Oxbow' shaped in appearance, having maximum water spread area of 80 ha, and the depth ranged between 2-7m. The *maun* is also a cut off meander of Budhi Gandak River. The submerged and marginal weeds are present along the periphery and shallow part of the *maun,* covering 40-45% of the total area, vary with seasons, and water spread.

Basic ecological features, trophic state and fish catch composition of the Majharia *maun* was assessed using standard methods and protocols for determining stocking needs and developing site-specific fisheries enhancement strategy. Selection and combination of fish species and their stocking density was based on the ecosystem characteristics prevailing at Majharia *maun*. The followed stocking density of five

carp species (Grass carp, Common carp, Catla, Rohu & Mrigal) combination was 2000 numbers per hectare (fingerling, weight – 25-80g; total length – 100-150 mm). The proportionate stocking density of different carp species combination was done based on the season (especially considering winter season) and food availability or productivity of the Majharia *maun*

Table.10 Stocking ratio of different carp species combination followed in Majharia *maun* (in %)

Season	Fish species combination		
	Surface feeders	Column feeder	Bottom feeders
Summer	Catla (20)	Grass carp (30), Rohu (20)	Common carp (20), Mrigal (10)
Winter	Catla (≈15)	Grass carp (30), Rohu (≈15)	Common carp (30), Mrigal (10)

Stocking enhancement activity with advanced fingerlings (Weight: 25-80g; Total length – 100-150 mm) was undertaken in a staggered manner (3 times) at a time interval of 60 days in an year.

Table. 11 Annual cycle of fisheries activities at Majharia *maun*

Fish stocking	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
01												
02												
03												

Colour code					
Description	Fish seed stocking period	Selective harvest of large carnivorous fishes	Peak fish harvest period	Peak rain (monsoon period)	

The size at stocking of fish seeds was progressively increased from 25gm to 80gm due to availability of larger sized fish seeds, avoidance of stocking loss by large predatory fishes and counteracting slow growth and disease occurrence during winter.

13.3. Habitat improvement through macrophytes management

Majharia *Maun* exhibited moderate infestation of macrophytes, particularly submerged rooted species. To address this issue effectively, a stocking strategy involving 50–60% of grass carp and common carp was adopted, which proved highly successful. This was evident from the impressive fish growth and harvest yield, with

these two species contributing approximately 40–50% of the total fish production. In parallel, manual removal and cleaning of excess macrophytes from the wetland were carried out to ensure that these aquatic weeds did not become a hindrance. Unchecked macrophyte proliferation can compete for essential nutrients, obstruct sunlight penetration, and reduce plankton productivity—thereby limiting food availability for filter-feeding fish species, which form the backbone of culture-based fisheries.

Despite their potential to disrupt the productivity of managed fisheries, macrophytes are also integral structural elements of wetland ecosystems. Their presence supports ecological balance and biodiversity, underscoring the need for their scientific and balanced management. Furthermore, growth patterns among different stocked fish species varied significantly, indicating species-specific responses to environmental conditions and feed availability within the *maun*. This variation highlights the importance of strategic species selection and adaptive stocking practices for optimizing fish yield in culture-based fishery systems.



Fig 60 Macrophytes infestation, removal Marginal shrubs and weeds (A), rooted submerged weed (B), marginal surface weeds



Fig.61 Grass carp fish harvest from Majharia

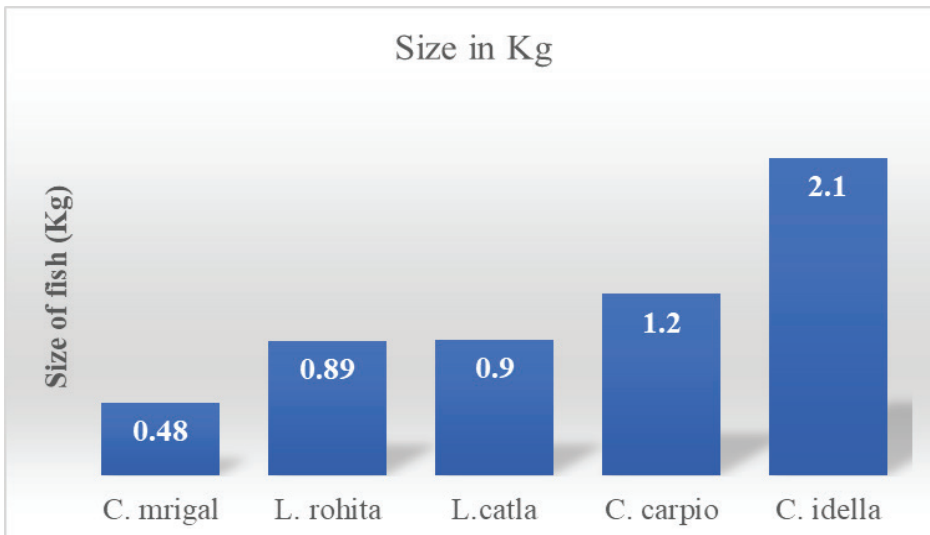

Fig. 62 Growth performance of stocked fish species in Majharia *maun*

13.4. Management of harvestable size of fish and its fishing schedule

The members of the cooperative society traditionally engaged in daily fishing activities, with peak harvest occurring during February to March each year. As part of the scientific intervention, ICAR-CIFRI recommended shifting the fishing schedule to extend beyond April up to June–July or until the onset of seasonal flooding. Additionally, fishers were encouraged to intermittently remove large predatory species—such as *Wallago attu* and *Channa marulius*—prior to stocking fish seed in the open wetland.

Fishing nets were also regulated, with a focus on using mesh sizes that targeted larger fish (>500 g), allowing smaller ones to grow and supporting sustainable stock management. This approach led to noticeable improvements in fish size at harvest and increased annual yield.

As a result, total fish production from Majharia *Maun* rose from 3,085 kg in 2017–18 to 7,696.3 kg in 2018–19. Although there was a decline in the third year, the yield remained significant at 5,279.75 kg in 2019–2020, reflecting the success of the management interventions.

