वार्षिक प्रतिवेदन | ANNUAL REPORT

2021

भाकृअनुप
ICAR

भाकृअनुप-केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान
बैरकपुर, कोलकाता-700 120, पश्चिम बंगाल

ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
Barrackpore, Kolkata - 700120, West Bengal

ANNUAL REPORT

2021

भा.कृ.अनु.प.-केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान
बैरकपुर, कोलकाता–700120, पश्चिम बंगाल
ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
Barrackpore, Kolkata - 700120, West Bengal
www.cifri.res.in
(ISO 9001:2015 Certified Institution)

Published by
Dr. B. K. Das, Director
ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata – 700120

Compilation & Editing
B.K. Das, S.K. Manna, A. Pandit, A. Roy, B.K. Behera, Sunita Prasad & Ambily, M.N.

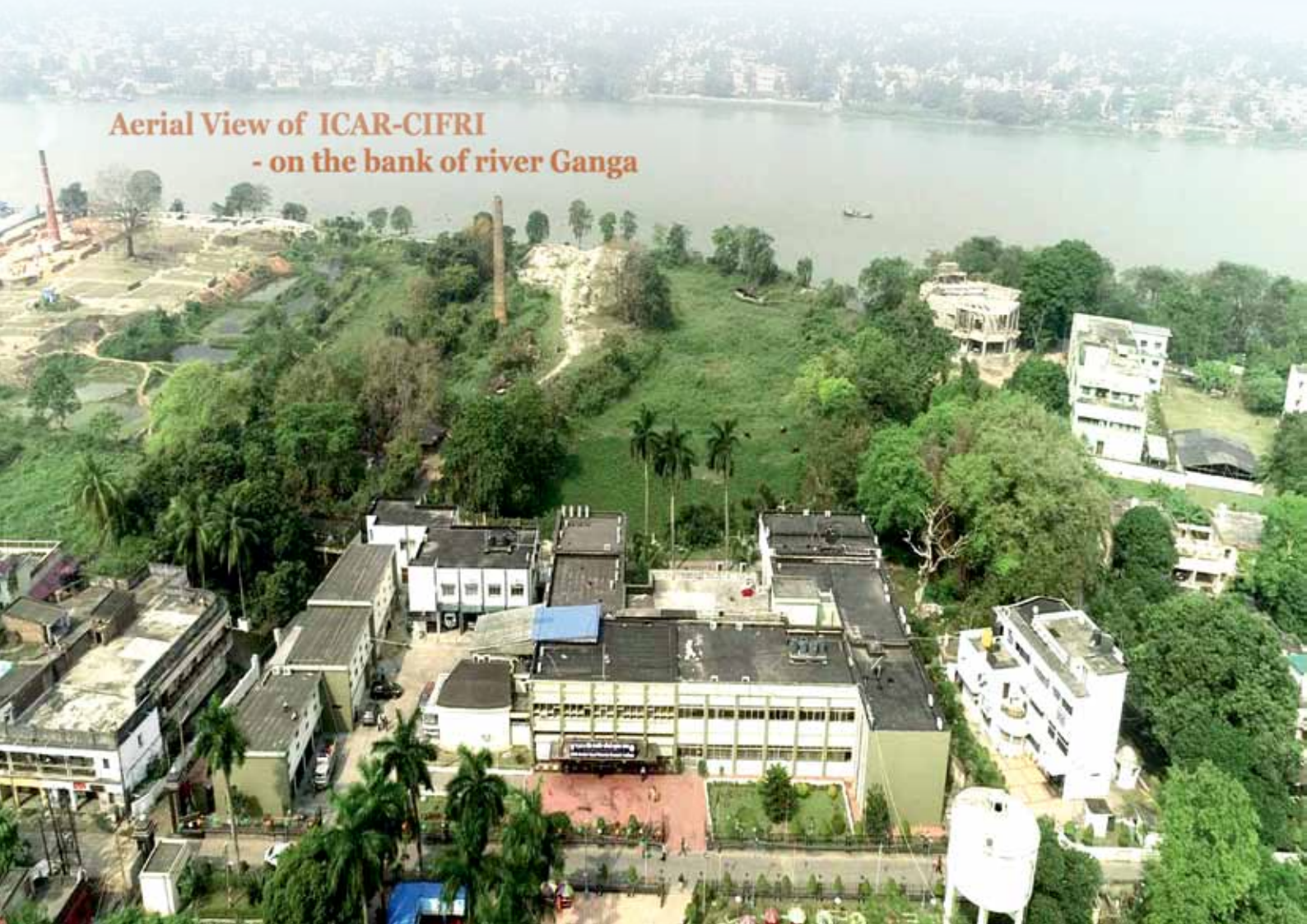
Photography and Reproduction
Sujit Chowdhury, Manabendra Roy & all Project Staff

Hindi Translation
Sumita Prasad, Sumedha Das

ISSN: 0970-6267

Design & Printed at :
M/s Royal Offset Printers, A-89/1 Naraina Industrial Area, Phase-I, New Delhi 110 028, **Phone :** 9811622258

CONTENTS



PREFACE

India has witnessed a remarkable growth in fish production in the last couple of years. In spite of several waves of COVID-19 it has produced 142 lakh metric tonnes of fish in 2019-20, of which 74% came from the inland sector. In addition to providing about 50% of the inland fish production, vast inland open water resources of the country, viz., 45,000 km of rivers, 0.3 million ha of estuaries, 0.19 million ha of backwaters and lagoons, 3.524 million ha of reservoirs, 0.354 million ha of floodplain wetlands and 0.72 million ha of upland lakes provide water, food and nutrition, transport, livelihood and several other ecological services to a large section of the population, beside other innumerable economic and social benefits. However, there exists enough potentials to increase fish production from these large resources.

Inland open water resources provide employment and livelihood support to 1.24 million inland fishers, beside being the vital germplasm conservator. Due to huge fish production potentials wetlands, lakes, and reservoirs have been heavily emphasized for fish production enhancement to achieve the targeted second blue revolution of the country. However, declining water availability, pollution, habitat degradation, over-exploitation of natural fish stocks, and other associated threats put serious challenges for sustainable fish production from these resources in recent times. The institute has been attempting to mitigate the challenges and to enhance the fish production through research, training, extension, HRD and development activities in the sector, networking with fishers and other stakeholders and demonstrations/ implementation of its technologies in NEH, STC, SCSP programmes, etc. The Institute took lead in generating information in the areas of inland open water fisheries through ecosystem based research and community participation. The Institute imparted extensive training to more than 4000 fishers, officials, and students through off-line and on-line modes. It has also generated awareness, developed skill and distributed essential inputs among underprivileged SC and tribal fishers.

Majority of the present research activities have been in operation since April 2020. Extensive field based research studies could not be done due to COVID-19 restrictions. Temporal assessments of fisheries of Hooghly-Matla, Rushikulya, Mandovi - Zuari, Netravathi-Gurupur estuaries and Vembanad lake were conducted. Ecological impacts of dams and barrages in some rivers with special references to fisheries have been assessed. The fish landings and catch structure in Barak and Tapti rivers were attempted. For the first time, work has been initiated to assess fish diversity and habitat characteristics of priority habitats in protected and less-explored areas of the country. Bhitarkanika National Park, Jaldapara National Park, Panna National Park, major waterfalls region of Chhota Nagpur plateau and a couple of wetlands and reservoirs were taken into account for this purpose.

Eco-variability and impacts of river Yamuna on river Ganga with special emphasis on fisheries were assessed. The experiments on diversification of fish species for enclosure culture in reservoir and wetlands were continued. The spatio-temporal variations of reservoir ecosystem of Hirakud, Panam, Idukki, Kodar, Poondi, Seruli B, Gayatri, Beko, Upper Khaguria and Sunei were studied for developing improved fisheries management strategies including tropho-dynamic modelling of reservoirs in different eco-regions. Eco-orientation approach was applied for fisheries enhancement in floodplain wetlands in NE states, West Bengal, Bihar, Uttar Pradesh, and Madhya Pradesh. Sustainable production enhancement and livelihood improvement through technological intervention (pen culture) were done in selected reservoirs and wetlands of India. The status of pesticides and emerging contaminants including heavy metals and arsenic in selected water bodies are being monitored. Efficacy of fish epidermal mucus as a biomarker for the environmental stress and potential antimicrobial agent against fish pathogens are being tested using 'omics' technologies. In Ecosystem health risks, food safety assessment in relation to chemical contaminants, evaluation and management of environmental health through omics technologies are important areas in fisheries ecosystem secor. Experiments are being continued for fish health management using

different biomolecules. Stock characterization of two bagrid species (*Mystus cavasius* and *M. gulio*) are being carried out for fisheries management. Inland open-water ecosystem assessments specifically the fisheries resource assessment, does not include integrated data-driven system. Therefore, attempt has been initiated to fill the gap and creating an integrated data discovery system using BigData concept.

North eastern region was given special emphasis like the earlier years. Refining fisheries management guidelines and technologies; assessing techno-economic feasibility of fisheries management guidelines; standardizing the enclosure culture technology and fish stock enhancement, developing human resources for openwater fisheries management were some of the key areas of research in north eastern region. Seven of the SDG goals, viz., end poverty (SDG 1), zero hunger (SDG 2), gender equity and women empowerment (SDG 5), economic growth (SDG 8), sustainable consumption and production (SDG 12), culturing and popularizing the climate resilient species in wetlands and reservoirs (SDG 13) and to conserve the fish diversity in flood plain wetland and small reservoirs (SDG 15) were being addressed through inland fisheries management. Research on antimicrobial resistance in fisheries and aquaculture and breeding of indigenous fish species of ornamental value were undertaken in network mode. Remediation of phosphate and arsenic polluted water bodies using fabricated nano-structured materials was being attempted for the first time.

The Institute has bred and ranched Indian major carp seeds for ecosystem restoration and fisheries conservation in river Ganga. Emerging pollutants such as microplastics, their impacts on the ecosystem, and fish health have been studied in several resources. Modern modeling tools were applied to predict river ecology and fish catch. Adaptive measures were recommended to reduce the impact of climate change risk. Fish diseases were investigated and emphasis were given on the development of formulations for the mitigation option of arsenic toxicity and control of infectious diseases using cutting edge methodologies. The ecology, fish diversity, and fisheries potential were studied in 7 reservoirs and 7 floodplain wetlands along with the implementation of enclosure culture technologies for fish production enhancement. The Institute demonstrated cage and pen culture technologies in the states of Odisha, Telangana, Bihar, Assam, West Bengal, and Arunachal Pradesh. Keeping in view the market demand, the Institute examined suitability of fish species other than *Pangasianodon hypophthalmus* with the objective of species diversification in cage culture. Cages were also installed in wetlands, addressing the diversified climate-resilient species and *in situ* raising of fingerlings.

The Institute had put thrust on the outreach of its recently commercialized technologies such as CAGEGROW FEED, CIFRI GI CAGE, CIFRI HDPE PEN to make them available at field level for fish production enhancement. Several interactive meetings, workshops, trainings, etc. were organized for the sectoral development. In the socio-economics and statistics areas, resource assessment and predictions under AI and BigData Platform and achieving Sustainable Development Goals (SDGs) through inland fisheries have been undertaken. Through these projects, the Institute would be able to develop newer protocols for sustainable production enhancement and ecosystem health conservation that would push the inland open water fisheries sector to a new height.

I deeply acknowledge the constant support and guidance received from Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR. I am also grateful to Dr. J. K. Jena, Deputy Director General (Fisheries Science); Dr. B.P. Mohanty, Assistant Director General (Inland Fisheries); Dr. Pravin Putra, Assistant Director General (Marine Fisheries); and other staff members of the Fisheries Division of ICAR for their cooperation and help in our endeavours. Guidelines and recommendations given by IRC, learned RAC, IMC, QRT for Institute's development, and streamlining of the Institute's research and activities are also humbly acknowledged.

Dated: **1 April, 2022**
Barrackpore

(B. K. Das)
Director

प्रस्तावना

भारत में पिछले कुछ वर्षों में मछली उत्पादन में उल्लेखनीय वृद्धि दर्ज हुई है। कोविड–19 महामारी के बावजूद देश का मत्स्य उत्पादन 2019–20 में 142 लाख मीट्रिक टन हुआ जिसमें से अंतर्स्थलीय क्षेत्र का योगदान 74 प्रतिशत आँका गया है। अंतर्स्थलीय मछली उत्पादन का लगभग 50 प्रतिशत भाग देश के विशाल अंतर्स्थलीय खुले जल संसाधनों से आता है जिसके अंतर्गत 45,000 किमी नदियाँ, 0.3 मिलियन हेक्टेयर मुहाना क्षेत्र, 0.19 मिलियन हेक्टेयर बैकवाटर और लैगून, 3.524 मिलियन हेक्टेयर जलाशय, 0.354 मिलियन हेक्टेयर बाढ़कृत मैदान तथा आर्द्रभूमि और 0.72 मिलियन हेक्टेयर पर्वतीय झील हैं। ये जल निकाय असंख्य लोगों को आर्थिक और सामाजिक लाभ के अलावा जल, पोषक तत्वों से भरपूर भोजन, परिवहन, आजीविका तथा कई अन्य पारिस्थितिक सेवाएं प्रदान करते हैं। हालांकि, इन बड़े संसाधनों में मछली उत्पादन वृद्धि की पर्याप्त संभावनाएं व्याप्त हैं।

अंतर्स्थलीय खुले जल संसाधन महत्वपूर्ण जर्मप्लाज्म संरक्षण के साथ 1.24 मिलियन अंतर्स्थलीय मछुआरों को रोजगार और आजीविका सहायता प्रदान करते हैं। देश में दूसरी नीली क्रांति के लक्ष्यों को प्राप्त करने के लिए आर्द्रभूमि, झीलों और जलाशयों पर अत्यधिक जोर दिया जा रहा है क्योंकि इन संसाधन क्षेत्रों में मछली उत्पादन वृद्धि की असीम संभावनाएँ हैं। हालांकि, जल की घटती उपलब्धता, प्रदूषण, मत्स्य आवास में ह्रास, प्राकृतिक तौर पर उपलब्ध मत्स्य स्टॉक का अति–दोहन और अन्य समस्याओं के कारण इन संसाधनों को स्थायी मछली उत्पादन के लिए गंभीर चुनौतियों का सामना करना पड़ रहा है। संस्थान इन क्षेत्रों में अनुसंधान, प्रशिक्षण, विस्तार और प्रसार कार्यक्रमों, मानव संसाधन विकास और विकास गतिविधियों, मछुआरों और अन्य हितधारकों के साथ पारस्परिक संवाद तथा पूर्वोत्तर राज्यों में विकास, आदिवासी उप–योजना, अनुसूचित जाति उप–योजना कार्यक्रम के द्वारा संस्थान प्रौद्योगिकियों का प्रदर्शन/कार्यान्वयन हेतु लगातार सचेष्ट है जिससे व्याप्त चुनौतियों को कम करके मछली उत्पादन में वृद्धि की जा सके। संस्थान ने पारिस्थितिकी तंत्र आधारित अनुसंधान और सामुदायिक भागीदारी के माध्यम से अंतर्स्थलीय खुला जल मत्स्य पालन संबधित सूचनाओं के संचयन तथा प्रलेखन में अग्रणी भूमिका निभाई है। रिपोर्ट अवधि के दौरान संस्थान ने 4000 से अधिक मछुआरों, मत्स्य विभाग के अधिकारियों और शोध छात्रों को ऑफलाइन और ऑनलाइन मोड के माध्यम से व्यापक तौर पर प्रशिक्षण प्रदान किया है। साथ ही, मछुआरों में मत्स्य पालन संबंधित विभिन्न पहलुओं पर जागरूकता पैदा कर उनका कौशल विकास किया है और साधनहीन अनुसूचित जाति और आदिवासी मछुआरों में मत्स्य पालन हेतु आवश्यक आदानों का वितरण किया है।

वर्तमान अनुसंधान परियोजनाओं में से अधिकांश गतिविधियां अप्रैल 2020 से कार्यान्वित की गई हैं पर कोविड–19 प्रतिबंधों के कारण फील्ड आधारित अनुसंधान गतिविधियों को समय पर पूरा नही किया जा सका। हुगली–मातलह, रुशिकुल्या, मंडोवी–जुआरी, नेत्रावती–गुरुपुरस्चुअरी और वेम्बानाड की मात्स्यिकी का सामयिक आंकलन किया गया है। मत्स्य पालन के परिपेक्ष्य में कुछ नदियों में बांधों और बैराजों के पारिस्थितिक प्रभावों का आंकलन किया गया है। बराक और ताप्ती नदियों में फिश लैंडिंग और कैच संरचना को दर्ज किया गया। वर्ष 2021 में प्रथम बार देश के संरक्षित और सुदूर क्षेत्रों में प्राथमिकता के आधार पर मत्स्य विविधता और मछली आवास संबंधी विशेषताओं के आंकलन हेतु कार्यारंभ किया गया है। इसके लिए भीतरकनिका राष्ट्रीय उद्यान, जलदापारा राष्ट्रीय उद्यान, पन्ना राष्ट्रीय उद्यान, छोटा नागपुर पठार के प्रमुख जलप्रपात क्षेत्र और कुछ आर्द्रभूमि और जलाशयों को इसके लिए चयनित किया गया है।

मत्स्य पालन के संदर्भ में पारिस्थितिकी परिवर्तनशीलता और गंगा नदी पर यमुना नदी के प्रभावों का आंकलन किया गया। जलाशय और आर्द्रभूमि में घेरे में मछली पालन में मछली प्रजातियों का विविधीकरण किया गया। हीराकुंड, पनम, इडुक्की, कोडर, पूंडी, सेरुली बी, गायत्री, बेको, ऊपरी खगुरिया और सुनेई जलाशयों के पारिस्थितिकी तंत्र के सामयिक–स्थानिक विविधताओं के अध्ययन द्वारा इन जलाशयों के ट्रोफो–डायनामिक मॉडलिंग सहित उत्तम मत्स्य प्रबंधन रणनीतियों को विकसित किया गया। पूर्वोत्तर क्षेत्र, पश्चिम बंगाल, बिहार, उत्तर प्रदेश और मध्य प्रदेश के बाढ़कृत आर्द्रभूमि में मत्स्य पालन बढ़ाने के लिए पारिस्थितिकी–उन्मुख योजनाएँ लागू की गई हैं। भारत के चयनित जलाशयों और आर्द्रभूमि में पेन में मछली पालन के माध्यम से सतत उत्पादन वृद्धि और आजीविका सुधार किया गया।

चयनित जल निकायों में कीटनाशकों, भारी धातुओं और आर्सेनिक संबंधित उभरते हुए प्रदूषकों की निगरानी की जा रही है। पर्यावरणीय तनाव के लिए बायोमार्कर के रूप में मछली एपिडर्मल बलगम की प्रभावकारिता और मछली रोगजनकों के लिए संभावित रोगाणुरोधी सूचक का परीक्षण 'ओमिक्स' प्रौद्योगिकी द्वारा किया जा रहा है। पारिस्थितिक तंत्र स्वास्थ्य संबधित खतरोंध्समस्याओं, रासायनिक संदूषकों के संदर्भ में खाद्य सुरक्षा मूल्यांकन, ओमिक्स के माध्यम से पर्यावरणीय स्वास्थ्य का मूल्यांकन और प्रबंधन किया गया। विभिन्न जैव अणुओं के उपयोग से मछली स्वास्थ्य प्रबंधन किया जा रहा हैं। मात्स्यिकी प्रबंधन के लिए दो बैग्रिड प्रजातियों, मिस्टस कैवासियस और एम. गुलियो स्टॉक का अध्ययन किया जा रहा है। अंतर्स्थलीय खुले जल पारिस्थितिकी तंत्र, विशेषतः मत्स्य संसाधन मूल्यांकन में एकीकृत डेटा–संचालित प्रणाली को सम्मिलित नहीं किया जाता है। इसलिए, बिगडेटा द्वारा इस अंतर को भरने और एक एकीकृत आंकड़ा प्रणाली तैयार किया गया है।

गत वर्षों की तरह इस वर्ष भी पूर्वोत्तर क्षेत्र के विकास पर विशेष बल दिया गया। पूर्वोत्तर क्षेत्र के विकास में निम्नलखित पहलुओं पर कार्य किया गया– मत्स्य पालन प्रबंधन दिशानिर्देशों और प्रौद्योगिकियों में सुधार करना, मात्स्यिकी प्रबंधन दिशानिर्देशों की तकनीकी–आर्थिक व्यवहार्यता का आंकलन करना, घेरे में मछली पालन तकनीक और मत्स्य स्टॉक संवर्धन का मानकीकरण, खुला जल क्षेत्रों में मात्स्यिकी प्रबंधन के लिए मानव संसाधन का विकास आदि। सतत विकास के लक्ष्यों (एसडीजी) में से सात लक्ष्यों जैसे गरीबी उन्मूलन (लक्ष्य 1), शून्य भूखमरी (लक्ष्य) 2), लैंगिक समानता और महिला सशक्तिकरण (लक्ष्य 5), आर्थिक विकास (लक्ष्य 8), सतत खपत और उत्पादन (लक्ष्य 12), आर्द्रभूमि और जलाशयों में जलवायु लचीला प्रजातियों का संवर्धन और उन्हे लोकप्रिय बनाना (लक्ष्य 13) तथा बाढ़कृत आर्द्रभूमि और छोटे जलाशयों में मछली विविधता का संरक्षण (लक्ष्य 15) को अंतर्स्थलीय मत्स्य प्रबंधन के माध्यम से संबोधित किया गया। मत्स्य पालन और जलीय कृषि में रोगाणुरोधी प्रतिरोध और सजावटी मूल्य की स्वदेशी मछली प्रजातियों के प्रजनन अनुसंधान नेटवर्क मोड में किया गया। फैब्रिकेटेड नैनो–संरचित सामग्री द्वारा फॉस्फेट और आर्सेनिक प्रदूषित जल निकायों का रिमेडीएशन पहली बार किया गया है ।

संस्थान ने गंगा नदी में पारिस्थितिकी तंत्र की बहाली और मत्स्य संरक्षण के लिए इंडियन मेजर कार्प के बीजों का प्रजनन और रैंचिंग किया है। जल संसाधनों में माइक्रोप्लास्टिक जैसे उभरते प्रदूषक, पारिस्थितिकी तंत्र पर उनके प्रभाव और मत्स्य स्वास्थ्य का अध्ययन किया गया है। नदी पारिस्थितिकी और मछली पकड़ने के पूर्वानुमान हेतु आधुनिक मॉडलिंग उपकरण तैयार किए गए हैं। जलवायु परिवर्तन संबंधित खतरों के प्रभाव को कम करने हेतु लिए अनुकूलन उपायों को अपनाया गया है। मछली रोगों की जांच की गई है और आर्सेनिक विषाक्तता के निदान के वैकल्पिक और अत्याधुनिक पद्धतियों द्वारा मत्स्य रोगों/संक्रमण के नियंत्रण पर जोर दिया गया। मछली उत्पादन में वृद्धि के लिए घेरे में मछली पालन प्रौद्योगिकी के क्रियान्वयन के साथ 7 जलाशयों और 7 बाढ़कृत मैदानों की पारिस्थितिकी, मछली विविधता और मत्स्य पालन क्षमता का अध्ययन किया गया। संस्थान ने ओडिशा, तेलंगाना, बिहार, असम, पश्चिम बंगाल और अरुणाचल प्रदेश राज्यों में पिंजरे और पेन क्षेत्रों में मछली पालन प्रौद्योगिकियों का प्रदर्शन किया है। मछली की बढ़ती मांग को देखते हुए, संस्थान ने पिंजरे में मछली पालन हेतु मत्स्य प्रजातियों के विविधीकरण के उद्देश्य से *पंगासियानोडोन हाइपोफथाल्मस* के अलावा अन्य मछली प्रजातियों की उपयुक्तता की जांच की है। आर्द्रभूमि में विविध जलवायु–लचीला प्रजातियों और मूल–स्थान पर अंगुलिका पालन के लिए पिंजरों को लगाया गया है।

संस्थान ने मछली उत्पादन बढ़ाने के लिए तथा व्यावसायिक तकनीकों जैसे केजग्रो फीड, सीआईएफआरआई जीआई केज, सीआईएफआरआई एचडीपीई पेन को फील्ड स्तर पर उपलब्ध कराने के लिए इसके विस्तार पर जोर दिया है। क्षेत्र के आधार पर विकास के लिए कई पारस्परिक संवादात्मक बैठकें, कार्यशालाएं, प्रशिक्षण आदि आयोजित किए गए। सामाजिक–आर्थिक और सांख्यिकी क्षेत्रों में आर्टिफिसीयल इन्टेलिजन्स और बिगडाटा प्लेटफॉर्म के तहत संसाधन मूल्यांकन और पूर्वानुमान तथा अंतर्स्थलीय मत्स्य पालन के माध्यम से सतत विकास लक्ष्यों (एसडीजी) को प्राप्त करने पर कार्य किया गया है। इन परियोजनाओं के माध्यम से संस्थान स्थायी तथा सतत मत्स्य उत्पादन वृद्धि और पारिस्थितिकी तंत्र स्वास्थ्य संरक्षण के लिए नए प्रोटोकॉल विकसित करने में सक्षम होगा जो अंतर्स्थलीय खुले जल मत्स्य पालन क्षेत्र को एक नई ऊंचाई पर ले जाएगा।

मैं संस्थान के कार्यों एवं उपलब्धियों के लिये डॉ. टी. महापात्रा, सचिव, कृषि अनुसंधान तथा शिक्षा विभाग और महानिदेशक, भारतीय कृषि अनुसंधान परिषद के निरंतर सहयोग और मार्गदर्शन हेतु अत्यंत आभारी हूं। मैं डॉ. जे. के. जेना, उप महानिदेशक (मत्स्य विज्ञान);

डॉ. बी.पी. मोहंती, सहायक महानिदेशक (अंतर्स्थलीय मात्स्यिकी); डॉ. प्रवीण पुथरा, सहायक महानिदेशक (समुद्री मात्स्यिकी) और भाकृअनुप के मात्स्यिकी प्रभाग के सदस्यों के सहयोग और सहायता के लिए आभारी हूं। मैं संस्थान के विकास के लिए अनुसंधान सलाहकार समिति, संस्थान सलाहकार समिति तथा पंचवार्षिक समीक्षा समिति द्वारा संस्थान के अनुसंधान और गतिविधियों को सुव्यवस्थित करने हेतु दिए गए दिशानिर्देशों और सुझावों के लिए आभार प्रकट करता हूँ। मैं संस्थान के समस्त वैज्ञानिकों, अधिकारियों एवं कर्मचारियों और इस वार्षिक प्रतिवेदन के प्रकाशन टीम के अथक प्रयासों एवं सहयोग हेतु आभार प्रकट करता हूँ।

दिनांकः **1 अप्रैल, 2022**
बैरकपुर

(बि के. दास)
निदेशक

FROM THE DIRECTOR'S DESK

I am happy to inform that the year 2021 blossomed with a positive vibration as the prestigious Sardar Patel Outstanding ICAR Institution Award 2020 (under Large Institute category) was bestowed upon our Institute by the ICAR. With this coveted recognition, we feel even more accountable and committed to the upliftment of fisherman communities and fulfilling our mandated activities. Along with the best Institution award, I was conferred with Rafi Ahmed Kidwai Award 2020 for outstanding research in agricultural sciences under Animal & Fisheries Sciences Category. The Institute has also received Agri-Food Award of Excellence 2021, and Ganesh Shankar Vidyarthi Protsahan Purashkar (for Hindi magazine 'Nilanjali').

In the year 2021, the Institute has taken up programmes and projects to foster the sustainability of inland fisheries, promote culture-based fisheries for augmenting fish production and elevate livelihood of the fishers population. Studies have been conducted for development of ecosystem-management plans for riverine and estuarine fisheries. Developing captive breeding and rearing protocols of Hilsa, *Tenualosa ilisha,* can bring a radical change in the conservation and revival of this valuable species. The ecological impacts of dams and barrages in different rivers with special reference to fisheries have been assessed. For the first time, assessment of habitat quality and fish diversity in protected and less-explored wetlands and reservoirs of different eco-regions

of India have been taken up. The ecology, fish diversity and fisheries potential of reservoirs and floodplain wetlands along with the implementation of enclosure culture technologies for fish production and yield enhancement were studied. In addition, natural resource management to maximize the production potential from the inland aquatic bodies, including diversification of fish species for cage culture are progressing well.

In compliance with Namami Gange Programme, a flagship programme of the Government of India to restore the depleting population of endemic and endangered biodiversity of the river Ganga, ICAR-CIFRI is consistently involved in rejuvenation of the fisheries of river through ranching of indigenous fish species. To enhance/restore Hilsa population wild hilsa seeds/juveniles have been ranched. To restore/enhance carp fishery, wild stocks of IMC have been bred and fingerlings ranched in different depleted stretches of river Ganga.

The Institue has put efforts in developing sensor-based technology to detect pollutants like heavy metals, pesticides, etc. in inland aquatic systems. Gold and silver nanoparticles with different capping agents were synthesized for development of the biosensor. Manganese oxide and cobalt hydroxide nanostructures were also prepared for contaminant detection in open waters. For valorization of agricultural and industrial waste to wealth Black Soldier fly have been utilized in manufacturing low-cost fish feed that would reduce waste problem of the silk industry and help in doubling fishers' income.

The Institute has been working to increase the income of inland fishers through capacity building of the Primary Fisherman Cooperative Societies, Farmers Producer Organizations and Self Help Groups; Nutri-smart villages for nutritional well-being and security; women centric clusters in SIFs and ornamental fisheries; and production enhancement of climate-smart fish species for addressing seven Sustainable Development Goals (SDGs) of the United Nations. The livelihood improvement activities taken up under NEH, SCSP, STC programmes have been successfully conducted in different parts of the country through technology dissemination, input distribution, knowledge and skill upgradation, and other supports. Efforts have been initiated for creating an integrated data repository and discovery system in BigData platform.

the institute is now in the forefront of technology development and Intellectual Property Rights management. In 2021, the trademark "CIFRI ARGCURE" has been registered and the technology has been commercialized. A trademark application has been filed for registration of "CIFRI Fish Tanavhari" technology. During the reporting period, the Institute has published a total of 141 peer reviewed research articles with a total impact factor of 308, beside publication of 7 books, 27 book chapters and a good number of deliberations in different scientific platforms.

Benefit of stakeholders was our prime objective of research. Despite challenges posed by the COVID-19 pandemic, ICAR-CIFRI imparted extensive training to more than 4700 fishers, officials and students in off-line and on-line platforms. The Second Sub-committee of the Parliamentary Committee on Rajbhasha expressed their happiness in the progress made by the Institute. The Institute also warmly welcomed Dr. Sanjeev Kumar Balyan, Hon'ble Minister of State, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, and Shri Srikanta Mahata, Hon'ble Minister of the Department of Micro, Small & Medium Enterprises and Textiles, Government of West Bengal.

We are thankful to Dr. T. Mohapatra, Secretary, DARE & DG, ICAR and Dr. J. K. Jena, DDG (Fisheries Science) for visiting the Institute and inaugurating the Multi-facility Training Complex. Hon'ble DG also inaugurated ICP-MS facility and laid the foundation stone of 2nd floor of the main building of the Institute. The Institute also acquired drone facility for effective samplings in vast inland open waters in coming days.

The Institute organized various events and programs such as national campaign on ecosystem based management for sustainable fisheries; national campaign on system diversification in aquaculture; 75th Platinum Jubilee Foundation Day of ICAR-CIFRI; platinum jubilee lectures; workshop on the business plan for fishery FPC; stakeholders meet for GIZ sponsored project on Pong reservoir; workshop on Hirakud reservoir; workshop-cum-training program on wetland fisheries development; workshop on open water fisheries enhancement of Northeast region of India; swachh Bharat abhiyan, etc. following COVID-19 protocols.

I appreciate the efforts of all the staff in bringing the Institute to the forefront. I also thank all the Heads of the Divisions and Heads of the Centres and Administration and Finance for their inputs to bring out this document on time. The human resource of the Institute is further strengthened with joining of a Scientist, Finance & Accounts Officer and Assistants. I hope that they will contribute wholeheartedly for betterment of the Institute and the fisheries sector. During the period, several staff members were promoted and many of them brought laurels to the Institute. I congratulate all of them.

Dated: **1 April, 2022**
Barrackpore

(B. K. Das)
Director

निदेशक की कलम से

मुझे यह सूचित करते हुए अत्यंत खुशी हो रही है कि वर्ष 2021 एक विशिष्ट वर्ष के रूप में उभर कर आया है क्योंकि हमारे संस्थान को भारतीय कृषि अनुसंधान परिषद के प्रतिष्ठित सरदार पटेल उत्कृष्ट संस्थान पुरस्कार 2020 (वृहद संस्थान श्रेणी के अंतर्गत) प्रदान किया गया। इस प्रतिष्ठित सम्मान के साथ हम मछुआरा समुदाय के विकास और उत्थान की दिशा में अपना उत्तरदायित्व और प्रतिबद्धता और भी अधिक महसूस करते हैं। सर्वश्रेष्ठ संस्थान पुरस्कार के साथ, मुझे पशु और मत्स्य विज्ञान श्रेणी के तहत कृषि विज्ञान में उत्कृष्ट शोध के लिए रफी अहमद किदवई पुरस्कार 2020 से सम्मानित किया गया। उपरोक्त पुरस्कारों के अलावा संस्थान को उत्कृष्ट कृषि–खाद्य पुरस्कार 2021 और इसकी वार्षिक हिंदी पत्रिका 'नीलांजलि' के लिए गणेश शंकर विद्यार्थी प्रोत्साहन पुरस्कार दिया गया है।

वर्ष 2021 में संस्थान ने अंतर्स्थलीय मात्स्यिकी में सतत मत्स्य उत्पादन को बढ़ावा देने, मछली उत्पादन वृद्धि हेतु पालन आधारित मात्स्यिकी तथा मछुआरों की आजीविका उन्नयन के लिए कई कार्यक्रम और परियोजनाएं शुरू की हैं। नदी और ज्वारनदमुख (मुहाना) मात्स्यिकी के लिए पारिस्थितिक तंत्र के प्रबंधन योजनाओं के विकास का अध्ययन किया गया है। हिल्सा प्रजाति, *टेनुआलोसा इलीशा* का घेरे में प्रजनन और पालन प्रोटोकॉल विकसित किया गया है जिससे इस मूल्यवान प्रजाति के संरक्षण और पुनरुद्धार में एक महत्वपूर्ण परिवर्तन आ सकता है। मत्स्य पालन के परिपेक्ष्य में विभिन्न नदियों पर बांधों और बराजों के पारिस्थितिक प्रभावों का आंकलन किया गया है। पहली बार, देश के विभिन्न संरक्षित और सुदूर क्षेत्रों के आर्द्रभूमि और जलाशयों में आवास गुणवत्ता और मछली विविधता का आंकलन किया गया है। मछली उत्पादन और उपज बढ़ाने के लिए घेरे में मछली पालन के साथ–साथ जलाशयों और बाढ़कृत मैदानों की पारिस्थितिकी, मत्स्य विविधता और मत्स्य पालन की संभावनाओं का अध्ययन किया गया। इसके अलावा, संस्थान पिंजरे में मछली पालन हेतु मत्स्य प्रजातियों का विविधीकरण सहित अंतर्स्थलीय जल निकायों से उत्पादन क्षमता को बढ़ाने के लिए प्राकृतिक संसाधन प्रबंधन के लिए प्रयास कर रहा है।

भारत सरकार के एक महत्वपूर्ण कार्यक्रम नमामि गंगे कार्यक्रम के अंतर्गत गंगा नदी की स्थानिक और लुप्तप्राय प्रजातियों के संरक्षण और पुनरुद्धार के लिए संस्थान स्वदेशी मत्स्य प्रजातियों का रैंचिंग करता रहा है। हिल्सा के उपज वृद्धि / पुनरस्थापना हेतु वाइल्ड हिल्सा मछली के बीज/अंगुलिकाओं का पालन किया गया है। कार्प प्रजातियों के संरक्षण और पुनरुद्धार के लिए इंडियन मेजर कार्प के वाइल्ड प्रजातियों का प्रजनन किया गया है तथा गंगा नदी के अलग–अलग हिस्सों में इसके अंगुलिकाओं की रैंचिंग की गई है।

संस्थान ने अंतर्स्थलीय जलक्षेत्र की प्रजातियों में भारी धातुओं, कीटनाशकों आदि जैसे प्रदूषकों का पता लगाने के लिए सेंसर–आधारित तकनीक विकसित किया है। सोने और चांदी के नैनोकण से बने विभिन्न कैपिंग एजेंट को बायोसेंसर के विकास के लिए संश्लेषित किया गया। खुलाजल क्षेत्रों में प्रदूषण जांच के लिए मैंगनीज ऑक्साइड और कोबाल्ट हाइड्रॉक्साइड के द्वारा नैनोस्ट्रक्चर तैयार किए गए। "कचरे से कंचन" वाले सिद्धांत के अनुप्रयोग की दिशा में ब्लैक सोल्जर फ्लाई का उपयोग कम लागत वाली मछली फीड को तैयार करने में किया गया है जो रेशम उद्योग की अपशिष्ट समस्या को कम करेगा और मछुआरों की आय को दोगुना करने में मदद करेगा।

संस्थान संयुक्त राष्ट्र के सात सतत विकास लक्ष्यों (एसडीजी) की पूर्ति की दिशा में किसान उन्मुख संगठन जैसे प्राथमिक मछुआरा सहकारी समिति, किसान उत्पादक संगठन, स्वयं सहायता समूह, पोषण कल्याण और सुरक्षा के लिए न्यूट्री–स्मार्ट गांव, छोटी देशी मछली पालन हेतु महिलाओं का कौशल विकास और आर्थिक–सामाजिक सशक्तिकरण के माध्यम से अंतर्स्थलीय मछुआरों की आय बढ़ाने के लिए काम कर रहा है। संस्थान ने देश के विभिन्न राज्यों में किसानों की आय वृद्धि हेतु विभिन्न विकास कार्यक्रमों जैसे पूर्वोत्तर राज्यों में विकास, अनुसूचित जाति उप–योजना, आदिवासी जाति उप–योजना के अंतर्गत प्रौद्योगिकी हस्तांतरण, आदान वितरण, कौशल और क्षमता विकास तथा अन्य सहायता प्रदान कर रहा है। संस्थान बिगडेटा प्लेटफॉर्म पर एक एकीकृत डेटा रिपोजिटरी और डिस्कवरी सिस्टम तैयार करने के लिए प्रयासरत हैं।

संस्थान अब प्रौद्योगिकी विकास और

बौद्धिक संपदा अधिकार प्रबंधन में उन्नत प्रयास कर रहा है। वर्ष 2021 में ''सिफरी आर्गक्यूर (CIFRI ARGCURE) के प्रौद्योगिकी ट्रेडमार्क को पंजीकृत कर इसका व्यावसायीकरण किया गया है। ''सिफरी फिश तनवरी'' प्रौद्योगिकी के पंजीकरण के लिए एक ट्रेडमार्क आवेदन किया गया है। रिपोर्ट अवधि के दौरान संस्थान ने 308 इम्पैक्ट फैक्टर सहित कुल 141 शोध पत्र, 7 पुस्तक और 27 बुक चौप्टर आदि प्रकाशित किया है। इनमें से 13 शोध पत्र 5 से अधिक इम्पैक्ट फैक्टर वाली पत्रिकाओं में प्रकाशित किए गए थे।

संस्थान का एक प्रमुख उद्देश्य हितधारकों के लाभ के लिए कार्य करना है। इस क्रम में कोविड–19 महामारी के बावजूद संस्थान ने 4700 से अधिक मछुआरों, अधिकारियों और शोध छात्रों को ऑफलाइन और ऑनलाइन प्लेटफॉर्म पर प्रशिक्षण दिया। इसी प्रकार राजभाषा पर संसदीय समिति की दूसरी उप–समिति ने संस्थान के हिन्दी कार्यों की समीक्षा की तथा हिन्दी कार्यों की प्रगति पर संतोष व्यक्त किया। रिपोर्ट अवधि के दौरान संस्थान में मत्स्य पालन, पशुपालन और डेयरी मंत्रालय के माननीय राज्य मंत्री, डॉ संजीव कुमार बालियान और सूक्ष्म, लघु और मध्यम उद्यम तथा कपड़ा विभाग, पश्चिम बंगाल सरकार के माननीय मंत्री श्री श्रीकांत महता का आगमन हुआ।

संस्थान के बहु–सुविधा प्रशिक्षण परिसर का उद्घाटन करने के लिए हम डॉ. टी. महापात्रा, सचिव, कृषि अनुसंधान एवं शिक्षा विभाग और महानिदेशक, भारतीय कृषि अनुसंधान परिषद तथा डॉ. जे.के. जेना, उपमहानिदेशक (मत्स्य विज्ञान) के अत्यंत आभारी हैं। इस अवसर पर माननीय महानिदेशक ने आईसीपी–एमएस सुविधा का भी उद्घाटन किया और संस्थान के मुख्य भवन की दूसरी मंजिल का शिलान्यास रखा। संस्थान ने विशाल अंतर्स्थलीय खुला जलक्षेत्रों से प्रभावी आंकड़ा संग्रहण ड्रोन सुविधा भी विकसित की है।

संस्थान ने सतत मत्स्य पालन के लिए पारिस्थितिकी तंत्र आधारित प्रबंधन पर कई राष्ट्रीय स्तर के कार्यक्रमों का आयोजन किया जिनमें प्रमुख है– जलीय कृषि में प्रणाली विविधीकरण पर राष्ट्रीय अभियान, संस्थान का 75वां प्लेटिनम जुबली स्थापना दिवस, प्लेटिनम जुबली व्याख्यान, मत्स्य पालन से जुड़े एफपीसी के लिए उद्यम योजना पर कार्यशाला, पोंग जलाशय पर जीआईजेड प्रायोजित परियोजना के लिए हितधारकों की बैठक, हीराकुंड जलाशय पर कार्यशाला, आर्द्रभूमि मात्स्यिकी विकास पर कार्यशाला–सह–प्रशिक्षण कार्यक्रम, भारत के पूर्वोत्तर राज्यों के खुलाजल क्षेत्र में मात्स्यिकी संवर्धन पर कार्यशाला, स्वच्छ भारत अभियान आदि। ये समस्त कार्यक्रम कोविड–19 प्रोटोकॉल का पालन करते हुए आयोजित किए गए।

मैं संस्थान के अनुसंधान कार्यक्रमों के सफल कार्यान्वयन तथा इसके गतिविधियों के प्रचार–प्रसार हेतु सभी संस्थान कर्मियों के लगन और अथक प्रयासों की सराहना करता हूं। मैं इस रिपोर्ट के समयानुकूल प्रकाशन के लिए समस्त प्रभागाध्यक्षों, केंद्र प्रमुख, प्रभारी अधिकारियों तथा प्रशासनिक एवं वित्त प्रमुखों को संबंधित सूचनाएँ उपलब्ध कराने के लिए धन्यवाद देता हूं। संस्थान में एक वैज्ञानिक, वित्त व लेखा अधिकारी और सहायक पदों पर नियुक्ति हुई है और मैं यह आशा करता हूँ कि वे संस्थान तथा मात्स्यिकी क्षेत्र के विकास में अपना सम्पूर्ण योगदान देंगे। रिपोर्ट अवधि के दौरान, कई संस्थान सदस्यों को पदोन्नत किया गया और मैं उन सभी को बधाई देता हूं।

बि. के. दास

दिनांक : 1 अप्रैल 2022
बैरकपुर

(बि. के. दास)
निदेशक

ACRONYMS

Abbreviation	Expanded form	Abbreviation	Expanded form
₹	Indian Rupees	mgC	Milligram carbon
µg	Micro gram	mm	Millimetre
µS	Micro Siemens	Mn	Manganese
^{0}C	Degree Celsius	MON	Monsoon
AFDC	Assam Fisheries Development Corporation	MP	Madhya Pradesh
avg.	Average	mS	Specific conductivity
Avl.	Available	MT	Metric Tonnes
BOD	Biochemical Oxygen Demand	N	Nitrogen
C	Carbon	NE	Not Evaluated
$CaCO_3$	Calcium carbonate	nos.	Numbers
CCC	Criterion continuous concentration	nos.	Numbers
Cd, Cr, Cu, Pb, Zn, Fe	Cadmium, chromium, copper, lead, zinc, iron	NP	National Park
CF	Cat Fishes	NT	Near Threatened
Chl-a	Chlorophyll *a*	NT	Near Threatened
cm	Centimetre	NTU	Nephelometric Turbidity Unit
CP	Crude Protein	OC	Organic carbon
CPUE	Catch per Unit Effort	P	Phosphorous
DD	Data Deficient	P_2O_5	Phosphorus pentoxide
DO	Dissolved Oxygen	PCA	Principal Component Analysis
DOM	Dissolved Organic Matter	PER	Protein Efficiency Ratio
EC	Electrical Conductivity	PFCS	Primary Fishermen Cooperative Society
EN	Endangered	pH	
ESBN	Estuarine Set Bag Net	POM	Post Monsoon
FAD	Fish aggregating device	ppt	Parts per thousand
FCE	Feed Conversion Efficiency	PRM	Pre monsoon
FCR	Feed Conversion Ratio	R^2	Coefficient of determination

FRL	Full Reservoir Level	RA	Relative abundance
g/gm	gram	SCSP	Scheduled Caste Sub Plan
GPP	Gross Primary Productivity	SD	Standard Deviation
ha	Hectare	T	Ton
hr	Hour	TDS	Total dissolved Solids
IMC	Indian Major Carps	TSI	Trophic State Index
IUCN	International Union for Conservation of Nature	U	Unit
kg	Kilogram	u/L	Unit/litre
km	Kilometre	UP	Uttar Pradesh
L	Litre	VU	Vulnerable
LC	Least Concern	WBNF	Winter Bagnet Fishery
m	Metre	WMBN	Winter migratory bag net
mg	Milligram	Yr	Year

EXECUTIVE SUMMARY

The Institute executed research activities through 19 Institute funded and Network projects, 17 externally funded research projects and one consultancy project in the year 2021. Despite multiple restrictions imposed due to COVID-19 pandemic, the Institute made significant progress in research and development activities. The livelihood improvement activities under NEH, SCSP, STC programmes were executed in several parts of the country through technology dissemination, input distribution, knowledge and skill upgradation, etc. Salient achievements of the Institute in the year 2021 are summarized below:

Awards

The Institute has been conferred upon the Sardar Patel Outstanding ICAR Institution Award 2020 under Large Institute category by ICAR. The Institute was also bestowed with the Agri-Food Empowering India Awards 2021 as a recognition for excellence in Research & Development in agri-food and its remarkable contribution to the food sector. ICAR-CIFRI Regional Centre, Bengaluru was awarded with the Second prize for excellent implementation of Official Language in office works in the year 2019-20. Dr. B.K. Das, Director, was conferred with Rafi Ahmed Kidwai Award 2020 for outstanding research in agricultural sciences under Animal & Fisheries Sciences category.