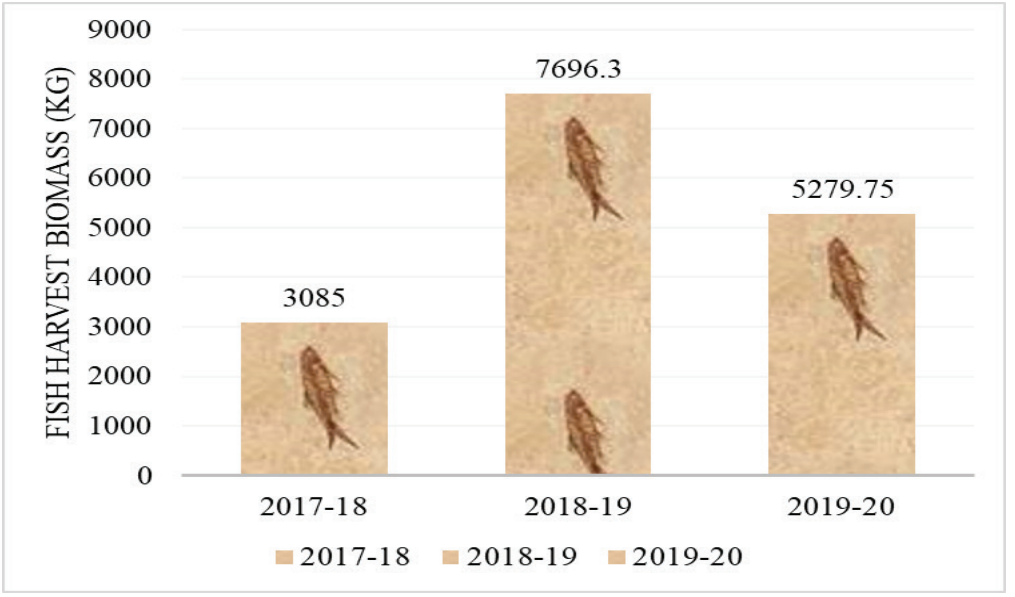

Fig. 63 Annual trends of fish yield from Majharia *maun* during project

13.5 Introduction and refinement of enclosure culture systems

Sustainable enhancement and maintenance of table-size fish production in wetlands can be effectively achieved through in situ rearing of fish seed—particularly species of local importance—by nurturing them from fry to fingerling stages. Key seed rearing methods include land-based nurseries and enclosure systems such as pens and cages, which are established either along the wetland periphery (for nurseries) or within the wetland itself (for pens and cages). These technologies ensure a consistent year-round

supply of fingerlings for stocking in open waters, thereby lowering input costs and supporting continuous production of table-size fish. In addition to improving fish yield, these practices contribute to livelihood security and nutritional support for local communities throughout the year.

With this objective, enclosure culture systems—specifically pens and cages—have been refined and adapted to suit local conditions, thereby enhancing fish production from Majharia *Maun*. The in situ seed rearing technologies developed by ICAR-CIFRI for replenishing depleted stocks of major and minor carps were assessed for feasibility, scaled up for extension, and promoted for adoption in the wetland ecosystem. As part of this intervention, six "CIFRI GI Cages" and one pre-fabricated "CIFRI HDPE Pen" (0.5 ha) were installed in scientifically selected marginal areas of Majharia *Maun* for producing advanced fingerlings during the fry-availability period from July to September. While the standard dimensions of the cage frames were retained, the size and design of the hapa were customized to better suit wetland conditions.

The introduction of these refined enclosure systems marked a significant innovation for wetland fisheries in Bihar, enabling year-round fish seed availability for stocking and strengthening the sustainability of culture-based fisheries. Additionally, the installed cages were successfully utilized for table fish production of Amur carp (*Cyprinus carpio haematopterus*), highlighting the adaptability and productivity of the approach.

13.6. Introduction of land based nursery ponds

Nursery ponds, which are conventionally part of hatchery complexes for fish seed rearing, have been effectively integrated with culture-based fisheries (CBF) for the sustainable management of natural aquatic resources like oxbow lakes and wetlands. This integration ensures the timely availability of cost-effective, high-quality fingerlings of desired sizes for stocking. At Majharia *Maun*, three nursery ponds, each of 0.5 hectares, have been established specifically for the production of advanced fingerlings to support CBF practices in the open wetland. The fingerlings produced were utilized for stocking in both the *maun* and in installed cages, thereby enabling concurrent production of table-size fish. This infrastructure plays a dual role—meeting the seed requirement for enhancing fish production in the wetland while also augmenting the income of fisher communities through the sale of surplus seeds and marketable-size fish.

13.7. Market demand and fish species selection

The selection of fish species for stocking in the wetland was carefully aligned with the regional consumption patterns, focusing on those species that are highly demanded by local communities. As a result, larger-sized Indian Major Carps (IMCs), grass carp, and common carp were given priority due to their popularity in the fresh and live fish market and their ability to command higher prices. This approach, driven by consumer preferences, not only enhanced market returns for the fishers but also ensured a sustainable and culturally relevant supply chain that supports both livelihood and nutritional security in the region.

13.8. Record keeping and maintenance

Prior to the implementation of the project, the cooperative society operating in Majharia *Maun* had little understanding or appreciation of the importance of maintaining records related to fisheries activities, especially in the context of culture-based fisheries (CBF). The lack of documentation not only hindered effective planning and monitoring but also limited transparency in the functioning of the cooperative. Recognizing this gap, the project placed a strong emphasis on institutional development and introduced the concept of systematic record-keeping as a core component of capacity building. The society was actively motivated and guided to begin maintaining detailed records of various operational aspects, including fish seed stocking, fishing schedules, catch data, financial transactions, and sales.

This newly adopted practice of record-keeping brought about a significant transformation in the functioning of the cooperative. It enhanced transparency in decision-making processes and created a sense of accountability among the members. Furthermore, the availability of reliable data enabled the cooperative to interact more confidently with government agencies and policymakers, who could now design evidence-based strategies and support mechanisms tailored to the actual needs and performance of the society.

To further institutionalize transparency and reduce intra-group disputes, a standardized method for documenting daily fish catch was introduced. This was done at both the individual fisher level and the cooperative level to ensure fair tracking of contributions and equitable profit-sharing. The data served as a critical tool in resolving conflicts, building mutual confidence among members, and fostering a sense of collective ownership and responsibility.