Technology management

The Institute registered 2 trademarks, commercialized CIFRI ARGCURE technology and released "CIFRI Fish Tanavhari" for benefits of the fisheries sector.

Riverine and estuarine fisheries

Research was conducted on Ganga, Yamuna, Mahanadi, Krishna, Barak and Kosi rivers, Hooghly-Matlah, Rushikulya, Mandovi-Zuari, Netravathi-Gurupur estuarine and Vembanad estuarine systems and some of the protected habitats with different objectives.

- Matlah estuary recorded significantly higher transparency and salinity regimes as compared to Hooghly estuary (receiving less freshwater discharge) resulting in higher availability of marine fish species such as *Harpodon neherius*, *Coilia dussumieri*, *C. ramcarati*, etc. Pollution study of Hooghly-Matlah estuary detected presence of Cu and Cr in sediment above moderate pollution limits in Hooghly estuary, specifically in Gadakhali to Nischintapur stretch.
- A total of 94 and 136 finfish species were recorded from Hooghly-Matlah estuary during pre-monsoon and monsoon seasons respectively, with highest species diversity at Fraserganj (Bakkhali). Spot-fin porcupine fish, *Diodon hysterix* and Indian frogfish, *Antennarius indicus,* were recorded for the first time from Hooghly-Matlah estuary. Wanton destruction of fish juveniles, especially Sciaenids and mullets, in bag net was severe at Diamond Harbour and Nischintapur.
- Rushikulya, a shallow and short estuary in the East Coast, is important for Olive Ridley turtle (*Lepidochelys olivacea*) breeding ground and milk-fish (*Chanos chanos*) fishery. Salinity of the estuary ranged widely from 5.2 ppt to 34 ppt. High salinity favoured immigration of stenohaline marine species such as *Chaetodon decussatus*. An average fish landing of 85 kg/day was recorded in Rushikulya estuary in August 2021.
- In Mandovi-Zuari estuary, 32 fish species belonging to 19 families including three elasmobranchs and seven shellfish species were recorded.
- No pesticide residue and traces of heavy metals (Cd, Cr, Cu, Fe, Mn, Pb, Zn) were detected in the water and sediment of Netravathi-Gurupur estuary. An estimated 129.7 t and 10.92 t of fishes were landed at various landing centres of the estuary during monsoon and post-monsoon seasons with CPUE of 8.11 kg and 10.9 kg, respectively.
- The Vembanad lake showed 6.93% shrinkage in area with maximum conversion observed in its north-west region (Udayamperoor, Cheppanam and Maradu) and Willington Island. Trophic state index estimates of 60.96 indicated mid-eutrophic status of the estuary. A total of 57 finfish, 7 shrimp, one each of crab,

clam, mussel and cephalopod species were recorded during monsoon season.

- In Barak river, fish landing was dominated by *Sperata seenghala* (32.88 % of the total catch), *Labeo calbasu* (15.78 %), *T. ilisha* (10.52 %), *Mastacembelus armatus* (9.87 %) and *S. aor* (9.21 %). Average CPUE of gillnet for Hilsa fishing was 1.6 kg/boat/day.
- The Brahmani and Baitarani river water in Bhitarkanika was highly turbid with low dissolved oxygen and high BOD. There was significantly high specific conductivity (382 µS/cm) and hardness (192 mg/l) in Hollong river in Jaldapara. The Hundru and Johna waterfalls had high conductivity (169.1-172.8 µS/cm).
- A total of 30 finfish species were recorded from Bhitarkanika National Park with dominance of Perciformes. From Jaldapara National Park area 43 finfish species have been recorded with dominance of Cypriniformes. In Dassam, Hundru, Johna and Panchghagh waterfalls a total of 27 finfish species were recorded with dominance of Cypriniformes.
- Near Threatened (NT) *Arius gagora* was recorded from Bhitarkanika. Vulnerable (VU) *Schizothorax richardsonii* and Endangered (EN) *Tor putitora* were recorded in Jaldapara, and Near Threatened (NT) *Ompok pabo* was recorded from Hundru waterfalls.

Reservoir and wetland fisheries

- Ecosystem characteristics and fisheries of few large, medium and small reservoirs were studied for development of improved fisheries management strategies.
- A total of 41 fish species were recorded in commercial catches from Hirakud reservoir with dominance of catfishes and Indian major carps. CPUE of the reservoir ranged from 1.5-4 kg/day/fisher for gill net and 100-150 kg/day for drag net.
- A total of 18 fish species belonging to 7 order and 10 families were recorded from Panam reservoir. *Sperata seenghala*, *Cirrhinus mrigala*, *Systomus sarana* and *C. reba* formed bulk of the catch from the reservoir.
- In Idukki reservoir, exotics (Common carp and Tilapia) grossly dominated the catch. Stocked fishes such as *Labeo catla* and *Labeo rohita* contributed to the tune of 22% to the fisheries. CPUE ranged from 1.2-10 kg/day/fisher with highest CPUE in monsoon season.
- Water and sediment quality characteristics indicated low to moderate productivity of Kodar reservoir. Cyprinidae constituted 45% of the total fish species in the reservoir. Fishers largely comply with existing mesh size, minimum size regulations as well as state-imposed fishing ban in monsoon. As a result, fishers' earnings immediately after the commencement of fishing season in monsoon were found to exceed ₹900/day.
- Ecological study indicated conducive aquatic environments for culture-based fisheries in the small reservoirs. Muruguma, Gatatri and Kalo reservoirs were in the mesotrophic state and the remaining were in oligotrophic state.
- The stocked Indian major carps contributed around 90% to the total fish catch indicating the positive impact of stocking on fish production in Sunei reservoir. In Gayatri reservoir fish production ranged from 62 - 125 t during 2016-17 to 2020-21.
- Ecology, fisheries and management of 12 wetlands of Assam, West Bengal, Uttar Pradesh and Madhya Pradesh were studied to develop ecosystem based enhancement protocols.
- In Assam, fish yields were 610, 504.7, 335.1 and 1047.2 kg/ha/yr in Lakhanabandha, Rupahi, 46-Morakolong and Dandua wetlands, respectively during 2020-21. Fish species diversity, vulnerability of ecosystems and management protocols including socio-economics of fishers were found to be wetland-specific.
- In wetlands of West Bengal, Uttar Pradesh and Madhya Pradesh water quality parameters were in the favourable ranges for fish production. The productivity indicators like phosphate and specific conductivity indicated that Chara and Daserchara beels are the most productive among the studied wetlands of West Bengal.
- A total of 47 fish species were recorded from the *tals* of Uttar Pradesh while only 22 species were documented from the wetlands of Madhya Pradesh. The wetlands were not scientifically stocked. The fish yield of all these *tals* ranged between 100 and 1500 kg/ha.

IMCs were the most important contributors to the fish catch.

Fisheries Enhancement and Management

- With objective of fish species diversification, growth performances of *Cyprinus carpio* var. *haematopterus* and *Ompok bimaculatus* were evaluated in cages. The early fry (avg. size 0.47 ± 0.05 g) of Amur carp attained 38-45 g size at 100-300 no./m^3 stocking densities in 3 months. Fingerlings of butter catfish (avg. size 8.05±3.27g) grew by 717.67±39.10% at the lowest stocking density of 15 no./m^3 in 6 months.
- Experiment in Assam wetland showed that Amur carp can be stocked at a density of 25 fingerlings/m^3 for table fish production in cages.
- Periphyton based fish production was tested in cages incorporated with bamboo, sugarcane basse, and mosquito net as periphyton substrates. Highest growth of *Systomus sarana* was obtained in cages containing bamboo as periphyton substrate suggesting its potential use in cage culture of *S. sarana*.

Fishery Resource Assessment and Informatics

- An herbal product christened as "CIFRI Fish Tanavhari" has been developed and field tested as a water dispersible unique sedative/ anaesthetic formulation suitable for fish handling and transportation.
- A slow-release oxygen formulation was developed by encapsulating CaO_2 tablets with biopolymer solution with extended O_2 delivery for more than 24 h.
- A water-soluble formulation of a plant extract with fish stupefying property has been developed for fish harvesting or killing weed fishes.
- A natural origin fish immunity enhancer composition comprising of plant origin water soluble polysaccharide as prebiotic, bacterial cell and plant origin edible antioxidant as a feed additive was developed.
- Prebiotic characteristics of dietary *Terminalia arjuna* bark powder-based fish feed was investigated. *In-silico* interaction study of plant compounds belonging to esters and ketones from the aquatic macrophyte, *Cyperus rotundus* with aerolysin was studied which revealed a promising prospect in preventing aermoniasis in fish.
- Pathogenic bacteria like *Aeromonas hydrophila*, *A. caviae* and *Pseudomonas aeruginosa* were found to be associated with TiLV infection in Tilapia suggesting requirement of an integrated health management practice covering both virus and bacteria.
- Fish disease investigation in cage culture system of Madhya Pradesh suggested that *Pangasianodon hypophthalmus* cultured in cages are mostly susceptible to septicaemia caused by *Edwardsiella ictaluri*, and *Klebsiella pneumoniae*.
- Outer membrane proteins (OMPs) of bacterial pathogens of fish having potentials in vaccine development were characterized using 2D and LCMS/MS spectra.
- Vermicompost extract has been used to enhance lipid production from a freshwater microalga, *Graesiella emersonii*, for biodiesel production with better quality.
- Presence of toxic heavy metals and metalloid like Pb, Cd, Cr, As, residues of pesticides like cypermethrin (synthetic pyrethroid) and chlorpyrifos (organophosphate) were detected in biotic and abiotic components of some of the wetlands of West Bengal.
- Presence of heavy metals in the Loktak lake and the associated rivers in Manipur has been detected at concentrations less than the recommended US EPA safe values suggesting overall safe environment of the lake.
- Pattern of arsenic accumulation in different tissues of IMC through chronic exposure study has been investigated. Bioremediation of arsenic using natural substrate was explored and some promising results have been observed.
- With an aim to develop AI and Big Data platform in inland fisheries 194 bulletins of ICAR-CIFRI published were consulted and relevant data, especially on river aquatic environment, were digitized. Further, all the research papers published on river, reservoir and floodplain wetlands in Journal of the Inland Fisheries Society of India during 1990-2020 were scrutinized and data have been extracted. As many as 180 sampling locations of 10 perennial rivers were georeferenced for GIS deployment of data.
- One standalone e-Atlas was developed for the river Krishna, displaying water and sediment

quality information with six layers, viz., digital elevation, India state boundary, river basin, Krishna basin, Krishna river, and sampling station.

- A data-driven Web-GIS application is in process of development. Presently, it includes the river environment and can disseminate various information, such as water quality, sediment quality, physical habitat, etc. of the river ecosystem.
- E-Atlas of the water bodies of the Telangana state has been developed.

Aquatic Environmental Biotechnology and Nanotechnology

- Impact of anthropogenic pressure generated from urban wastewater in sewage canals, wetlands proper and outlet canals of East Kolkata wetlands have been investigated. Although the levels of heavy metals in water and fish were within considerable limits, sediments were heavily polluted with Cd and Zn. A few bacteria have been isolated for remediation of the pollutants.
- Water quality of Borsola beel, situated at heart of the Guwahati city, has been assessed and found to very poor with little dissolved oxygen and high free CO_2 levels. Only a few fish species, majorly air breathing and catfishes, have been recorded from the water body.
- The mitochondrial *Cytochrome b* (*cyt b*) partial gene of *Mystus gulio* and *M. cavasius* has been sequenced. *M. gulio* showed negative allometric growth in Hooghly-Matlah estuary, while *M. cavasius* from Cauveri and Ganga rivers showed a positive allometric growth pattern.

Fisheries Socioeconomics

- The Institute took up research and development activities in small reservoirs and wetlands in West Bengal, Odisha and Jharkhand to address SDGs 1, 2, 5, 8, 12, 13 and 14 of the United Nations. Women empowerment through culture of ornamental fisheries in four clusters in West Bengal and five clusters in Odisha is being carried out by providing training and hand-holding support to 342 rural women beneficiaries belonging to Scheduled Caste and Scheduled Tribe. Successful entrepreneurs have emerged out of such interventions in Chunakoli in Khurda district of Odisha and in Kultali in Sundarbans in West Bengal.
- The Sarana Model (culture of *Puntius sarana* in pens) was developed and demonstrated in the floodplain wetlands of North 24 Parganas district as a self-replenishing livelihood model towards nutritional security and conservation of fish biodiversity with special reference to SIFs.
- Fish production in Beledanga wetland has increased from 24,271 kg in 2019-20 to 32,817 kg in March, 2020-21 with increment in income from the sale of fish from ₹ 23,34,450 to ₹ 29,14,974.

Network projects

- *M. aral* was successfully breed in captivity by injecting synthetic hormone at different doses and baseline for seed production and larval rearing of the species have been established.
- A total of 248 bacterial isolates of *E. coli*, *Aeromonas* spp. and *Staphylococcus* spp. were collected from culture fish farm. Study showed that more than 70% of *Aeromonas* isolates were resistant to ampicillin-sulbactam and more than 95% *Staphylococcus* isolates were penicillin resistant, 60% were oxacillin and cefoxitin resistant.

Externally funded projects

- A total of 139 fish species, including 131 native and 8 exotics, have been recorded from Harshil to Frasergunj stretch of the river Ganga. At Prayagraj total annual IMC landing during 2021 was estimated to be 11.381 with dominance of *Cirrhinus mrigala*. At Patna, IMC contributed only about 6% of total fish landing of 7.41 t. Total fish catch at Barrackpore stretch has been estimated to be 0.29 t with 52.7% contribution from *Tenualosa ilisha*, followed by *Pangasius pangasius* (21%) and *Rita rita* (16%).
- Seasonal assessment of water quality parameters did not show significant difference between upstream and downstream of the Farakka barrage. However, *Tenualosa ilisha* and *Glyptothorax telechitta* were recorded only in downstream of the barrage showing physical hindrance posed by the Farakka barrage on their migration.
- *Tenualosa ilisha* population showed a steep decline in stretches above the Farraka barrage. To increase the fish population, 27173 Hilsa brood fish were ranched in upstream of Farakka barrage.

- To restore/enhance carp fishery, wild caught IMC have been bred and 75 lakhs of spawn was produced which were reared to fingerling sizes and ranched in different depleted stretches of river Ganga. Migration of IMC and Hilsa in river Ganga has been studied through tagging experiment.
- Study in 15 wetlands of West Bengal indicated great reduction in total ecological services of these systems due to climate change and anthropogenic pressure. The maximum Ecological Services Index (ESI) was estimated for Purbastali beel of Bardhaman and Chand beel of Nadia whereas Raja beel of North 24-Parganas district has the lowest ESI.
- Fish production from Vembanad lake declined to the tune of 4.56% which was correlated with decrease in rainfall @ 0.8% per year and increase in temperature @ 0.02% per year. Climate associated variation in species composition study indicated that contribution of penaeid prawns to the fish production has greatly enhanced in 2020 as compared to 1988-1989.
- Study predicted that Gonado Somatic Index (GSI) of male and female *Etroplus suratensis* will be reduced by 38% and 80.2%, respectively with increase in temperature by 3°C, indicating reproductive vulnerability of the species to climatic stress.
- Estimation of carbon contents of sediments up to 30 cm depth showed accumulation of 17.44 Mg C/ha (1Mg=1t) in Raja beel, 15.85 Mg C/ha in Beraberia, and 15.11 Mg C/ha in Tetulia wetland showing wetlands as great carbon sinks.
- Demonstration of Climate Resilient Cage System (CRCS) has been initiated for fish seed raising and table fish production in Media wetland. The indigenous *Labeo bata* and *Systomus sarana* were stocked along with IMCs to enhance fish production, conserve selected indigenous fish species and to increase adaptive capacity of fishers in changing climate scenario.
- A total number of 66 fish species of the Gangetic floodplain wetlands were screened based on their recent abundance and biological characteristics to identify climate smart species. The preliminary assessment indicated fish species like *Anabas testudineus, Channa punctata, Channa striata, Clarias magur, Heteropneustes fossilis, Labeo bata, Mystus cavasius, Pethia ticto, Puntius sophore, Cirrhinus mrigala, Amblypharyngodon mola, Eutropiichthys vacha, Glossogobius giuris* as climate resilient species.
- Several fish pathogenic bacteria and parasites such as *Bacillus cereus*, *Aeromonas veronii*, *A. hydrophila*, *Citrobacter freundii*, *Klebsiella pneumoniae*, *Myxobolus* spp., *Ichthyophthirius multifiliis*, *Thelohanellus* spp., *Henneguya* spp., *Chaetogaster* spp., *Chilodonella* spp. and *Argulus* spp. were identified from the diseased fishes of West Bengal and Assam.
- To assess ecosystem health and functioning, microbial metagenomic study of sediment at three sites of river Ganga at Farakka was done. It showed dominance of bacterial Class Betaproteobacteria, Deltaproteobacteria, Gammaproteobacteria, and Archaea phyla Thaumarchaeota and Crenarchaeota. Genes associated with carbohydrate metabolism were higher than other functional categories.
- A survey conducted in nearly 3000 freshwater cages estimated 14.11% mortality of stocked fishes due to diseases in major cage culture states of India. Fish mortality and expenses on chemicals etc. incurred an average loss of ₹13069/cage/year highlighting an urgent need of controlling fish diseases in cages.
- Safety and pharmacokinetic studies have established safe nature of the antibiotic florfenicol in *Pangasianodon hypophthalmus*. Following in-feed use, 21.58% of the administered antibiotic was bioavailable, which is reasonably good, in the catfish species. Further, for consumer safety only one-day withdrawal time was needed to clear the antibiotic from fish flesh. These suggest prospective use of florfenicol in health management of Pangasius.
- Gold and silver nanoparticles with different capping agents (citrate, and tyrosine) were synthesized and characterized for MRE development of the biosensor. Manganese oxide and cobalt hydroxide nanostructures were also prepared for detection of hazardous materials in open waters.
- In Gobindsagar reservoir majority of the water and soil parameters were in the optimal ranges for fish production. In

last decade (2010-20) bulk of the fish catch in the reservoir was contributed by silver carp, *Hypophthalmichthys molitrix*.

- With the objective of developing captive breeding and rearing protocols of Hilsa a pond rearing facility has been developed and stocked with 239 fingerlings of 22.84 ±1.56 g average size.
- Endocrine disruptive effects of triclosan and cypermethrine have been studied through sub-lethal chronic exposure to *Labeo catla*. Significant changes at both biochemical (catalase, superoxide dismutase, glutathione peroxidase, 17 beta estradiol and 11 ketotestosterone) and molecular level (*GnRH, FSH, Kiss1, Kiss2* and *Vtg*) were detected.
- Two Farmer Field School (FFS) groups have been formed for empowering women of wetland-dependent fisherfolk community around Khalsi beel who are now successfully practicing pen culture of carps, backyard farming of poultry birds, kitchen gardening of vegetables with capacity building and other active support of the Institute.
- Proximate composition analysis of pupa meals of *Antheracea mylitta* and *Bombyx mori* revealed presence of high levels of crude protein and crude lipid, and low contents of chitin and ash. High levels of antinutritional factors like oxalate, alkaloid, and saponin were, however, detected. Feeding trials of feed prepared using pupa meal showed desired growth of *Pangasionodon hypophthalmus* and *Oreochromis niloticus* without any deleterious effect.
- An acetylcholine esterase-based electrode has been prepared and under testing for detection of endocrine disrupting chemicals at trace levels.
- A prototype biosensor has been developed and under field validation for detection of EDCs like organophosphate pesticides from inland open waters.
- A survey showed poor socio-economic status of the households of Bor beel, Arunachal Pradesh. For improved livelihood and income generation, culture of carps was done in improvised pens in Bor beel in participatory mode. Culture of carps was also demonstrated in specially constructed pens using *phumdi* in Takmu pat, Manipur.
- For fisheries development and livelihood improvement of fishers 3210 kg fish seeds were stocked in the Kothia maun and excavated ponds with harvest of more than 5 t of fish in the year 2021. Indian major carps and Amur carp were grown to either fingerling or table sizes in excavated ponds and in cages for income generation.
- A study was carried out in 12 states encompassing fresh and brackish-water aquaculture, and capture fisheries to develop databases on Gross value added (GVA) and input-output ratios that would aid in policy formulation. The input cost was estimated to range from ₹3,929 in reservoir to ₹46,360 in lagoons and backwaters per fishermen per year. The gross value of output by a fisherman per year ranged from ₹1,04064 in wetlands to ₹5,98172 in backwaters and lagoons.
- In brackish water aquaculture sector, a farmer household incurred ₹2.69 lakh/acre/year worth of inputs, with major cost on feed. The cost was highest in Gujarat, followed by Andhra Pradesh and Odisha.

NEH activity

- Fish production enhancement for livelihood improvement through sustainable utilization of different openwater resources of Assam, Meghalaya, Nagaland, Manipur, Tripura were targeted through demonstrations, input supply, capacity building and community participation. Demonstrations of pen culture of IMC in five wetlands of Assam, cage culture of *Osteobrama belangeri* in Takmu pat of Manipur, cage culture of *Cyprinus carpio* in Dumbur reservoir of Tripura, cage culture of carp species in Umiam reservoir of Meghalaya were successfully done for seed raising for wetland stocking or table fish production and for adoption of the technologies by fishers' communities.
- Besides, fish stock enhancement activities were carried out in 11 floodplain wetlands of Assam. A total of 4.29 lakh advance fingerlings of Indian major carps and minor carps were supplied with aim to enhance wetland production.
- Field days, on-site training-cum-awareness programs, workshops were organized at Takmu pat and Mapithel dam in Manipur, Umiam lake of Meghalaya for public awareness and capacity building on enclosure culture technologies.

- A study in 37 wetlands of Assam showed that stocking of IMC and minor carps has resulted in significant increase in mean yield of fish from 234.51 kg/ha/year during 2011-12 to 704.60 kg/ha/year during 2014-15. Fish production per capita also recorded significant increase from 119.40 kg/fisher/year (2011-12) to 358.46 kg/fisher/year (2014-15).
- Ecology and fisheries of Mapithel dam of Manipur, Dumbur reservoir of Tripura and Umiam reservoir of Meghalaya were investigated to know fisheries status and potential of these large resources for fisheries enhancement for livelihood support. The water bodies were found productive and suitable for fisheries. Mapithel dam has present fish production of about 25 t. Long-term average (2001-2020) fish yield rate of Dumbur reservoir is 119 kg/ha/yr. Small indigenous fishes constitute the major fishery in Dumbur; common carp has established in the Umiam reservoir.

STC and SCSP activities

- Different fisheries development activities including four trainings, twelve awareness and sensitization programmes, and distribution of fish seed, feed, chemicals, CIFRI HDPE pens (35 numbers), coracle (30), boats (12) etc. were carried out in West Bengal, Jharkhand, Odisha, Kerala, and Gujarat providing livelihood support to 980 tribal households through fisheries development under STC programme.
- Livelihood and economic upliftment of backward people belonging to Scheduled Castes was ushered through demonstration, training and input distribution in Odisha, West Bengal, Jharkhand and Karnataka. The pen culture technology was demonstrated in 13 wetlands of West Bengal and 2 wetlands of Odisha and one reservoir in Karnataka, one reservoir of Odisha and 7 reservoirs of Jharkhand for enhancing fish production, benefitting 3,430 SC fishers.
- Climate resilient species *Systomus sarana* model and Grass carp model for controlling aquatic macrophytes were demonstrated in wetlands of West Bengal which has helped in ensuring nutritional security of 1150 SC beneficiaries.
- The initiative for the development of five ornamental cluster in West Bengal, two cluster in Odisha and one cluster in Jharkhand has befitted 175 rural SC women for their empowerment and livelihoods support.
- In cyclone affected Sundarbans, 1150 individual SC beneficiary were supported with fish farming inputs for production enhancement form their backyard ponds for household nutritional security and livelihood improvement.

HRD and other activities

- The Institute organized 35 trainings and 42 mass awareness programmes imparting knowledge and skill to more than 4700 participants.
- The Institute organized various important events and programs such as National campaign on Ecosystem based management for sustainable fisheries, National campaign on System diversification in aquaculture, 75th Foundation Day of ICAR-CIFRI, Platinum jubilee lectures, workshop on Business plan for fishery FPC, Stakeholders meet for GIZ project on Pong reservoir, Workshop on Hirakud reservoir, Workshop-cum-training program on Wetland fisheries development, Workshop on Open water fisheries enhancement of Northeast region of India, Multi-location ranching in river Ganga, Swachh Bharat Abhiyan, etc. following COVID-19 protocols.
- Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR inaugurated the Multi-facility Training Complex, ICP-MS facility and laid the foundation stone for 2nd floor of main building of the institute.
- A total of 141 research papers with total Impact Factor of 308 were published by the Institute, beside publication of 7 books, 27 book chapters, etc. Among these, 13 research papers were published in journals having impact factor more than 5.

विशिष्ट सारांश

संस्थान ने वर्ष 2021 में 19 संस्थान द्वारा वित्त पोषित और नेटवर्क परियोजनाओं, 17 बाह्य वित्त पोषित अनुसंधान परियोजनाओं और एक परामर्शी परियोजना पर अनुसंधान कार्य किया है। कोविड–19 महामारी के कारण लगाए गए कई प्रतिबंधों के बावजूद, संस्थान के अनुसंधान और विकास गतिविधियों में महत्वपूर्ण भूमिका रही। संस्थान ने पूर्वोत्तर राज्यों में विकास, आदिवासी उप–योजना, अनुसूचित जाति उप–योजना कार्यक्रम के तहत आजीविका सुधार गतिविधियों के माध्यम से देश के कई हिस्सों में प्रौद्योगिकी प्रसार, इनपुट वितरण, ज्ञान और कौशल उन्नयन आदि के माध्यम से निष्पादित किया है। वर्ष 2021 में संस्थान की मुख्य उपलब्धियों का सारांश नीचे दिया गया है:

पुरस्कार

संस्थान को भारतीय कृषि अनुसंधान परिषद द्वारा बड़े संस्थान श्रेणी के तहत सरदार पटेल उत्कृष्ट आईसीएआर संस्थान पुरस्कार 2020 से सम्मानित किया गया है। संस्थान को कृषि–खाद्य सशक्तिकरण भारत पुरस्कार 2021 में कृषि–खाद्य क्षेत्र में अनुसंधान और विकास में उत्कृष्टता और इसके उल्लेखनीय योगदान के लिए भी सम्मानित किया गया है। वर्ष 2019–20 में नगर राजभाषा कार्यान्वयन समिति (TOLIC), बैंगलोर द्वारा कार्यालय कार्यों में राजभाषा के उत्कृष्ट कार्यान्वयन के लिए संस्थान के क्षेत्रीय केंद्र, बैंगलोर को द्वितीय पुरस्कार से सम्मानित किया गया। संस्थान के निदेशक, डॉ. बि. के. दास को प्राणी और मत्स्य विज्ञान श्रेणी के तहत कृषि विज्ञान में उत्कृष्ट अनुसंधान के लिए रफी अहमद किदवई पुरस्कार 2020 से सम्मानित किया गया।

प्रौद्योगिकी प्रबंधन

रिपोर्ट अवधि के दौरान संस्थान ने 2 ट्रेडमार्क पंजीकृत किया, एक तकनीक, सिफरी आर्गक्यूर का व्यवसायीकरण किया तथा मात्स्यिकी विकास हेतु "सिफरी फिश तनावहरी" जो एक मत्स्य संक्रमण निरोध मिश्रण है, का प्रदर्शन किया।

नदीय और ज्वारनदमुख मात्स्यिकी

इसके अंतर्गत गंगा, यमुना, महानदी, कृष्णा, बराक और कोसी नदियों तथा हुगली–मतलाह, रुशिकुल्या, मंडोवी–जुआरी, नेत्रावती–गुरुपुर और वेम्बनाड मुहाना क्षेत्र एवं कुछ संरक्षित मत्स्य आवास संबंधित पहलुओं पर अनुसंधान किया गया।

- मातलाह ज्वारनदमुख में हुगली ज्वारनदमुख की तुलना में पारदर्शिता तथा लवणीयता का स्तर अधिक पाया गया क्योंकि हुगली ज्वारनदमुख में मीठे जल का प्रवाह कम होता है। इससे हुगली ज्वारनदमुख में समुद्री मत्स्य प्रजातियों जैसे *हारपारडोन नेहेरियस, कोइलियडस सुमेरी, सी. रामकारती* आदि की उपलब्धता अधिक पाई गई। हुगली–मातलाह मुहाना के जल में धातु का स्तर अधिक पाया गया जो हुगली मुहाना, विशेष रूप से गोदाखली से निश्चितपुर खंड में कॉपर और क्रोमियम धातु संदूषण को दर्शाता है।
- पूर्व–मानसून और मानसून के मौसम के दौरान हुगली–मातलह मुहाना से कुल 94 और 136 फिनफिश प्रजातियों को दर्ज किया गया था, जिसमें फ्रेजरगंज (बक्खाली) में उच्चतम प्रजाति विविधता थी। स्पॉट–फिन साही मछली, डायोडोनहिस्टरिक्स और इंडियन फ्रॉगफिश, *एंटेनारियस इंडिकस* को पहली बार हुगली–मातलह मुहाना से दर्ज किया गया था। डायमंड हार्बर और निश्चिंतपुर में बैग नेट द्वारा मत्स्ययन में विशेष रूप से सियानीड और मलेट की किशोर मछलियों की अधिक संख्या में मृत्यु हुई।
- पूर्वी तट में स्थित रुशिकुल्या एक उथला और छोटा मुहाना क्षेत्र है जो ओलिव रिडले कछुओं *(लेपिडोचेली सोलिवेसिया)* के प्रजनन क्षेत्र और मिल्क फिश *(चानोस चानोस)* पालन के लिए महत्वपूर्ण है। मुहाना की लवणता 5.2 पीपीटी से 34 पीपीटी तक पाई गई। लवणता का स्तर अधिक होने से स्टेनोहालाइन समुद्री प्रजातियों जैसे *किटोडोन डीक्यूसैटस* का मुहाना में अधिक अभिगमन हुआ। अगस्त 2021 में रुशिकुल्या मुहाना में औसतन 85 किग्रा/दिन मछली की लैंडिंग दर्ज की गई।
- नेत्रावती–गुरुपुर मुहाना के पानी और तलछट में कोई कीटनाशक अवशेष और भारी धातुओं (कैडमियम, क्रोमियम, कॉपर, आयरन, मैंगनीज, लेड, जिंक) के अवशेष नहीं पाए

गए। इसके नेत्रावती–गुरुपुर मुहाना में विभिन्न लैंडिंग केंद्रों पर अनुमानतः 10.92 टन मछलियों को उतारा गया, जिनका प्रति इकाई मत्स्ययन प्रयास (सीपीयूई) मानसून तिमाही के दौरान 10.9 किलोग्राम आँका गया, जबकि मानसून के दौरान यह सीपीयूई अनुमानित 8.11 किलोग्राम था (कुल मछलियाँ – 129.7 टन)।

- मंडोवी–जुआरी मुहाना क्षेत्र में 19 परिवारों की 32 मत्स्य प्रजातियां दर्ज की गईं जिनमें तीन इलास्मोब्रांच और सात कवच मीन प्रजातियां हैं।
- वेम्बनाड झील के उत्तर–पश्चिम क्षेत्र (उदयमपेरूर, चेप्पनम और मराड़ू) और विलिंगटन द्वीप के कुल क्षेत्र में 6.93 प्रतिशत की कमी देखने को मिला । ट्रॉफिक सूचकांक 60.96 पाया गया जो इस मुहाना की मध्य–यूट्रोफिक स्थिति को बताते हैं । मानसून में कुल 57 फिनफिश, 7 झींगा, 1 केकड़ा, 1 सीपी, 1 मसेल और 1 सेफलोपॉड प्रजातियां दर्ज की गईं।
- जल की गुणवत्ता के मापदंडों के मौसमी आंकलन में फरक्का बैराज के ऊपरी और निचले क्षेत्रों में महत्वपूर्ण अंतर नहीं देखने को मिला। हालांकि, *टेनुआलोसा इलिशा* और *ग्लीप्टोथोरैक्स टेलचिट्टा* केवल बैराज के ऊपरी भाग में दर्ज किए गए जो उनके अभिगमन में फरक्का बैराज के कारण उत्पन्न अवरोध को दर्शाता है।
- बराक नदी में *स्परेराटा सिंघला* (कुल कैच का 32.88 प्रतिशत), *लेबियो कलबासु* (15.78 प्रतिशत), *टी. इलिशा* (10.52 प्रतिशत), *मास्टेसेम्बेलरस आर्मेटस* (9.87 प्रतिशत) और *एस. एओर* (9.21 प्रतिशत) की प्रचुरता देखी गई। हिल्सा मछली पकड़ने के लिए गिलनेट का औसत सीपीयूई 1.6 किग्रा प्रति नाव प्रति दिन था।
- भीतरकणिका में ब्राह्मणी और वैतरणी नदी का जल में घुलित ऑक्सीजन कम और बीओडी का स्तर उच्च होने के कारण इसमें गंदलापान अत्यधिक था। जलदापारा में होलोंग नदी में विशिष्ट चालकता (382 µS/cm) और कठोरता (192 mg/l) उच्च पाई गई । हुंडरू और जोना जलप्रपात में अवशिष्ट प्रदूषण के कारण चालकता (169.1–172.8 µS/cm) उच्च दर्ज की गई ।
- भीतरकनिका राष्ट्रीय उद्यान से 30 फिनफिश प्रजातियों को दर्ज किया गया जिसमें पर्सिफॉर्म प्रजातियों का प्रभुत्व था। जलदापारा राष्ट्रीय उद्यान क्षेत्र से 43 फिनफिश प्रजातियों में साइप्रिनफॉर्मिस प्रजातियों का प्रभुत्व देखा गया है। दशम, हुंडरू, जोना और पंचघाघ जलप्रपातों में साइप्रिनफॉर्मिस के प्रभुत्व के साथ कुल 27 फिनफिश प्रजातियों को दर्ज किया गया था।
- लुप्तप्राय प्रजातियों में भीतरकनिका से *एरियस गगोरा, साइजोथोरैक्स रिचर्डसोनी* और *टोर पुतिटोरा* तथा हुंडरू जलप्रपात से *ओमपोक पाबदा* को दर्ज किया गया ।