From a socio-economic perspective, the majority of fishers associated with Majharia *Maun* belong to the economically weaker sections of society. Many of them live in kuccha (non-permanent) houses, highlighting the precarious nature of their livelihoods and the urgent need for structured interventions. By integrating basic financial management practices and promoting inclusive development through better documentation, the project laid a foundation for long-term sustainability and empowerment of the fishing community.

13.9. The institutionalisation of profit sharing and generation of a sustainability fund

The management regimes of open water fisheries in Bihar can be classified into four categories based on property rights and access: Private management (which involves individuals or groups), Fishers' cooperative management, Self-Help Group (SHG)-based management, and Open access with no management. The ownership of water bodies, including wetlands, lies under the jurisdiction of the Department of Fisheries, but the management rights to these wetlands are leased out to the highest bidder, typically either a Fishermen Cooperative Society or an SHG of fishers.

In the context of cooperative management of floodplain wetlands, the cooperative society's members, governed by the rules set forth by the society, handle the management of fisheries operations. Membership within the cooperative determines access to the fisheries resources. There are two common types of sharing arrangements within these cooperatives. In some, the fish catch is pooled together, and the total catch is sold in the market, with the income distributed among the members of the cooperative. In other societies, fishers contribute fifty percent of their catch as a share of the revenue to the society.

In the case of Majharia *Maun*, a hybrid model of revenue sharing was implemented. For the harvesting of stocked fish, the sharing arrangement between the cooperative and the fishers was set at 50:50, ensuring equal distribution of profits. However, for the self-recruiting group of fish, a 30:70 sharing model was implemented to promote equity and balance in the distribution of income among the fishers. This approach aimed to ensure that all stakeholders, particularly the individual fishers, received a fair share of the profits derived from the fishery.

In addition to the revenue-sharing model, the project introduced a successful strategy to ensure the long-term financial sustainability of the cooperative. A common fund was raised by depositing 10% of the revenue generated from the sale of fish during the project into a designated sustainability fund. This fund is intended to provide a financial backup for the cooperative and ensure the continuity of the fisheries management activities even after the project's completion. The establishment of this fund represents a forward-thinking approach to securing the long-term viability of the fisheries and supporting the cooperative's ongoing operations.

13.10. Prevention of fish escape through link channel

The wetlands in Bihar are highly susceptible to flooding during the monsoon season, which often leads to the escape of stocked fish and the ingress of large predatory species. Majharia wetland, in particular, faces severe flooding each year, exacerbating these challenges. To address this issue, nylon mesh was fitted onto bamboo structures and installed along the link channels to prevent the escape of fish and to block the entry of large predators. This proactive measure aims to safeguard the stocked fish and maintain the ecological balance within the wetland.

13.11. Fulfillment of the project's purposes

Issues addressed:

- Assessment and realization of production potential through stocking enhancement to improve fish yield.
- Macrophyte (weed) management to maintain ecological balance and prevent overgrowth that impacts fish productivity.
- Circumvention of inadequate seed supply by creating land-based nurseries

along wetland peripheries and adopting enclosure culture techniques.

- Production of advanced fingerlings and development of a seed bank in pens and cages for year-round seed availability.
- Organized harvesting and documentation of catches to ensure transparency and effective resource management.
- Prevention of stock loss by establishing iron mesh walls at water outlets/inlets to prevent fish escape and predator ingress.
- Strengthening institutional and governance frameworks to enhance community participation in fisheries management, improving livelihoods.
- Capacity building and awareness campaigns to educate local communities on sustainable fishery practices.
- Addressing inadequate extension and service delivery mechanisms to ensure efficient knowledge transfer and support.
- Building alliances and partnerships to improve research, development, and technology dissemination for the fisheries sector.

Gaps bridged:

- Lack of technological intervention to enhance productivity and create livelihood opportunities.
- Insufficient supply of quality fish seed in a timely manner for successful stocking.
- Underutilization of available water resources for fish cultivation and management.
- Limited earnings due to poor fish harvest and inefficient production methods.
- Lack of preparedness measures/strategies to prevent fish loss due to escape through link channels during floods.
- Insufficient capacity and skills for implementing effective fisheries management practices.
- Ineffective mechanisms for knowledge dissemination, hindering wider adoption of best practices and new technologies.

14. Recommendations

Wetlands are crucial ecosystems that provide a wide range of goods and services, benefiting both the environment and society. According to the Millennium Ecosystem Assessment, wetlands cover about seven percent of the Earth's surface, yet they contribute an impressive 45% of the world's natural productivity and ecosystem services. Among the diverse ecosystem goods, fish stand out for their significance in supporting the livelihoods of fishers and ensuring the nutritional security of communities. In India, Bihar is particularly rich in natural water resources, including rivers, floodplain wetlands, reservoirs, ponds, and tanks. Among these, floodplain wetlands hold special importance, particularly in the form of waterlogged depressions (*Chaurs*) and oxbow lakes or meanders (*Maun*s). These wetlands are widely distributed across the state, with *Chaurs* covering around 200,000 hectares and *Maun*s spanning about 9,000 hectares.

Despite the abundance of these resources, the fish yield in Bihar remains suboptimal. This contrasts with the well-managed wetlands in West Bengal and Assam, which have been able to sustainably produce more than 800 kg of fish per hectare per year. The lack of optimal fish yield in Bihar highlights the need for scientific management of wetland resources. Such management, driven by coordinated efforts from government bodies and social agencies, is essential for enhancing productivity and sustainability. ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) has successfully implemented a project in Bihar that demonstrates the potential of integrated wetland management in improving fish yield and fisher livelihoods.

The experiences and insights gained from this project have yielded valuable lessons, which have been compiled into a series of recommendations. These recommendations are intended to guide fisheries policymakers and planners, offering practical solutions for improving wetland management and enhancing the socio-economic outcomes for fishing communities in Bihar. The project's success underscores the importance of coordinated, science-based interventions in maximizing the potential of wetland fisheries.