जलाशय और आर्द्रभूमि मत्स्य पालन

- उन्नत मात्स्यिकी प्रबंधन रणनीतियों के विकास के लिए कुछ बड़े, मध्यम और छोटे जलाशयों की पारिस्थितिकी तंत्र विशेषताओं और मत्स्य पालन का अध्ययन किया गया।
- हीराकुड जलाशय से कुल 41 मछली प्रजातियों को दर्ज किया गया जिनमें कैटफ़िश और इंडियन मेजर कार्प प्रजातियों की प्रचुरता थी। गिल नेट के लिए जलाशय का प्रति इकाई मत्स्ययन प्रयास (सीपीयूई) 1.5–4 किग्रा प्रति दिन प्रति मछुआरा और ड्रैग नेट के लिए 100–150 किग्रा प्रति दिन था।
- पानम जलाशय से 7 ऑर्डर और 10 फैमिली से कुल 18 मछली प्रजातियों को दर्ज किया गया था, जिनमें *स्पेराटा सिंघाला, सिरहीनस मृगला, सिस्टोमस सराना* और *सी रेबा* प्रमुख थे।
- इडुक्की जलाशय में विदेशी प्रजातियाँ, कॉमन कार्प और तिलपिया की प्रचुरता दर्ज की गई है। स्टॉक की गई मछलियों जैसे *लेबीओ कतला* और *लेबीओ रोहिता* 22 प्रतिशत पाए गए। प्रति इकाई मत्स्ययन प्रयास (सीपीयूई) 1.2–10 किग्रा प्रति दिन प्रति मछुआरा देखा गया। मानसून में सीपीयूई उच्चतम दर्ज किया गया ।
- कोडर जलाशय में जल और तलछट की गुणवत्ता के कारण इसकी उत्पादकता निम्न से मध्यम पाई गई। जलाशय की कुल मछली प्रजातियों में साइप्रिनिडे प्रजातियाँ 45 प्रतिशत थी। यहाँ मछुआरे बड़े पैमाने पर मौजूदा जाल आकार, न्यूनतम आकार संबंधी नियमों के साथ–साथ मानसून में राज्य द्वारा लगाए गए मछली पकड़ने संबंधी प्रतिबंध नियमों का पालन करते हैं। परिणामस्वरूप, मत्स्ययन अवधि में इन मछुआरों की आय रू. 900 प्रति दिन अधिक पाई गई।
- छोटे जलाशयों की पारिस्थितिक पालन आधारित मात्स्यिकी के अनुकूल पाया गया। मुरुगुमा, गटात्री और कालो जलाशय मेसोट्रोफिक

और शेष ऑलिगोट्रोफिक पाए गए।

- स्टॉक की गई इंडियन मेजर कार्प का कुल मछली पकड़ में लगभग 90 प्रतिशत का योगदान देखा गया, जो सुनेई जलाशय में मछली उत्पादन पर स्टॉकिंग के सकारात्मक प्रभाव को दर्शाता है। गायत्री जलाशय में वर्ष 2016–17 से 2020–21 के दौरान मछली उत्पादन 62 – 125 टन के बीच दर्ज किया गया ।
- पारिस्थितिकी तंत्र आधारित उत्पादन वृद्धि प्रोटोकॉल विकसित करने के लिए असम, पश्चिम बंगाल, उत्तर प्रदेश और मध्य प्रदेश की 12 आर्द्रभूमि की पारिस्थितिकी, मत्स्य पालन और प्रबंधन का अध्ययन किया गया।
- असम में, 2020–21 के दौरान लखनबंधा, रूपाही, 46–मोराकोलोंग और डंडुआ आर्द्रभूमि से मत्स्य उत्पादन क्रमशः 610, 504.7, 335. 1 और 1047.2 किग्रा प्रति हेक्टेयर प्रति वर्ष था। मछली प्रजातियों की विविधता, पारिस्थितिक तंत्र की भेद्यता और मछुआरों का सामाजिक–आर्थिक स्तर तथा प्रबंधन प्रोटोकॉल आर्द्रभूमि–विशिष्ट पाए गए।
- पश्चिम बंगाल, उत्तर प्रदेश और मध्य प्रदेश की आर्द्रभूमि में जल गुणवत्ता मानदंड मछली उत्पादन के अनुकूल पाए गए। फॉस्फेट और विशिष्ट चालकता जैसे उत्पादकता सूचक के अनुसार पश्चिम बंगाल के चारा और दसेरचार बील सबसे अधिक उत्पादक आर्द्रभूमि हैं।
- उत्तर प्रदेश के आर्द्रभूमि से कुल 47 मछली प्रजातियों को दर्ज किया गया था, जबकि मध्य प्रदेश के आर्द्रभूमि से केवल 22 प्रजातियों का संकलन किया गया था। इन आर्द्रभूमि में वैज्ञानिक रूप से मछलियों का संचयन स्टॉक नहीं किया गया था। इन सभी आर्द्रभूमि (स्थानीय नाम : ताल) की मत्स्य उपज 100 से 1500 किग्रा प्रति हेक्टेयर के बीच थी। मत्स्य पकड़ में इंडियन मेजर कार्प का महत्वपूर्ण योगदान था।

मात्स्यिकी संवर्धन और प्रबंधन

- मछली प्रजातियों के विविधीकरण के उद्देश्य से पिंजरों में साइप्रिनस कार्पियो की प्रजातियों के विकास प्रदर्शन हेतु *हेमेटोप्टेरस* और *ओम्पोक बिमाकुलैटस* का मूल्यांकन किया गया। अमूर कार्प के छोटे पोना मछलियों (औसत आकार 0.47 ± 0.05 ग्राम) का 3 महीनों में 100–300 मछली प्रति घन मीटर स्टॉकिंग घनत्व पर 38–45 ग्राम वृद्धि देखि गई । बटर कैटफ़िश के अंगुलिकाओं (औसत आकार 8.05 ± 3.27 ग्राम) में 717.67 ± 39. 10 प्रतिशत की वृद्धि हुई, जिन्हे 6 महीनों में 15 मछली प्रति घन मीटर स्टॉकिंग घनत्व पर पाल गया था।
- असम आर्द्रभूमि में परीक्षण में यह देखा गया कि पिंजरों में टेबल फिश उत्पादन के लिए अमूर कार्प को 25 अंगुली प्रति घन मीटर घनत्व पर स्टॉक किया जा सकता है।
- पेरीफाइटन आधारित मछली उत्पादन का परीक्षण बांस, गन्ना अवशिष्ट और मच्छरदानी के साथ पेरिफाइटन सब्सट्रेट के रूप पिंजरों में किया गया था। सिस्टोमस सराना की उच्चतम वृद्धि उन पिंजरों में देखी गई थी जिनमें पेरीफाइटन सब्सट्रेट के रूप में बांस का प्रयोग किया गया था। अतः पिंजरे में *एस. सरना* के पालन में पेरीफाइटन सब्सट्रेट का उपयोग किया जा सकता है।

मत्स्य संसाधन मूल्यांकन और सूचना विज्ञान

- "सीआईएफआरआई फिश थनावरी" नाम का एक हर्बल उत्पाद विकसित किया गया है जिसका उद्देश्य मछलियों के परिवहन में उपयोग किया जाना है। यह जल में घुलित ऐसा उत्पाद है जिसे मछलियों को निश्चेत करने के लिया किया जाता है ।
- कार्बन पेरक्साईट (CaO_2) टैबलेट और बायोपॉलिमर अपमिश्रण का उपयोग करके धीमी गति से विस्तारित होने वाला एक ऑक्सीजन सूत्रीकरण विकसित किया गया है जिसके द्वारा 24 घंटे से अधिक के लिए ऑक्सीजन का उत्सर्जन किया जा सके।
- मछली पकड़ने अथवा खरपतवार जीवों को मारने के लिए जल में घुलनशील पौधे से निर्मित एक अर्क विकसित किया गया है।
- पौधे से निर्मित प्राकृतिक मछली प्रतिरक्षा बढ़ाने वाली एक अपमिश्रण विकसित किया गया है जिसमें जल में घुलनशील पॉलीसेकेराइड को प्रीबायोटिक के रूप में, जीवाण ु कोशिका और पादप आधारित खाद्य को एंटीऑक्सिडेंट के रूप में प्रयोग किया जा सके।
- डायटरी टर्मिनालिया अर्जुन छाल पाउडर आधारित फिश फीड की प्रीबायोटिक विशेषताओं की जांच की गई। जलीय मैक्रोफाइट, साइपरस रोटंडस–सह–एरोलिसिन के एस्टर और केटोन्स से संबंधित पादप यौगिकों के सिलिकोन के साथ पारस्परिक क्रिया का अध्ययन किया गया जिसमें मछली में एरोमोनीसिस संक्रमण को रोका जा सके।
- *एरोमोनास हाइड्रोफिला, ए कैवियाई*

और *स्यूडोमोनास एरुगिनोसा* जैसे रोगजनक बैक्टीरिया को तिलापिया में टीआईएलवी संक्रमण से जुड़ा पाया गया, जिससे मछलियों के एकीकृत स्वास्थ्य प्रबंधन में वायरस और बैक्टीरिया दोनों संक्रमण पर ध्यान दिया जा सके।

- मध्य प्रदेश के पिंजरा पालन में मछली रोग की जांच से पता चला है कि पिंजरों में संवर्धित *पंगासियानोडोन हाइपोथाल्मस* प्रजाति में सेपटिसेमिया संक्रमण जीवों, *एडवरडीसीएला इक्टलुरि* और *क्लेबसिएला निमोनिया* तथा फंफूदी संक्रमण से बहुत अधिक संक्रमित हो जाते हैं।
- टीके के विकास के लिये संबंधित मछलियों के जीवाणु रोगजनकों के बाहरी झिल्ली प्रोटीन (ओएमपी) को 2डी और एलसीएमएस/एमएस स्पेक्ट्रा द्वारा पहचान की गई थी।
- बेहतर गुणवत्ता के साथ बायोडीजल उत्पादन के लिए मीठे पानी के माइक्रोएल्गा, *ग्रेसीलाएमर्सोनि* से लिपिड उत्पादन बढ़ाने के लिए वर्मीकम्पोस्ट के अर्क का उपयोग किया गया है।
- पश्चिम बंगाल के कुछ आर्द्रभूमि के जैविक और अजैविक घटकों में जहरीले भारी धातुओं और मेटलॉइड जैसे लेड, क्रोमिअम ऑक्साइड, साइपरमेथ्रिन (सिंथेटिक पाइरेथ्रॉइड) और क्लोरपाइरीफोस (ऑर्गोफॉस्फेट) जैसे कीटनाशकों के अवशेष पाए गए।
- मणिपुर में लोकतक झील और संबंधित नदियों में भारी धातुओं की उपस्थिति का पता लगाया गया है, जो झील के समग्र सुरक्षित वातावरण हेतु निर्धारित यूएस ईपीए सुरक्षा मानदंडों से कम सांद्रता में है।
- क्रोनिक एक्सपोजर अध्ययन के माध्यम से आईएमसी के विभिन्न ऊतकों में आर्सेनिक संचय की जांच की गई है। प्राकृतिक सब्सट्रेट का उपयोग करके आर्सेनिक के बायोरेमेडिएशन का पता लगाया गया था और इस दिशा में कुछ आशाजनक परिणाम देखे गए हैं।
- अन्तर्स्थलीय मात्स्यिकी में एआई और बिग डेटा प्लेटफॉर्म विकसित करने के उद्देश्य से प्रकाशित आईसीएआर–सीआईएफआरआई के 194 बुलेटिनों के संदर्भ में विशेष रूप से नदी जलीय पर्यावरण पर, डिजिटलीकरण किया गया। इसके अलावा, 1990–2020 के दौरान जर्नल ऑफ द इनलैंड फिशरीज सोसाइटी ऑफ इंडिया में नदी, जलाशय और बाढ़ के मैदान की आर्द्रभूमि पर प्रकाशित सभी शोध पत्रों की जांच की गई और डेटा निकाला गया। जीआईएस परिनियोजन के लिए 10 बारहमासी नदियों के 180 नमूना स्थानों को भू–संदर्भित किया गया था।
- कृष्णा नदी के लिए एकल ई–एटलस विकसित किया गया था, जिसमें छह परतों के साथ पानी और तलछट की गुणवत्ता की जानकारी प्रदर्शित की गई थी– जैसे, डिजिटल एलिवेशन, देश की सभी राज्यों की सीमारेखा, नदी बेसिन, कृष्णा बेसिन, कृष्णा नदी और सैंपलिंग स्टेशन। इसी प्रकार, तेलंगाना राज्य के जल निकायों का ई–एटलस विकसित किया गया है।
- वर्तमान में डेटा–संचालित वेब–जीआईएस अनुप्रयोग पर एक एपलिकेशन विकास प्रक्रिया में है। इसमें नदीय पर्यावरण रखा गया है जिससे नदी पारिस्थितिकी तंत्र की जल गुणवत्ता, तलछट की गुणवत्ता, भौतिक मत्स्य आवास आदि जैसी विभिन्न आंकड़ों को सूचनाबद्ध किया जा सके।

जलीय पर्यावरण जैव प्रौद्योगिकी और नैनो प्रौद्योगिकी

- ईस्ट कोलकाता वेटलैन्ड में शहरी अपशिष्ट के प्रवाह तथा मानवजनित कार्यकलापों से पड़ने वाले हानिकारक प्रभाव की जांच की गई है। हालांकि इसके जल और मछली में भारी धातुओं का स्तर निर्धारित सीमा के भीतर था पर तलछट में कैडमिअम और जिंक का प्रदूषण स्तर अधिक पाया गया। प्रदूषकों को हटाने के लिए के लिए कुछ जीवाणुओं को पृथक किया गया है।
- गुवाहाटी शहर के बीचोबीच स्थित बोरसोलाबील के जल की गुणवत्ता प्रदूषित पाई गई है, जिसमें घुलित ऑक्सीजन कम और उच्च मुक्त कार्बन डाई ऑक्साईड का स्तर उच्च पाया गया हैं। इस जल निकाय में केवल कुछ मछली प्रजातियों, प्रमुखतः वायु श्वासी और कैटफ़िश को दर्ज किया गया है।
- मिस्टस गुलियो और एम. केवसियस प्रजातियों के माइटोकॉन्ड्रियल साइटोक्रोम बी (साइट बी) के आंशिक जीन को अनुक्रमित किया गया है। हुगली–मातलह मुहाना में *एम. गुलियो* की एलॉमेट्रिक वृद्धि नकारात्मक देखी गई जबकि कावेरी और गंगा नदियों के *एम. कैवासियस* की वृद्धि सकारात्मक पाई गई है ।

मत्स्य पालन का सामाजिक आर्थिकी पहलू

- संस्थान ने संयुक्त राष्ट्र द्वारा

निर्धारित सतत विकास लक्ष्यों (एसडीजी), 1, 2, 5, 8, 12, 13 और 14 को संबोधित करने की दिशा में पश्चिम बंगाल, ओडिशा और झारखंड में छोटे जलाशयों और आर्द्रभूमि से स्थायी मछली उत्पादन बढ़ाने के लिए प्रयास कर रहा है। पश्चिम बंगाल और ओडिशा में सजावटी मछली पालन द्वारा महिलाओं का सशक्तिकरण के लिए अनुसूचित जाति और आदिवासी समुदाय के 342 महिलाओं को कौशहल विकास हेतु प्रशिक्षण दिया गया। ओडिशा के खुर्दा जिले के चुनाकोली गाँव और पश्चिम बंगाल के सुंदरबन के कुलतोली गाँव में इस प्रयास से कई महिला उद्यमियों ने सफलतम कार्य किया है।

- सराना मॉडल (पेन में *पुंटियस सराना* का पालन) को छोटी देशी मछली के संदर्भ में पोषण सुरक्षा और मछली जैव विविधता के संरक्षण के लिए उत्तर 24 परगना जिले के बाढ़कृत मैदानों में विकसित और प्रदर्शित किया गया था।
- बेलेडंगा आर्द्रभूमि में मछली उत्पादन 2019–20 में 24,271 किलोग्राम से बढ़कर मार्च, 2020–21 में 32,817 किलोग्राम हो गया है, जिसमें मछली की बिक्री से मछुआरों की आय रुपये 23,34,450 से बढ़कर 29,14,974 रुपये हो गया है।

नेटवर्क प्रोजेक्ट

- *एम. अराल* को सिंथेटिक हार्मोन का इंजेक्शन लगाकर घेरे में सफलतापूर्वक प्रजनन किया गया और प्रजातियों के बीज उत्पादन और लार्वा पालन के लिए आधार रेखा स्थापित की गई है।
- *ई.कोलाई,* एरोमोनास और स्टैफिलोकोकस प्रजातियों के कुल 248 जीवाणु आइसोलेट पालन आधारित मछली फार्म से एकत्र किए गए थे। अध्ययन से पता चला है कि 70 प्रतिशत से अधिक एरोमोनस आइसोलेट्स एम्पीसिलीन–सल्बैक्टम के प्रतिरोधी, 95 प्रतिशत से अधिक स्टैफिलोकोकस आइसोलेट पेनिसिलिन प्रतिरोधी और 60 प्रतिशत ऑक्सासिलिन और सेफॉक्सिटिन प्रतिरोधी थे।

वाह्य वित्त पोषित परियोजनाएँ

- गंगा नदी के हर्षिल से फ्रेजरगंज खंड तक 131 देशी और 8 विदेशी प्रजातियों सहित कुल 139 मछली प्रजातियों को दर्ज किया गया है। प्रयागराज में 2021 के दौरान इंडियन मेजर कार्प की कुल वार्षिक अनुमानित लैंडिंग *(सिरिनस मृगला* की प्रचुरता के साथ) 11.381 टन था। पटना में इंडियन मेजर कार्प का 7.41 टन की कुल मछली लैंडिंग में केवल 6 प्रतिशत का योगदान देखा गया। बैरकपुर खंड में कुल अनुमानित मत्स्ययन 0.29 टन है, जिसमें *टेनुआलोसा इलिशा* 52.7 प्रतिशत पाए गए। इसके बाद *पंगेसियस पंगेसियस* (21 प्रतिशत) और *रीटा रीटा* (16 प्रतिशत) पाए गए।
- फरक्का बैराज के ऊपरी और निचले भाग के जल गुणवत्ता में कोई महत्वपूर्ण अंतर नहीं देखा गया। हांलाकि इस क्षेत्र में *टेनुआलोसा इलीशा* और *ग्लाइप्टोथोरैक्स टेलीचिट्टा* केवल बैराज के निचले भाग में दर्ज किए गए थे, जो फरक्का बैराज के कारण उनके अभिगमन पर उत्पन्न अवरोध को दर्शाता है।
- फरक्का बैराज के ऊपर के हिस्सों में *टेनुआलोसा इलीशा* की संख्या में भारी गिरावट देखी गई। मछलियों की संख्या बढ़ाने के लिए फरक्का बैराज के ऊपरी भाग में 27173 हिल्सा ब्रूड मछलियों की रैंचिंग की गयी ।
- कार्प मत्स्य पालन का पुनरुद्धार/संवर्धन के लिए, इंडियन मेजर कार्प की वाइल्ड प्रजातियों के 75 लाख स्पॉन का उत्पादन किया गया और इनकी अंगुलिकाओं को गंगा नदी के विभिन्न निष्क्रिय भागों में छोड़ा गया है । टैगिंग के माध्यम से नदी में इंडियन मेजर कार्प और हिल्सा के अभिगमन मार्ग और प्रकृति का अध्ययन किया गया है।
- पश्चिम बंगाल के 15 आर्द्रभूमि में अध्ययन में जलवायु परिवर्तन और मानवजनित दबाव के कारण इन जलतंत्रों की कुल पारिस्थितिक सेवाओं में भारी कमी देखने को मिला । अधिकतम पारिस्थितिक सेवा सूचकांक (ईएसआई) बर्धमान के पूरबस्थली बील और नादिया के चांद बील में दर्ज किया गया था, जबकि उत्तर 24–परगना जिले के राजा बील में सबसे कम ईएसआई देखा गया।
- वेमबानाड झील से मछली उत्पादन में 4.56 प्रतिशत की गिरावट दर्ज की गई है जिसका कारण है प्रति वर्ष वर्षापात में 0.8 प्रतिशत की कमी और तापमान में 0.02 प्रतिशत की वृद्धि। मछली उत्पादन का वर्षापात तथा तापमान के प्रतिशत से पारस्परिक संबंध देखने को मिला। प्रजाति संरचना के अध्ययन में जलवायु भिन्नता यह संकेत देते हैं कि मछली उत्पादन में पेनाइड झींगे के उत्पादन में वर्ष 1988–1989 की तुलना में 2020 में अधिक वृद्धि देखने को मिला।
- अनुमानित अध्ययन के अनुसार, एट्रोप्लस सुरटेंसिस के नर और मादा के गोनैडो सोमैटिक इंडेक्स

(जीएसआई) में तापमान में 3 डिग्री सेल्सियस की वृद्धि होने से क्रमशः 38 प्रतिशत और 80.2 प्रतिशत की कमी आ सकती है, जो जलवायु परिवर्तन का प्रजातियों की प्रजनन पर हानिकारक प्रभाव को दर्शाता है।

- राजा बील में 30 सेमी गहराई तक तलछट में अनुमानित कार्बन जमाव 17.44 मिलीग्राम प्रति हे (1 एमजी = 1 टन) पाया गया। इसी प्रकार यह बेराबेरिया में 15.85 मिलीग्राम प्रति हे और टेटुलिया आर्द्रभूमि में 15.11 मिलीग्राम प्रति हे पाया गया।
- मेदिया आद्रभूमि में मछली बीज पालन और टेबल फिश उत्पादन के लिए जलवायु उन्मुख पिंजरा पालन (सीआरसीएस) का प्रदर्शन शुरू किया गया है। मछली उत्पादन बढ़ाने, चयनित स्वदेशी मछली प्रजातियों के संरक्षण और बदलते जलवायु परिदृश्य में मछली पालन को अनुकूलन क्षमता बढ़ाने के लिए स्वदेशी प्रजातियों, *लेबीओ बाटा* और *सिस्टोमस सराना* को इंडियन मेजर कार्प प्रजातियों के साथ स्टॉक किया गया ।
- जलवायु स्मार्ट प्रजातियों की पहचान करने के लिए हाल में बहुतायता और जैविक विशेषताओं के आधार पर गंगा के बाढ़कृत आर्द्रभूमि की कुल 66 मछलियों की प्रजातियों की जांच की गई। प्रारंभिक मूल्यांकन में *एनाबास टेस्टुडीनस, चन्ना पंक्टाटा, चन्ना स्ट्रेटा, क्लेरियस मागुर, हेटेरोपनेस्टेस फॉसिलिस, लेबीओ बाटा, मिस्टस कैवासियस, पेठिया टिक्टो, पुंटियस सोफोर, सिरिनस मृगाला, एंब्लीफेरीनगोडन मोला, यूट्रोपिइचथिस वाचा, ग्लॉसो गोबियस* जैसी मछली प्रजातियों को दर्ज किया गया है।
- पश्चिम बंगाल और असम की रोगग्रस्त मछलियों के परीक्षण में कई मछली रोगजनक बैक्टीरिया और परजीवी जैसे *बैसिलस सेरेस, एरोमोनस वेरोनी, ए. हाइड्रोफिला, सिट्रोबैक्टर फ्यूंडी, क्लेबसिएला न्यूमोनिया, मायक्सोबोलस प्रजातियाँ, इचथियोफ्थिरियस मल्टीफिलिस, थेलोहैनेल* प्रजातियाँ और अर्गुलस प्रजातियाँ की पहचान की गई है।
- पारिस्थितिकी तंत्र के स्वास्थ्य और कार्यप्रणाली का आकलन करने के लिए गंगा नदी के फरक्का के तीन स्थलों पर तलछट में उपस्थित सूक्ष्मजीवी मेटागेनोमिक अध्ययन किया गया। इसने जीवाणु वर्ग बीटाप्रोटोबैक्टीरिया, डेल्टा–प्रोटोबैक्टीरिया, गैमप्रोटोबैक्टीरिया, और आर्किया फ़ाइला थौमारियोटा और क्रैनार्चियोटा की प्रचुरता दर्ज की गई है। कार्बोहाइड्रेट चयापचय से जुड़े जीन अन्य कार्यात्मक श्रेणियों की तुलना में अधिक पाए गए।
- लगभग 3000 मीठा जल क्षेत्रों में स्थापित पिंजरों में किए गए एक सर्वेक्षण में भारत के प्रमुख पिंजरा पालन राज्यों में मछलियों में बिमारी संक्रमण के कारण संचयित मछलियों की 14.11 प्रतिशत की मृत्यु का अनुमान लगाया गया है। मछली मृत्यु दर और रसायनों आदि पर खर्च औसतन रू. 13069 प्रति पिंजरा प्रति वर्ष हुआ। अतः पिंजरों में मछली रोगों को नियंत्रित करने की तत्काल उपाय करने की आवश्यकता है।
- सुरक्षा और फार्माकोकाइनेटिक अध्ययनों के अनुसार *पेंगासियानोडोन हाइपोथाल्मस* में एंटीबायोटिक फ्लोरफेनिकॉल का प्रयोग सुरक्षित देखा गया है। इन एंटीबायोटिक को भोजन में मिल कर दिया गया। प्रयोग किए गए एंटीबायोटिक का 21.58 प्रतिशत जैवरूप में उपलब्ध था, जो कैटफ़िश प्रजातियों के लिए अधिक उपयुक्त है। इसके अलावा, उपभोक्ता सुरक्षा की दृष्टि से उपयुक्त है क्योंकि यह एंटीबायोटिक मछली के शरीर में केवल एक दिन ही रहता है। पंगेसियस के स्वास्थ्य प्रबंधन में फ्लोरफेनिकॉल के संभावित उपयोग सुरक्षित माना गया हैं।
- विभिन्न कैपिंग एजेंट (साइट्रेट और टाइरोसिन) के साथ सोने और चांदी के नैनोकणों को बायोसेंसर के एमआरई विकास के लिए संश्लेषित और चित्रण किया गया। खुले जल क्षेत्रों में हानिकारक पदार्थों का पता लगाने के लिए मैंगनीज ऑक्साइड और कोबाल्ट हाइड्रॉक्साइड के नैनोस्ट्रक्चर भी तैयार किए गए थे।
- गोबिंद सागर जलाशय में अधिकांशतः जल और मिट्टी के प्राचल मछली उत्पादन के लिए इष्टतम और उपयुक्त पाए गए। पिछले दशक (2010–20) में जलाशय के मछली उत्पादन में सिल्वर कार्प, *हाइपोफथाल्मिचथिस मोलिट्रिक्स* की प्रचुरता पाई गई।
- हिल्सा मछली का घेरे में पालन तथा तालाब में रियरिंग सुविधा हेतु पालन प्रोटोकॉल विकसित करने के उद्देश्य से इसकी 239 अंगुलिकाओं (औसत आकार 22. 84 ±1.56 ग्राम) को विकसित और संचयित किया गया है।
- ट्राईक्लोसन और साइपरमेथ्रिन के अंतःस्रावी विघटनकारी प्रभावों का अध्ययन लेबियो कतला के उप–घातक क्रोनिक एक्सपोजर के माध्यम से किया गया है। जैव रासायनिक (केटालेज,

सुपरऑक्साइड डिसम्यूटेज, ग्लूटाथियोन पेरोक्सीडेज, 17 बीटा एस्ट्राडियोल और 11 केटोटेस्टोस्टेरोन) और आणविक स्तर (GnRH, FSH, Kiss1, Kiss2 और Vtg) दोनों में महत्वपूर्ण परिवर्तन पाए गए।

- मछुआरा समुदाय की महिलाओं के सशक्तिकरण के लिए खलसी बील में स्थापित पेन में इंडियन मेजर कार्प प्रजातियों का पालन किया गया। इसके साथ इस आर्द्रभूमि पर निर्भर महिलाओं को निम्नलिखित ये उपार्जन के साधन जैसे घर के पिछवाड़े में पोल्ट्री पक्षियों का पालन, सब्जियों को उगाना, आदान वितरण आपूर्ति और क्षमता विकास गतिविधियों के माध्यम से सामुदायिक भागीदारी मोड में सहायता दी गई। इस प्रयास हेतु दो किसान फील्ड स्कूल (एफएफएस) समूह बनाए गए हैं।
- *एंथेरेसिया माइलिट्टा* और बॉम्बिक्स मोरी के प्यूपा आहार के संरचना विश्लेषण से पता चला इसमें कच्चा प्रोटीन और कच्चे लिपिड के उच्च स्तर और राख का कम उपयोग किया गया है। हालाँकि इसमें, ऑक्सालेट, अल्कलॉइड और सैपोनिन जैसे उच्च स्तर के एंटीन्यूट्रीशनल कारकों की उपस्थिति भी देखी गई था। प्यूपा मील से तैयार किए गए मछली फ़ीड के फीडिंग परीक्षणों के अनुसार इसका कोई हानिकारक प्रभाव *पैंगासियोनोडोन हाइपोफथाल्मस* और ओरियोक्रोमिस निलोटिकस पर देखने को नहीं मिला साथ ही इन प्रजातियों की वृद्धि भी अनुमान के अनुरूप देखा गया।
- एसिटाइलकोलीन एस्टरेज़–आधारित एक इलेक्ट्रोड तैयार किया गया है और ट्रेस स्तर पर अंतःस्रावी विघटनकारी रसायनों का पता लगाने के लिए परीक्षण किया जा रहा है।
- अन्तर्स्थलीय खुले जल में ईडीसी जैसे ऑर्गनोफॉस्फेट कीटनाशकों का पता लगाने के लिए एक प्रोटोटाइप बायोसेंसर विकसित किया गया है और इसका क्षेत्र सत्यापन भी किया गया है।
- अरुणाचल प्रदेश के बोरबील में किए गए एक सर्वेक्षण के अनुसार यहाँ के मछुआरों की सामाजिक–आर्थिक स्थिति अच्छी नहीं है। इनके बेहतर आजीविका और आय सृजन के लिए बोरबीलि सहभागी मोड में उन्नत पेन क्षेत्र में कार्प प्रजातियों का पालन किया गया। मणिपुर के ताकमू पाट में फुमदी का उपयोग करके विशेष रूप से निर्मित पेन क्षेत्र में कार्प प्रजातियों का पालन का भी प्रदर्शन किया गया।
- मत्स्य पालन विकास और मछुआरों की आजीविका में सुधार के लिए वर्ष 2021 में कोठिया मन खुदाई वाले तालाबों में 5 टन से अधिक मछली की फसल के साथ 3210 किलोग्राम मछली के बीज का स्टॉक किया गया था। खुदाई में भारतीय प्रमुख कार्प और अमूर कार्प या तो फिंगरलिंग या टेबल आकार में उगाए गए थे। आय सृजन के लिए तालाबों और पिंजरों में।
- वर्ष 2021 में बिहार मे कोठिया मन में खुदाई वाले तालाबों में 3210 किलोग्राम का स्टॉक किया गया था जिससे 5 टन से अधिक मछली उत्पादन हुआ। साथ ही, मछुआरों की आय में वृद्धि के लिए खुली आर्द्रभूमि में अमूर कार्प का बीज का संचयन और इसकी अंगुलिकाओं का पिंजरे में पालन किया गया।
- ताजा और खारे पानी के जलीय कृषि तथा प्रग्रहण मात्स्यिकी के मूल्यांकन के लिए देश 12 राज्यों में एक अध्ययन किया गया। इस अध्ययन में सकल मूल्य वर्धित (जीवीए) और आगत–निर्गत अनुपात पर डेटाबेस विकसित करने के लिए आंकड़ों को संग्रहीत किया गया जिससे इस क्षेत्र के नीति निर्माण में सहायता होगी। जलाशय में आगत राशि का अनुमानतः रू. 3,929 तथा लैगून और बैकवाटर में प्रति वर्ष प्रति मछुआरों में रू. 46,360 तक आँका गया। आर्द्रभूमि में प्रति मछुआरा द्वारा प्रति वर्ष सकल मूल्य वर्धित रू. 95,385 तथा बैकवाटर और लैगून में रू. 5,51,812 तक पाया गया। कुल मिलाकर सकल मूल्य वर्धित (रुपये प्रति एकड़/वर्ष) रू. 1,04,544 आँका गया है जो केरल में उच्चतम और ओडिशा में सबसे कम पाया गया। कुल मिलाकर, आगत–निर्गत अनुपात 0.51 था।
- खारे जल क्षेत्र में एक मछुआरा परिवार का फ़ीड पर खर्च रू. 3.6 लाख/एकड़/वर्ष मूल्यांकन किया गया। गुजरात में यह लागत सबसे अधिक थी, उसके बाद ओडिशा और आंध्र प्रदेश में देखा गया। कुल मिलाकर, आगत–निर्गत अनुपात 0.61 था। केरल में यह अनुपात 0.40 और गुजरात में 0.68 तक था। खारे पानी में आगत–निर्गत अनुपात प्रग्रहण मात्स्यिकी तुलना में बहुत अधिक है और मीठे पानी के जलीय कृषि क्षेत्र की तुलना में थोड़ा अधिक है।

पूर्वोत्तर राज्यों में कार्य

- असम, मेघालय, नागालैंड, मणिपुर, त्रिपुरा के विभिन्न खुले जल संसाधनों के सतत उपयोग के माध्यम से आजीविका में सुधार

के लिए मछली उत्पादन में वृद्धि को प्रदर्शनों, आगत आपूर्ति, क्षमता निर्माण और सामुदायिक भागीदारी के माध्यम से लक्षित किया गया था। असम की पांच आर्द्रभूमि में इंडियन मेजर कार्प के पेन पालन का प्रदर्शन, मणिपुर के ताकमू पाट में ओस्टियोब्रामा बेलंगेरि का पिंजरे में पालन, त्रिपुरा के डंबूर जलाशय में *साइप्रिनस कार्पियो* का पिंजरे में पालन, मेघालय के उमियम जलाशय में कार्प प्रजातियों का पिंजरे में पालन को आर्द्रभूमि के लिए मत्स्य बीज उत्पादन के लिए सफलतापूर्वक प्रयोग किया गया। मछली का संचयन या टेबल मछली उत्पादन और मछुआरों के समुदायों द्वारा प्रौद्योगिकियों को अपनाने के लिए पहल की गई ।

- इसके अलावा, असम के 11 बाढ़कृत मैदानों में मछली स्टॉक बढ़ाने की गतिविधियाँ की गईं। आर्द्रभूमि उत्पादन को बढ़ाने के उद्देश्य से भारतीय मेजर कार्प और माइनर कार्प की कुल 4.29 लाख बड़ी अंगुलिकाओं को प्रदान किया गया ।
- जन जागरूकता और घेरे में मछली पालन प्रौद्योगिकियों पर क्षमता निर्माण के लिए मणिपुर के ताकमू पाट और मैपिथेल बांध, मेघालय की उमियम झील में फील्ड दिवस, ऑन–साइट प्रशिक्षण–सह–जागरूकता कार्यक्रम, कार्यशालाएं आयोजित की गईं।
- असम की 37 आर्द्रभूमियों में किए गए एक अध्ययन से पता चला है कि इंडियन मेजर कार्प और माइनर कार्प के संचयन के परिणामस्वरूप मछली की औसत उपज 2011–12 के दौरान 234.51 किलोग्राम प्रति हे प्रति वर्ष से बढ़कर 2014–15 के दौरान 704.60 किलोग्राम प्रति हेक्टेयर प्रति वर्ष हो गई। प्रति व्यक्ति मछली उत्पादन भी 119. 40 किग्रा प्रति मछुआरा प्रति वर्ष (2011–12) से 358.46 किग्रा प्रति मछुआरा प्रति वर्ष (2014–15) तक उल्लेखनीय वृद्धि दर्ज की गई।
- आजीविका वृद्धि हेतु मत्स्य पालन बढ़ाने के लिए मत्स्य पालन की स्थिति और इन बड़े संसाधनों की उत्पादन क्षमता आँकलन के लिए मणिपुर के मैपिथेल बांध, त्रिपुरा के डंबूर जलाशय और मेघालय के उमियम जलाशय की पारिस्थितिकी और मत्स्य पालन की जांच की गई। जल निकायों को उत्पादक और मत्स्य पालन के लिए उपयुक्त पाया गया। मैपिथेल बांध में वर्तमान में लगभग 25 टन मछली का उत्पादन होता है। डंबूर जलाशय की लंबी अवधि की औसत (2001–2020) मछली की उपज दर 119 किग्रा प्रति हे. प्रति वर्ष है। डंबूर में मत्स्य पालन में प्रमुख तौर पर छोटी स्वदेशी मछलियाँ की प्रचुरता देखि गई । उमियम जलाशय में कॉमन कार्प का पालन किया जा रहा है।

आदिवासी उप–योजना, अनुसूचित जाति उप–योजना कार्यक्रम की गतिविधियां

- पश्चिम बंगाल में चार प्रशिक्षण, बारह जन जागरूकता और संवेदीकरण कार्यक्रम तथा मछली बीज, चारा, रसायन, 35 सीआईएफआरआई एचडीपीई पेन, 30 कोराक, 12 नाव आदि वितरण सहित विभिन्न मत्स्य विकास गतिविधियां सम्पन्न की गयीं। झारखंड, ओडिशा, केरल और गुजरात के आदिवासी समुदाय विकास कार्यक्रम के तहत 980 आदिवासी परिवारों को आजीविका सहायता प्रदान की गई हैं।
- ओडिशा, पश्चिम बंगाल, झारखंड और कर्नाटक में प्रदर्शन, प्रशिक्षण और आदान वितरण के माध्यम से अनुसूचित जाति के लोगों की आजीविका और आर्थिक विकास के लिए प्रयास किया गया है। मछली उत्पादन बढ़ाने के लिए पश्चिम बंगाल के 13 आर्द्रभूमि और ओडिशा के 2 आर्द्रभूमि और कर्नाटक में एक जलाशय, ओडिशा के एक जलाशय और झारखंड के 7 जलाशयों में पेन में मछली पालन तकनीक का प्रदर्शन किया गया, जिससे अनुसूचित जाति के 3,430 मछुआरे लाभान्वित हुए हैं ।
- जलीय मैक्रोफाइट को नियंत्रित करने के लिए जलवायु अनुकूल प्रजाति, *सिस्टोमस सराना* मॉडल और ग्रास कार्प मॉडल का प्रदर्शन पश्चिम बंगाल की आर्द्रभूमि में किया गया जिससे अनुसूचित जाति के 1150 लाभार्थियों की पोषण सुरक्षा सुनिश्चित करने में मदद मिली है।
- पश्चिम बंगाल में पांच सजावटी मछली पालन स्थल, ओडिशा में दो सजावटी मछली पालन स्थल और झारखंड में एक सजावटी मछली पालन स्थल के विकास पहल से 175 ग्रामीण अनुसूचित जाति के महिलाओं के सशक्तिकरण और आजीविका विकास के लिए पहल किया गया है।
- चक्रवात प्रभावित सुंदरबन में, 1150 अनुसूचित जाति के लाभार्थी को घरेलू पोषण सुरक्षा और आजीविका में सुधार के लिए उनके घर के पिछवाड़े स्थित तालाबों से मछली उत्पादन बढ़ाने के लिए सहायता प्रदान की गई ।

मानव संसाधन विकास और अन्य गतिविधियां

- संस्थान में 4700 से अधिक प्रतिभागियों को ज्ञान और कौशल प्रदान करते हुए 35 प्रशिक्षण और 42 जन जागरूकता कार्यक्रम आयोजित किए गए ।
- संस्थान ने विभिन्न महत्वपूर्ण कार्यक्रमों जैसे स्थायी मत्स्य पालन के लिए पारिस्थितिकी तंत्र आधारित प्रबंधन पर राष्ट्रीय अभियान, जलीय कृषि में प्रणाली विविधीकरण पर राष्ट्रीय अभियान, आईसीएआर–सीआईएफआरआई का 75वां स्थापना दिवस, प्लेटिनम जयंती व्याख्यान, मत्स्य पालन एफपीसी, हितधारकों के लिए व्यवसाय योजना पर कार्यशाला। पोंग जलाशय पर जीआईजेड परियोजना के लिए बैठक, हीराकुंड जलाशय पर कार्यशाला, आर्द्रभूमि मत्स्य विकास पर कार्यशाला–सह–प्रशिक्षण कार्यक्रम, भारत के पूर्वोत्तर क्षेत्र के खुले जल मत्स्य पालन संवर्धन पर कार्यशाला, गंगा नदी में बहु–स्थानीय पशुपालन, स्वच्छ भारत अभियान, आदि। का आयोजन किया । इन सभी कार्यक्रमों का आयोजन कोविड–19 प्रोटोकॉल के साथ किया गया ।
- डॉ. त्रिलोचन महापात्र, सचिव, कृषि अनुसंधान एवं शिक्षा विभाग और महानिदेशक, भाकृअनुप ने बहु–सुविधा प्रशिक्षण परिसर, आईसीपी–एमएस सुविधा का उद्घाटन किया और संस्थान के मुख्य भवन की दूसरी मंजिल की आधारशिला रखी।
- संस्थान द्वारा 308 इम्पैक्ट फैक्टर सहित कुल 141 शोध पत्र प्रकाशित किए गए। साथ ही 7 पुस्तकों, 27 बुक चैप्टर आदि का प्रकाशन किया गया। इनमें से 13 शोध पत्र 5 से अधिक इम्पैक्ट फैक्टर वाली पत्रिकाओं में प्रकाशित किए गए थे।

VISION

Sustainable fisheries from inland open waters for environmental integrity, livelihood and nutritional security

MISSION

Knowledge based management for enhanced fishery, conservation of biodiversity, integrity of ecological services and to derive social benefites from inland open waters

MANDATE

- Basic and strategic research for sustainable management of inland open water resources
- Develop protocols for productivity enhancement in reservoirs and wetlands and aquatic ecosystems health management
- Act as repository of information on inland open water fisheries resources
- Human resource development through training, education and extension

INTRODUCTION

History

As India celebrates the momentous occasion of the 75th year of its independence, ICAR-Central Inland Fisheries Research Institute also reaches the landmark of the 75th year of its establishment. The Institute has followed a growth curve that is parallel to that of the country and has been an essential part of inland fisheries development. Looking back at its glorious 75 years, the Institute was established as Central Inland Fisheries Research Station at Calcutta under the Ministry of Food and Agriculture, Government of India on 17 March 1947 following the recommendation of the sub-committee of Central Government on Agriculture, Forestry and Fisheries. The Station was promoted to Central Inland Fisheries Research Institute in 1959 and shifted to Barrackpore, West Bengal. It was brought under the umbrella of Indian Council of Agricultural Research (ICAR), New Delhi in 1967. During the last seven and half decades, CIFRI has established itself as a pioneer research institute in the field of inland fisheries research in India and abroad. The major responsibilities of the Institute were to assess inland fishery resources and to develop strategies to optimize fish production in sustainable manner.