1. The cooperative society should actively collaborate with ICAR-CIFRI for technological support and skill development initiatives, and engage with the Department of Fisheries (DoF), Government of Bihar, for policy guidance, financial assistance, and infrastructure development. This integrated approach is essential for effective wetland management, ensuring sustainable livelihoods and nutritional security for its members.

2. The fisher community should be organized under the Primary Fishermen Cooperative Society (Piprakothi Prakhand Matsyajeevi Sahyog Samiti Ltd.) through regular awareness programs and meetings. This will help members gain a clear understanding of the society's functions, their individual roles, and collective responsibilities in managing the wetland fisheries of Majharia *Maun* effectively.

3. Regular capacity-building and skill development initiatives—such as awareness programs, training sessions, and exposure visits—should be conducted to familiarize fishers with the principles and operational protocols of cooperative functioning and culture-based fisheries (CBF). Practical hands-on training in CBF, along with exposure visits to well-managed wetlands in West Bengal and Assam, is strongly recommended to enhance technical know-how and broaden their perspective.

4. Inadequate documentation of the society's activities—such as meeting records, fish stocking and harvest data, details of extreme events like floods and droughts, and financial transactions—posed significant challenges during the implementation of the present project in Majharia *Maun*. To address this, regular review and auditing of records by the Department of Fisheries (DoF), Bihar should be institutionalized. Furthermore, an authenticated and updated copy of all records should be maintained at the district fisheries office under DoF, Bihar. This systematic documentation will greatly support the society in securing financial assistance and implementing future development projects effectively.

5. The successful implementation of culture-based fisheries (CBF) in the oxbow lakes of Bihar should be preceded by detailed reconnaissance studies, particularly to assess the carrying capacity of the wetland. Such preliminary assessments are crucial for understanding the ecological and physical characteristics of the site, and they enable the executing agency to anticipate and address potential challenges specific to the wetland. This informed approach ensures better planning, sustainable fish production, and effective management throughout the project cycle.

6. Shrinkage and degradation of wetlands in Bihar, driven by increasing population pressure and anthropogenic activities, pose significant threats to their sustainability. To safeguard the livelihoods of wetland-dependent fishers, it is imperative to implement regular habitat monitoring. This should include tracking encroachment, identifying pollution sources, assessing the extent of macrophyte infestation, and monitoring siltation in both the link channels and the wetlands themselves. Timely and scientific management of these issues is essential to ensure the long-term ecological health of the wetlands and the economic well-being of the local fishing communities.

7. Each wetland possesses a unique ecological character that supports the growth of specific fish species. In the case of Majharia *Maun*, it was identified as an oligotrophic wetland moderately infested with submerged rooted macrophytes. Based on its ecological status, a stocking strategy that included 50–60% grass carp and common carp proved highly effective, resulting in larger harvest-size fish and contributing 40–50% of the total fish yield. This underscores the importance of conducting detailed ecological assessments during the reconnaissance survey phase, which should be a prerequisite for designing site-specific, scientifically informed fish stocking and management strategies.

8. Majharia *Maun*, being a seasonally connected oxbow lake linked to the Burhi Gandak River, is highly susceptible to flooding during the monsoon. To mitigate the risk of stock loss, both fish seed stocking and harvesting schedules were strategically adjusted in accordance with the flood patterns. This experience highlights the critical importance of incorporating the potential impacts of extreme climatic events, particularly floods, into the planning and implementation of culture-based fisheries (CBF) to ensure resource sustainability and minimize losses.

9. Majharia *Maun* supports a rich indigenous fish diversity, with 52 recorded species. However, the presence of large predatory fishes—particularly *Wallago attu*—posed a significant challenge in determining the appropriate size of fish seeds for stocking. To address this, the size of the fish seeds was progressively increased from 25 grams in September to 80 grams by January each year during the project period. This strategy, adopted by ICAR-CIFRI, significantly reduced stock loss due to predation. Therefore, in culture-based fisheries (CBF) programs, it is strongly recommended to conduct thorough assessments of fish biodiversity, especially the presence and abundance of large predatory species, to inform appropriate seed stocking strategies.

10. Additionally, the practice of stocking progressively larger-sized fish seeds as time advanced from the breeding season proved effective in mitigating the challenges of slow growth and the risk of disease outbreaks during the winter months. This strategy was particularly beneficial given that the wetland is located in a region severely affected by harsh winter conditions. By ensuring that fish were already at a robust growth stage before the onset of winter, the overall survival rate and health of the stock were significantly improved.

11. The combination of fish species and their stocking density for Majharia *Maun* was carefully determined based on the wetland's ecological characteristics, trophic state, and fish catch composition. The stocking plan involved fingerlings (weight range 25-80g; total length 100-150 mm) of five carp species—Grass carp, Common carp, Catla, Rohu, and Mrigal—at a density of 2000 fish per hectare. The stocking ratio for these species was set at 3:2:2:2:1 in the summer and 3:3:1.5:1.5:1 in the winter. This approach emphasized the importance of considering the wetland's ecological features, food availability, and seasonal changes for effective culture-based fisheries (CBF) management.

12. Each oxbow lake has a specific carrying capacity, which can be quantified through primary productivity estimation. To optimize fish yield in Majharia *Maun*, stock enhancement with advanced fingerlings was carried out in a staggered approach, with three separate stockings at intervals of 50-60 days throughout the year. This staggered stocking strategy proved effective and is therefore recommended for implementation in culture-based fisheries (CBF) programs.

13. A staggered stocking program in culture-based fisheries (CBF) requires a substantial supply of high-quality fish seeds at different intervals, but Bihar has historically faced challenges in producing adequate fish seeds, particularly during the off-season. To address this issue and ensure a steady supply of fish seeds for Majharia *Maun*, a seed bank was established within land-based nursery ponds, as well as through floating cages and pens. This infrastructure not only ensured a consistent seed supply but also helped reduce the overall cost of seed procurement. Therefore, the establishment of fish seed banks within wetland premises is highly recommended for CBF programs.