The plan priorities of Government of India during the late sixties and seventies were on aquaculture research and development. The Planning Commission sanctioned five All-India Coordinated Research Projects, namely, Composite Fish Culture, Riverine Fish Seed Prospecting, Air-breathing Fish Culture, Ecology and Fisheries Management of Reservoirs and Brackishwater Fish Farming during 1971-1973. The Institute, besides several other technologies, developed induced breeding and composite fish culture technologies that ushered blue revolution in the country and laid down the foundation of freshwater aquaculture development.

Since late 1980s, the Institute focused its research on inland open water fisheries of rivers, reservoirs, floodplain wetlands, estuaries, lagoons and backwaters. This resulted in development of fisheries management/development protocols for large, medium and small reservoir and for wetlands, and progressive production enhancement from these large resources. A vast amount of information were generated on ecology and fisheries of nearly all the major river systems, reservoirs, wetlands and lagoons with technologies, protocols and policy recommendations for fisheries management and development in inland open water resources of the country. In recent past, to address the national need, focus of the Institute has been inclined towards Natural Resource Management, sustainable production enhancement and ecosystem health with revision in mandate and for the fulfillment of these objectives the institute has prioritized adaptation of the latest available technologies and also introduction of new ones.

Organizational Structure

To address the mandate, the Institute is organized in the following manner:

Headquarters of the Institute is located at Barrackpore, West Bengal; the Regional Research Centers are located at Prayagraj, Guwahati, Bengaluru, and Vadodara with Research stations at Kochi and Kolkata. In 2020 ICAR has granted two more Divisions in the Institute. The research activities are now taken up through five Research Divisions, viz.,

- Riverine and Estuarine Fisheries Division
- Reservoir and Wetland Fisheries Division
- Fisheries Enhancement and Management Division
- Fisheries Resources Assessment and Informatics Division
- Aquatic Environmental Biotechnology and Nanotechnology Division

Besides these, socio-economic research, extension and training activities are carried out through the 'Economics and Policy Unit' and 'Extension and Training Unit', respectively. The research activities of each division are led by Head of Division appointed by ICAR. While the Regional Research Centers at Allahabad, Guwahati and Bengaluru are administered by Heads of Regional Centers appointed by ICAR, other research centres and stations are administered by Officers-in-Charges. The Institute has

sanctioned cadre strength of 88 Scientists, 81 Technical Officers, 67 Administrative and 65 Supporting personnel.

The Headquarters of the Institute has a number of support services, viz. Administration Section, Audit and Accounts Section, PME Cell, Hindi Cell, AKM Unit, Library and Informatics Section, Institute Technology Management Unit, Stores Section, Vehicle Section, and Nodal Officers for MGMG programme, STC programme, SCSP programme, and HRD executing different functions of the Institute.

The Director leads the Institute and is responsible for overall research, administrative and financial management with guidelines from Institute Management Committee, Institute Research Committee, Research Advisory Committee and Quinquennial Review Team. The Institute is ISO 9001: 2015 certified.


Prayagraj RRC


Bengaluru RRC


Vadodara RRC

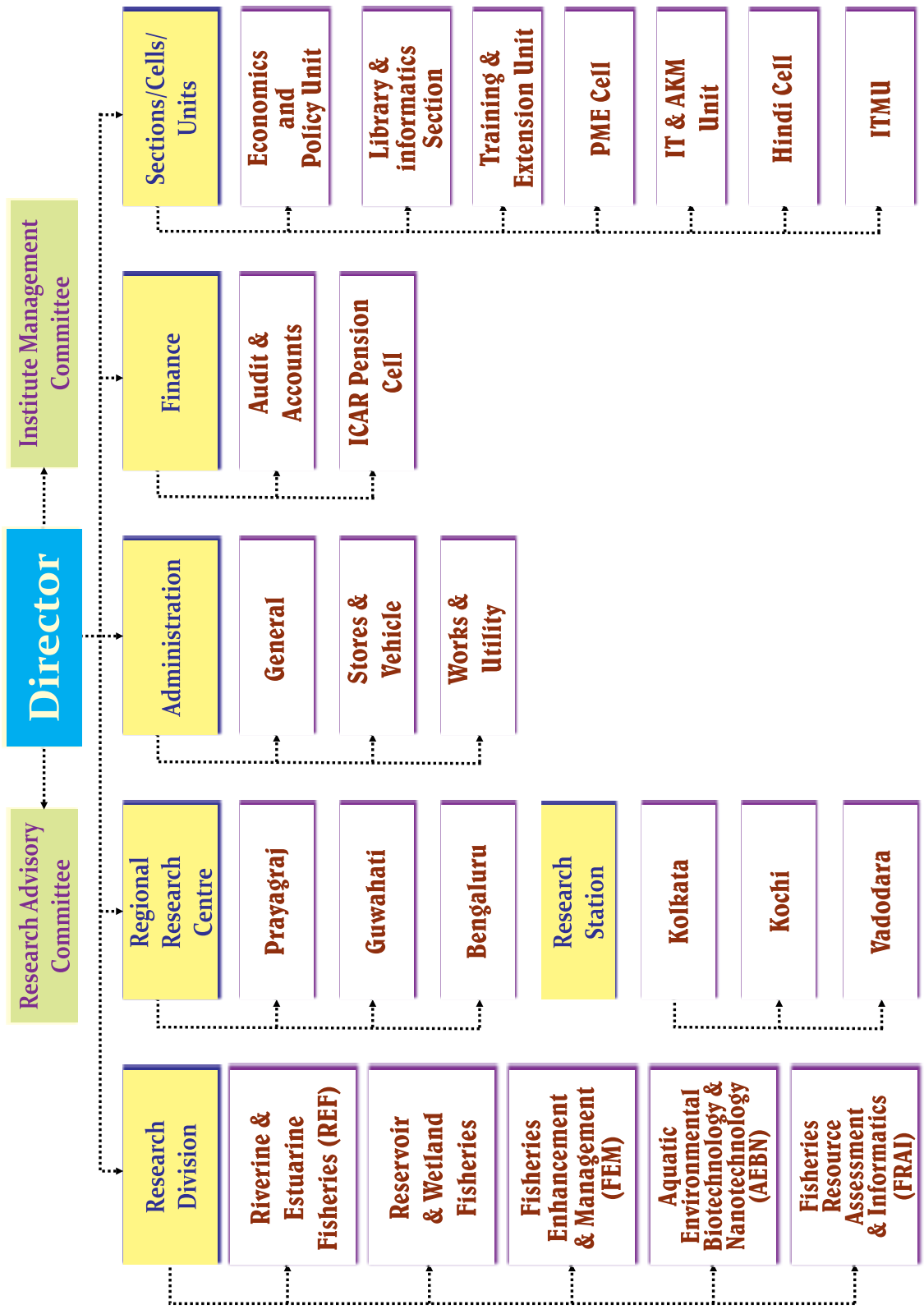

Kochi RS


Guwahati RRC

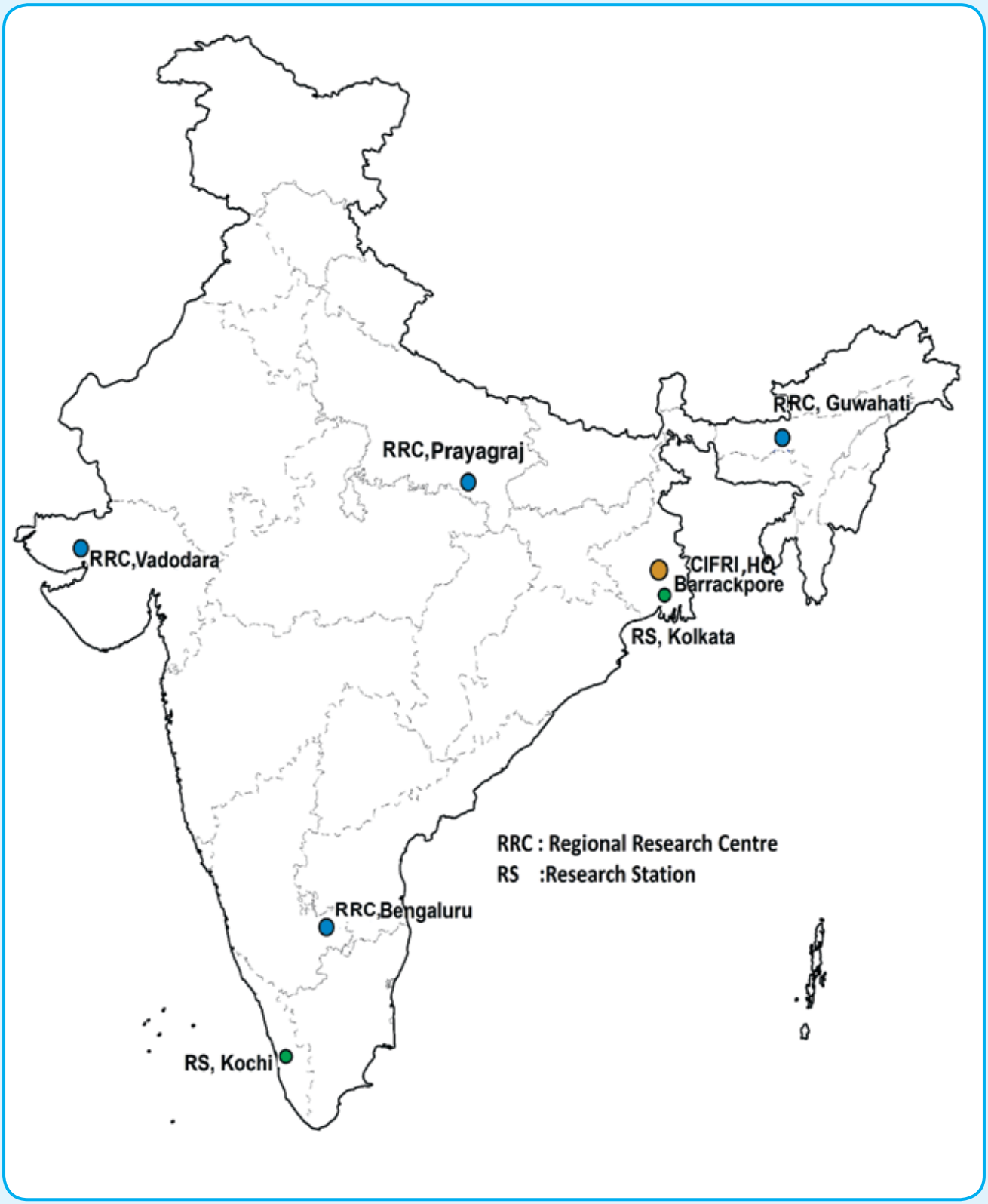

Kolkata RS


Barrackpore HQ

ORGANOGRAM OF ICAR-CIFRI



LOCATION OF ICAR-CIFRI HEADQUARTERS, REGIONAL RESEARCH CENTRES AND RESEARCH STATIONS



BUDGET DETAILS

Budget of the Institute for the year 2021-22 (up to 31.12.2021; ₹ in lakh)

Head of Accounts	Budget (RE)	Expenditure
Pay and Allowance including OTA*	9872.42	8617.72
TA	70.00	16.33
Other charge including Equipment, Library, IT and HRD	1375.00	667.31
Works	30.00	16.98
Grand Total	**11347.42**	**9318.34**

*includes Pension also

The Budget & Expenditure under Institute for the financial year 2021-22 (up to 31.12.2021; ₹ in lakh)

Budget Head	Budget	Expenditure
Revenue		
Estt. Charges	2973.78	2449.81
OTA	0.00	0.00
TA	70.00	16.33
Other charges	675.00	392.36
Office Building	35.00	19.98
Residential Building	25.00	1.37
Minor Works	20.00	8.42
Misc. Expenses including HRD	55.00	12.34
TSP General	45.00	39.45
NEH General	100.00	40.15
Capital		
Equipment	150.00	7.68
Information Technology	30.00	19.05
Library Books	5.00	2.23
Vessels / Vehicles	0.00	0.00
Furniture & Fixture	25.00	0.25
Works	0.00	0.00
Minor Works	30.00	16.98
TSP Capital	25.00	13.66
NEH Capital	50.00	6.65
SCSP Capital	30.00	15.80
SCSP General	105.00	87.92
Total	**4448.78**	**3150.43**
Pension	6898.64	6167.91

Budget Head	Budget	Expenditure
Grand Total	**11347.42**	**9318.34**
Loans & Advances	**36.84**	**10.00**

Other Projects 2021-22 (up to 31.12.2021; ₹ in lakh)

Budget Head	Receipts including opening balance	Expenditure	Refund
NICRA	56.50	27.18	9.89
CABIN	13.50	7.23	0.00
NASF	91.03	33.43	0.00
ITMU	6.00	3.58	0.00
SIF-EXMU	0.00	0.00	0.00
Fish Health	21.00	11.80	0.99
Deposit Schemes (Externally funded)	127.18	166.63	35.32
Consultancies	6.47	66.56	0.00

Revenue Receipts 2021-22 (up to 31.12.2021; ₹ in lakh)

Head	ICAR	Institute
Income from Sales / Services	7.12	
Fee / Subscription	0.00	
Income from Royalty, Publication etc.	0.00	
Other income	27.18	46.05
STD Interest	0.00	
Sale of Assets	0.00	
Recoveries on Loans and Advances	10.65	
CPWD / Grants Refund	0.00	
Total	**44.95**	**46.05**

ONGOING PROJECTS

Institute projects including network projects

S. No.	Project Code & Title	P.I.
1	REF/20-23/11: Temporal assessment of estuarine fisheries resources for sustainable management (Hooghly – Matla, Rushikulya, Mandovi – Zuari, Netravathi – Gurupur and Vembanad lake)	S. Samanta
2	REF/20-23/12: Assessment of ecological impacts of dams and barrages in selected rivers with special references to fisheries	A.K. Sahoo
3	REF/20-23/13: Estimation of fish landings and catch structure in the Rivers Mahanadi, Krishna, Barak, Tapti and Kosi	Roshith C.M.
4	REF/20-23/14: Exploration and assessment of fisheries in protected inland water bodies	R.K. Manna
5	REF/20-23/15: Eco-variability and impact study of River Yamuna on River Ganga with special emphasis on fisheries	D.N. Jha
6	REF/20-23/16: Assessment of environment variability, nutrient fluxes and biotic community interactions of a few mangrove stands of Indian mangrove eco-region	S. Dam Roy
7	RWF/17-20/09: Diversification of fish species for enclosure culture in reservoir and wetlands	B.K. Das
8	RWF/20-23/10: Understanding spatio-temporal variations of reservoir ecosystem and developing improved fisheries management strategies for different eco-regions: A new perspective	U.K. Sarkar
9	RWF/20-23/11: Eco-orientation approach for fisheries enhancement of floodplain wetlands in diverse eco-regions of India	A.K. Das
10	RWF/21-24/12: Sustainable production enhancement and livelihood improvement through technological intervention (pen culture) in selected reservoirs and wetlands of India	M.A. Hassan
11	FREM/17-20/14: Fish health management in inland open waters	B.K. Das
12	FREM/20-23/16: Ecosystem health risks and food safety assessment in relation to chemical contaminants in inland aquatic environment	S.K. Nag
13	FREM/20-23/17: Evaluation and management of environmental health through omics technologies	B.K. Behera
14	FREM/20-23/18: Fisheries resource assessment and predictions in inland open-water under AI and BigData platform	M. Naskar
15	FREM/21-24/19: Development of ammonium and phosphate remediation techniques using nanostructured materials for refurbishment of polluted wetlands	D.J. Sarkar
16	FSE/20-23/04: Sustainable inland fisheries development pathways to ensure Sustainable Development Goals	B.K. Das
17	NEH/20-23/03: Refinement of management strategies for openwater fisheries of Northeastern Region through location and ecosystem-based approaches	B.K. Bhattacharjya
18	Network Project: Antimicrobial resistance (AMR) in fisheries and aquaculture	A.K. Sahoo
19	Network Project: Breeding of indigenous fish species of ornamental value from West Bengal and Assam	U.K. Sarkar

Externally Funded Projects

S. No.	Project Title	Funded by
1	Fish stock enhancement including Hilsa and livelihood improvement to sustainable fisheries and conservation in river Ganga under Namami Gange Programme.	NMCG
2	Impact of climate change in inland fisheries and development of adaptation strategic Research component of National Innovation in Climate resilient Agriculture.	NICRA
3	National surveillance programme for aquatic animal diseases	NFDB-NSPAAD
4	Microbiome meta transcriptomics assessment of Indian river basins for ecosystem health monitoring.	ICAR-IASRI
5	All India Network Project on Fish Health	ICAR-CIBA
6	Development of Biosensor for detection of fish pathogenic bacteria and hazardous metalloids in selected waterbodies.	ICAR-NASF
7	Capture Breeding of Hilsa, *Tenualosa ilisha*	ICAR-NASF
8	Environmental and aquaculture animal health monitoring in Hirakund Reservoir under cage culture programme	Directorate of Fisheries, Govt. of Odisha
9	Collaborative research project with WorldFish Centre under Window-3 Program	ICAR-WorldFish
10	Assessment of endocrine disruption in fish production.	DBT
11	Empowering women of wetland dependent fisher flock community of lower Gangetic plain through cost effective technologies.	DBT
12	Utilization and diversification of silkworm pupae products for human & animal consumption and composting	Central Silk Board
13	Investigation on fisheries and ecological status threats and remedial measures for enhancement of fish production in Govind Sagar Reservoir.	Govt. of Himachal Pradesh
14	Mean: Measuring EDCs and aquatic diagnostics through biosensor networks with special reference to NE India	Ministry of Electronics and Information Technology, Govt. of India.
15	Up-scaling of climate-friendly pen aquaculture technology for improved livelihood, employment generation and enhanced income of wetland fishers of North-eastern India	National Mission on Himalayan Studies, Ministry of Environment, Forest and Climate Change, Govt. of India.
16	Fisheries development in Kothia *maun* of Bihar - a pilot project	NFDB, Hyderabad
17	A study on input cost and farm gate prices in inland fisheries of India	Ministry of Statistics and Programme Implementation, Govt. of India

Consultancy Project

S. No.	Project Title	Funded by
1.	Assessment and Impact study on biodiversity, eco-hydrology, fish population dynamics and livelihood of fishers in Narmada River with special focus on downstream of Sardar Sarovar Dam and Bhadbhut Reservoir	Govt. of Gujarat, Narmada Water Resources, Water Supply and Kalpasar Department

Title of the project: Temporal assessment of estuarine fisheries resources for sustainable management

Sub-project 1: Temporal assessment of Hooghly-Matla estuarine fisheries resources for sustainable management

Sub Project 2: Assessment of ecohydrological dynamics in relation to fish fauna and their recruitment towards development of sustainable management strategies in Rushikulya estuary

Sub-project 3: Temporal assessment of the Mandovi-Zuari estuarine fishery resources for sustainable management

Sub-Project 4: Temporal assessment of Netravathi-Gurupur estuarine fishery resources for sustainable management

Sub-project 5: Temporal assessment of Vembanad estuarine fisheries resources for sustainable management

Project Code: REF /20-23/11

Duration: April 2020 to March 2023

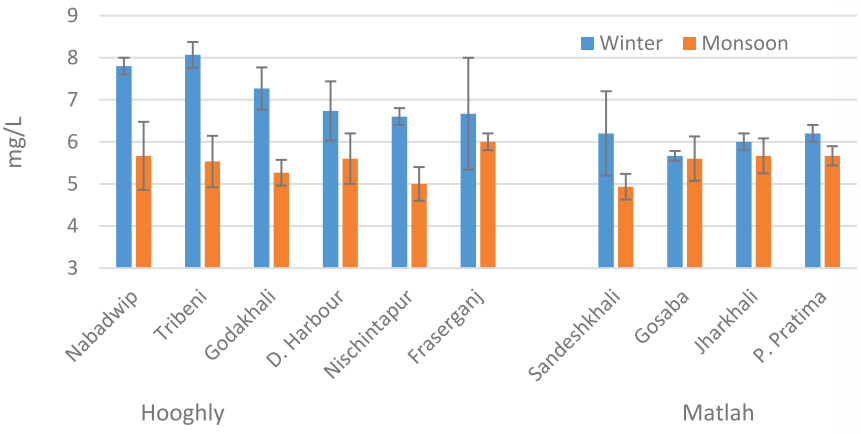
Project Personnel: S. Samanta (P.I.), D. Bhakta (Sub-Project 1 Leader), R.K. Manna, S.M. Nair, S.K. Das (Sub-Project 2 Leader), Roshith, C.M., K. Lohith Kumar, S.P. Kamble (Sub-Project 3 Leader), W.A. Meetei, Vaisakh G., M. Feroz Khan (Sub-Project 4 Leader), A. Saha, Sibina Mol S., T.T. Paul (Sub-Project 5 Leader), D. Sudheesan

Sub-project 1: Temporal assessment of Hooghly-Matla estuarine fisheries resources for sustainable management

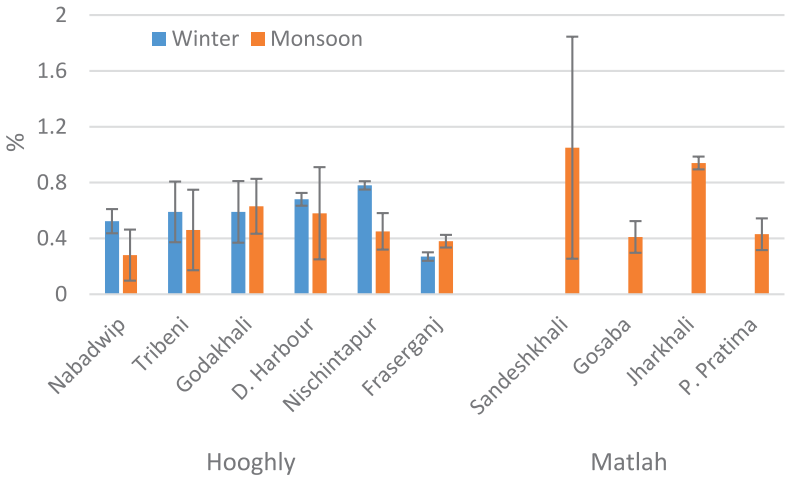
Water quality of the Hooghly-Matla estuary

Ecosystem characteristics and biota including fish and fisheries were studied in the Hooghly-Matla estuary. Water was more transparent in Matla estuary as compared to Hooghly estuary due to less riverine discharge. At Jharkhali, water was highly transparent (even during monsoon) with Secchi depth ranged between 95 and 127 cm. Water pH was more than 7.9 at all the stations in Hooghly-Matla estuary with higher pH during winter. In Matla estuary, there was a steady increase of pH from upper to lower estuary during monsoon and winter seasons. Lower pH at Sandeshkhali might be attributed to the impact of pollution from Kolkata city sewage and wastewater discharge from nearby wetlands (*bheri*). Dissolved oxygen was higher during winter as compared to monsoon at all the stations both in Hooghly and Matla estuary. The lowest oxygen (4.9 ± 0.3 mg/l) was recorded at Sandeshkhali during monsoon indicating impact of pollution due to discharge of Kolkata city sewage at upstream.

Low specific conductivity in stations of Hooghly estuary indicated impact of riverine freshwater discharge which is lacking in Matla estuary where higher values were recorded due to seawater intrusion during high tide. Congenial total alkalinity (~100 mg/l) was recorded at all the stations with significantly higher values in upper and middle Hooghly estuary during winter. Seasonal variation of total alkalinity was less in Matla estuary. Salinity was low in stations of Hooghly estuary except at Fraserganj, the lowermost station situated in estuary mouth. Higher salinity existed in stations of Matla estuary in both the seasons indicating lack of freshwater discharge from upstream. Higher salinity regime supported the dominance of marine species like *Harpodon neherius* at all the stations in Matla river system.



Dissolved oxygen in Hooghly-Matla estuary



Soil organic C (%) in Hooghly-Matla estuary

Sediment characteristics

Soil pH was alkaline at all the stations of Hooghly and Matla estuaries. In Hooghly estuary decreasing trend of soil pH from upper to lower estuary was recorded during winter. In Matla estuary, lower soil pH at Sandeshkhali was likely due to regular pollution from Kolkata city in upper Sundarbans. In Matla system, higher soil organic carbon (1.05 ± 0.8 %) at Sandeshkhali was attributed to pollution load from upstream, whereas at Jharkhali, it might be contributed by litter falls from dense mangrove forest in the area.

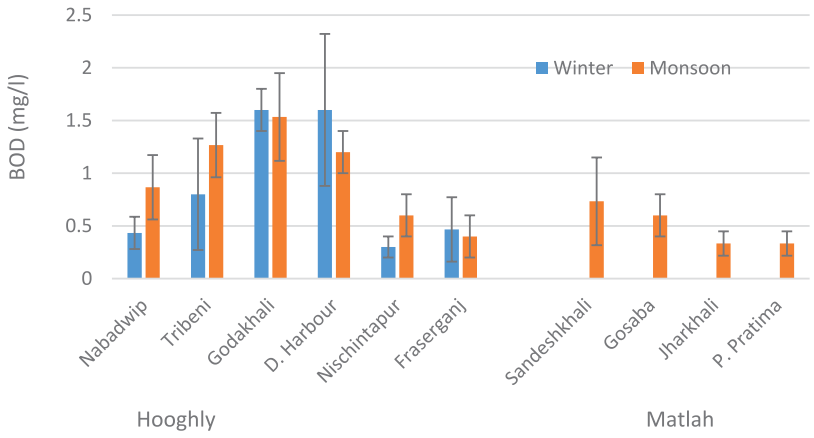
Bottom sediment had dominance of sand with higher content at Fraserganj, the estuary mouth. Slightly lower sand content was recorded in Hooghly estuary as compared to Matla estuary.

Pollution status

High BOD, an indicator of organic pollution, was observed near city stretch especially at Godakhali in Hooghly estuary. In Matla estuary, higher BOD was recorded in Sandeshkhali due to discharge of Kolkata city sewage in upstream. Decreasing trend of BOD was noticed from upper to lower stretch in Matla estuary.

Heavy pollution in the form of macroplastic materials was recorded both in Hooghly and Matla estuaries. Heavy load of plastic garbage was observed in bag net catch, more in city stretch (Godakhali) in Hooghly estuary and Sandeshkhali in Matla estuary.

Studies on heavy metals viz., Cd, Cr, Cu, Pb, Zn in water of Hooghly-Matla estuary indicated that the Hooghly estuary is having more of the metal contaminants and specifically from Gadakhali to Nischintapur stretch. The average Cu concentration variation was 14.3-24.0 µg/l; Zn 28.3-28.6µg/l (Fresh water CCC 120 µg/l, Saline water CCC 81 µg/l); Cd 0.53-1.55 µg/l (Fresh water CCC 0.72 µg/l, Saline water CCC 7.9 µg/l); Pb 2.8-24.3 µg/l (Fresh water CCC 2.5 µg/l, Saline water CCC 8.1 µg/l); the impact was recorded due to the effluents from Kolkata city agglomerations. Although some of the samples in upper estuary were found contaminated with Cu (8.3 µg/l at Nabadwip) or Cr (8.5-15.7 µg/l at Nabadwip to Tribeni stretch), the levels were not very high. Cr was detected above moderate pollution limit in 9 out of 10 sampling sites and Cu was also above moderate pollution limit in 5 out of 10 sampling sites. All the sampling sites of Hooghly estuary had relatively higher content of Cu, categorized as moderate level of contamination. In Matla estuary Dhamakhali area was contaminated with Cu. Rest of the studied metals were below the moderate pollution limits and were environmentally safe. In general, the content of Cr, Cu and Zn were recorded more in the Hooghly estuary. Cd content was recorded more in the upper part of Hooghly estuary. The sediment metal



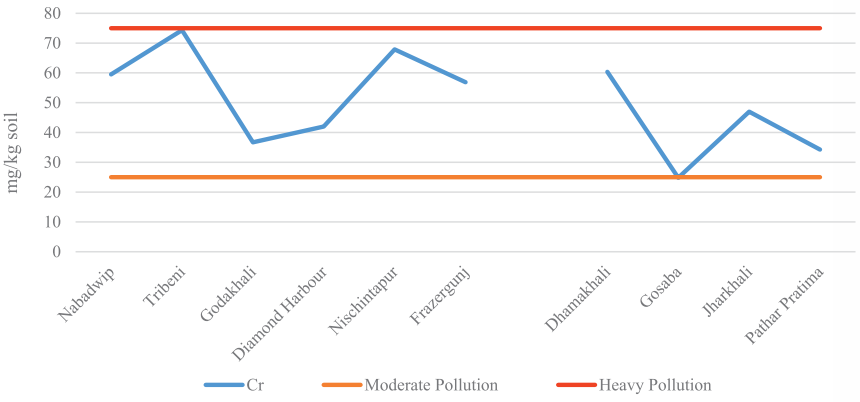
BOD (mg/l) in Hooghly-Matla estuary

Difficulties in fish sorting from bag net catch caused by macroplastics (Sandeshkhali)

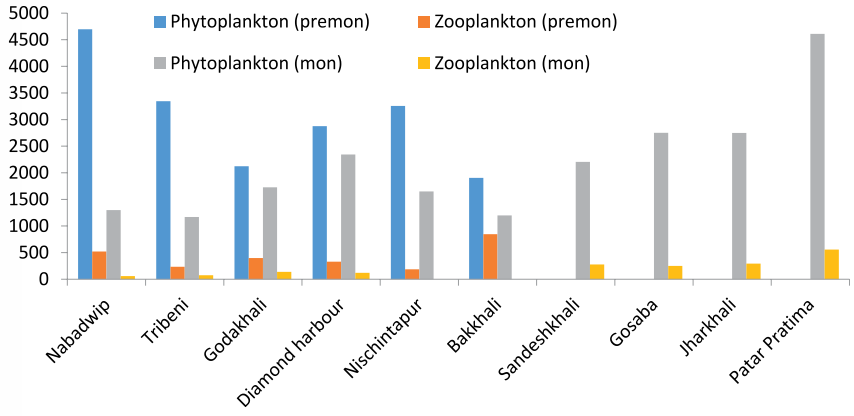
contamination trend was like those of 2020 and Matla estuary is having much fewer metal contaminations.

Plankton and periphyton assemblage

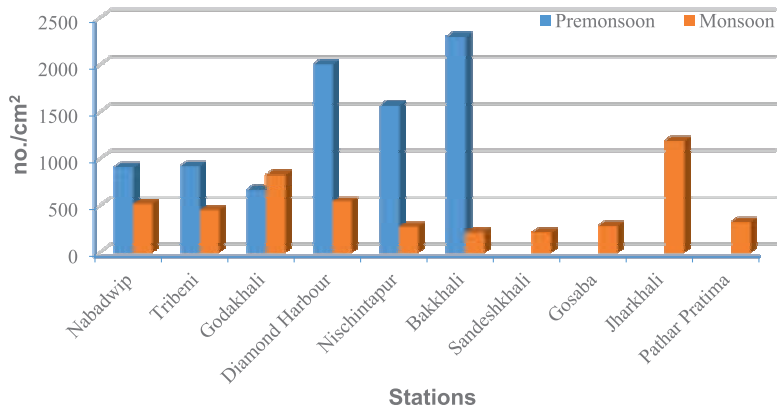
A total of 62 species of plankton were recorded during 2021 in the Hooghly-Matla estuary. Out of 62, only 9 species were zooplanktons. Bacillariophyceae was the dominant class among phytoplankton populations which contributes 54.3 and 75.8% during pre-monsoon and monsoon, respectively. During the survey period, *Euglena* sp. (Euglenophyceae) was reported only in pre-monsoon whereas *Tribonema* sp. (Dendrophyceae) was reported only in monsoon. Chlorophyceae was the second dominant class, followed by Cyanophyceae The total plankton population was higher in monsoon (24077 u/l) as compared to pre-monsoon (21651 u/l). *Aulacoseira* sp. was the dominant species under Bacillariophyceae whereas *Scenedesmus* sp. was the dominant one under Chlorophyceae. The highest density of zooplankton population was recorded in Nabadwip (5527 u/l) and the lowest in Godakhali (2520 u/l) during pre-monsoon, whereas Pathar Pratima (5232 u/l) contributed higher density and Tribeni (1245 u/l) contributed lower density during monsoon season. The periphyton population is composed of three classes, viz., Cyanophyceae, Chlorophyceae, and Bacillariophyceae, of which Bacillariophyceae was the dominant class in both the seasons and contributing 65% to the total periphyton community. *Navicula* was the dominant genus under Bacillariophyceae during pre-monsoon and *Gomphonema* in monsoon season. The density of



Sediment Cr contamination in Hooghly-Matla estuary during monsoon



Plankton population recorded from Hooghly-Matla estuary



Periphyton assemblage in Hooghly-Matla estuary

periphyton was recorded higher at Bakkhali (2302 no./cm^2) and lower in Tribeni (930 no./cm^2) during pre-monsoon. Monsoon season recorded higher periphyton population in Jharkhali (1197 no./cm^2) and lower in Bakkhali (210 no./cm^2).

Macrobenthic fauna

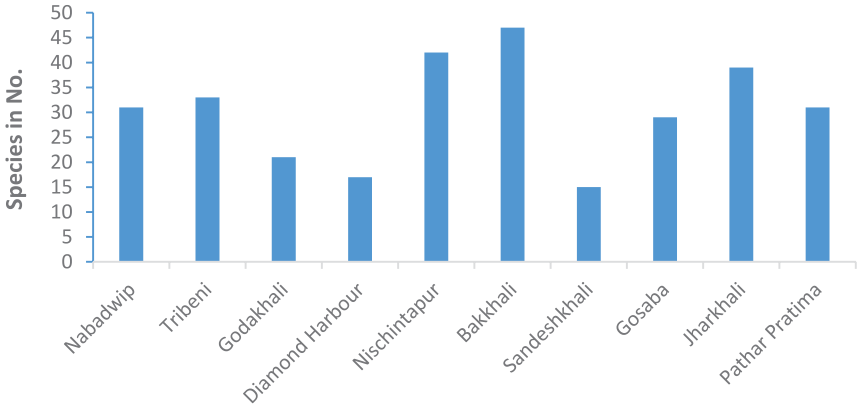
A total of 22 species of macrobenthic fauna belonging to sixteen families comprising of bivalves (4 species, 4 families) and gastropods (18 species, 12 families) were recorded during pre-monsoon and monsoon season of 2021. Bivalves included *Novaculina gangetica, Barnea candida, Mactra luzonica* and the dominant gastropods included *Neripteron violaceum, Filopaludina bengalensis, Pugilina cochlidium, Mekongia crassa, Tarebia granifera* and *Brotia costula*. *Neripteron violaceum* in pre-monsoon and *Filopaludina bengalensis* in monsoon were the dominant gastropods.

Fish and fisheries

A total of 10 sampling stations were selected (6 in Hooghly estuary, and 4 in Matla estuary) covering freshwater, intermediate, and brakish regions. During the pre-monsoon season, a total of 94 fish species belong to 14 orders, and 41 families were recorded. Overall, order Perciformes dominated with 37.23% share, followed by Cypriniformes (17.02%) and Clupeiformes (15.96%). Station-wise diversity pattern showed that the Fraserganj stretch in Hooghly estuary was having the maximum fish diversity with 55 species, followed by Tribeni (31 species) and Nischintapur (24 species).

In monsoon season, a total of 136 finfish species were recorded from the Hooghly-Matla estuarine system. In the Hooghly estuary, the highest species diversity was recorded from the Fraserganj-Bakkhali stretch with 47 species, followed by Nischintapur (42 species) and Tribeni (33 species). In the Matla estuary, most species diversity was recorded from Jharkhali with 39 finfish species, followed by Pathar Pratima (31 species).

Winter migratory bag net (WMBN), locally called '*been-jals*', fishery is an intensive way of bagnet fishing commencing from the end of October to mid-February at the lower zone of Hooghly estuary.



Station-wise finfish species recorded from Hooghly-Matla estuary in monsoon period

Transportation of WMBN catch to *khuties*

Sorting of WMBN catch

Many fishers migrate from various zones of the estuary towards the sea-mouth, establish a temporary fishing camps (locally called '*khuties*'). Bag nets were found to operate from one km to the shore and continue up to 55-60 km way from the shore. WMBN fishery contributes >40% of the total yield of the Hooghly estuary, and the importance of its fishery lies in its high total fish catch from the lower zone. Prawns, crabs, finfishes such as *Coilia dussumieri, Setipinna taty, Trichiurus lepturus, Harpadon neherius, Coilia ramcarati, Esculosa thoracata, Sillago sihama, Secutor insidiator, Stolephorus indicus, Otolithoides pama*, etc. formed the major catch composition from WMBN fishery.

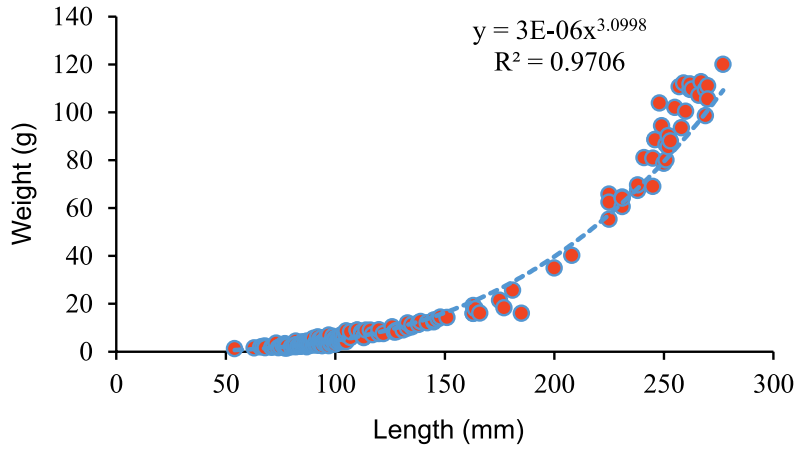
Estuarine set bag net (ESBN) locally known as "*Been jal*" or "*Behundi jal*" is a dominant fishing gear in the estuarine zone of Hooghly-Matla estuary. This type of net is about 25 m long, 7 m wide at the mouth, polyethylene netting with 40 mm mesh size near the mouth which reduced to 10 mm in the cod-end and even zero mm in certain cases. Though such net is found to operate throughout the year in the Hooghly-Matla estuary, October-June is the peak period. Fish juveniles dominated (>80%) the ESBN catch composition.

At Diamond Harbour, juveniles of sciaenid *Otolithoides pama* was found to be targeted species with more than 90% of catch, along with prawns, *Setipinna phasa*, flatfishes, etc. At Nischintapur, catch composition was mainly comprised of juveniles of mullets (*Liza parsia*, *Chelon planiceps*, etc.) with more than 85% catch, along with catfishes, prawns, etc. Catch per unit effort (CPUE) was observed to be 30.0-35.0 kg, and 33.0-42.0 kg/unit/day in Diamond Harbour and Nischintapur, respectively.

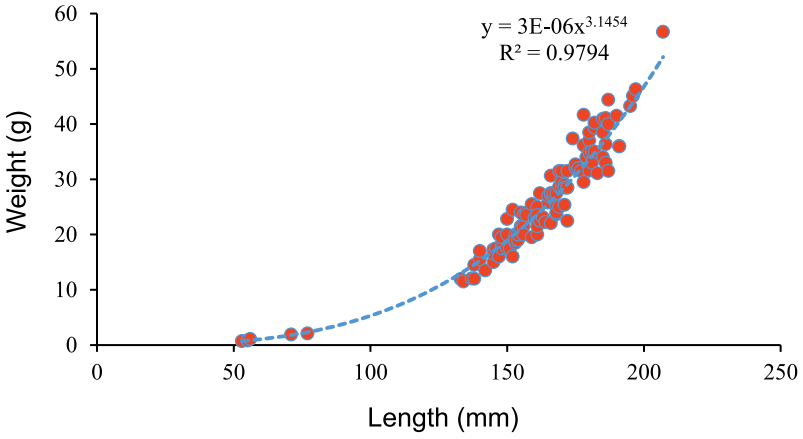
Two species, viz., *Polynemus paradesius*, and *Setipinna phasa* were selected for the stock assessment study. For *P. paradesius* length-frequency data of 117 samples were taken with the size ranging from 53-207 mm in length, and 0.70-56.71 g in weight. The exponent value 'b' was 3.1454 with a coefficient of determination (R^2) as 0.98 showing a positive allometric growth pattern for the species. For *S. phasa* length-frequency data were collected for 212 samples with size ranging from 54-277 mm in length, and 1.20-120.0 g in weight, respectively. The exponent value 'b' was 3.0998 with a correlation of determination (R^2) as 0.99 showing an isometric growth pattern for the species.

Sorting of ESBN catch

O. pama juveniles – the targeted catch of ESBN at Diamond Harbour



Length-weight relationship of *P. paradesius* from Hooghly-Matla estuary



Length-weight relationship of *S. phasa* from Hooghly-Matla estuary

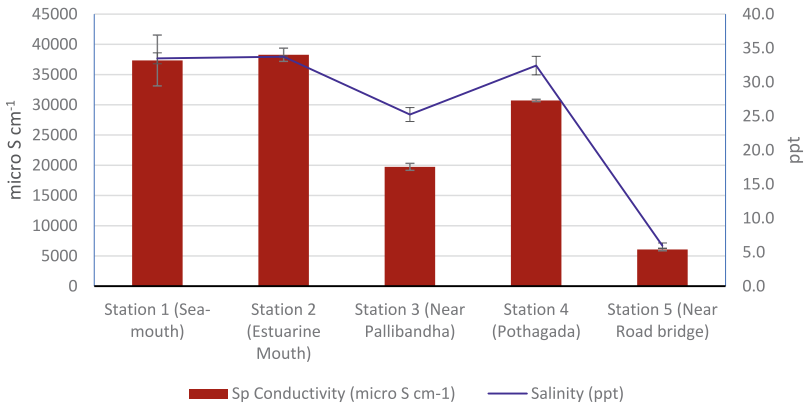
For assessing the reproductive biology, a total of 19 matured *P. paradiseus*, with sizes ranging from 137-195 mm, and weighted 14.35-47.16 g were considered. Gonad weight ranged from 2.29 to 6.20 g (3.66±1.10), absolute fecundity ranged from 5748 to 15741 eggs (mean 9122±2665) and relative fecundity ranged from 209 to 767 eggs per g body weight (mean 348±145). For *S. phasa*, a total of 7 matured specimens were selected for the reproductive biology study, with the size ranging from 245-267 mm, and weighted 80.74-122.71g, respectively. For this, gonad weights ranged from 5.45 to 11.22 g (mean 8.39±2.00), absolute fecundity ranged from 4742 to 18064 (mean 12133±4577) eggs and relative fecundity ranged from 42 to 195 (mean 125±49) eggs/g body weight.

Fishing gears and CPUE

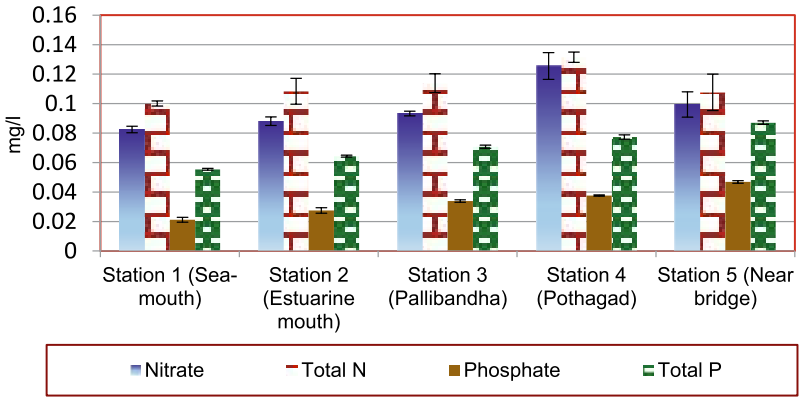
During the sampling period, fishing gears such as gill nets (surface, and drift gill net), bag nets (surface, sub-surface, and bottom set bag nets), set-barrier net, shore seine, lift net (fixed type), small bag net (*meenjal*), etc. were found to be operational at Hooghly-Matla estuarine system. Wide ranges of catch per unit effort (CPUE) were recorded from the different fishing gears and landing sites. Gear-wise highest CPUE was recorded from the winter migratory bag net, operated at lower stretch (3.0-45.0 kg/ bag/operation), and lowest from lift net (0.5-2.5 kg/net/day).

Sub-Project 2: *Assessment of ecohydrological dynamics in relation to fish fauna and their recruitment towards development of sustainable management strategies in Rushikulya estuary*

Rushikulya is one of the major estuarine systems in Odisha on the east coast of India. This estuary is characterized by bar-mouth, moderately low depth (maximum 3-4 m at deeper zone), and semi-diurnal tidal. This estuary is largely being used for the collection of prawn seeds and fries of milkfish for aquaculture. The milkfish *Chanos chanos* is one of the fin fisheries resources of this estuary. Study conducted in five sampling stations in January 2021 showed that salinity of the estuary was 5.9-33.7 ppt which is close to 34.2 ppt at sea mouth reflecting lack of freshwater



Specific conductivity and salinity at Rushikulya estuary in January 2021



Nitrogen and phosphorus contents at different stations of Rushikulya estuary in January

influx in the estuary. Reduced flow rate has led to formation of sandbar in the estuarine mouth. Specific conductivity was obviously high, ranging from 6063 – 38267 µS/cm. Nitrate content in the estuary was 0.082-0.126 mg/l, and phosphate was 0.023-0.047 mg/l Station 5, near the bridge, exhibited higher soluble phosphate from anthropogenic activities and had a fish landing centre. Monsoon sampling was done in August, but enough rainfall was not received till that time; as a result, salinity remained high (22-32 ppt) except near the bridge in monsoon period.

Metal pollution in water

In January 2021 station 3 near Pallibanda had the highest Cu level. In the water samples collected in August 2021, the estuarine mouth at Purnabandha also had copper contents (7.55 and 9.74 µg/l in January and August 2021, respectively) which are above the safe limit for aquatic life.

Sediment characteristics

Specific conductivity and organic carbon values at station 4 were higher than the other stations indicating ingress of organic rich effluent. Sand content in the sediment (49%) is less than that in other three stations with high silt content (41%) putting this under 'loam' class in textural category. The concentration of lead in sediment of estuarine mouth was quite high, whereas higher amount of chromium deposition was found in station 4.

Plankton assemblages

A total of 32 genera of phytoplankton were recorded. Bacillariophyta dominated across the stations accounting 82% of the total phytoplankton population followed by Cyanophyta (9%). Among zooplanktons, Copepod nauplii showed their maximum abundance (43%) across the stations followed by Cyclopoida (28%), Calanoida (17%) and Rotifera (4%). Altogether, holoplankters contributed maximum within the range between 49-64%, and meroplankters 46-51% of the total zooplankton population in Rusikulya.

Fish and shellfish diversity

A total of 55 fish species belonging to 28 families were recorded from various sampling stations. Mullets (Mugilidae) were the dominant group with 6 species, followed by the family Carangidae with a diversity of 5 species. The other

Chaetodon decussatus (Indian vagabond butterfly fish)

Pennahia anea (Big-eye croaker)

Nibea maculata (Blotched croaker)

significant species rich families include Leiognathidae (pony fishes), Clupeidae (shads, sardines, and herrings) and Engraulidae (anchovies): each family being represented by 4 species. The prevalence of high salinities during major part of the year has paved way for the immigration of stenohaline marine species such as *Chaetodon decussatus* (Indian vagabond butterfly fish, *Pennahia anea* (Big-eye croaker) and *Nibea maculata* (Blotched croaker) into the estuary.

The shell fishes encountered in the fish catch from Rushikulya included five species of prawns and two species of crabs. The prawn species recorded include *Fenneropenaeus indicus* (Indian white prawn), *F. merguiensis* (Banana prawn), *Penaeus monodon* (Tiger prawn), *P. semisulcatus* (Green tiger prawn) and *Metapenaeus monoceros* (Speckled shrimp). The

Fenneropenaeus merguiensis (Banana prawn)

Portunus sanguinolentus (Blood-spotted swimming crab)

Boat seine operation in Rushikulya estuary

Hilsa kelee (Kelee shad)

Sardinella gibbosa (Gold-stripe sardinella)

Striped grey mullet (*Mugil cephalus*)

Threadfin sea catfish (*Arius arius*)

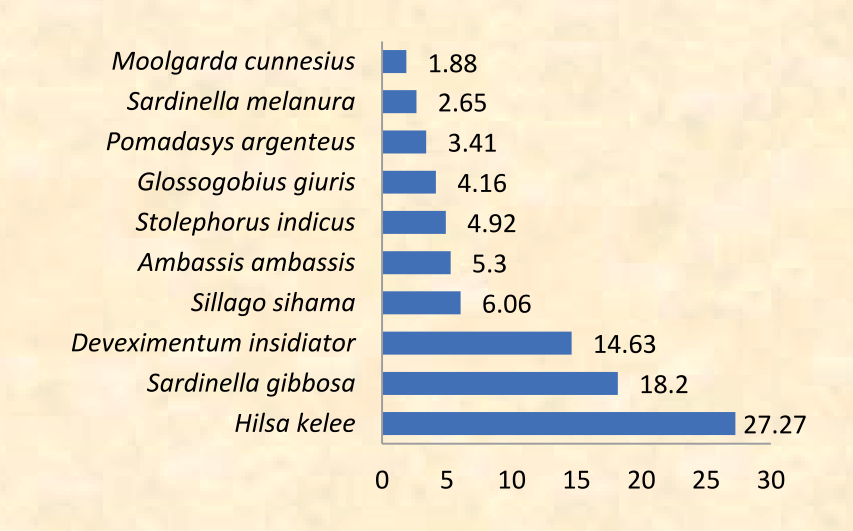
crab catch was mainly comprised of the mud crab (*Scylla* sp.) with occasional landings of *Portunus sanguinolentus* (blood spotted swimming crab).

Fishing gears and catch structure

The seine nets (locally known as '*gada jalo*') were the principal fishing gears operated along the Rushikulya estuary. Though, both beach seines and boat seines (Fig. 8) are operated, boat seines are more widely employed in different zones of the estuary. During boat seine operation, a single seine net is hauled from four fishing boats, whereas, in beach seine operation the net is set by a single fishing boat and is hauled from the shore. Marked seasonal variations were observed in the seine net catches during January and August (2021). Although 24 species were captured in the seines during January (2021), about 69.75 % of the catch was constituted of kelee shad (*Hilsa kelee*), gold stripe sardinella (*Sardinella gibbosa*), Indian pony fish (*Secutor insidiator*), sand whiting (*Sillago sihama*) and Indian anchovy (*Stolephorus indicus*) with relative abundances (% of total numbers) of 29.03 %, 19.35 %, 9.68 %, 6.45 % and 5.24 % respectively.

There was a shift in fish assemblage structure in August (2021). The kelee shad (*H. kelee*), which dominated the catches during January (2021) with relative abundance (RA) of 27.27 % was recorded significantly lower numbers in August with 3.37%. RA of The seine net catch during August was dominated by the common pony fish (*Leiognathus equula*) with RA of 25.71 %. The other significant species observed in the catch includes the long-arm mullet (*Moolgarda cunnesius*), striped grey mullet (*Mugil cephalus*), orange fin pony fish (*Photopectoralis bindus*) and the threadfin sea catfish (*Arius arius*) with RA (% of total numbers) of 13.12 %, 9.93 %, 8.51 % and 7.27 %, respectively.

Data on estuarine fish landings were collected during August (2021)



Relative abundance (% of total catch)

Seine net catch composition in August 2021

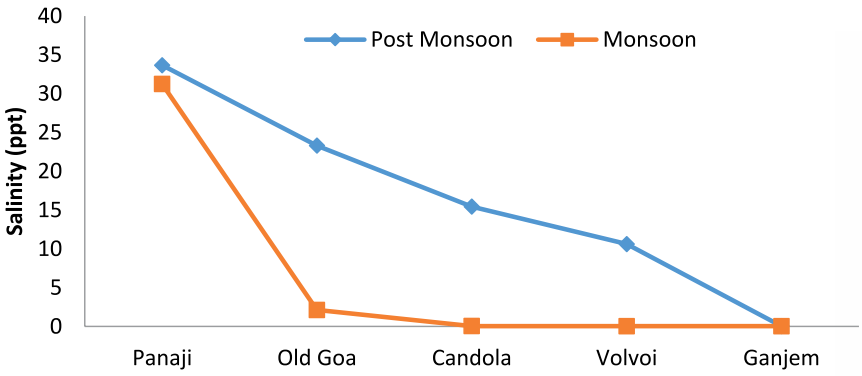
at landing centre near Rushikulya Bridge. The daily fish landings varied from 70 to 95 kg with an average of 85 kg/day. The overall fish catch was dominated by *Mugil cephalus* (38.04 % of total catch by weight), followed by *Moolgarda cunnesius* (22.13 %), *Arius arius* (12.45 %), *Rhabdosargus sarba* (6.92 %) and *Lutjanus johnii* (5.81 %). The prawns formed a significant part of the estuarine landings and were mainly comprised of *Fenneropenaeus indicus* (4.21 % of total catch) and *F. merguiensis* (3.16 %).

Sub-project 3: Temporal assessment of the Mandovi-Zuari estuarine fishery resources for sustainable management

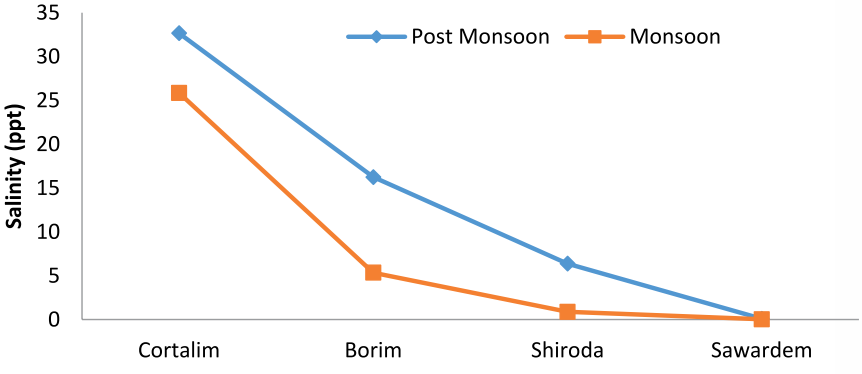
Post-monsoon and monsoon seasonal samplings were conducted in February and September 2021, respectively in the Mandovi-Zuari estuarine system. In February, a total of six stations (Panjim, Old Goa and Candola on Mandovi river, Cortalim and Borim on Zuari river and Banastarim on cumbarjua canal) based on salinity gradient were selected while additional four stations (Volvoi and Ganjem on Mandovi and Shiroda and Sawardem on Zuari river) were added in September 2021 to ascertain tidal influence. There was a significant fall in salinity during monsoon; similar trend was also observed for total dissolved solids, Specific conductivity and Total Hardness.

Water transparency was high (≥80 cm) at all stations of Mondovi and Zuari estuary. Major nutrients, viz., nitrate-N and phosphate-P were higher during monsoon than post monsoon season in both the estuaries. A similar trend was also observed for sediment nutrients such as available phosphorus and available nitrogen.

In the estuarine water, a total of 24 phytoplankton and 11 zooplankton species were identified. Bacillariophyceae was the dominant class with 19 species. *Ceratium furca, Chaetoceros peruvianus, Bacteriastrum* sp., *Chaetoceros decipiens, Chaetoceros curvicetus* were the dominant plankton species. The benthic community was comprised of 20 species, of which *Telescopium telescopium* and *Polymesoda* sp. were mostly observed in the mangrove mudflats.



Seasonal water salinity changes in Mandovi Estuary



Seasonal water salinity changes in Zuari Estuary

The fish fauna collected at the estuarine waters was represented by 48 fish species belonging to 19 families during monsoon and post-monsoon season. This includes three elasmobranchs and seven shellfish species. The two commercially important species viz. *Sillago sihama* and *Lates calcarifer* are selected for the study of biology and population dynamics studies. The average length of the *S. sihama* observed in the commercial landings from the estuarine system during the period was 12.9-212 mm. Three fishing gears such as gill net, crab trap (Kurli Panjara) and scoop net (Kobale) was found commonly operated in the Mandovi-Zuari estuarine system.

Crab trap (Kurli Panjara)

Scope net (Kobale)

Subproject 4: Temporal assessment of Netravathi-Gurupur estuarine fisheries resources for sustainable management

Water quality of the estuary

The nutrients and physico-chemical parameters were assessed in the Netravathi-Gurupur estuary at nine sampling stations covering estuary-sea confluence (NG I, NG II & NG III), Netravathi (NG IV, NG V & NG VI), and Gurupur stretch (NG VII, NG VIII & NG IX). Study revealed that pH was slightly higher than neutral with an average value of pH 7.9 in post-monsoon season, whereas the values were slightly acidic (avg. 6.65) in monsoon season. There was a higher level of dissolved oxygen in Netravathi stretch, whereas comparatively higher BOD was observed at Gurupur stretch due to anthropogenic stress. The higher values of salinity were observed throughout the estuary in pre-monsoon season, while the estuary behaves as salt-wedge estuary in monsoon season where the outflow of fresh water is strong enough to prevent the denser ocean water to enter through the surface resulted in negligible salinity. Very high value of total hardness in post-monsoon season revealed that the hardness in the estuarine stations is from saline sources. High river discharge could have resulted in higher nutrients content (nitrate-N, phosphate P, total-P and silicate) in the monsoon period with decrease in transparency. The higher nutrient concentrations at Gurupur stretch of the estuary was due to sewage dumping. Study indicates that this aquatic ecosystem can be restored if anthropogenic activities are regulated.

Sediment characteristics

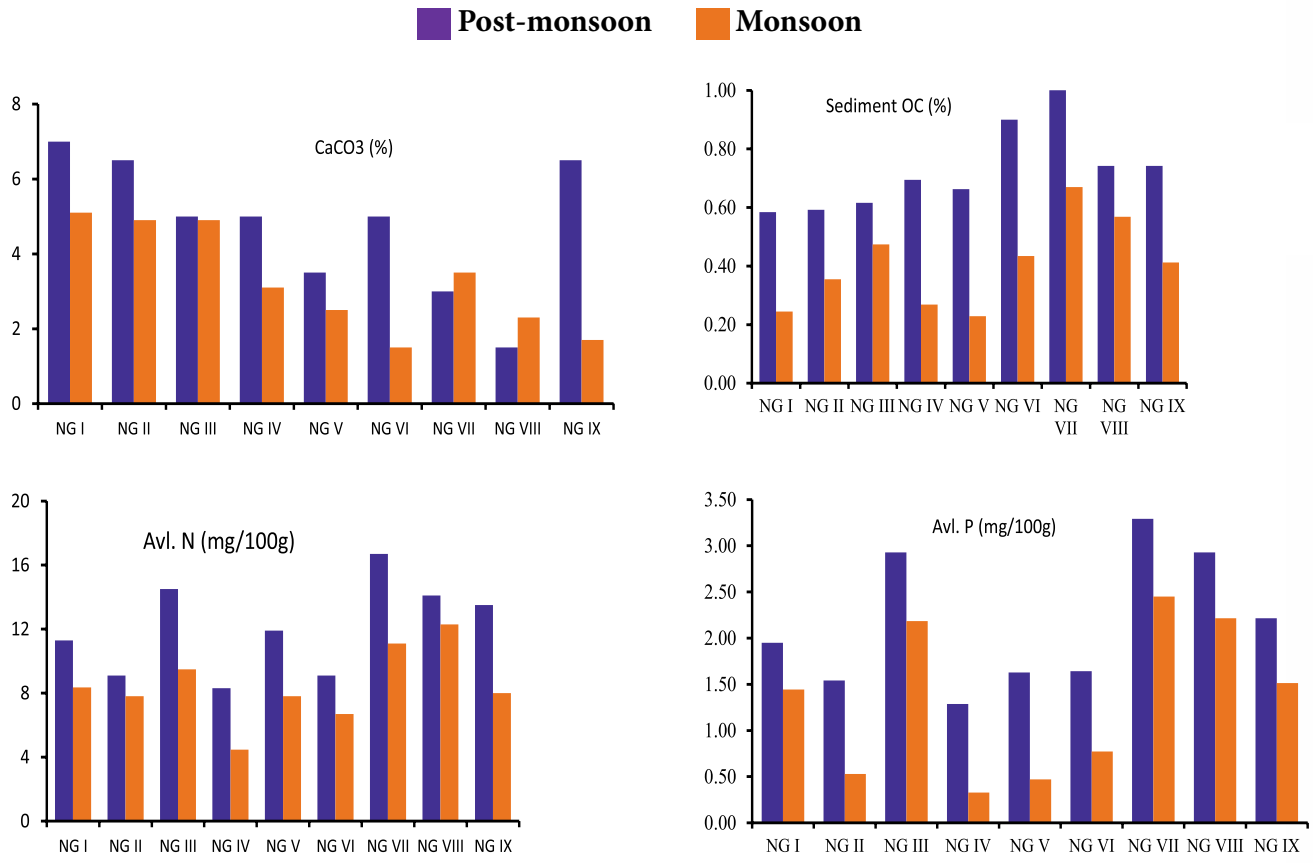
Sediment pH varied from 7.2 to 7.6 and from 6.57 to 7.3 in post-monsoon and monsoon seasons, respectively. The calcium carbonate ($CaCO_3$) concentration ranged from 1.5 to 7.0% in post-monsoon and 1.5-5.1% in monsoon season. Higher $CaCO_3$ in the estuary barmouth may be related to the shell fragments from marine origin. Distribution of $CaCO_3$ follow the similar pattern

Sampling locations in the in the Netravathi-Gurupur estuary

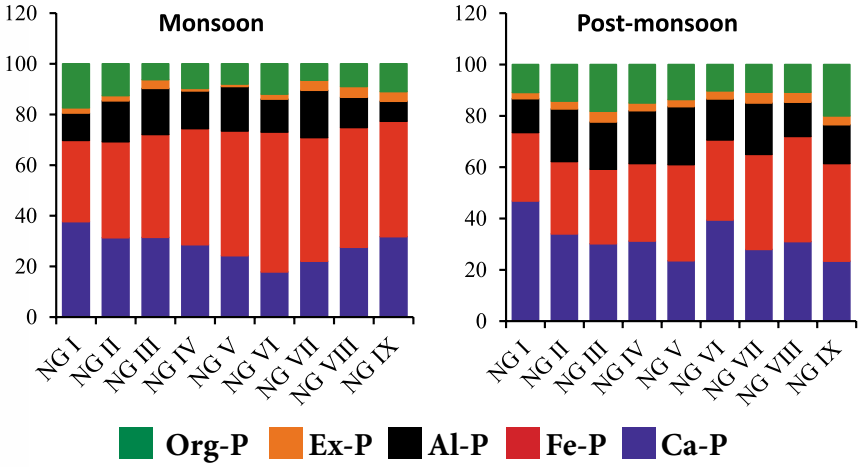
of sand content which indicates that shell fragments associated with sand are the main contributor of $CaCO_3$. Organic carbon content ranged from 0.58 to 1.03% and 0.23 to 0.67% in post-monsoon and monsoon season, respectively. The available nitrogen (mg/100g) contents in different sites varied from 4.46 -16.7, and available P (mg/100g) varied from 0.33-3.29. Distribution of sediment texture followed a unique pattern where barmouth and Netravathi stretch are having higher sand content, while Gurupur stretch contains less sand. This may be because of sediment of marine origin at barmouth and high-energy environment at Netravathi stretch. Gurupur stretch is typically characterized as low energy environment favouring the deposition of comparatively fine sediment.

Spatiotemporal variability in phosphorus in the sediment

The Netravathi-Gurupur estuary passes through urbanized coastal city of Mangalore from where polluted water ingress and adversely affect the ecosystem health. Phosphorus is a major driver of plankton growth and eutrophication – but the nutrient remains in several forms with different bioavailability potential. Sequential extraction procedure was used to evaluate the abundance of different species of phosphorus in estuarine sediment. Total phosphorus (TP) content varied from 435-810 mg/kg and 257.9-699.1 mg/kg in post-monsoon and monsoon, respectively. Iron bound phosphorous (Fe-P) was dominating in both the seasons. More than half of sedimentary inorganic phosphorus was bio-available and can be conditionally released into water column. However, average phosphorus pollution index, except few cases, were lower than one and showed lower eutrophication risk in relation to the sedimentary TP load.



Variations in sediment parameters of the Netravathi-Gurupur estuary



Spatio-temporal variations in contribution (%) of P fractions to total P

Occurrence of pesticide and heavy metals in the water and sediment

Seven heavy metals and 28 pesticides were measured in the water and sediment of the Netravathi-Gurupur estuary collected during monsoon season. Metal (Cd, Cr, Cu, Fe, Mn, Pb and Zn) contents in water were in traces. The concentration of seven heavy metal elements in the surface sediments of Netravathi-Gurupur estuary was in the order: Fe > Mn > Cr > Zn > Cu > Pb > Cd with higher concentration at Gurupur stretch. Fe has the highest mean value (12710.1 mg/kg) in the sediment for all the sampling sites whereas Cd has the lowest mean value (0.02 mg/kg). The higher levels of Fe and Mn in the estuarine sediment might be derived from both natural and anthropogenic sources. Gas chromatography–mass spectrometry was used to measure the residues of 28 pesticides and none of the samples were found to contain any pesticide residues.

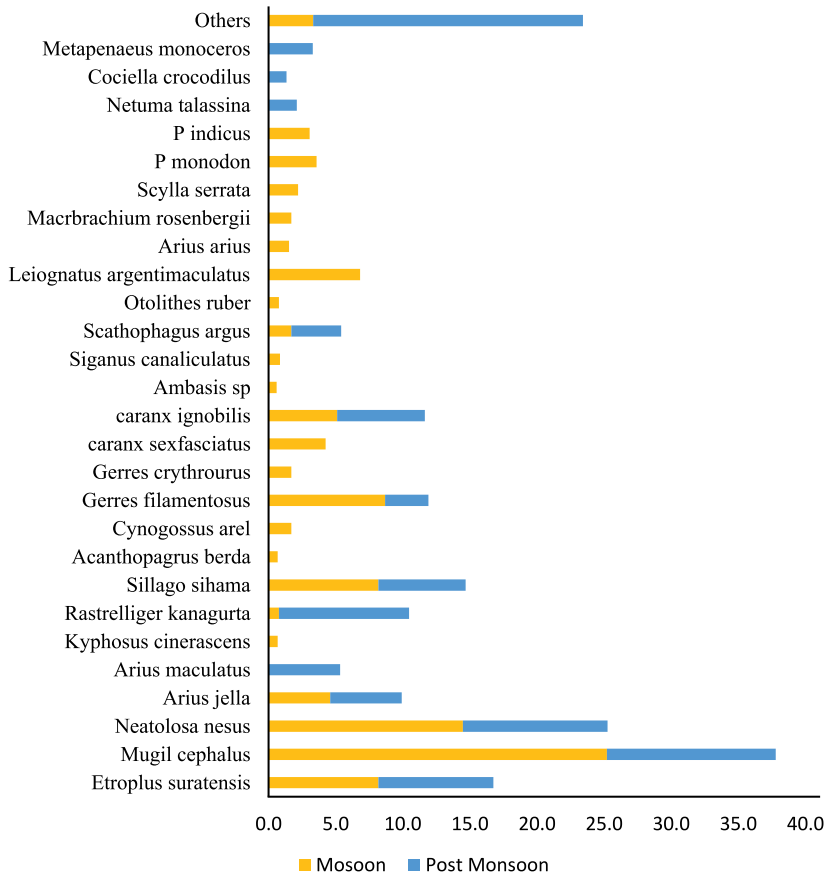
Fishery

Landing of 10.92 t of fishes was recorded at different landing centres in the Nethravathi-Gurupur estuary with a CPUE of 10.9 kg during post-monsoon quarter, whereas during monsoon an estimated 129.7 t of fish was caught with a CPUE of 8.11 kg. The catch was dominated by *Mugil cephalus* (15.03%), followed by *Etroplus suratensis* (12.06), *Nematalosa nasus* (8.63%), *Gerres filamentosus* (5.18%), *Sillago sihama* (4.88), *Leognathus splendens* (4.06 %), *Caranxig nobilis* (3.05%), *Arius jello* (2.74%), *Caranxsex fasciatus* (2.58%), *Penaeus monodon* (2.13%), *P. indicus* (1.83%), *Macrobrachium rosenbergii* (1.02%), *Cynoglossus arel* (1.02%) and Miscellaneous (35.79%).

The sizes of *Rastrelliger kanagurta* ranged from 18-23.3 cm with a mean length of 20.3 cm, whereas the sizes of *N. nasus* ranged from 15.5 to 19.0 cm with a mean length of 17.6 cm. The sizes of *Etroplus suratensis* ranged from 12.5 to 20.5 cm with a mean length of 15.9 cm whereas the sizes of *Mugil cephalus* ranged from 18.5 to 26.0 cm with a mean length of 22.0 cm.

Sub-Project 5 : Temporal assessment of Vembanad estuarine fisheries resources for sustainable management

Vembanad Lake is a prominent fisheries resource of Kerala.



Fish species composition (%) of the Netravathi-Gurupur estuary

Shrinkage of the lake area was recorded to the tune of 6.93%. Maximum human encroachment of the lake area was noted in north-west region of lake (Udayamperoor, Cheppanam and Maradu) and Willington Island.

Trophic and productivity estimates

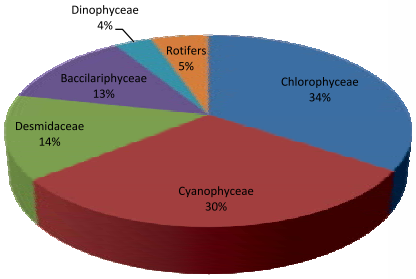
The lake had a trophic estimate of 60.96 indicating mid-eutrophic status. The average primary productivity of the lake was estimated at 23.44 mgC/m^3/h. Average BOD levels of the lake were estimated at 2.14 (moderate pollution) during pre-monsoon but decreased to 1.96 (low pollution) during monsoon due to the freshwater influx.

Fish and shellfish diversity

A total of 35 finfish species belonging to 22 families, 4 shrimp species, 2 crab species and 1 clam species were recorded from commercial fisheries during pre-monsoon season. A total of 57 finfish species belonging to 36 families, 7 shrimp species, 1 crab, 1 clam, 1 mussel and 1 cephalopod species were recorded during monsoon season. Commercial crustaceans recorded at Vembanad Lake are *Metapenaeus dobsoni, Fenneropenaeus indicus, Penaeus monodon, Scylla serrata, Villorita cyprinoides,* etc.

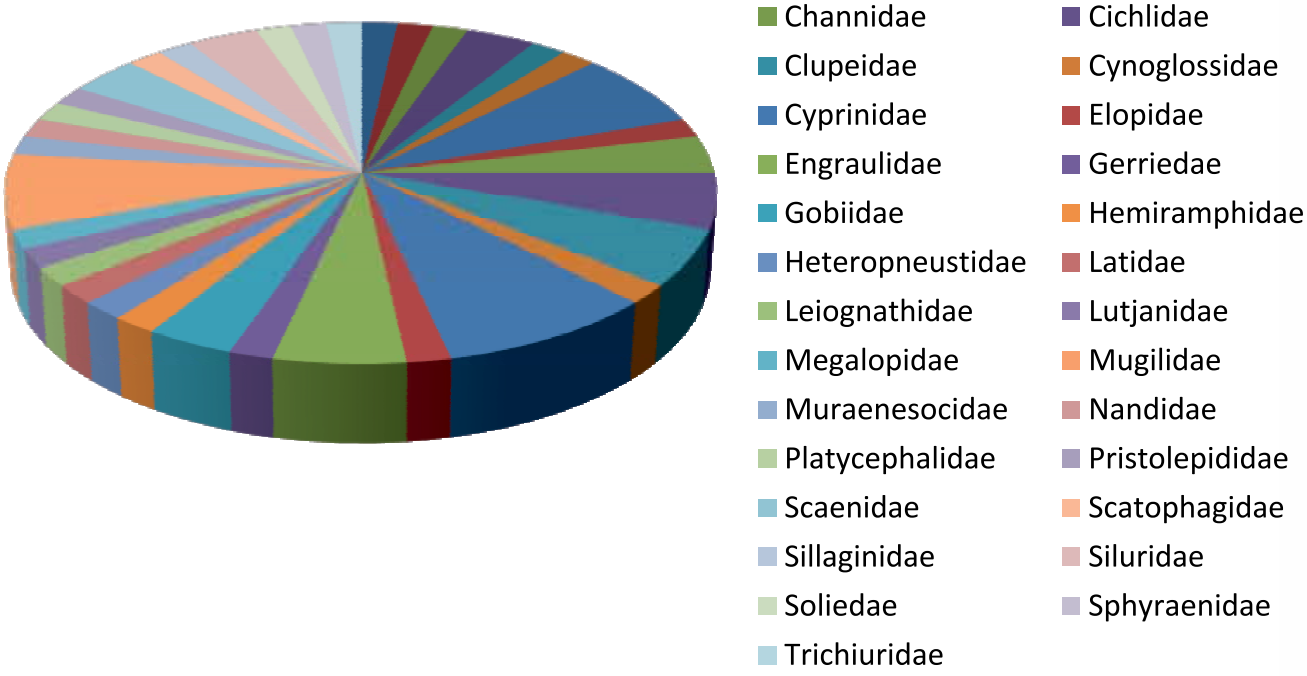
Plankton diversity

A total of 28 genera of planktons belonging to six algal groups were recorded from six sampling stations across the Vembanad estuary. Among the six algal groups, chlorophyceae (34%) was dominant in terms of abundance. During pre-monsoon, 22 species belonging to 22 genera and 5 groups of phytoplankton were identified.



Plankton diversity of Vembanad Lake

The quantitative abundance of phytoplankton ranged from 20 to 280 no./l with highest abundance at high saline station (Munambam) and lowest at medium saline station (Arookutty) during monsoon season. During pre-monsoon season Diatomaceae (*Diatoma* sp. and *Chaetoceros* sp.) was found to be the dominant group constituting 50% of the total phytoplankton, whereas during monsoon Chlorophyceae dominated the estuarine system to the tune of 34%, followed by Cyanophyceae



Family-wise fish diversity of the Vembanad estuary in monsoon season

(30%). Salinity-wise gradient of plankton study indicated that Chlorophyceae (43.5%) dominated the medium saline zone, whereas Cyanophyceae dominated the high saline (44.23%) and low saline (36.67%) zones during pre-monsoon. The quantitative abundance of zooplankton ranged from 20 to 40 no./l. Zooplankton abundance was observed in all stations during monsoon.

Project Title: Assessment of ecological impact of dams in selected rivers of India

Project Code: REF/20-23/12

Duration: April 2020 –March 2023

Project Personnel: A.K. Sahoo (P.I.), S. K. Das, Sangeetha M. Nair, R. Baitha, M. Ramteke (up to 31.3.2021)

Dams play a key role in human development by controlling floods, generating electricity, and providing water for industry, irrigation and municipal purposes. Currently, there are 4710 completed large dams and 390 are under-construction dams in India. Almost every river in India is regulated by several dams and barrages which may have a multitude of direct and indirect effects on aquatic ecosystems. Therefore, understanding the environmental impact of dams relates to its potential effect on fish communities are complex and challenging. To understand the impact of dams and barrage on river ecology and fisheries, well established Farakka barrage on the river Ganga was studied. Four sites representing two sites each in upstream and downstream of barrage was selected for study of water quality parameters and fish diversity.

Water quality

A total of eight water quality parameters viz., water temperature, dissolved oxygen, alkalinity, carbon dioxide and nitrate, silicate, total phosphorous, sulphate were measured in three seasons (lean, pre-monsoon, and monsoon). Majority of the parameters ($p<0.05$) showed significant difference between seasons, but not between upstream and downstream sites, except for carbon dioxide. Nutrient like nitrate-N and sulfate were minimum in pre-monsoon, started increasing in monsoon, but concentration remained low because of dilution, attained peak in lean or post-monsoon season. Temperature was an important factor for changes in the dissolved nitrogen forms. Total P concentration was dependent on discharge. The upstream acted as reservoir and so concentration of nitrate was less there as compared to downstream except in monsoon when nutrient levels were almost at par at both the places due to high flow.

Fish diversity

A total of 81 fish species were documented from the landing sites and experimental fishing representing at upstream and downstream of the barrage. Hilsa (*Tenualosa ilisha),* is an anadromous and *Glyptothorax telchitta* are potamodromous fish species. Interestingly, *T. ilisha,* and *G. telchitta* were not recorded in the upstream of the barrage indicating impact of the barrage on migration of these species. *Aspidoparia jaya* and *Brachydanio rario* were recorded only in the upstream of the barrage suggesting that these small-bodied fishes are established in the river with less flows.

Project Title : Estimation of fish landings and catch structure in the rivers Mahanadi, Krishna, Barak and Kosi

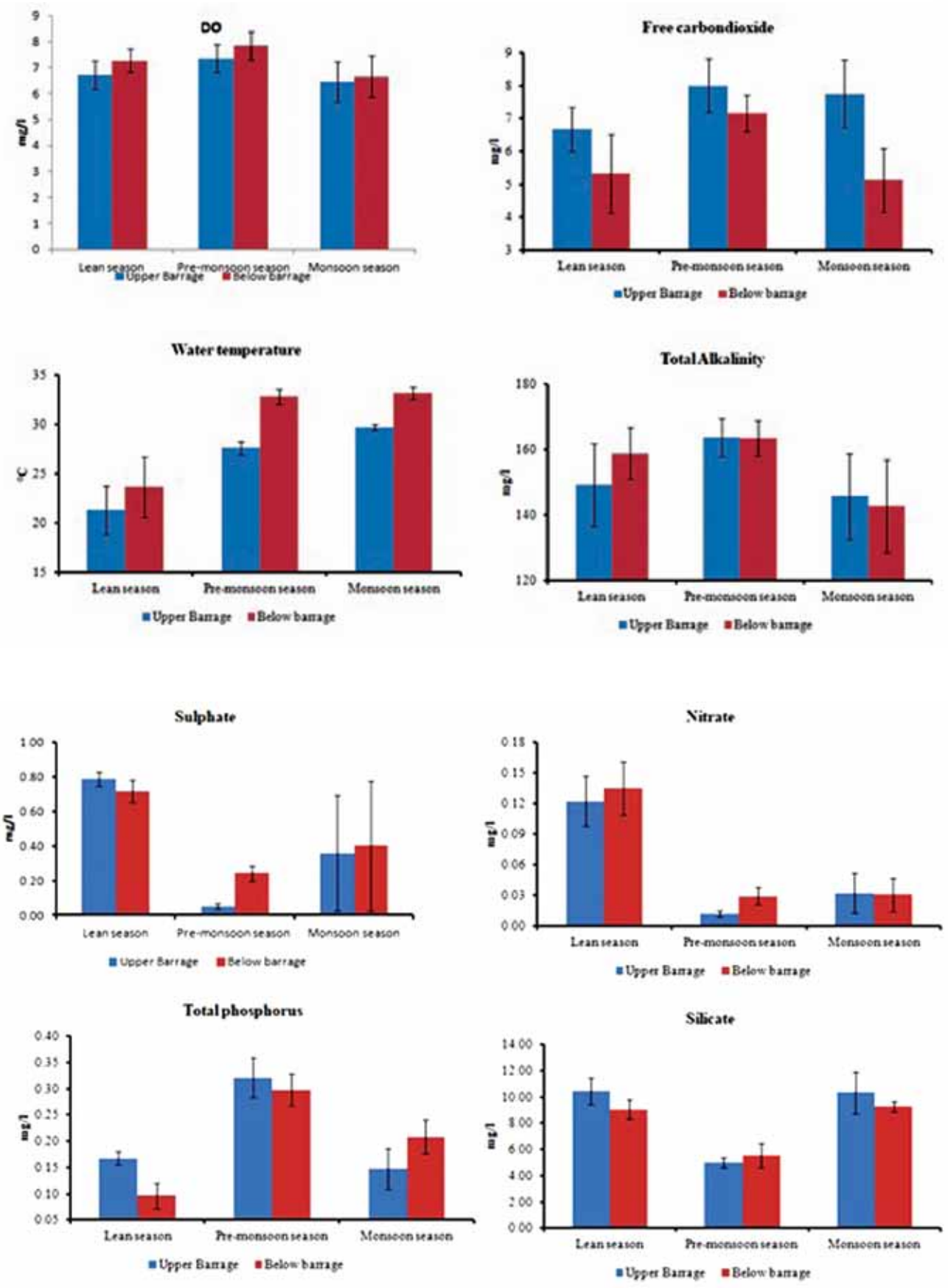
Project Code: REF/20-23/13

Duration: April 2020 –March 2023

Project Personnel: Roshith C.M. (P.I.), A. Pandit, C. Jana, K. Lohith Kumar, R. Baitha, C. Johnson

The project is intended to generate information on fish landings and catch structure, assessment of indigenous and economically important fisheries and socio-economic status of fishermen along selected stretches of four Indian rivers (Mahanadi, Krishna, Barak

Study site at Farakka barrage on river Ganga



Water quality parameters at upstream and downstream sites of the barrage

Tenualosa ilisha (A), and *Glyptothorax telchitta* (B) recorded from downstream of the barrage

and Kosi) representing different eco-climatic zones.