14. Natural fisheries in wetlands typically do not offer year-round employment for the members of the community. To address this, the project introduced technologies such as culture-based fisheries (CBF), cage culture, and land-based nurseries, which significantly increased the number of employment days from 40-45 to 109 days, without impacting the natural fisheries of Majharia *Maun*. Additionally, the seed banks were utilized to produce table fish, creating further livelihood opportunities for the community members. Therefore, the adoption of technological interventions like CBF, enclosure culture, and land-based nurseries is strongly recommended in CBF programs.

15. Effective fisheries management, including mesh size regulation, closed seasons, theft monitoring, and the regulation of destructive fishing practices, is crucial for the sustainability of fisheries in wetlands. Therefore, a comprehensive fisheries management protocol should be incorporated into integrated wetland fisheries management strategies.

16. Fish in the water are non-perishable goods, making it essential to implement an efficient supply chain management system (input and output linkages). A well-planned harvest regime aligned with market demand will ensure improved profitability for the society.

15. Acknowledgment to the stalwards visited to site/ witnessing success of project

We would like to extend our heartfelt gratitude to the following individuals and organizations for their invaluable support and contributions to the success of this project:

- Honorable Minister of Agriculture & Farmers Welfare, Government of India, Sri Radha Mohan Singh
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- Deputy Director General, ICAR, Dr. J. K. Jena
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- Mukhia, Majharia
- The Fishers of Majharia *Maun*
- Scientific Team of the NFDB Project

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16. Publications

a. M. Puthiyottil, U.K. Sarkar, L. Lianthuamluaia, G. Karnatak, M.A.Hassan, S. Kumari, B.D. Ghosh, and B.K. Das Floodplain wetlands of eastern India in a changingclimate: Trophic characterization, ecological status, and implications for fisheries. October 2022. Aquatic Ecosystem Health and Management 24(3).

b. Suman Kumari*, G. Karnatak, P. Mishal , Lianthuamluaia , Raju Baitha, M. A. Hassan, H. S. Swain, Ganesh Chandra, U. K. Sarkar And B. K. Das (2023). Influence Of Hypophthalmichthys Molitrix (Valenciennes, 1844) On Cyanobacterial Bloom And Its Succession In Wetland, India. J. Inland Fish. Soc. India, 55 (4) : 422-431, 2023 422 http://dx.doi.org/10.47780/jifsi.55.4.2023.153760

c. M.A. Hassan, B.K. Das, P. Mishal, G. Karnatak and Suman Kumari (2021). Fisheries Enhancement through Participatory Technological Interventions in Oxbow Lakes of Eastern India: A Success Story, WORLD AQUACULTURE • SEPTEMBER 2021 64-69.

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Award

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2. Copy right : L-152230/2024 dated 6th August 2024

Book Chapters/training manual

1. बि. के. दास एवं सुमन कुमारी, बिहार के आद्रक्षेत्रों में मात्स्यिकी आजीविका का एक विकल्प सम्पादकीय मंडल बि. के. दास, एम. ए. हसन, संध्या के एम्, सुमन कुमारी, गुंजन कर्नाटक प्रशिक्षण मैनुअल, वर्ष-2018, अंक-4, pp. 1-5.

2. सुमन कुमारी, आर्द्रक्षेत्रों (झील, चौर एवं मन) में जैविक समुदायों की भूमिका और इसके महत्व, सम्पादकीय मंडल बि. के. दास, एम. ए. हसन, संध्या के एम्, सुमन कुमारी, गुंजन कर्नाटक प्रशिक्षण मैनुअल, वर्ष-2018, अंक-4, pp. 38-44.

3. प्रशिक्षण पुस्तिका "बिहार के चौर और मन में मात्स्यि की प्रबंधन" for training programme under CSS-Blue revolution 'Fisheries management in Chaur and *Maun* for doubling fisher's income' February 13-15, 2019 at Motihari, Bihar.

4. सुमन कुमारी, गणेश चन्द्र, राजू बैठा, गुंजन कर्नाटक, लिअमतुआमलुआइआ, एच. एस. स्वाइन, मिशाल पी., एम. ए. हसन एवं बि. के. दास (2019). बिहार के मनों में मात्स्यिकी प्रबंधन की चुनौतियां और अवसर: पांच मनों का संक्षिप्त अध्ययन इन. बी. के. दास. प्रवीण मौर्य, संजीव कुमार साहु एवं सुमन कुमारी (सम्पादकीय मंडल), मात्स्यिकी संवर्धन हेतु प्रौद्योगिकी एवं आजीविका सुरक्षा (130 -142), ISBN: 81-85282-30-6.

Leaflet

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2. Hassan MA, Das BK, Mishal P, Karnatak G, Baitha R, Chandra G, Kumari S, Liamthuamluaia L and Swain HS (2019). Stride in fish yield through participatory Technological Interventions in Oxbow lakes of Bihar. Folder. ICAR-CIFRI, Barrackpore, Kolkata

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1. 1. ICAR-FS-CIFRI-Protocol-2025-006



AQUATIC ECOSYSTEM
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Floodplain wetlands of eastern India in a changing climate: Trophic characterization, ecological status, and implications for fisheries

M. Puthiyottil, U.K. Sarkar, L. Lianthuamluaia, G. Karnatak, M.A. Hassan, S. Kumari, B.D. Ghosh, and B.K. Das

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India is endowed with vast floodplain wetland resources (0.5 million ha), which provide both livelihood and nutritional security to much of the rural populace. These biologically sensitive ecosystems are threatened by a range of anthropogenic and climatic factors. Assessment of their ecological vulnerability, and of the environmental threats that they face, is essential both in evaluating the health of these ecosystems and in developing sustainable management strategies for conservation and fisheries enhancement. In this context, eight wetlands in the Ganga basin were studied for two consecutive years across the seasons and were characterized ecologically based on chlorophyll a, primary productivity, and trophic state index. A warming temperature (+0.20 – +0.47 °C) and a decreasing total annual rainfall (257–580 mm) have been observed along the Ganga basin in the last three decades. The chlorophyll a *(mean ± S.E.) content of the water varied from 4.08±1.04 to 38.0±14.11 µg* l^{-1}*. The high primary productivity, gross primary productivity/plankton respiration ratio and trophic state index correlated positively with the high fish yield in the wetlands. Analysis of data based on Carlson's method revealed five wetlands in the eutrophic category, whereas based on Lamparelli's method, two wetlands fall into the eutrophic category. The Lamparelli TSI value ranged from 54.1 in Majharia to 65.8 in Kararia among the wetlands. The Bishnupur wetland in West Bengal and Kararia wetland in Bihar were found to be eutrophic due to cascading sewage incursion from nearby towns. These altered ecosystems with high TSI values were prudently exploited by selecting suitable fish species for high fish production, and a fish yield of 1200 kg* ha^{-1} yr^{-1} *was achieved in Bishnupur. The study revealed that eutrophic wetlands can be strategically managed for maintaining both ecosystem services and fish production. Careful selection of suitable fish species and stocking rate is crucial. The planned disposal and treatment of sewage is recommended to maintain the ecological health of floodplain wetlands for sustainable fisheries management in the context of a changing climate.*