River Barak, the second largest river system of Northeast India, forms part of one of the freshwater biodiversity hotspots of the world. The river has been among the critical habitats of the endangered Ganges River dolphin and several endemic fish species. The Barak River rises from the Manipur hills, south of Mao in Senapati district of Manipur, then flows along the Nagaland-Manipur border through hilly terrains and enters Assam. It further enters Bangladesh where it is known by the name of the Surma and the Kushiyara and later called the Meghna before receiving the combined flow of the Ganga and the Brahmaputra. The length of the Barak River from its origin up to the border of Assam along the Kushiyara is 564 km.

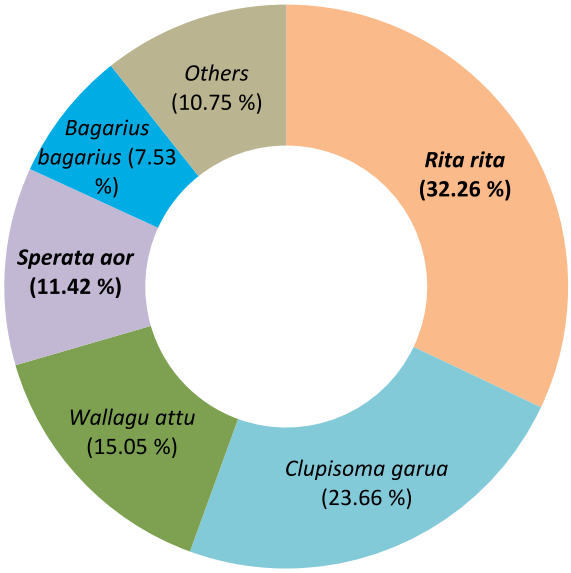
To conduct studies on the fishing gears, crafts and catch patterns in the River Barak, a survey was carried out during monsoon (August 2021) season along the riverine stretch in Silchar, Assam. In consultation with the State Fisheries Department of Assam, preliminary survey was conducted at fishing villages situated around Madhuraghat, a major riverine fish landing centre in Silchar.

Since the survey was conducted during peak monsoon period, the diversity of fishing gears was less with only three principal gears being operational in the study area, *viz*., gill nets (three local variants *'hilsa jal'*, *'current jal'* and *'chela jal'*), seine nets (locally known as *'maha jal'*) and hook and line. The fish catch was represented by 21 species of fishes (belonging to five families) and one species of prawn (*Macrobrachium gangeticum*).

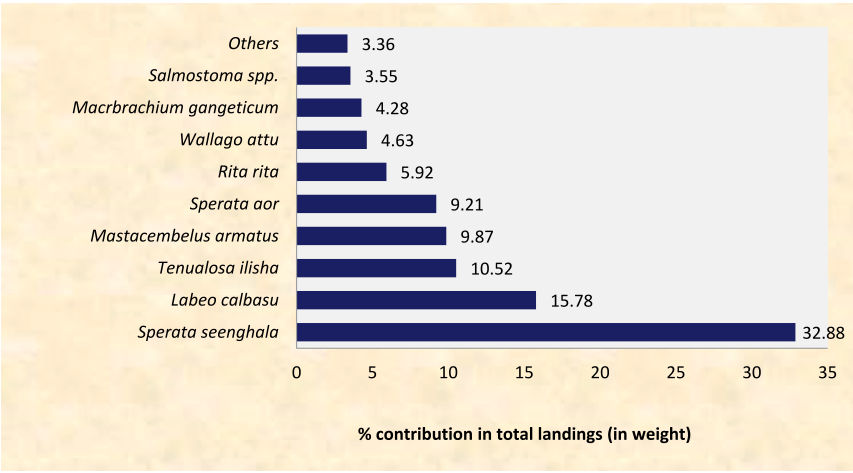
The *'hilsa jal'* is widely operated during the period of peak availability of hilsa shad (*Tenualosa ilisha*) in River Barak which commences from May and extends till late October. The average CPUE from *'hilsa jal'* observed during the survey was 1.6 kg/boat/day. The unique feature of fishing observed in the zone during monsoon is the extensive use of hook & line by the fishers in the Madhuraghat. The gear is basically a long line with each fishing unit comprising of 150 hooks and primarily targets the bagrid catfish *Rita rita*(contributed to 32.26% of total catch), which is a prized fish with high market demand. The other significant fish species encountered in hook and line catches include *Clupisoma garua*, *Wallago attu* and *Sperata aor* with catch contributions of 23.66 %, 15.05 % and 11.42 % respectively. The daily catch from hook and line varied from 0.45 – 4.2 kg/boat/day with an average of CPUE of 1.6 kg/boat/day. At Rangpur, the major fish species observed in landings were *Sperata aor* (56.34%), *Labeo calbasu* (17.2%), *R. rita* (12.51%), *T. ilisha* (7.35%) and miscellaneous fishes (comprising mainly of *Salmostoma* spp. and *Rasbora daniconius*). In terms of overall fish landings from river Barak during monsoon, giant river catfish *Sperata seenghala* was the dominant species contributing 32.88% to the total catch. The other significant catch components include *L. calbasu* (15.78%), *T. ilisha* (10.52%), *Mastacembelus armatus* (9.87%) and *S. aor* (9.21%). The average riverine fish landings during the sampling period varied from 45 kg/day (Madhuraghat) to 70kg/day (Rangpur).

River Barak at Madhuraghat (Silchar, Assam)

Hook and line catch from River Barak



Catch strcucture of hook and line from river Barak



Dominant species in riverine fish landings from river Barak at Silchar

Project Title: Assessment of fish diversity and identification of priority habitat in protected and less-explored inland water bodies

Sub-Project 1: Aquatic biodiversity assessment and priority fish habitat identification in protected and less-explored inland water bodies (Bhitarkanika National Park, Jaldapara National Park, Panna National Park, major waterfalls region of Chhota Nagpur plateau)

Sub project 2: Assessment of fish diversity and identification of priority habitat in protected and less-explored inland water bodies of different eco-regions

Project Code : REF/20-23/14

Duration : April 2020–March 2023

Project Personnel : R.K. Manna (P.I.), D. Bhakta, Sangeetha M. Nair, S. Kumari (Sub-project 2 leader), Sajina A.M., B.K. Bhattacharjya, N.S. Singh, S. Bora, A. Alam, D.N. Jha, J. Kumar

Sub-Project 1: Aquatic biodiversity assessment and priority fish habitat identification in protected and less-explored inland water bodies (Bhitarkanika National Park, Jaldapara National Park, Panna National Park, major waterfalls region of Chhota Nagpur plateau)

Exploratory surveys were conducted in five selected stations in Bhitarkanika National Park in August, four stations in Jaldapara National Park in September and four major waterfalls situated around Ranchi, Jharkhand viz., Dassam, Hundru, Johna and

Lates calcarifer caught by set barrier at Jaynagar (Bhitarkanika)

Drift gillnet fishing in Torsha (Jaldapara)

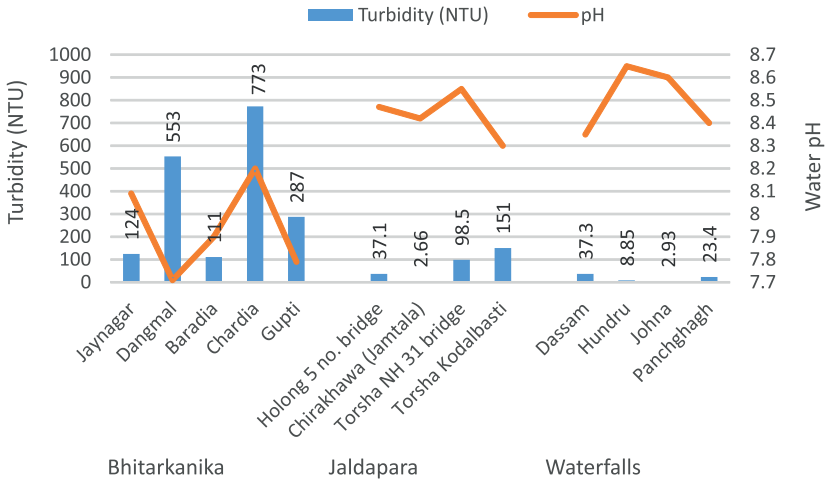
Sampling below Hundru falls

Sampling below Johna falls

Panchghagh waterfalls during November 2021. Fishery exists in the rivers in the fringe areas of the National Park. Subsistence fishery also exists in all waterfalls.

Water quality of the protected aquatic habitats

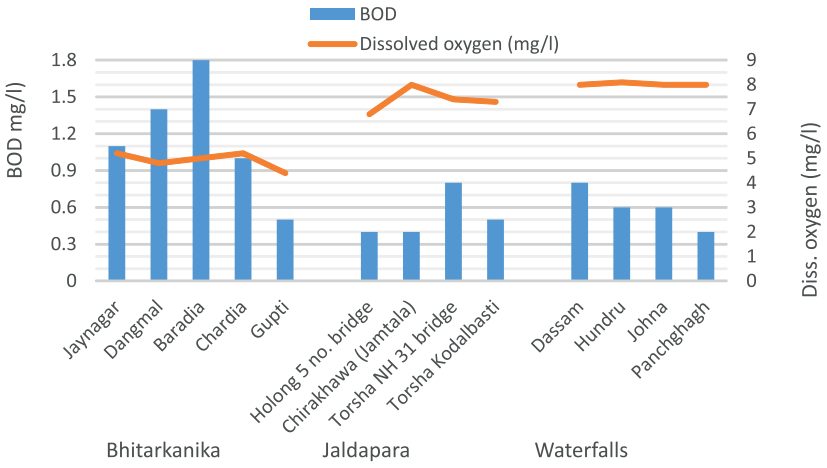
Water was highly turbid (124-773 NTU) during monsoon (August) in selected stations of Brahmani and Baitarani River around Bhitrakanika National Park. In Jaldapara National Park higher turbidity was observed during September in stations of Torsha River. Higher turbidity in Holong River as compared to Chirakhawa River may be attributed to dolomite mining at upstream of Holong River. Turbidity was less (2.93-37.3 NTU) in waterfalls around Ranchi during November.



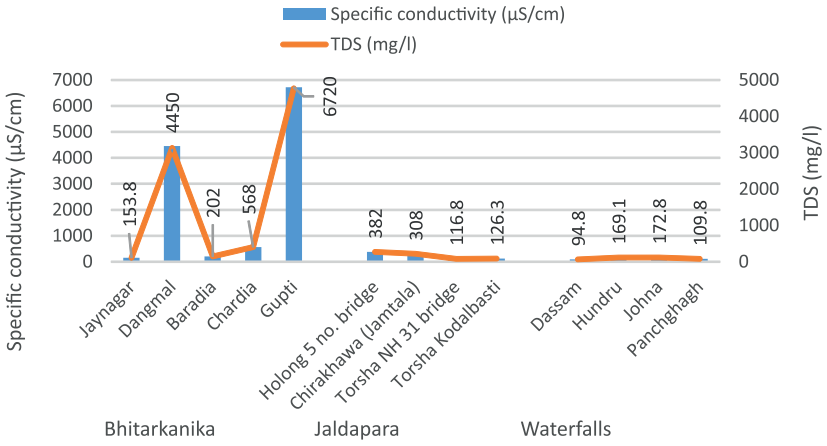
Water pH and turbidity of studied protected habitats / less explored water bodies

River water in Bhitarkanika had lower dissolved oxygen (DO, 4.4-5.2 mg/l) whereas rivers of Jaldapara and waterfalls had significantly higher DO (>7 mg/l) except in turbid Holong river (6.8 mg/l). Higher dissolved oxygen (>8 mg/l) in waterfalls were recorded and may be attributed to rapid water flow and turbulence. Biochemical oxygen demand was more (>1 mg/l) in stations of Bhitarkanika with the highest value of 1.8 mg/l in Baradia of Baitarani River. All the stations in Jaldapara and major waterfalls observed low BOD (<0.8 mg/l).

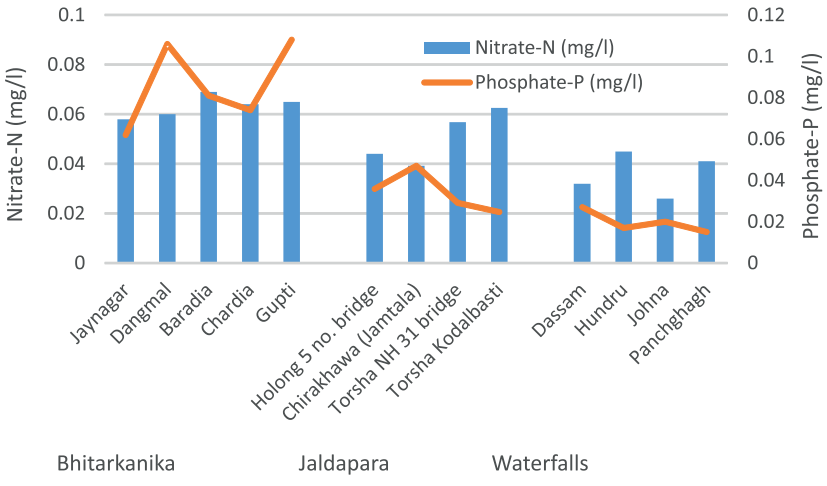
In Bhitarkanika, Dangmaland Gupti observed less freshwater discharge with higher specific conductivity and TDS, whereas other stations (*i.e.*, Jaynagar, Baradia and Chardia) located on Brahmani and Baitarani River observed more freshwater during monsoon period survey. In



Dissolved oxygen and BOD of studied protected habitats / less explored water bodies



Specific conductivity (µS/cm) and TDS (mg/l) of studied protected habitats / less explored water bodies



Available nutrients of water of studied protected habitats / less explored water bodies

Jaldapara, higher conductivity in Holong river may be attributed to dolomite mining and among waterfalls, higher conductivity was found in Hundru and Johna falls. This may be due to anthropogenic pollution from Ranchi city.

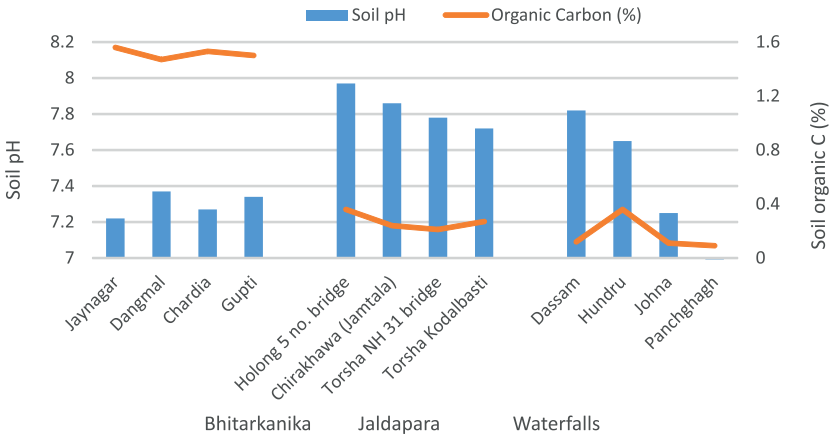
Total alkalinity of all the stations in Bhitarkanika, Jaldapara and major waterfalls of Ranchi was low except Holong and Chirakhawa river in Jaldapara where significantly higher total alkalinity (192 and 148 mg/l) was recorded. Significantly higher total hardness in Dangmal and Gupti indicated estuarine saline water dominance in absence of less freshwater influx from upstream. Higher nitrate-N and Phosphate-P were recorded from Bhatarkanika, whereas significantly lower phosphate-P was recorded from all the studied waterfalls of Ranchi.

Soil quality

Higher soil pH was recorded in Jaldapara National Park, whereas pH was relatively low (7.2-7.4) in Bhitarkanika. Higher accumulation of organic carbon (1.5%) was recorded in river bottom of Bhitarkanika, whereas it was very low in Jaldapara. High sand content in bottom sediment of Jaldapara and major waterfalls of Ranchi is responsible for low organic accumulation in soil.

Plankton assemblage of Bhitarkanika National Park

A total of 19 species of phytoplankton were encountered in Bhitarkanika National Park during monsoon survey. Out of the four stations studied, Dangmal reported maximum density of phytoplankton (890 u/l), followed by Chardia (864 u/l). The dominance of Bacillariophyceae (86.17%) was noted at all the stations, followed

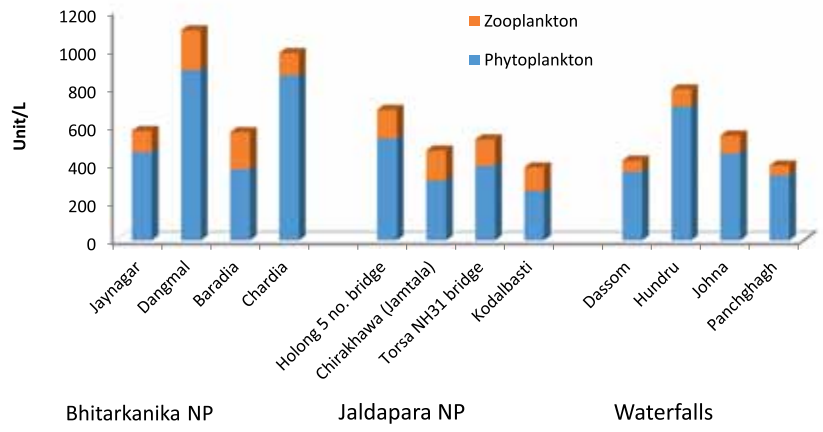


Soil pH and organic carbon of studied protected habitats / less explored water bodies

by Chlorophyceae (7.57%) and Cyanophyceae (6.25%). The phytoplankton composition consists of Bacillariophyceae (15 species), Chlorophyceae (3 species) and Cyanophyceae (1 species). The abundance of *Cylindrotheca closterium* from Dangmal and *Fragilaria* sp. From Baradia and Chodiya were recorded in the class Bacillariophyceae. The zooplankton community comprised of only four species under copepoda (44.17%), followed by protozoa (41.78%) and rotifera (14.03%).

Plankton assemblage of Jaldapara National Park

The phytoplankton community of Jaldapara National supported by 20 species during September 2021. Phytoplankton alone contributed 72.52% of the total plankton community with maximum contribution by Chlorophyceae (40.5%), followed by Bacillariophyceae (37.68%), Cyanophyceae (16.86%) and Desmidaceae (4.95%). The density of phytoplankton was found maximum in Holong-river (535 u/l) and the least from Kodalbasti (257 u/l). The phytoplankton composition consists of Chlorophyceae (8 species), Bacillariophyceae (7 species), Cyanophyceae (3 species) and Desmidaceae (2 species). *Pediastrum* sp. and *Microspora* sp. were abundant among Chlorophyceae. Among the zooplanktons, copepods (2 species) were dominant and contributed 82 % of the total zooplankton population.



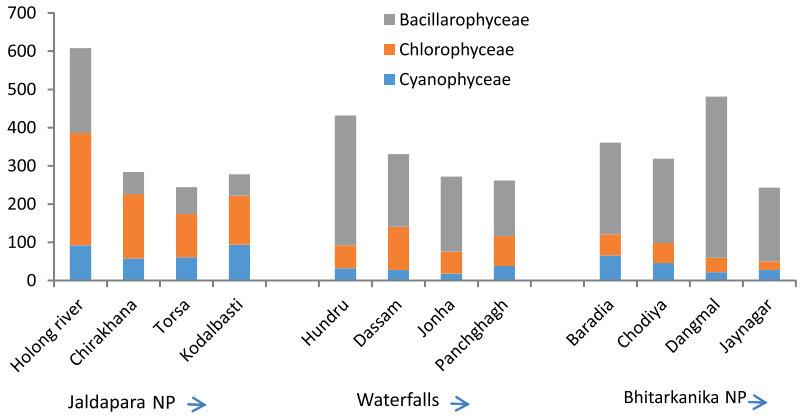
Plankton assemblage in twelve stations of the selected protected areas

Plankton assemblage of Jharkhand waterfalls

Study on four waterfalls in Jharkhand in November 2021 recorded 22 species of phytoplankton and 2 species of zooplankton. The total population was dominated by phytoplankton which contributed 86.5 % whereas zooplankton contributed 13.47%. Among the phytoplankton groups, Bacillariophyceae (82.26%) is the dominant family and *Fragilaria* is the dominant genus. The density of phytoplankton was found to be higher in Hundru (700 u/l) and less in Panchghagh (340 u/l). The zooplankton population is dominated by copepods (85.46%).

Periphyton composition in Bhitarkanika National Park, Jaldapara National Park and Jharkhand waterfalls

Field survey was conducted on twelve sites of three protected areas revealed the periphyton assemblage pattern with varying composition of three classes viz. Bacillariophyceae, Chlorophyceae and Cyanophyceae. Among the three protected areas, maximum density of periphyton was found in Jaldapara (1414 no./cm^2) which was followed by Bhitarkanika (1404 no./cm^2) and Jharkhand waterfalls (1297 no./cm^2). Bacillariophyceae were dominant in Bhitarkanika (76.5%) and Jharkhand waterfalls (67.23%), whereas Chlorophyceae were dominant in Jaldapara (49.71%). Almost the 12 sites, the periphyton population was found highest in Holong river, Jaldapara (608 no./cm^2) and lowest in Jaynagar, Bhitarkanika (243 no./cm^2).



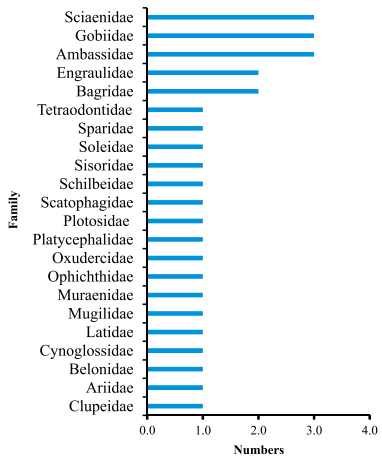
Periphyton composition from three selected protected areas of India

Macrobenthic community in protected areas

A total of nine species of macrobenthic fauna belonging to seven families were recorded in three protected areas. The abundance of gastropod *Brotia costula* was observed in Chirakawa River, Jaldapara National Park except in Holong River which is impacted by pollution due to dolomite mining. Highest number of gastropods were recorded in Choddiya (520 no./m^2) of Bhitarkanika National Park, followed by Chirakawa river (478 no./m^2). Miscellaneous group includes fish seeds, prawn seeds, crab juveniles and insects and their population were found maximum at Dangamal (50%) of Bhitarkanika. The other dominant gastropods were *Telescopium telescopium, Vittina smithi* and *Neripteron violaceum*.

Finfish diversity of the Bhitarkanika National Park

During monsoon survey, a total of 30 finfish species belonging to 10 orders, and 22 families were recorded in Bhitarkanika National Park complex. Order Perciformes was the most dominant group (12 species) followed by Siluriformes (6 species), Clupeiformes (3 species), etc. Familywise Sciaenidae was found to be the most species diverse group (3 species), followed by Gobiidae (3 species) and Ambassidae (3 species), etc. As per IUCN Red List Status, 21 species fall under Least Concern (LC) category, 5 species as Data Deficient (DD), 3 species as Not Evaluated and 1 species as Near Threatened (NE).



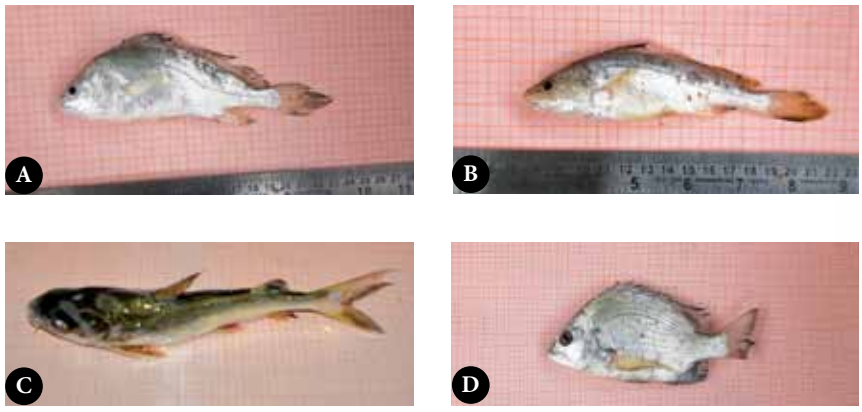
Family-wise finfish species recorded in Bhitarkanika in monsoon season

Finfish diversity of the Jaldapara National Park

In monsoon season a total of 43 finfish species belonging to 9 orders, and 18 families were recorded in Jaldapara National Park complex. Order Cypriniformes was the most dominant group (23 species) followed by Siluriformes (6 species), Anabantiformes (5 species), Synbranchiformes, etc. Family-wise,Cyprinidae was found to be the most species diverse group (14 species), followed by Danionidae (7 species), Channidae (3 species), etc. As per IUCN Red List Status,38 species fall under the Least Concern (LC) category, 3 species as Near Threatened (NE), 1 species each as Endangered (EN), and Vulnerable (VU) category. Snow trout *Schizothorax richardsonii* (Gray, 1832) was the Vulnerable (VU) species, and Putitora mahseer *Tor putitora* (Hamilton, 1822) as Endangered (EN) in the studied systems.

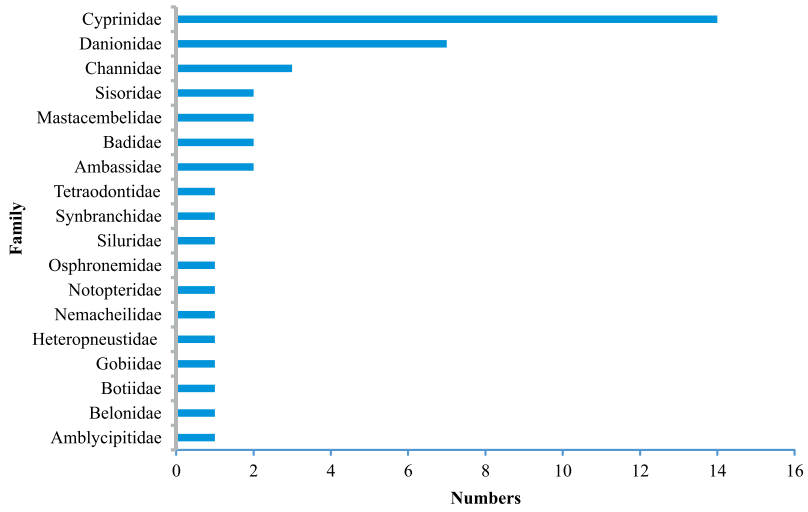
Finfish diversity in major waterfalls of Jharkhand

In post-monsoon period a total of 27 finfish species belonging



A. *Macrospinosa cuja*, B. *Johnius gangeticus*, C. *Arius gagora*, D. *Acanthopagrus latus*

Fish species recorded at Bhitarkanika

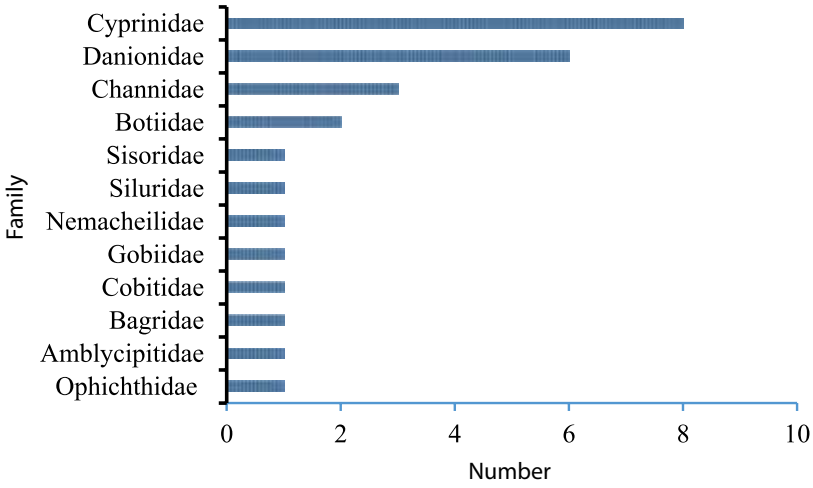


Family-wise finfish species recorded in Jaldapara National Park during monsoon

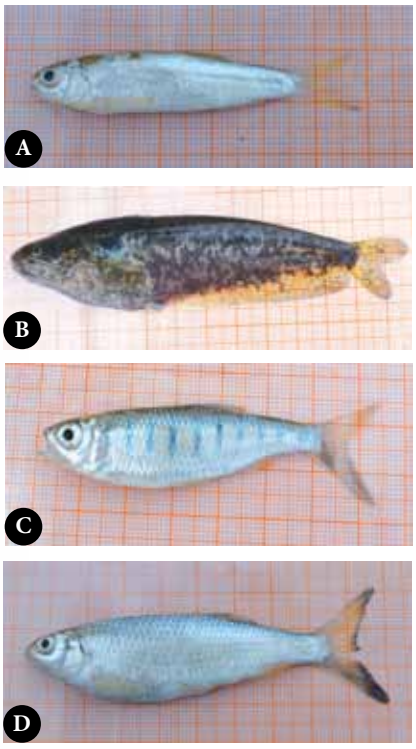
to 5 orders and 12 families were recorded in four selected waterfalls of Jharkhand. Order Cypriniformes was the most dominant group (18 species), followed by Siluriformes (04 species), Anabantiformes (3 species), Synbranchiformes, etc. Familywise, Cyprinidae was the most species diverse group (08 species), followed by Danionidae (06 species), Channidae (03 species), etc. As per IUCN Red List Status, 25 species fall under Least Concern (LC) category, 1 species Not Evaluated (NE), and 1 species as Endangered (EN) category. *Ompok pabo* (Hamilton, 1822) was observed to be Near Threatened (NT)in the studied systems.

Indigenous Technical Knowledge (ITKs) recorded

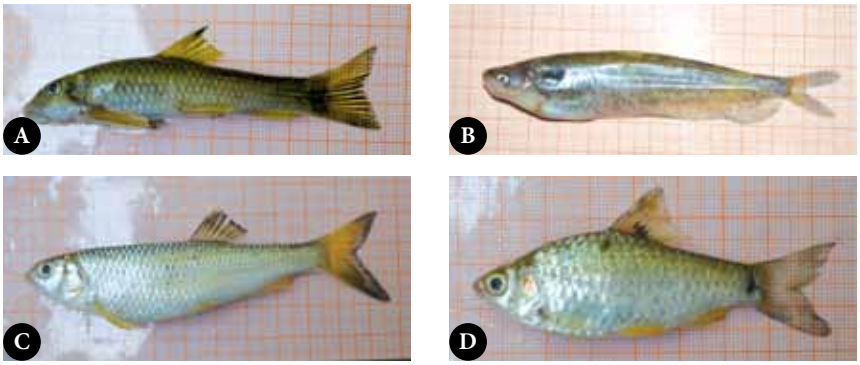
At Bhitarkanika, besides conventional fishing gears like gill net, beg net, cast net, set barrier, etc. there are some unique indigenous fishing methods / implements. At Chardia, a unique device for catching crabs has been recorded. At Gupti, mangrove fruit is observed to be used as bait in hook & line operation. Locally made fishing traps like a conical



Family-wise finfish species recorded in major waterfalls of Jharkhand in post-monsoon season



Some of the finfish species recorded in Jaldapara National Park
A. *Cabdio morar*, B. *Ompok pabda*, C. *Opsarius barna*, D. *Opsarius bendelisis*



Finfish species recorded in major waterfalls of Jharkhand
A. *Garragotyla*, B. *Ompok pabo*, C. *Opsarius bendelisis*, D. *Puntius chola*

trap (Lanjha) and cuboidal box trap (*Aandhuni*) were observed to be used in low-lying areas.

Jaldapara, drift gill net, cast net, hook & line, etc. were used for fishing in river Torsa. However, fishers were observed to use locally made electrofishing equipment for catching the fish from the fast-flowing Torsa River, which is highly detrimental to sustainable fishery. Hook & line bait was observed to be supplemented with an herbal products like turmeric to have a better catch. Operation of drift gill net was improvised in fast-flowing Torsa River where fishers were observed running along with drifting net as boat plying was not possible in the river.

Crab trap used in Bhitarkanika with catfish juvenile as bait

Mangrove fruit used as fish bait in hook & line fishing in Bhitarkanika

Conical fish trap (Lanjha) used in Bhitarkanika

Electro-fishing in river Torsa near Jaldapara

Use of turmeric in hook and line bait in Jaldapara

In rivers of major waterfalls of Jharkhand, along with cast net and gill nets, locally made traps are also used to catch fish and prawns. It included a large cylindrical trap, called "Kumni" and two smaller traps - cylindrical one is called "Kuruwa" and rectangular box-shaped is called "Jhimar." Bait is used in both the small traps, but not in Kumni. Bait made of fermented rice, rice bran and methi dust is used in Jhimar to catch small prawns. White ant egg mass with nest is used as bait in Kuruwa.

Sub project 2: Assessment of fish diversity and identification of priority habitat in protected and less-explored inland water bodies of different eco-regions

Nagi and Nakti bird sanctuaries, Jamui district, Bihar

The twin bird sanctuaries, Nagi and Nakti, are protected small reservoirs lying close to each other located in Jamui district of Bihar. Fishing activities are not allowed in both the sanctuaries. Water bodies

Kumni, a large cylindrical trap used in waterfall areas

Kuruwa, a small cylindrical trap used in waterfall areas

Jhimar, a small rectangular trap used in waterfall areas

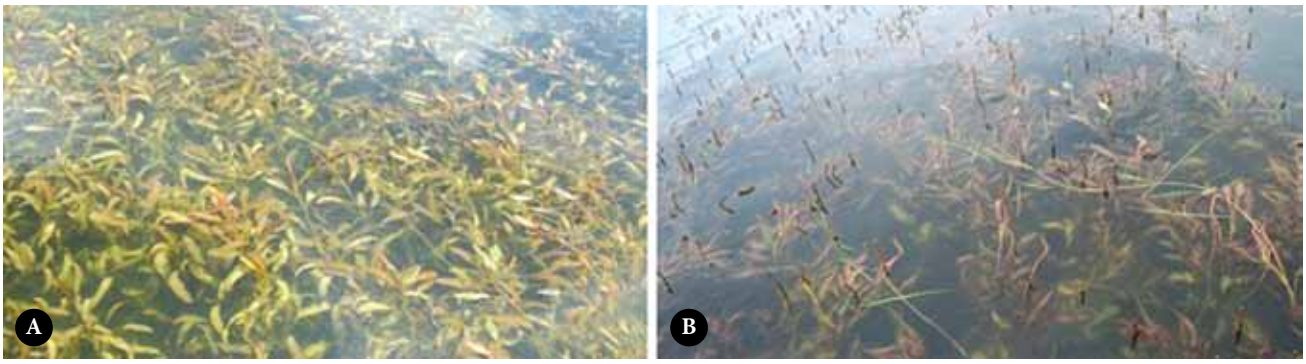
were infested with submerged macrophytes (>90% coverage) and fish stockings were done occasionally for the purpose of feeding of migratory birds. The two sanctuaries have been the home of a wide variety of indigenous and winter migratory birds.

The present exploratory survey recorded 22 fish and 2 prawn species in these protected habitats. Other than the stocked species, most native species were small sized fishes (viz.,*Chanda nama, Parambassis lala, Pseudambassis ranga, Macrognathus* spp., *Puntius* sp., *Pethia* sp., *Salmophasia* sp., *Amblypharyngodon* sp., *Rasbora* sp., *Aplocheilus* sp., etc.), and many of them have ornamental value. The Tilapia, introduced in Nagi reservoir through stocking is proliferating and has established breeding populations in the reservoir.

The study on the hydro-biological attributes indicated pH was in the alkaline side, DO >7 in all sites suggest favorable environment for fishes. Yet, the very shallow depth with very high transparency levels in both the reservoirs shows very less plankton abundance indicative of not so congenial environment for fisheries. The high proliferation of macrophytes may be the reason of less plankton abundance. These macrophytes are important as the migratory birds depend on them as food.

Kusheshwar Asthan Bird Sanctuary, Darbhanga district, Bihar

Kusheshwar Asthan *chaurs* under Kosi-Gandak basin has been highly significant from fisheries and biodiversity point of view and has been notified as a Bird Sanctuary by Govt. of Bihar in 1994. The chaurs are rainfed wetlands and monsoon run off with flow from a network of rivers like Kamala, Balan, Bagmati and Kareh are the prime sources of water. The Kusheshwar Asthan chaurs are interspersed with 14 highly populated villages. The protected water bodies provide



Macrophyte beds in (A) Nagi and (B) Nakti reservoirs

The littoral zone of Nakti reservoir

The dam side of Nagi reservoir

Common small indigenous fish species of Nagi-Nakti reservoirs

Major fishes of Kusheshwar Asthan

numerous ecological services and harbor a rich aquatic diversity. The exploratory survey conducted in four chaurs, *viz*., Mahraila chaur (North), Narailchaur (East), Bararichaur (West), and Manoria chaur (South) of Kusheshwar Asthan recorded 61 fish species, 2 prawn species and 2 crab. The study also identified various ecological services provided by the wetland system such as fisheries, agriculture, aesthetic value, bird conservation, fuel and fodder source, edible resources such as macrophyte tubers and seeds, etc. Among the fish species reported, 5 are under Vulnerable, 3 species under Near Threatened and 1 species (*Clarias magur*) under Endengered categories based on IUCN Red data list. The major large-sized fishes in the capture landings were *Wallago attu, Channa striatus*, *Mastacembelus armatus, Gibelion catla, Labeo rohita, Cirrhinus mrigala*, *Systomus sarana,* etc. Most abundant native species were small sized fishes (viz. *Anabas testudineus*, *Macrognathus* sp., *Puntius* sp., *Pethia* sp., *Chanda nama, Pseudambassis ranga, Salmophasia* sp., *Amblypharyngodon* sp., *Rasbora* sp., etc.), and many of them have ornamental value.

'Jaing' fishing in Kusheshwar Asthan chaurs

A traditional fishing practice based on the concept of FADs, called '*Jaing*' fishing, was prevalent in the chaurs. Increased siltation of chaurs, poor water storing ability, increased occurrences of floods, conflicts between various stakeholders like fishing and non-fishing communities, indiscriminate and destructive fishing practices, decreased bird sightings, poor Govt. interventions and lack of community participation in management and inept fisheries co-operatives were the major issues observed. There is great need for implementing a proper conservation management plan, awareness on the importance of conservation of aquatic resources considering the vast potential of these important wetland resources for livelihood support and conservation of fish as well as birds.

Women involved in collecting tubers of aquatic macrophytes in Kusheshwar Asthan

Project title: Eco-variability and impact study of river Yamuna on river Ganga with special emphasis on fisheries

Project Code: REF/20-23/15

Duration: April 2020- March 2023

Scientific personnel: D.N. Jha (P.I.), A. Alam, J. Kumar, V.R. Thakur, M. Gupta (till 08 October 2021)

Physico-chemical parameters of water

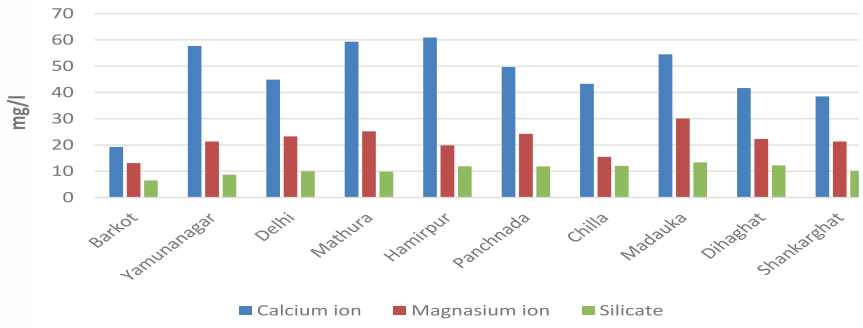
Exploratory surveys were conducted at fifteen sampling stations *viz.* Jankichatti, Barkot, Kalsi, Karnal, Yamunanagar, Chillaghat, Wazirabad, ITO, Mathura, Agra, Etawah, Panchnada, Maduka, Shaknar Ghat and Dihaghat of River Yamuna in 2021. The average water temperature of all the sampling sites is Barkot (16.9 °C), Yamuna nagar (29 °C), Delhi (27.5 °C), Mathura (28.6 °C), Hamirpur (30.4 °C), Panchnada (31.7 °C), Madauka (34.2 °C), Dihaghat (31°C) and Shankarghat (31.5 °C). Minimum water temperature was recorded at Barkot station situated at higher altitude near to the origin of the river, and the higher temperature was recorded on plains of Madauka and Panchnada. Calcium ion concentration was highest at Hamirpur station (60.92 mg/l). Silicate was almost equally reported at all the stations.