Keywords: climate change, trophic state index, fish yield

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INFLUENCE OF *HYPOPHTHALMICHTHYS MOLITRIX* (VALENCIENNES, 1844) ON CYANOBACTERIAL BLOOM AND ITS SUCCESSION IN WETLAND, INDIA

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Cyanophyte-harmful algal blooms (CyanoHABs) are a challenging issue in wetland ecosystems around the world. Cyanobacteria produce microcystins (MCs), which are associated with hepatotoxicity in animals. The seasonal blooms of *Microcystis* are widely reported in both freshwater and brackish ecosystems throughout the world. The present study aims to address a broader understanding of the seasonality of *Microcystis* in six wetland ecosystems in Eastern India under different management regimes during 2014-2020. Analysis of water physicochemical parameters such as dissolved oxygen, water temperature, pH, total dissolved solids, Sechi Depth, specific conductivity, total alkalinity, and nutrient parameters (nitrate and phosphate) shows significant ($p \leq 0.05$) seasonal variations. The contribution of *Microcystis* spp. abundance to the total phytoplankton abundance varies from 56 to 96% among the wetlands. The food and feeding habits of *H. molitrix* were studied, and the same food item present in the same environment was also assessed. Gut content analysis revealed that the dominance of phytoplankton in the gut was higher relative to the water column, and a substantial quantity of phytoplankton, especially *Microcystis*, was noted. The study also explained the toxicity effect of consumption of microcystins (MCs) on *H. molitrix*. The food selectivity indices and seasonal blooms of *Microcystis* spp. suggest *H. molitrix* is a potential fish species to control algal biomass in wetlands.

Keywords Algal Bloom, Cyanobacteria, Eastern India, Planktivorous Fish, Wetlands

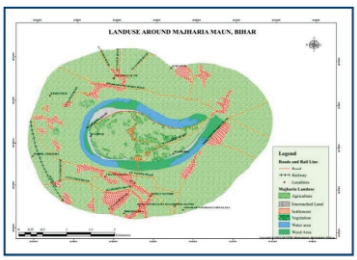
Introduction

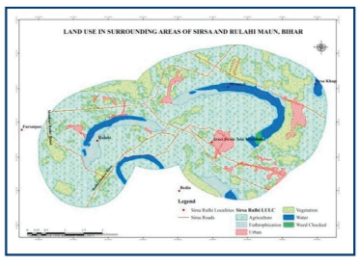
Inland freshwater ecosystems such as wetlands, reservoirs, ponds, tanks, and rivers are finite resources that have been damaged due to climatic and anthropogenic factors. Aquatic ecology is a complex biological process where different organisms occupy different niches and interact with their environment to thrive (Mohanty *et al.,* 2022). Wetlands, formed due to river meanderings, also known as oxbow lakes, are offering wide ranges of ecological services to support the livelihoods of many stakeholders (Sarkar *et al.,* 2021; Gogoi *et al.,* 2021; Das *et al.,* 2022). Ecological interactions of phytoplankton and environmental water quality parameters have been studied in wetlands (Majhi *et al.,* 2022; Kumari *et al.,* 2023) in West Bengal. Shallow inland open water bodies are facing serious issues of eutrophication frequently, and the intensity of the occurrence of freshwater seasonal blooms is becoming a serious issue in different parts of India (Sarkar *et al.,* 2024). In the pre-monsoon period, when the water depth gets reduced, the occurrence of toxic cyanobacterial blooms becomes a common

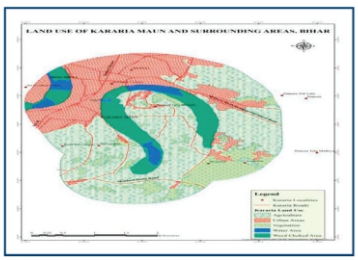
Fisheries Enhancement through Participatory Technological Interventions in Oxbow Lakes of Eastern India: A Success Story

M.A. Hassan, B.K. Das, P. Mishal, G. Karnatak and Suman Kumari

Oxbow lakes render multiple ecosystem goods and services to society, providing food, fuel, fodder and microclimate regulation, benefitting local communities. Fisheries exploitation of floodplain lakes by the resource poor for food security is very common on the Indian sub-continent. India has substantial fisheries resources in the form of oxbow lakes, natural flat or bowl-shaped depressions between levees in floodplains of major rivers, such as the Ganges, Brahmaputra, Mahanadi, Teesta and Imphal. Perennial oxbow lakes offer many possibilities for fisheries management and development.







Maps showing the oxbow lakes involved in the project.

Of late, fish biomass and biodiversity of oxbow lakes are declining due to resource shrinkage through encroachment, changes in morphometry and eutrophication (Das Sarkar *et al*. 2020). Changes in morphometry, especially loss of depth due to siltation, and closure of linking channels have resulted in reduced water volume and failure of self-recruitment by riverine fishes. These factors have contributed to low fish yield, affecting the livelihoods of fishers dependent on these resources.

The scientific management of fisheries for development and sustainability needs coordinated interventions among stakeholders. Despite the immense breadth and potential for fish production in oxbow lakes, that potential has not yet been realized in eastern India (Hassan *et al*. 2016). Insufficient access to scientific knowledge and technologies, poor fisheries infrastructure, weak financial capacity, lack of a co-operative approach, poor linkages between line departments and user groups and disorganized institutional arrangements pose challenges in achieving potential (Sarkar and Mishal 2017).

There is a general lack of knowledge and understanding among stakeholders about the role and effectiveness of various technologies and the value of infrastructure for fisheries development. Moreover, the tenural nature of lease arrangement is responsible for the lack of infrastructure in such open-access natural resources. Other impediments to fisheries infrastructure development are poor financial capacity of lease holders and a lack of government programs.

The Indian Council of Agricultural Research (ICAR) - Central Inland Fisheries Research Institute (CIFRI), Barrackpore has been working on the ecology of wetlands and the rational management and development of inland fisheries for the last several decades (Sugunan and Bhattacharjya 2000, Sugunan *et al*. 2000). The experience and expertise of CIFRI was used for pilot demonstration of a development module with funding support from the National Fisheries Development Board. The project aimed for integrated fisheries development in selected oxbow lakes of Bihar to enhance fish yield and the livelihoods of fishers, strengthening infrastructure, linkages and institutional arrangements.

Oxbow Lakes Targeted for Project Interventions

The wetlands in Bihar are experiencing low fish yield due to failure of self-recruitment and self-stocking of seed from depletion of riverine fish stocks and shrinkage of link channels, resulting in a yield gap. In addition, large carnivores, especially wallago catfish *Wallago attu* and snakehead *Channa marulius*, found abundantly in these wetlands preying on small fry and fingerlings of commercially important carp species, is another cause for low yield.

The State of Bihar has an estimated 9000 ha of oxbow lakes, locally known as *mauns*. The *mauns* selected for fisheries development were Majharia (100 ha), Kararia (100 ha), Rulhi (80 ha) and Sirsa (70 ha) of East Champaran district of Bihar, which supports the livelihoods of more than 600 fisher families.

Majharia (26°33'23.8" N, 84°56'01.6" E) is located 6 km south of Motihari and is a typical U-shaped oxbow lake. The *maun* has



आर्द्र क्षेत्रों में मात्स्यिकी संवर्द्धन

एम.ए. हसन*, बसंत कुमार दास*, लिएनथुआमलु आईएआएल*, राजू बैठा* और **गणेश चंद्रा***

"बिहार के प्राकृतिक खुला जल मत्स्य संसाधन क्षेत्र के अंतर्गत 9000 हैक्टर से अधिक मन (गोखुर झीलों) और 0.1 मिलियन हैक्टर चौर (बाढ़कृत मैदान) आते हैं। ये इन जल संसाधनों पर निर्भर हजारों मछुआरों को आजीविका और पोषण सुरक्षा प्रदान करते हैं। इनमें से अधिकांश मन और चौर निचले गांगेय मैदान के कोसी-गंडक उप बेसिन में स्थित हैं, जिनमें प्रत्येक वर्ष बाढ़ आ जाती है। यह बाढ़ मत्स्य संसाधन और उनपर निर्भर मछुआरों के लिए वरदान और शाप दोनों मानी जाती है। उत्पादकता की स्थिति के आंकलन से इन संसाधनों से वर्तमान उपज (70-180 कि.ग्रा./हैक्टर/वर्ष) और संभावित उपज (350-800 कि.ग्रा./हैक्टर/वर्ष) के बीच व्यापक अंतर देखा गया है। दोनों उपज के बीच इस अंतर के महत्वपूर्ण विश्लेषणों से पता चला है कि प्रतिवर्ष बाढ़, बहुहित धारकों का नियंत्रण, संस्थागत व्यवस्था का मंद होना, बड़े परभक्षी प्रजातियों की उपस्थिति, मत्स्यपालन के संबंध में अपर्याप्त ज्ञान, कौशल क्षमता में कमी कुछ ऐसी अन्य कमियां और खतरे हैं, जिनसे इन संसाधनों की उत्पादन क्षमता का पूर्ण रूप से उपयोग नहीं होता है।"

बिहार राज्य का मत्स्यपालन केवल अंतर्स्थलीय मछली उत्पादन पर निर्भर है। इन संसाधनों से रोजगार और आजीविका के अवसर सीमित होने के कारण मछुआरे दूसरे राज्यों में पलायन के लिए मजबूर हैं। इस स्थिति में व्यापक ज्ञान आधारित तकनीकी हस्तक्षेप, आधारभूत संरचना का निर्माण, क्षमता निर्माण, सशक्तिकरण, क्षेत्र विशिष्ट संस्थागत व्यवस्था का प्रबंध, संसाधन एवं उपयोगकर्ता का क्षमता विकास, रोजगार के अवसर में सुधार, स्थायी प्रबंधन और लाभ साझा करने में आसानी आदि कारक यहां के मात्स्यिकी विकास में मदद कर सकते हैं। सुनिश्चित क्षमता और समय पर निवेश की उपलब्धता के साथ मत्स्यपालन तरीकों का कार्यान्वयन इस तरह के प्राकृतिक जल संसाधनों से मछली उत्पादन में सुधार के लिए एक प्रभावी तकनीक है।

*भाकृअनुप-केंद्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर, कोलकाता-700120

पहल

बिहार के पूर्वी चंपारण जिले के मोतिहारी क्षेत्र में 4 आर्द्र क्षेत्रों: मझरिया (100 हैक्टर), करिया (100 हैक्टर), रुलही (80 हैक्टर) और सिरसामन (80 हैक्टर) को परियोजना के कार्यान्वयन के लिए चयनित किया गया। मछली उत्पादन पैटर्न को समझने और समस्या को हल करने के लिए एक दृष्टिकोण प्रणाली अपनायी गयी। इन जलाशयों में मत्स्य संवर्द्धन संबंधित चुनौतियों की पहचान की गई। राष्ट्रीय मात्स्यिकी विकास बोर्ड, हैदराबाद से प्राप्त वित्तीय सहायता के साथ भाकृअनुप-केंद्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर ने विभिन्न तकनीकी प्रौद्योगिकियों द्वारा मछली की पैदावार और रोजगार के अवसर को बेहतर बनाने के लिए कुछ चुनौतियों का समाधान किया।