BOD values were highest at Madauka (2.72 mg/l), which also had higher submerged macrophyte infestation. Total nitrogen content was also reported highest at Madauka station (2.45 mg/l). These nitrogen and other related nutrients help macrophytes to grow in these stations, and because of this BOD values become high. These conditions were not good for the growth of fishes and aquatic biodiversity. Dissolved organic matters (DOM) was recorded highest at Chilaghat (1.88 mg/l) and Dihaghat (1.88 mg/l). The data for DOM showed that the influx from other linked tributaries had impact on these stations for their higher values.

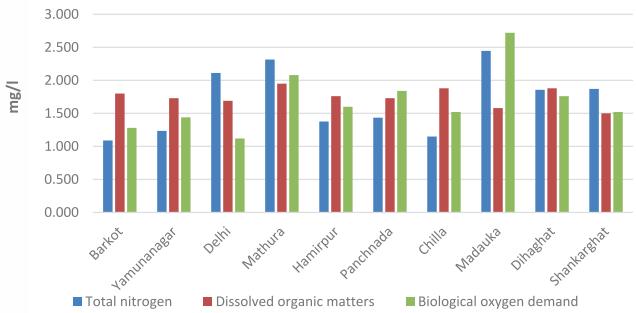
Transparency was reported highest at Barkot (25 cm) because of its pristine nature, low pollution, and higher water flow rate. The pH of all the stations was equal (6.8). Chloride ion concentration was recorded highest at Mathura (56.8 mg/l) and lowest at Barkot (7.1 mg/l). This may be due to pristine environmental condition of Barkot and higher domestic and agricultural waste disposal at Mathura. Bicarbonates ion was highest at Panchnada (190 mg/l) and lowest at Barkot (58.0 mg/l). Dissolved oxygen was highest at Barkot (10.46 mg/l) and lowest at Mathura (4.0mg/l) that may be because of high dissolved organic matter and pollution in NCR region of Delhi.

Physico-chemical parameters of sediment

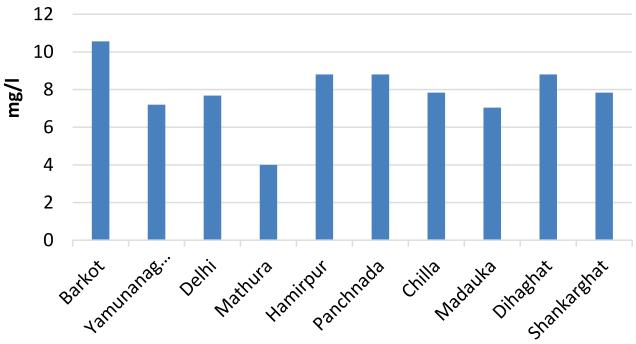
Clay percentage was recorded highest at Hamirpur (4.38%) and lowest at Yamuna Nagar (3.3%), I.T.O. Delhi (3.3%), Madauka (3.3%). Silt percentage was highest at Chilighat (25.8%) because of the runoff from all other rivers that merge at the Chillaghat; whereas, it was lowest at Jankichati (0.9%). The sand percentage was recorded



Station-wise average calcium ion, magnesium ion, and silicate ion in the river Yamuna



Station wise average Total Nitrogen, D.O.M., and B.O.D. in the Yamuna



Station-wise average dissolved oxygen levels in Yamuna

highest at Jankichati (95.3%) and lowest at Chilaghat (69.3%).

Free calcium carbonate concentration in sediment was highest at Yamunanagar and Karnal (12% each) and lowest at Agra (1%). Sediment available nitrogen (mg/100 g soil) was highest at the Ganga River stretch of the selected stations at Madauka (21), Dilhaghat (22.8), and Shankerghat (22.08) in sediment weight. The level of available phosphate (mg/100 g soil) was highest at Shankerghat (9.04) and lowest at Madauka (1.85) in sediment weight (Fig. 4).

Plankton and Chlorophyll

A total of 32 plankton species were recorded in winter and 48 species in monsoon season in River Yamuna during 2021. Plankton abundance ranged from 0.22-22 lakh u/l in the winter season and0.24-15 lakh u/l in monsoon. The lowest abundance was recorded at the upper stretch of river Yamuna, while the middle and lower stretch was highly variable in plankton richness and abundance. Chlorophyll *a* (chl-a) concentration ranged from 1.068-209.32 mg/m^3 in winter and 1.068-22.696 mg/m^3 in the monsoon season. The lowest chlorophyll-*a* concentration was recorded at Barkot in both seasons, while the highest concentration was recorded at Hamirpur in the winter season and Chilla ghat in the monsoon season. Periphyton load ranged from 100-5210 u/cm^2 in the winter season and 58-220 u/cm^2 in monsoon.

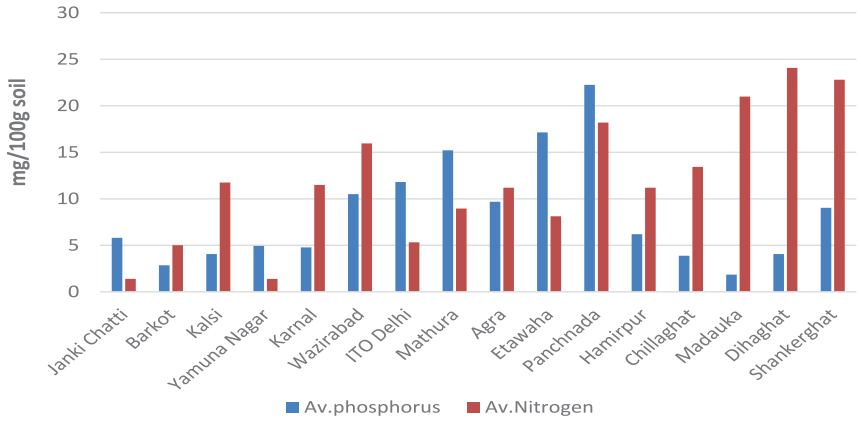
Simpson's diversity index ranged from 0.259-0.888 in winter and 0.666-0.912 in the monsoon season, respectively. Similarly, the Shannon index ranged from 0.509-2.349 in winter and 1.099-2.661 in the monsoon season. The lowest diversity was recorded at the upper stretch and higher diversity in the middle and lower stretches of river Yamuna.

Macrobenthic Analysis

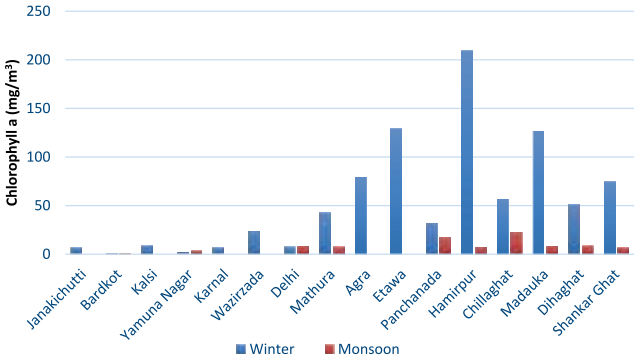
The monsoon sampling was done at ten selected sites during September-October 2021, which recorded 10 species (mollusc 4, bivalves 3, and insects 3) belonging to six orders and nine families. The benthos varied from 10-150 ind./m^2, with the highest species (5) abundance at Dihaghat. *Chironomous* was observed at four downstream sites and suggested organic pollution of the river. The only freshwater sinistral gastropod, *Physa acuta* was found in Wazirabad, which prefers polluted water and indicates pollution. The insect *Leptophlebia* sp., *Promoresia* sp., which favour fast running and well-oxygenated water of streams was dominant at upstream Barkot and found to be associated with bottom sediments. At the downstream, Gastropods such as *Bellamiya bengalensis*, *Melanoides tuberculata,* etc. and bivalves (*Parreysia favidens, P. corrugate, Corbicula striatella)* were observed during the monsoon season.

Fish species diversity

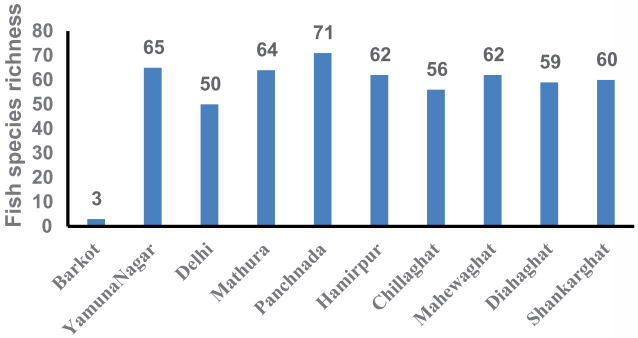
A total of 84 species belonging to 65 genera, 26 families, and eight orders were recorded. The species richness at Barkot, Yamunanagar, Delhi, Mathura, Panchnad, Hamirpur, Chilla ghat, and Mahewa ghat along the river Yamuna, Diha ghat, and Shankar ghat along the river Ganga were 3,65, 50, 64,71,62,56,62, 59 and 60, respectively.



Station-wise available nitrogen and available phosphorus concentrations in soil



Chl-*a* concentration at different stations of river Yamuna



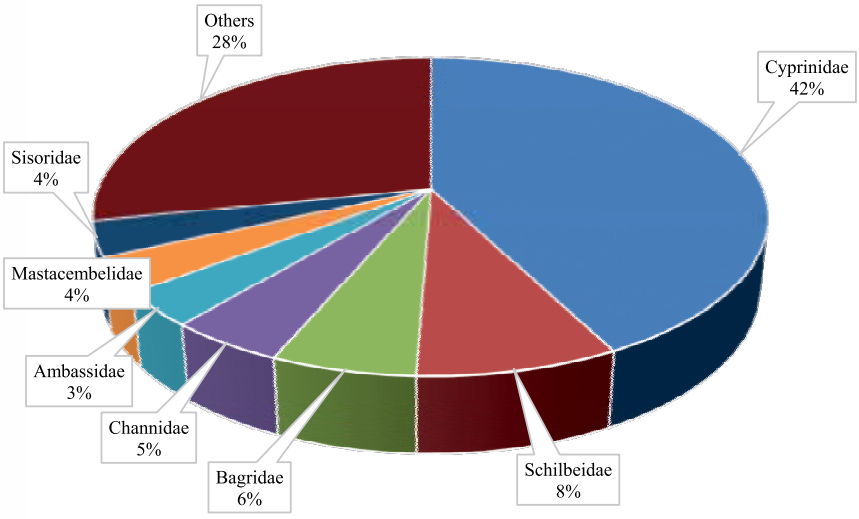
Fish species richness along the rivers Yamuna and Ganga

The nine orders recorded were Clupeiformes, Osteoglossiformes, Cypriniformes, Siluriformes, Perciformes, Gobiiformes, Beloniformes and Synbranchiformes. The most species-rich order was Cypriniformes (37), followed by Siluriformes (20) and Perciformes (14). Family Cyprinidae dominated (42%) with 34 species followed by Schilbeidae (18%), represented by seven species, Bagridae (6%) with five species, Channidae (5%) with four species, andAmbassidae (3%), Mastacembelidae, and Sisoridae with three species each. The remaining 19 families contributed the rest. Out of these, 7 were exotics viz. *Cyprinus carpio, Hypophthalmichthys molitrix, H. nobilis, Ctenopharyngodon idella, Oreochromis niloticus, Clarias gariepinus,* and *Pterygoplichthys disjunctivus*.

Out of 76 native species documented under this study, *Tor putitora* is under the Endangered (EN) category. *Naziritor chelynoides, Schizothorax richardsonii,* and *Wallago attu* were under the Vulnerable (VU) category. *Chitala chitala, Bagarius bagarius, Ailia coila,* and *Ompok bimaculatus* are under the Near Threatened (NT) category (IUCN, 2020). *Ailichthys punctatus*is under the data deficient category, while the remaining 68 species are under Least Concern (LC) category.

Pterygoplichthys disjunctivus recorded at Panchanada (Jalon) of the river Yamuna

At Barkotstation, the catch composition of minor fishes was mainly constituted by *Schizothorax richardsonii, Naziritor chelynoides, Barilius bendelensis,* etc. Exotics fish species form an important fishery in the river Yamuna, constituted mainly by *Oreochromis niloticus* and *Cyprinus carpio*. The dominant species at Yamunanagar were *Tor putitora, Labeo dyocheilus, Labeo dero, Cyprinus carpio, Sperata seenghala,* etc. At station Delhi, *Oreochromis niloticus* dominated in the catch, followed by *Cyprinus carpio* and *Clarias gariepinus*. At Mathura *Cyprinus carpio* and *Clarius gariepinus* dominated the catch. At Hamirpur, Panchnad, Chilla ghat, Mahewa ghat, Dhia ghat, and Shankar ghat *C. carpio* dominated the catch. The overall fish catch along the stretch of the Yamuna River showed a dominance of exotics, followed by the miscellaneous group of fishes.



Percentage representation of different families of fishes

Fish Landing

Estimated fish landing from Allahabad stretch of the river Ganga was 91.52 t during 2021 with 24.80% share of exotic fishes). In total fish catch, other group of fishes (miscellaneous) dominated (48.71%), followed by exotic fishes, catfishes, and Indian major carps. Common carp dominated over tilapia among the exotic fishes, while Mrigal had maximum contribution than Rohu, Catla and Calbasu among IMC. There was a decrease of 31.67% in average fish landing with respect to previous year which could be attributed to decrease in fishing efforts during the lockdown period due to COVID-19 pandemic and less market demand of consumer from fear of Coronavirus.

Project Title: Assessment of environmental variability, nutrient fluxes and biotic community interactions of a few mangroves stands of Indian Sundarbans eco-region

Project Code : REF/20-23/16

Duration : April 2020 to March 2023

Project Personnel : S. Dam Roy (P.I., up to 31.12.2021), Roshith C.M., Lohith Kumar, T. Nirupada Chanu, H. Chowdhury (up to 31.3.2021)

Surveys were conducted in December 2021 at Pathar Pratima and Bakkhali-Frazerganj in South 24 Parganas District of Indian Sundarbans eco-region on mangroves and sediment biota. Concerning mangroves in Pathar Pratima, site I (21°47'01.1" N and 088°22'45.0" E) was dominated by *Avicennia alba*, followed by *A. officinalis* and *A. marina*; the landside had the distribution of *Exoecaria agallocha*, *Sonneratia apetala*, *Aegialatis rotundifolia*, *Kandelia candel* and *Acanthus ilicifolius*. Site 2 (21°45'59.5" N and 088°22'46.1" E) was dominated by *Ceriops tagal, Sonneratia caseolaris, Aegiceras corniculatum, A. officinalis, A. marina* and *A. alba*. In Bakhkhali, Site I (21°32'41.7" N and 088°14'22.3" E) is dominated by *Avicennia alba*, *A. officiialis* and *A. marina*; *Rhizophora mucronata* and *Brugiera gymnorhiza* have sparse distribution there. *Sonneratia apetala*, *Ceriops decandra*, *Acanthus ilicofolius* and *Aegiceras corniculatum* are also available. At Site 2 (21°34'44.6" N and 088°14'23.4" E) of Bakkhali, which is near the sea mouth, is dominated by *Avecennia alba*; a few sparse trees of *Sonneratia caseolaris* can also be seen.

In Pathar Pratima the macrobenthos community is dominated by the gastropod *Cerithidia cingulata*, followed by *Teleoscopium teleoscopium*, *Nerita articulata*, *Cymialacera*, *Littorina melanostomata* and *Ellobium gangeticum*. The macrobenthos density ranged from 16-39m^2. In the site 1 of Frazerganj (Bakhkhali), the mangrove stands are also dominated by *Teleoscopium teleoscopium, Nerita articulata, Cerithidea obtusa, Cerithidea cingulata,* etc. *Littorina melanostomata* was found in abundance in the mangrove, leaf, and branches of *Avicennia officinalis; Nerita articulate* was also present but in less numbers. Site 2 (near the sea mouth, also called as 'Charbata') was once again dominated by *Cerithidea cingulata,* followed by *Nerita articulata, Teleoscopium teleoscopium, Cymialacera,* and *Pugilina cochlidium.* Apart from this the shell of *Tonna dolium, Murex* spp., and bivalves like *Macoma birmanica, Polymesoda bengalensis* were also observed. In Fraserganj *Neritia articulata* was recorded in the *Avicennia officinalis.* The quadrant study indicated macro-benthos density of 29-33 u/m^2 in Frazerganj.

Macro-bentihic population recorded at the sampling stations
1: *Telescopium Telescopium*, 2: *Cereithidia obtuse*, 3: *Thais lacera*, 4: *Amaca acuminata*, 5: *Cerithedia singulata*, 6: *Ellobium aurisjudae*, 7: *Littorina melanostoma*, 8: *Pythia pilcata*, 9: *Neritia ariculata*, 10: *Rock snails*,11: *Thais* shells

Project Title : Understanding spatio-temporal variations of reservoir ecosystems and developing improved fisheries management strategies for different eco-regions: a new perspective

Sub-project 1: Understanding spatio-temporal variations of large reservoir ecosystems (Hirakud, Panam, & Idukki) and developing improved fisheries management strategies

Sub-project 2: Development of ecosystem-based fisheries management strategies for medium reservoirs (Kodar, Upper Manair, Poondi, Seruli B) in different eco-regions

Sub-project 3: Refinement of culture based fisheries for small reservoirs (Gayatri, Beko, Upper Khaguria, & Sunei) in different ecoregions

Sub-project 4: Tropho-dynamic modeling of reservoirs for ecosystem-based fisheries management

Project Code : RWF/20-23/10

Duration : April 2020 to March 2023

Project Personnel : U.K. Sarkar (P.I.), A.K. Das (Sub-project 1 Leader), T.T. Paul, D. Sudheesan, Vaisakh G., W.A. Meetei, S.K. Koushlesh, C. Johnson, M.A. Hassan (Sub-project 2 Leader), Tasso Tayung, M. Feroz Khan, M. Karthikeyan, Ramya V.L., D. Debnath, S.C.S. Das, Lianthuamluaia (Sub-project 3 Leader), P. Panikkar (Sub-project 4 Leader), H. Chowdhury, Sajina A.M., A. Saha, S. Kumari, Mishal P., G. Karnatak, Sibina Mol S. and H.S. Swain

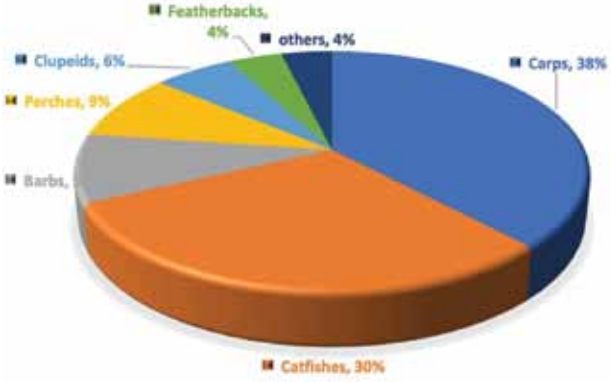
Sub-project 1: Understanding spatio-temporal variations of large reservoir ecosystems (Hirakud, Panam & Idukki) and developing improved fisheries management strategies

Ecology and fisheries of the Hirakud Reservoir

Hirakud Reservoir (21°30' & 21°50' N, and 83°30' & 84° 05' E) built across the river Mahanadi in Sambalpur district of Odisha has water spread area of 71,963 ha (FRL) and productive area of 54,076 ha and is being utilized for fisheries enhancement and cage culture. The experimental sampling was carried out at five points, namely, Jarimuli (Tamdei), Birenbandh, Kurla, Mahamadpur and Zeropoint (Durrakusum) in monsoon season for ecology and fisheries assessment.

The study revealed that the reservoir water depth varied from 6.22-11.40 m and the Secchi disc depth ranged from 79.0-139.0 cm. The pH of the water was slightly alkaline, ranging from 6.88 – 7.81 with an average of 7.35. The average DO value was 7.04 mg/l, average total alkalinity 54 mg/l, average specific conductivity 184.0 *µS/cm and total dissolved solids (TDS) was* 129 mg/l. The average nitrate-N and total phosphorus contents were 0.25 and 0.084 mg/l, respectively indicating moderate productivity of the reservoir. The gross primary productivity of Hirakud Reservoir was estimated to be 131.25 mgC/m^3/hr while the net primary productivity was 94.8 mgC/m^3/hr. Dominance of Cyanophyceae (26%) was observed in the reservoir during the monsoon season.

The CPUE ranged from 1.5-4 kg/day/fisher for gill net fishing while it was 100-150 kg/day for drag net fishing during monsoon season. Hooks and lines were also operated especially in the lotic zone of the reservoir. Catfishes contributed around 30% of the fish catch while carps including IMCs contributed to the tune of 38% of the fish catch of the reservoir. A total of 41 fish species under 15 families and 9 orders were recorded from the



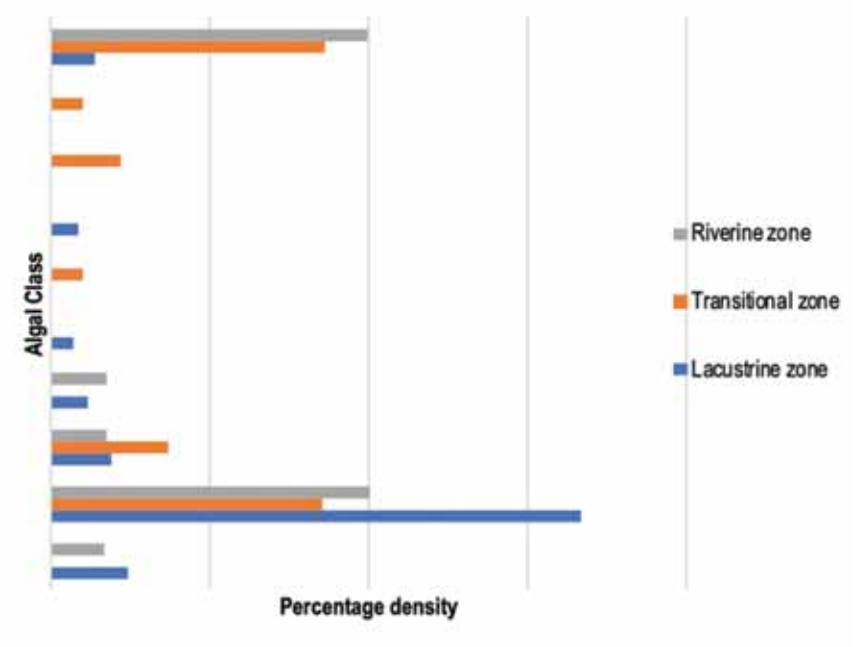
Fish catch composition of Hirakud Reservoir during monsoon season

commercial catches of the reservoir. Indigenous species included carps, catfishes, freshwater eels, etc.

Ecology and fisheries of the Panam Reservoir

Panam reservoir situated in the Panchmahal district of Gujarat was constructed in the year 1971 over the Panam River (Tributary of Mahi River) in the Mahi River basin. The reservoir is spread over a catchment area of 2314.46 km^2 and its area at FRL is 8,980 ha. Shoreline Development Index of the reservoir was estimated to be 6.035.

Water temperature of the reservoir ranged from 24-31 °C during the pre-monsoon and monsoon seasons. Total alkalinity in the reservoir varied from 119 to 142 mg/l and total hardness ranged from 88 and 112.7 mg/l. The average dissolved oxygen ranged from 7.29-9.16 mg/l and the average pH value was 8.5. The mean nitrate-N content varied from 0.11 to 0.19 mg/l and phosphate-P ranged from 0.01 to 0.045 mg/l. The available nitrogen of the sediment soil was found to be 26 mg/100g. Net primary productivity of the reservoir was estimated to be 77.09 mgC/m^3/hr. The phytoplankton analysis indicated that the density of *Microcystis* was relatively higher in the reservoir. The phytoplankton density of classes such as Cyanophyceae (blue green algae), Dinophycea (dinoflagellates) and Zygnemophytaceae (green algae) were significant in all the three zones of the reservoir during the study period. Among the blue green algae, *Microcystis* density was predominant, especially in the lacustrine zone of the reservoir. Among zooplanktons, nauplii and Cladocerans were dominant. Zooplankton density was higher in transitional and riverine zone of the reservoir. Among the catfishes, *Sperata seenghala* dominated the catch composition and fetches a very good price (₹ 250/kg) in local market. Occurrence of exotic fish species *Oreochromis niloticus* was also observed in riverine zone of the reservoir.



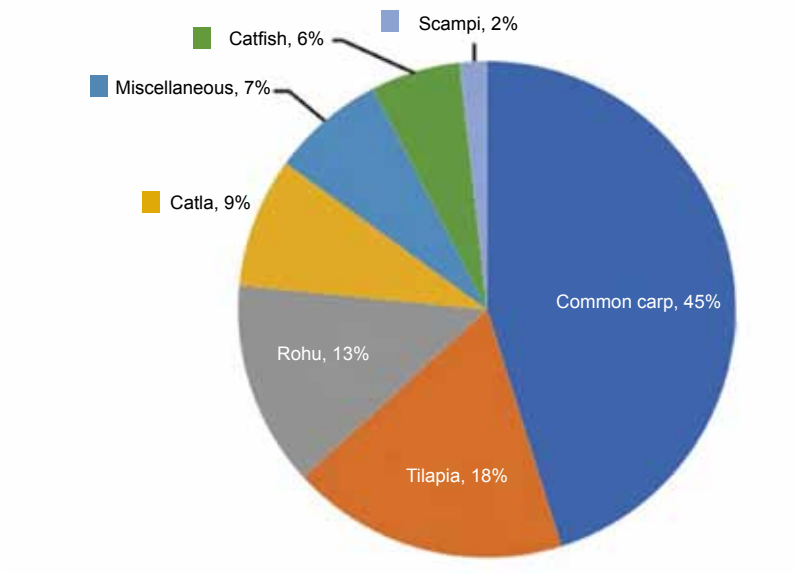
Zone wise percentage phytoplankton density in Panam Reservoir

Ecology and fisheries of the Idukki Reservoir

The Idukki Reservoir (9.839°N, 76.973°E), situated in Idukki district, Kerala, has a catchment area of 64 km^2, mean water depth of 32 m and a morpho edaphic index of 0.262. The indices based on morphometry indicated the suitability of reservoir for fishery enhancement through cage and pen culture system.

The trophic state index (TSI) of Idukki Reservoir was 31.67 indicating its oligotrophic nature. Out of the five algal groups, Bacillariophyceae (31%) was dominant in terms of abundance during post-monsoon season. While during pre-monsoon season, Chlorophyceae was the dominant group which constituted 36.82% of the total phytoplankton.

Indigenous fish species of the reservoir include *Ompok bimaculatus, O. malabaricus, Channa marulius, Tor* spp., *Mastacembelus armatus, Heteropneustes fossilis, Mystus* spp., *Anabas testudineus*, etc. Stocked fishes included IMCs, *Cyprinus carpio* and *Ctenopharyngedon idella. Labeo catla* and *Labeo rohita* contributed to the tune of 22% to the fish catch of the reservoir. Exotics found in the reservoir were *Arapaima* sp., *Cyprinus carpio*, *Ctenopharyngodon idella* and *Oreochromis* sp. Catch composition of Idukki Reservoir indicated that exotics dominated the catch to the tune of 63%. The major exotic species recorded from the reservoir included common carp (45%) and tilapia (18%). The predominance of exotics in the reservoir can have huge biosecurity concerns since the reservoir is situated in the Western Ghats biosphere.



Fish catch composition of Idukki Reservoir

Subproject 2: Development of ecosystem based fisheries management strategies for medium reservoirs (Kodar, Upper Manair, Poondi & Seruli B) in different eco-regions

This year, the Kodar Reservoir (21°11'40.3" N, 82°10'57.8" E), a medium size reservoir (2050 ha) located near Tumgaon in the district Mahasamund, Chhattisgarh was studied for ecology and fisheries. The main source of water of the reservoir is Kodar River, a tributary of the Mahanadi River. The reservoir is under the management of Chhattisgarh Matsya Mahasangh Maryadit (Chhattisgarh Co-operative Fisheries Federation Ltd.) which periodically stocks Indian major carp fingerlings to enhance the fish production of the reservoir. At present, the fishing right of the reservoir is leased to Jai Patai Mata Primary Fisheries Cooperative Society Ltd. for 10 years. The sampling was carried out at lotic, intermediate, and lentic zones during pre-monsoon and monsoon season.

Water and sediment quality

The water quality parameters recorded in the Kodar reservoir in pre-monsoon indicates conducive environment for fish production with water depth of 4.4-10.1 m, slightly alkaline pH of 8.4-8.74, water temperature 25.5-27.6 °C, dissolved oxygen 6.2-8.2 mg/l, total dissolved solids 79.3-82.5 mg/l, Secchi disk transparency 82-141 cm. In monsoon, the pH ranged from 7.8-8.06, dissolved oxygen 7.0-8.1 mg/l, total alkalinity 45-50 mg/l, specific conductivity 104.4-107.1 µS/cm and average total hardness 44-54 mg/l. Moreover, the nitrate-N and phosphate-P contents of the reservoir indicated low to moderate productivity of the reservoir. The net primary productivity of the reservoir was found to range from 41.66 to 62.5 mgC/m^3/hr in pre-monsoon while it was low (20-36.87 mgC/m^3/hr) in monsoon season. The analysis of sediment samples in the pre-monsoon and monsoon season showed low to medium productivity of the reservoir with available-P value of 1.22 mg/100g and organic carbon content of 1%. The sediment samples indicated predominantly sandy texture in pre-monsoon season.

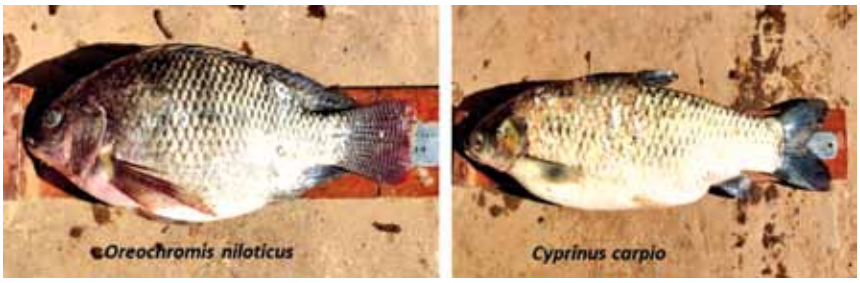
Plankton and macrophyte diversity

The plankon community of Kodar Reservoir was dominated by blue-green algae (*Microcystis* sp.) among the phytoplankton and *Diaphanosoma* sp. among the zooplankton. Infestation of aquatic plants in the reservoir was observed forming a thick bed in the shallow areas causing hindrances in fishing and navigation of boats. Around 10-15% of the reservoir was covered by aquatic plants. The common aquatic plants were *Hydrilla verticillata*, *Vallisneria* sp., *Ceratophyllum* sp., *Potamogeton* sp., *Ipomoea carnoea*, etc.

Fish and fisheries

A total of 40 fish species were recorded in the reservoir under 6 orders and 14 families. The Cyprinidae formed the most dominant family contributing 45% of the total fish species recorded. In the present study, eight additional species have been recorded from the reservoir viz., *Labeo gonius*, *Osteobrama cotio*, *Osteobrama vigorsii*, *Salmostoma phulo*, *Cabdio morar*, *Channa punctata*, *Pethia conchonius* and *Xenentodon cancila* which were not listed in the previous studies. Presence of four exotic fin fish, viz., *Ctenopharyngodon idella*, *Oreochromis niloticus*, *Cyprinus carpio* and *Hypophthalmichthys nobilis* were also observed.

Wooden boat of overall length of 10 feet is commonly used for fishing activities (especially for gill net operation). Boat made up of tin with an overall length of 5 feet was used specifically for hook and lines operation. Gill net of varying mesh size ranging from 0.5 inches to 14 inches was commonly used for catching the fish. Beside this,



Exotic fish recorded in Kodar Reservoir

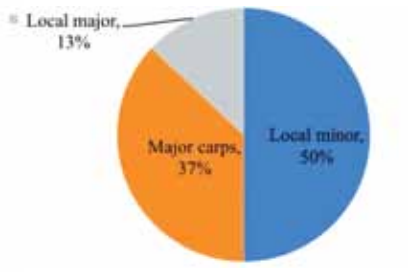
cast net and hook and line were operated occasionally. Also, hand seine net (*pelni jal*) was used for catching small freshwater prawns and small indigenous fishes. Bamboo made trap was used for catching small indigenous fishes and prawns.

Fishing in the reservoir is carried out by 230 fishermen. The main fishing gear employed for harvesting of fish is gill nets of varying mesh sizes (0.5 to 14 inches). In 2019-20, average fish catch per day was 147.94 kg, the highest fish catch per day was recorded in the month of August (377.15 kg/ day) and lowest was recorded in the month of April (54.43 kg/ day). The average fish catch per day per boat was estimated to be 8-12 kg. Based on the fish catch data of 2019-20, the present fish production and yield of Kodar Reservoir is 40.9 t and 19.95 kg/ ha/year, respectively. The monthly fish catch data indicated that the highest fish catch was observed in the month of November and December. During the monsoon, *Labeo catla* and other major carps were the main fish catch. Fishers' daily earnings immediately after the commencement of fishing season in monsoon were found highest (> Rs. 900) which might be due to the compliance with the monsoon fishing ban in reservoir.

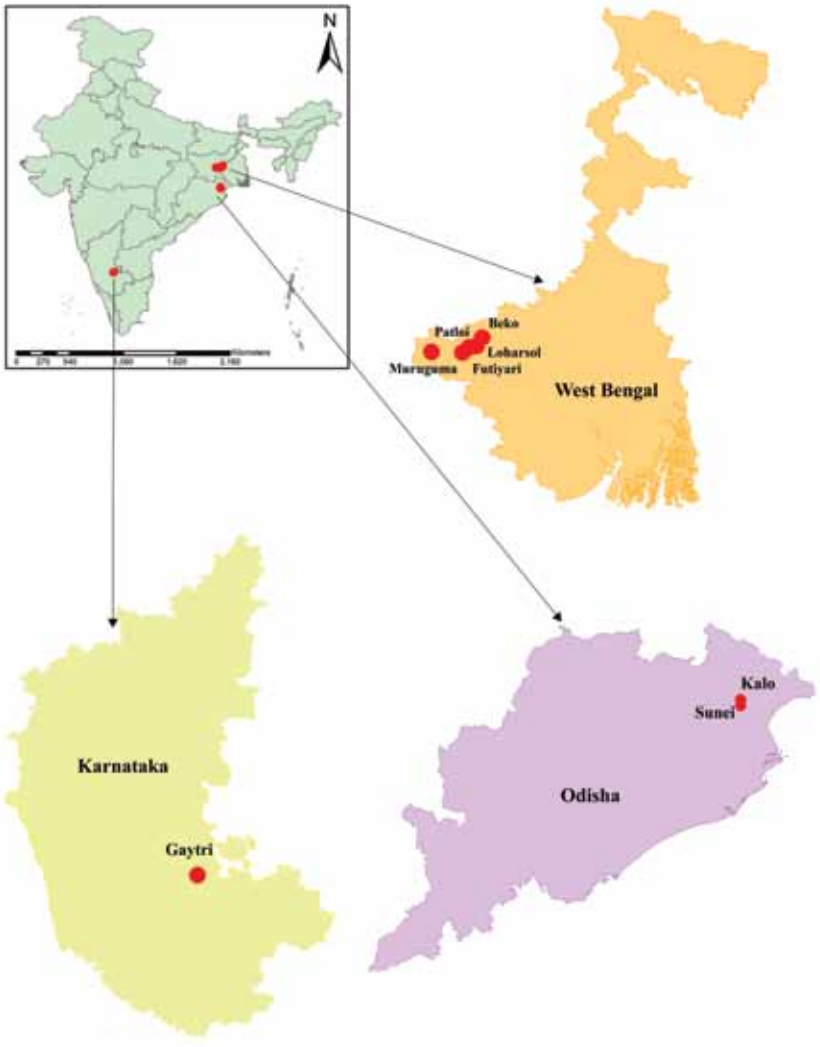
Fish catch composition in pre-monsoon comprised of 50 % local minor fishes (*Labeo gonius, Systomus sarana, Cirrhinus reba, Osteobrama* sp., *Notopterus notopterus, Anabus testudineus*) followed by 37 % major carps (IMCs, grass carp, bighead, common carp), and 13% other major fishes (*Labeo calbasu, Sperata* sp., *Channa* sp., *Ompok* sp., *Mystus* sp., *Wallago attu, Mastacembalus armatus*). Among the major carps, *Labeo catla* contributed the highest (72 %) followed by *Labeo rohita* (16 %) and *Cirrhinus mrigala* (12 %).

Subproject 3- Refinement of culture-based fisheries for small reservoirs (Gayatri, Beko, Upper Khaguria, & Sunei) in different ecoregions

An exploratory survey was conducted to assess the ecology and fisheries of five reservoirs (Beko,



Fish catch composition in the Kodar Reservoir

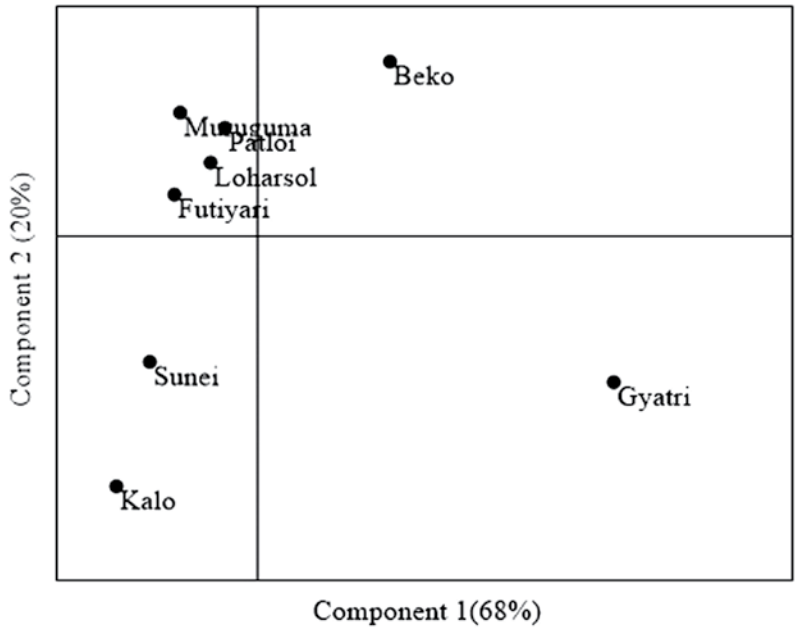


Location of the studied small reservoirs

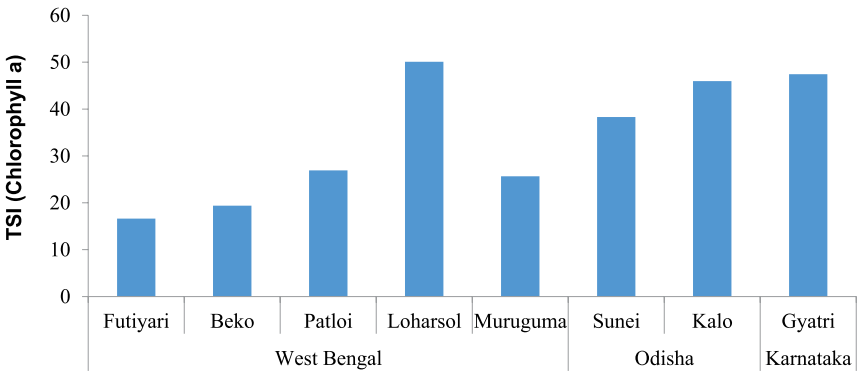
Patloi, Loharsol, Muruguma, Futiyari) in West Bengal, two reservoirs (Sunei, Kalo) in Odisha and one reservoir (Gayatri) in Karnataka.