रणनीति

बेस लाइन सर्वेक्षण

सामान्यत: प्रत्येक वर्ष अगस्त-सितंबर के दौरान बाढ़ से मात्स्यिकी उत्पादन का बहुत नुकसान होता है। छोटी गैरव्यावसायिक



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बिहार के मनों में मात्स्यिकी प्रबंधन की चुनौतियां और अवसरः संक्षिप्त अध्ययन

सुमन कुमारी, बसंत कुमार दास, गणेश चन्द्र, राजू बैठा, एम. ए. हसन, गुंजन कर्नाटक, लियानथुमलुइआ, मिशाल पी. एवं हिमांशु शेखर स्वैन

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सार

बिहार में नौ लाख हेक्टेयर में फैले बाढ़कृत आद्रक्षेत्र (चौर एवं मन) राज्य के सबसे महत्वपूर्ण मत्स्य संसाधन है। चौर एवं मन संसाधन सभी जलीय जीव जंतुओं के लिए विविधता से भरे आवास होते है। राज्य में चौर एवं मन के आसपास रहने वाले ग्रामीणों के लिए बाढ़कृत आद्रक्षेत्रों में मत्स्य प्रग्रहण एवं मत्स्य पालन जीवनयापन का एक महत्वपूर्ण आधार है। बाढ़कृत आद्रक्षेत्रो का प्रबंधन काफी हद तक अनुकूली प्रबंधन दृष्टिकोण पर निर्भर करता है। यह लेख, बाढ़कृत आद्रक्षेत्रों की चुनौतियों, आधारभूत जानकारी की कमी, कैचमेंट के भूमि उपयोग में परिवर्तन, उद्योग और घरों से होने वाले प्रदूषण, अतिक्रमण, व्यवस्था एवं शासन प्रणाली, मैक्रोफाइट्स (जलीय पौधा), प्राकृतिक संसाधनों के दोहन, अविरल मत्स्य पालन, और चौर एवं मन पारिस्थितिकी तंत्र के भीतर अस्पष्ट भूमि के पट्टे की अवधि, और स्वामित्व, जैसी विभिन्न समस्याओं एवं इससे व्यापक रूप से सामना करने के लिए हितधारकों के बीच जागरूकता प्रदान करने एवं ध्यान आकर्षण के उद्देश्य

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Roadmap for Fisheries Development in *Mauns* and *Chaurs* of Bihar

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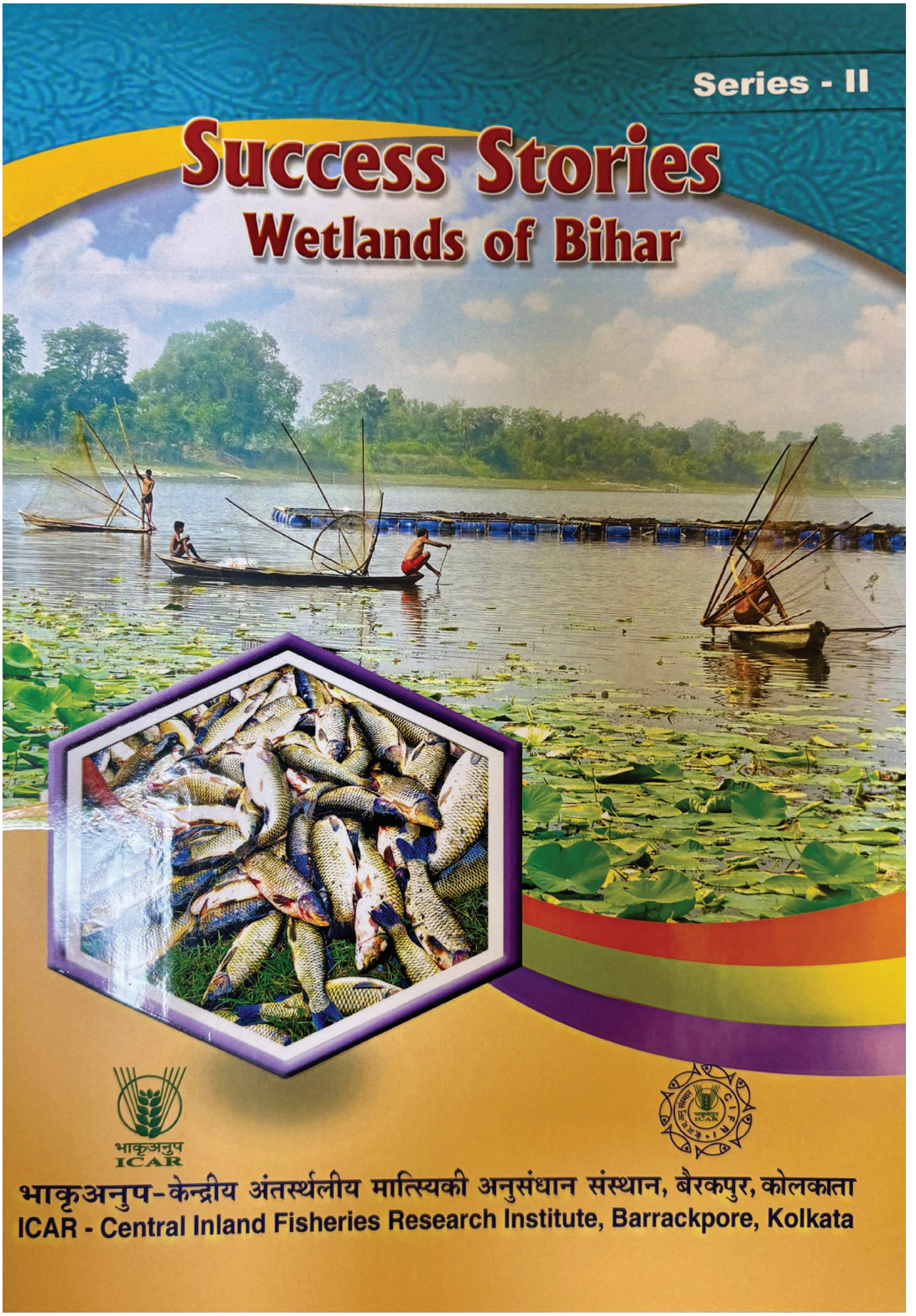
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