Water quality and trophic state index

The water quality parameter analysis of the eight reservoirs indicated that the aquatic environments of the reservoirs were conducive for culture-based fisheries. Dissolved oxygen, one of the most critical water quality parameters for fisheries, ranged from 5.9 to 7.8 mg/l with the highest in Gayatri Reservoir and the lowest in Muruguma Reservoir. The water pH ranged from 7.2 to 8.5 with the highest in Gayatri reservoir and the lowest in Laharsol Reservoir. The pH of the studied reservoirs was neutral to slightly alkaline. The nitrate and phosphorus contents of the water were higher in the reservoirs of West Bengal and the lowest in Gayatri Reservoir, Karnataka. The conductivity and TDS were comparatively higher in Gayatri Reservoir but lower in the reservoirs of Odisha. The total alkalinity and total hardness were higher in Beko reservoir but comparatively lower in the reservoirs of Odisha. The Principal Component Analysis (PCA) was used to find out the pattern of water quality parameters variations among the selected reservoirs of different eco-region of India. The first two component of the PCA explained 88% of the total variations. The PCA indicated that Gayatri Reservoir of Karnataka was distinct from the other reservoirs located in the state of West Bengal and Odisha which might be due to the geographical location of the reservoirs. The trophic status of the reservoirs was assessed based on the trophic state index (TSI) using chlorophyll-*a* content of the water. The TSI value indicated that Loharsol, Gayatri and Kalo reservoirs were in the mesotrophic state but the other reservoirs were in oligotrophic state.



PCA showing the pattern of variation of water quality parameters in the selected 8 small reservoirs



TSI of the 8 selected small reservoirs of West Bengal, Odisha and Karnataka

Fisheries status

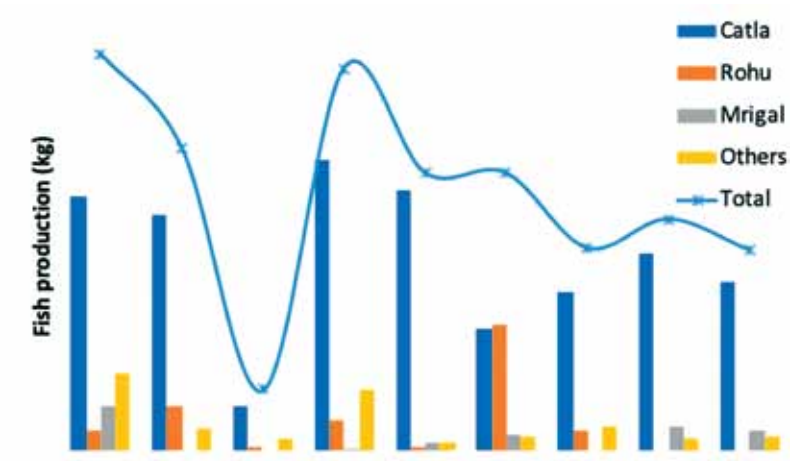
The fish production pattern in Sunei Reservoir, Odisha during 2012-2020 indicated that the production was highly fluctuating. The fish production has been decreasing in last six years. The decline in fish production may be due to the poor adoption of scientific stocking programme. The uneven fishing pattern and fishing effort could also be the important factor for the unsustainable and decreasing trend of fish production. The IMCs were stocked in the reservoir by the local Primary Fisheries Cooperative Society as well by other institutions including ICAR-CIFRI under SCSP programme. The regression analysis clearly indicated that stocking has a positive impact on fish production. The fish catch composition showed that the stocked fishes (IMCs) contributed around 90% of the total fish catch. The fish productions from Kalo Reservoir during 2018-19, 2019-20 and 2020-21 were 25.0, 30.9 and 50.2 t respectively.

The fish production from Gayatri Reservoir ranged from 62 to 125 t during 2016-17 to 2020-21. The highest fish production was achieved in 2017-18 and the lowest in 2016-17. Fish stocking was varying from 1.5 to 6.38 lakhs during 2016-17 to 2020-21. The fluctuation of the fish production might be due to the irregular stocking of fish seed in the reservoir. During the sampling period 22 fish species were observed in the reservoir. The cyprinidae was the most dominated family in the reservoir. The spatio-temporal analysis of the fish diversity indicated that the Shannon diversity index was having significant difference between the sampling seasons but there was no significant variation between the sampling stations.

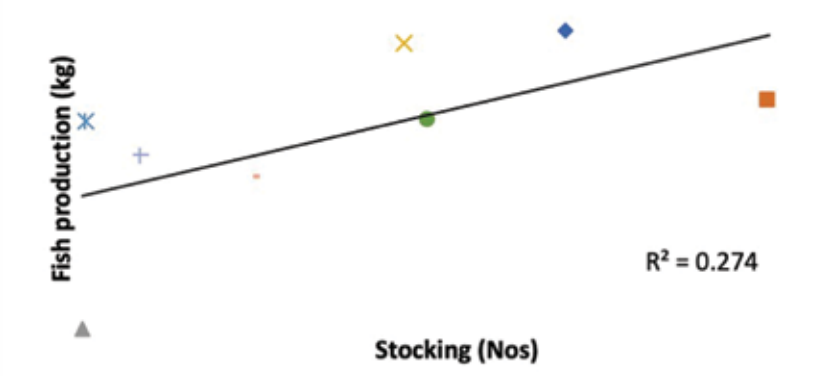
The daily fish catch per fisher in the small reservoirs of West Bengal ranged from 3 to 8 kg. Gill net was the main fishing gear operated in the selected small reservoirs of West Bengal except in Patloi Reservoir. The highest numbers of fishers were in Laharsol Reservoir with 250 fishers and the lowest was in Futiyari with 25 fishers. In most of the reservoirs fishing was done for 4 to 7 months in a year. Stocking was not practiced regularly in the studied reservoirs of West Bengal and the fish catch was dependent on the natural fish stock.

Sub-Project 4: Trophodynamic modelling of inland open water bodies for ecosystem based fisheries management

The biggest threat to biodiversity of inland water bodies in India is invasion by the non-native species. Two major species of tilapia, *Oreochromis mossambicus* and *O. niloticus* have invaded and expanded throughout India. The impact of these invasive tilapias on the foodweb structure in Manchanabele Reservoir was assessed by developing Ecopath models for two scenarios. Manchanbele Reservoir (12.97° N, 77.23° E) across the River Arkavathy in Karnataka, has a total area of 365 hectares. This reservoir was dominated by the *O. mossambicus* in the late 1990s. However, the mossambique tilapia population started declining after a decade and in last two decades, *O. niloticus* established in the reservoir forming a good contribution to the total fish catch. As a result of organised stocking with Indian Major Carps (IMC), there has been a shift in fisheries from the dominance of non -native species to IMC by 2016. The non-natives to IMC ratio was 4:3 in 2010-11, but it has gradually declined to 1:3 in 2016-17. Two models were developed: M model (dominance of *O. mossambicus*) and N model (dominance of *O. niloticus*). Despite fluctuations in abundance of various indigenous fish groups (murrels, cichlids, catfishes, gobids, major carps, barbs, minnows, and prawns) and invasives (tilapia) throughout the system, the core foodweb structure remains consistent.



Fish production pattern in Sunei Reservoir, Odisha in the last decade



Relationship of fish production and stocking of fish seed in Sunei Reservoir, Odisha

The Mixed Trophic Impact routine showed that *O. niloticus* and *O. mossambicus* affect several components of the modelled ecosystem: some negatively, others positively. The biggest impacts of *O. mossambicus* were negative, whereas those of *O. niloticus* were both positive and negative. The highest negative effect of *O. mossambicus* was on all fish groups including Indian Major Carps.

In contrast, *O. niloticus* did not negatively impact Indian Major Carps. Hence it co-exists with most commercially important fish groups in this reservoir.

The system indices indicate that replacement of *O. mossambicus* with *O. niloticus* caused moderate-to-strong changes in ecosystem function as shown in Table 1. These indices are useful in assessing the status of the ecosystem and its state of maturity. A generalized decrease of the flows of the system from *O. mossambicus* scenario to *O. niloticus* scenario is evident (–0.43%). The ecosystem in the *O. mossambicus* scenario was found to be more mature than in the *O. niloticus* scenario as there was a decrease in the primary production/total respiration ratio.

Project Title : Eco-orientation approach for fisheries enhancement of floodplain wetlands in diverse eco-regions of India

Sub-project 1: Eco-orientation approach for fisheries enhancement of floodplain wetlands in NE States of India

Sub-project 2: Eco-orientation approach for fisheries enhancement of floodplain wetlands in West Bengal

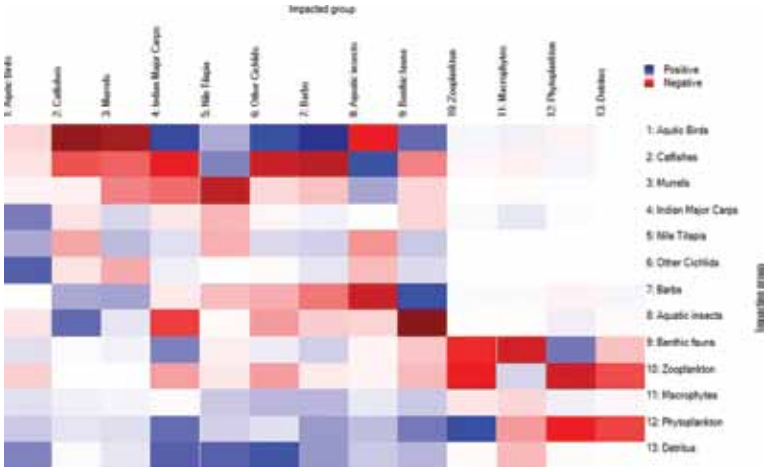
Sub-project 3: Eco-orientation approach for fisheries enhancement of floodplain wetlands in Bihar

Sub-project 4: Eco-orientation approach for fisheries enhancement in floodplain wetlands in UP/MP

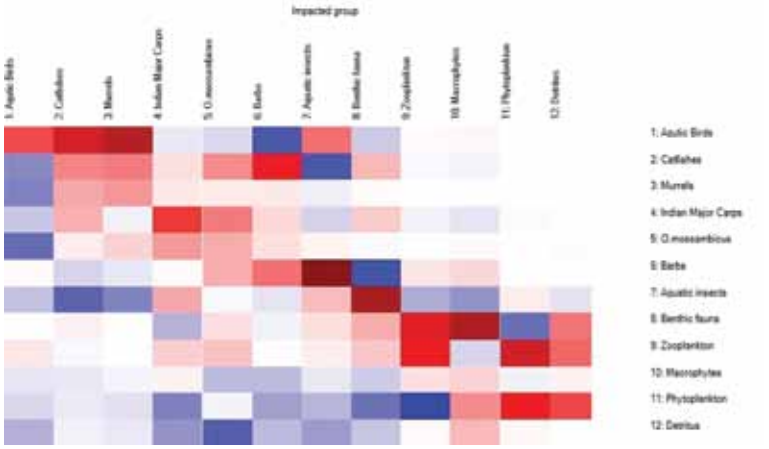
Project Code : RWF/20-23/11

Duration : January 2020 to December 2023

Project Personnel : A.K. Das (P.I.), U.K. Sarkar, B.K. Bhattacharjya, A. Sinha



(a) M model



(b) N model

The Mixed Trophic Impact Routine of Manchanbele Reservoir showing the impact of (a) *O. mossambicus* and (b) *O. niloticus* on other groups

Table 1. System summary indices of Manchanbele Reservoir modelled for two scenarios

Parameter	M model	N model
Sum of all consumption	1871.76	2281.23
Sum of all exports	1368.05	2124.42
Sum of all respiratory flows	570.985	975.58
Sum of all flows into detritus	1647.03	2444.01
Total system throughput	5457.83	7825.24
Sum of all production	2865.46	3949.40
Calculated total net primary production	1939.04	3100.00
Total primary production/total respiration	3.40	3.20
Net system production	1368.06	2124.42
Total primary production/total biomass	15.15	18.71
Total biomass/total throughput	0.023	0.021
Total biomass (excluding detritus)	128.00	165.65
Connectance Index	0.32	0.338
System Omnivory Index	0.203	0.219
Ecopath pedigree	0.4	0.6

(Subproject 3 leader), Md. Aftabuddin, A.K. Bera, G. Chandra, D. Debnath (Subproject 1 leader), S. Yengkokpam, S.C.S. Das, S. Borah, P. Das, A.K. Yadav, Lianthuamluaia, A. Alam (Subproject 4 leader), J. Kumar, V.R. Thakur, M. Gupta (up to 8.10.2021), N. Sharma

Sub-project 1: Eco-orientation approach for fisheries enhancement of floodplain wetlands in NE States of India

Fish diversity of wetlands

Four beels of Assam, namely Lakhanabandha, Rupahi, 46-Morakolong, and Dandua were studied during the year. The fish yield during 2020-21 were found to be 610, 504.7, 335.1 and 1047.2 kg/ha/yr from Lakhanabandha, Rupahi, 46-Morakolong, and Dandua beels, respectively.

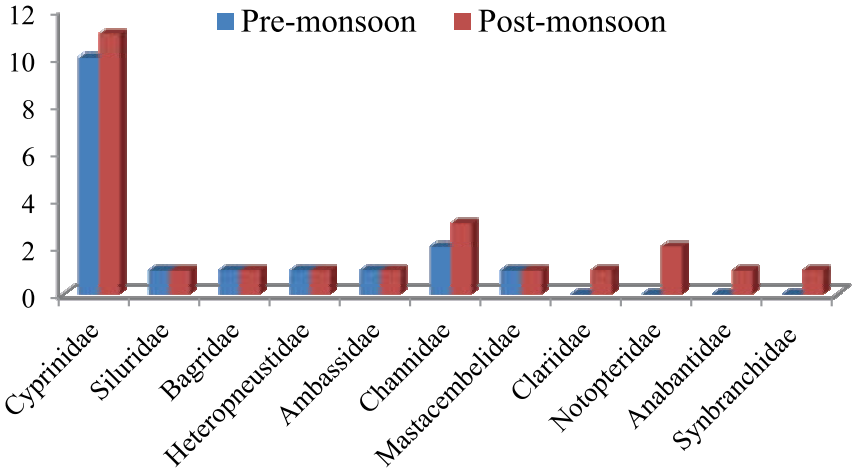
Lakhanabandha beel

Lakhanabandha beel (26°32'3.47"N, 92°53'11.59"E) is a closed floodplain wetland located in Nagaon district of Assam and is under the administrative control of AFDC Ltd. The wetland is having a water spread of 30 ha. A total of 24 fish species under 11 families were recorded from the beel during the course of the survey in post-monsoon and pre-monsoon seasons. Fish diversity was found to be higher during post-monsoon (24 species) as compared to pre-monsoon (17 species). Cyprinidae was found to be the most dominant family contributing 45.83% of the total number of species, followed by channidae (12.50%).

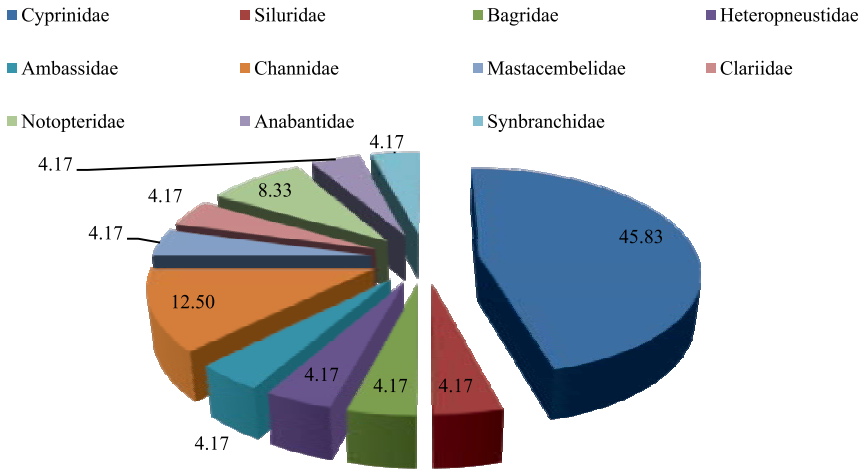
Rupahi Beel

Rupahi beel (26°26'22.465"N, & 92°47'33.95"E) is a seasonally open floodplain wetland located in Nagaon district of Assam and is

A view of the Lakhanabandha beel, Nagaon

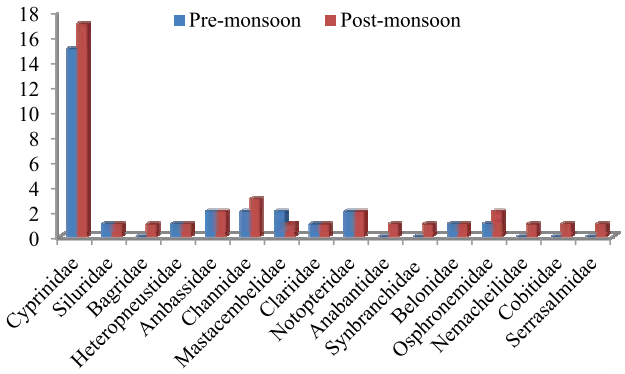


Seasonal variation of fish species richness in Lakhanabandha beel

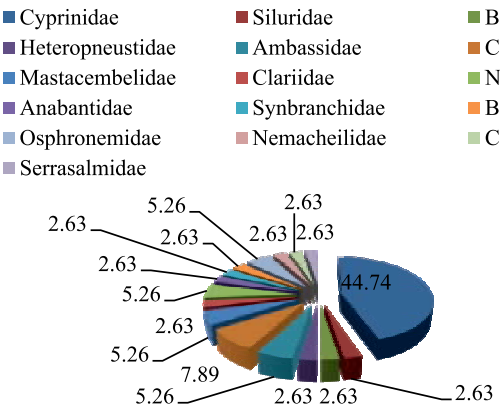


Relative abundance of fish families in Lakhanabandha Beel

A view of the Rupahi beel, Nagoan



Seasonal variation of fish species richness in Rupahi beel



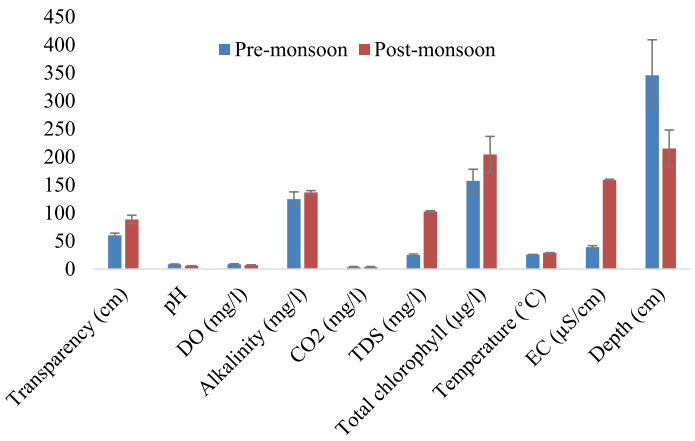
Relative abundance of fish families in Rupahi beel

Piaractus brachypomus recorded from Rupahi beel

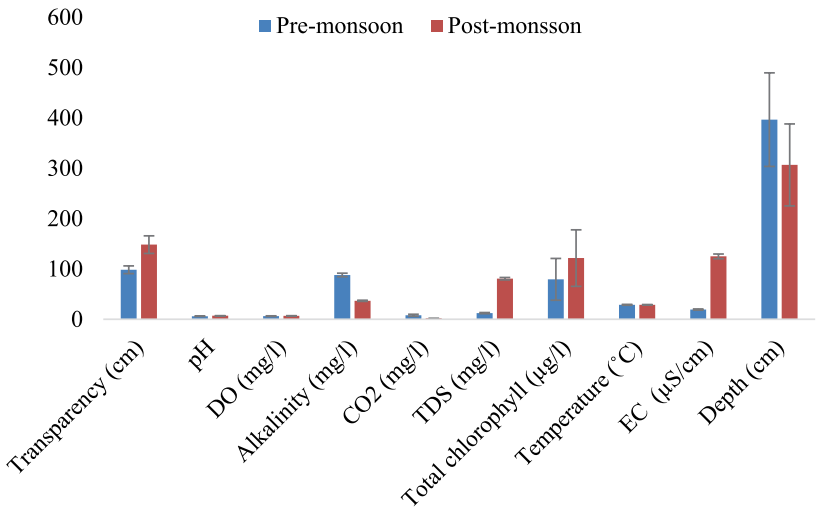
under the administrative control of AFDC Ltd. The wetland is having a water spread of 75 ha. A total of 38 fish species under 16 families were recorded from the beel during the course of the survey across two seasons, *viz.*, post-monsoon and pre-monsoon. Fish diversity was reportedly higher during post-monsoon (37 species) as compared to pre-monsoon (28 species). Cyprinidae was found to be the most dominant family contributing 44.74% of the total number of species reported followed by Channidae (7.89%). The exotic fish *Piaractus brachypomus*, weighing 2.11 kg and having a length of 21.6 cm, was recorded from Rupahi beel during the survey.

Water quality of the wetlands

Water quality parameters were analysed in pre-monsoon and post-monsoon seasons in Lakhanabandha and Rupahi beels. Significant differences in water quality parameters *viz.* transparency, pH, DO, TDS, water temperature, EC and water depth ($p>0.05$) were observed in Lakhanabandha beel; however, the difference was not significant for alkalinity, CO_2 and total chlorophyll. In case of Rupahi beel, significant difference in water quality parameters ($p>0.05$) across the seasons was observed in transparency, pH, alkalinity, CO_2, TDS and EC, while significant difference was not observed for



Limno-chemistry of water of the Lakhanabandha beel



Limno-chemistry of water of the Rupahi beel

DO, total chlorophyll, water temperature and water depth.

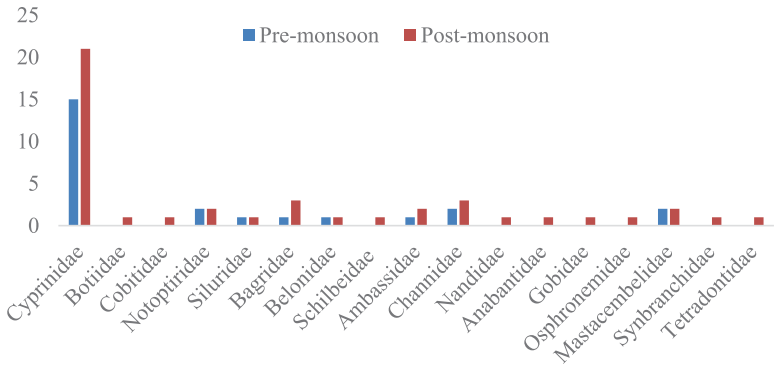
Primary productivity and production potential

The mean gross primary productivity (GPP) of the Lakhanabandha beel was 103.33±20 mgC/m³/hr, while in Rupahi beel it was estimated to be 123.75±31.25 mgC/m³/hr. Considering 1% of this GPP, production potential of Lakhanabandha beel was estimated to be 271.56±52.56 kg/ha/yr and that of Rupahi beel it was 379.42±95.81 kg/ha/yr. Production potential estimated in the present study is based on phytoplankton only and the values will definitely increase if macrophyte and detrital food chain are also considered, as the latter two contributes significantly to the productivity of floodplain wetlands.

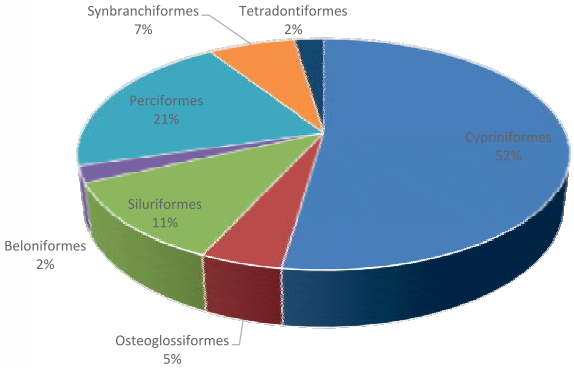
Fisheries of the Dandua Beel

Dandua beel (26°14′75″ N, 92°21′82″ E) is a closed floodplain wetland located in Morigaon district of Assam and is under the administrative control of AFDC Ltd. The wetland is having a water spread of 50 ha. A total of 44 fin fish species under 17 families were recorded from the beel during the course of the survey across two seasons *viz.* pre-monsoon and post-monsoon. Fish diversity was higher during post-monsoon (44 species) as compared to pre-monsoon (25 species). Order Cypriniformes was found to be the most dominant contributing 60 % followed by Perciformes (12%).

A view of the Dandua beel, Morigaon, Assam



Seasonal variation in fish species richness of the Dandua beel, Morigaon

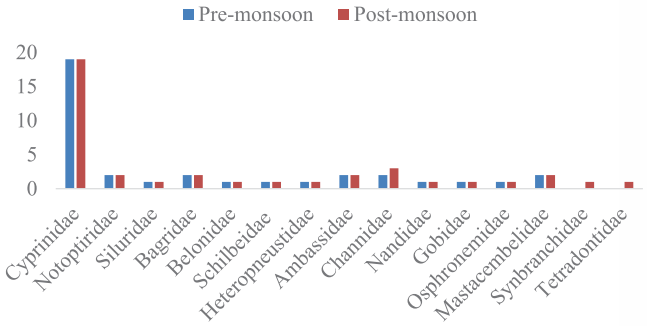


Order-wise relative abundances of fishes in the Dandua Beel

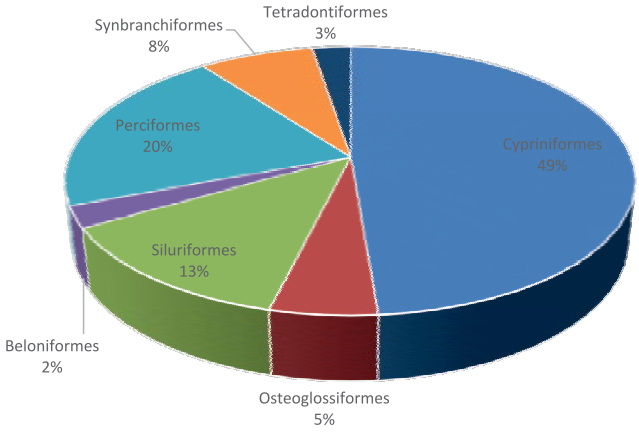
Fisheries of the 46- Morakolong beel

46-Morakolong Beel (26°14′72″ N 92°19′35″ E) is a seasonally open floodplain wetland located in Morigoan district of Assam and is under the administrative control of AFDC Ltd. The wetland is having a water spread of 76 ha. A total of 39 fish species under 15 families were recorded from the beel with higher diversity during post-monsoon (39 species) as compared to pre-monsoon (36 species) season. Order cypriniformes was found to be the most dominant contributing 49% followed by perciformes (20%).

A view of the 46-Morakolong Beel, Morigaon



Seasonal variation of fish species richness in 46-Morakolong beel, Morigaon



Order-wise relative abundances of fishes in 46-Morakolong beel, Morigaon

Water quality of Dandua beel and 46-Morakolong beel, Morigaon

Limno-chemistry of water in the two beels indicated productive environment for fishes. Seasonal water quality parameters were assessed in pre-monsoon and post-monsoon seasons. Average water temperatures in Dandua and 46-Morakolong beel were 30.10 °C and 31.38 °C, respectively. Slightly acidic pH was observed in both the beels in pre-monsoon, while in post-monsoon, the pH was 7.02 and 6.80 in Dandua and 46-Morakolong beel respectively. Average DO in Dandua and 46-Morakolong beel were 7.68 mg/l and 6.61 mg/l respectively. Parameters viz, total alkalinity (79-96.67 mg/l), free CO_2 (0-0.87 mg/l), electrical conductivity (126.17-157.67 µS/cm) and TDS (81.5-102 mg/l) were congenial.

Sub-project 2: Eco-orientation approach for fisheries enhancement of floodplain wetlands in West Bengal

Four wetlands (Rampara, Chara, Beloon, Daserchara) of Murshidabad, West Bengal were surveyed to assess the ecology and fisheries during 2021. The fisheries of Rampara, a seasonally open beel is managed by Shaktipur Rampara Fisherman Cooperative Society Ltd. having 720 members of which 50-60 members are fishing in the beel regularly. The beel area is 14.5 ha which is reduced to 7.4 ha in summer. Stocking is usually done in post-monsoon @ 15,000 no./ha and complete harvesting in April-May. The annual fish production of the wetland was 6.5 t. Besides the major carps the other small indigenous fishes including *Nandus nandus,*

Table 2. Limno-chemistry of water in Dandua and 46-Moralong beel, Morigaon district

	Dandua beel			46-Morakolong beel		
Parameters	**PRM**	**POM**	**Mean+ SD**	**PRM**	**POM**	**Mean + SD**
Water depth (m)	2.80±0.80	2.67±0.67	2.73±0.66	1.50±0.10	1.37±0.15	1.43±0.14
Air temp. (°C)	27.43±0.32	33.62±0.17	30.53±3.39	29.19±0.26	34.84±0.17	32.02±3.1
Water temp. (°C)	27.27±0.21	32.93±0.71	30.10±3.14	28.90±0.10	33.85±0.49	31.38±2.73
pH	6.88±0.13	7.02±0.13	6.95 ±0.13	6.30±0.44	6.80±0.08	6.55±0.39
DO (mg/l)	8.53±0.23	6.83±0.18	7.68±0.95	8.13±0.23	5.09±0.15	6.61±1.68
EC (µS/cm)	35.93±2.12	22.33±2.08	28.13±8.75	157.67±9.50	94.67±7.37	126.17±35.32
TDS (mg/l)	23.33±1.15	12.67±1.53	18±5.97	102±6.00	61.00±8.19	81.5±23.36
TA (mg/l)	29.33±1.15	26.67±1.15	28±1.79	96.67±3.06	61.33±2.31	79 ±19.5
CO_2 (mg/l)	0.67±1.15	0.53±0.23	0.60±0.75	0.00±0.00	1.73±0.23	0.87±0.96
Transparency (m)	1.30±0.20	1.44±0.09	1.37±0.16	0.88±0.06	0.82±0.04	0.85±0.05

Amblypharyngodon mola, *Labeo bata*, *Mastacembelus armatus, Chanda nama, Parambassis ranga, Mystus tengara, Mystus vittatus, Mastacembelus pancalus, Macrognathus aral, Gudusia chapra, Anabas tesudineus, Clarius magur, Heteropneustes fossilis, Glossogobius giuris, Systomus sarana, Puntius* sp., *Channa* sp., were available in the wetland. Floating macrophytes covered 15% beel area with the dominance of *Eichhornia crassipes, Salvinia* sp., *Lemna minor, Lemna major, Pistia* sp., *Azolla* sp. and *Hydrilla vorticillata.* The rooted submerged macrophytes like *Potamogeton* sp. and *Vallisneria* sp. covered around 20% of the wetlands.

Chara beel is a seasonally open beel managed by Shaktipur Rampara Fisherman Cooperative Society Ltd. About 70-80 fishers are fishing in this beel regularly. The beel area is around 30 ha which is reduced to 14 ha in summer. Fish production is around 10 t with the sale value Rs. 12 lakh. Apart from IMC, indigenous fishes like *Amblypharyngodon mola*, *Nandus nandus, Labeo bata*, *Mastacembelus armatus, Mastacembelus pancalus, Macrognathus aral, Gudusia chapra, Chanda nama, Parambassis ranga, Mystus tengara, Mystus vittatus, Anabas tesudineus, Clarius magur, Heteropneustes fossilis, Glossogobius giuris, Systomus sarana, Puntius* sp., *Channa* sp., were found in the wetland. Floating macrophytes covered 15% of the beel area and 20% of the wetland was infested with rooted submerged macrophytes.

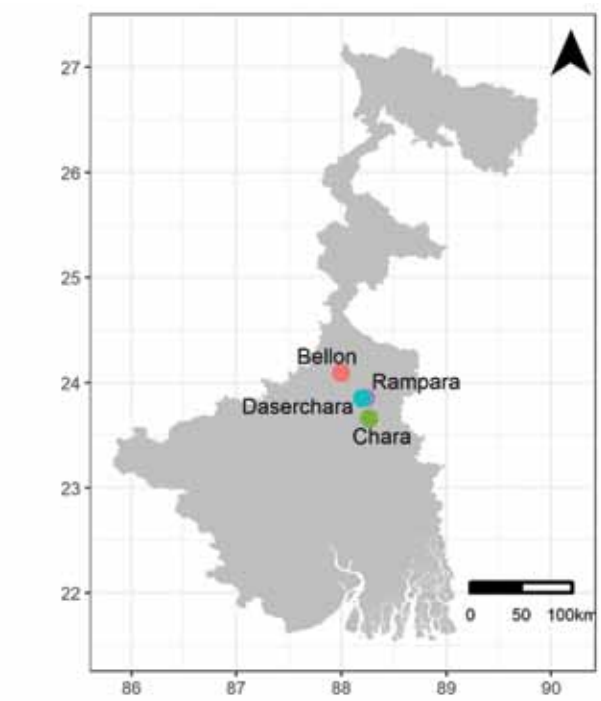
Beloon wetland is an open beel with Nagar Dhibar Samabai Samitee functioning as prime FCS with 302 members. The beel area is 335 ha which gets further expanded in monsoon inundating vast tract of nearby areas while in summer it gets reduced to even below 100 ha. Around 300 members are regularly fishing in this beel and ₹150-200/day/fisher was the average income from this beel. During sampling period, 70% of the beel area was infested with macrophyte (50% floating, 50% submerged). The common floating macrophytes in the wetlands were *Eichhornia crassipes, Lemna minor, Lemna major, Pistia* sp., *Azolla* sp. *Naja naja, Chara* sp., and *Hydrilla verticillata.* The common rooted submerged marcophytes were *Potamogeton* sp. and *Vallisneria* sp. Coverage with periphytic algae is worth mentioning. The craft being operated is only palm canoe. Gill nets with mesh size of 100-300 mm, 24 mm, 12 mm and 8 mm were operating in the wetland. No drag netting was practiced in this beel. Besides IMC and minor carps, the indigenous fishes including *Nandus nandus, Amblypharyngodon mola*, *Mastacembelus armatus, Mastacembelus pancalus, Macrognathus aral, Gudusia chapra, Chanda nama, Parambassis ranga, Mystus tengara, Mystus vittatus, Sperata aor, Xenontodon cancila, Anabas tesudineus, Clarias magur, Heteropneustes fossilis Glossogobius giuris, Systomus sarana, Puntius* spp., and *Channa* spp. were available. Open water fishery with no stocking is the regular practice. There is an immediate need to rejuvenate the beel through de-weeding, de-silting in littoral areas and clearing the openings of the beel mouth with Bhagirathi.

Daserchara wetland is managed by Daserchak Matsyajibi Samabay Samiti with 150 members. It is a closed beel with an area of 42 ha. Around 100 members were fishing regularly in this beel. Besides IMC, the indigenous fishes including *Gudusia chapra, Amblypharyngodon mola, Xenentodon cancila, Puntius* spp., *Mystus vittatus, M. tengara, Channa* spp., *Chanda nama, Parambassis ranga, Anabas testudineus* and *Heteropneustes fossilis* were available in the wetland. No catch is shared with the FCS. The daily earning by the fishing member is ₹200-250 with 1.5-2.0 kg fish being caught per day. Around 30% of the water was covered by macrophytes (40% floating, 60% submerged). The submerged macrophytes create hindrance in operating fishing gears especially drag nets. In most occasions, gill nets and traps are being used with no mesh regulation.

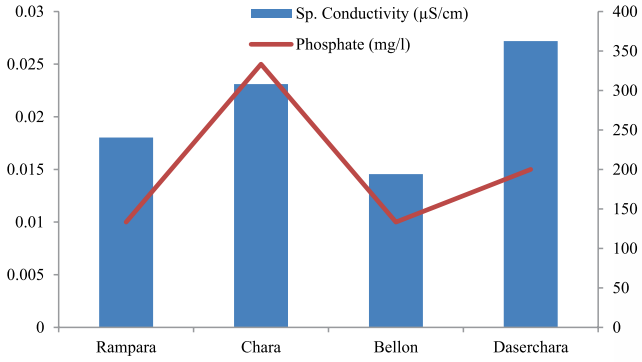
The analysis of water quality parameters indicated that most of the critical parameters like pH, DO, alkalinity were in the favourable range for fish production. The productivity parameters like phosphate-P and specific conductivity indicated that Chara and Daserchara beel were the most productive among the wetlands. The Principal Component Analysis (PCA) of the water quality parameters indicated that Beloon and Daserchara beel were highly distinct from the other two wetlands. Phytoplankton diversity and abundance were almost similar in the four wetlands. The species richness of phytoplankton was highest in Rampara (46), followed by Daserchara (45), Chara (44) and Beloon (44) beel.

Sub-Project 3: Eco-orientation approach for fisheries enhancement in floodplain wetlands in UP/MP

Four wetlands each in Uttar Pradesh and Madhya Pradesh were surveyed this year. These are Kitaman tal (150 ha), Jatiya tal (83 ha), Bakwa tals (13 ha) and Ramgarh tal (678 ha) in Uttar



Location of the studied wetlands of Murshidabad, West Bengal



Variations of specific conductivity and phosphate-P in four wetlands of Murshidabad, West Bengal

Pradesh and Govindgarh lake (307 ha), Devendra Nagar Lake (190 ha), Nirpat Sagar (240 ha) and Lokpal Sagar lake (185 ha) in Madhya Pradesh. All these tals barring Kitaman are Government-owned water bodies and leased for ten years through tendering to the highest bidders among the Fishers' Cooperative Societies.

A total of 47 fish species belonging to 32 genera, 18 families, and 7 orders were recorded from the tals of Uttar Pradesh while 22 species representing 19 genera, 9 families, and 5 orders were documented from the wetlands of Madhya Pradesh. Fish species richness in the wetlands of Uttar Pradesh viz. Kitaman, Jatiya, Bakwa and Ramgarh tals were 43, 46, 37 and 36, respectively. The fish species in the wetlands of Madhya Pradesh viz. Govindgarh, Devendra Nagar, Nirpat Sagar and Lokpal Sagar were 15, 8, 5, and 10, respectively. It was observed that the order Cypriniformes contributed significantly among all followed by Perciformes from the selected wetlands. Among the fish species recorded during the study *Clarias magur* is categorised as Endangered (EN), *Wallago attu* as Vulnerable (VU), and *Parambassis lala* and *Chitala chitala* as Near Threatened (NT) under the IUCN Red List status (2020).

The selected wetlands of Uttar Pradesh were stocked with fingerlings of IMCs, grass carp, Chinese carp, silver carp, and bighead carp @ 4000-5000 no./ha during August-September. The wetlands in Madhya Pradesh were arbitrarily stocked with fingerlings of IMC in the range of 2-3 lakhs per wetland by the state department in the monsoon season. The fish yield in all these tals ranged between 100-1500 kg/ha. IMCs were the most important contributors to the fisheries contributing between 13% (Lokpal Sagar) and 80% (Kitaman tal), followed by exotics. Harvesting was continuous except for July and August. The technology of pen culture for raising the stocking materials (fingerlings) *in situ* was not being adopted. In all these tals, the culture-based capture fisheries were practiced.

The physical composition of sediment reflected the dominance of sand in all the wetlands (60-99%). Chemically, the sediment was slightly acidic to alkaline with pH 6.4 to 8.5, sp. conductance 0.040-0.463 mS/cm, and free $CaCO_3$ 0.5-12 %. Organic carbon was moderate in Ramgarh Tal (1.47 %), Bakwa Tal (1.09 %), Govingarh lake, (1.01 %), Devendra Nagar (1.25 %), but in other wetlands, it was 0.24-0.77% only. The nutrient status in respect of available -N ranged from 90.84 to 217 mg/kg while available-P ranged 23.5 to 148.53 mg/kg.

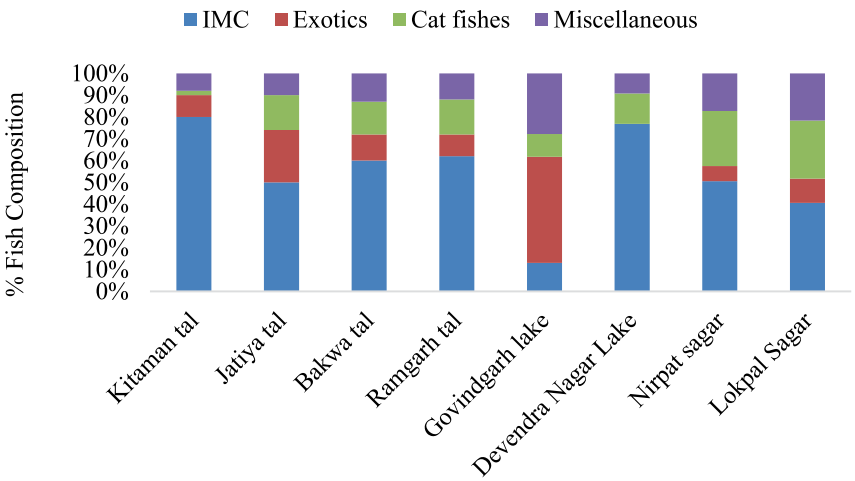
The analysis of water quality of the selected wetlands in Uttar Pradesh and Madhya Pradesh indicated that the transparency ranged from 31.6-106.3 cm, DO 5.01-11.28 mg/l, pH 7.3-9.1, alkalinity 29.3-190.3 mg/l, specific conductance 40-230.3 µS/cm and dissolved organic matter 2.4-4.9mgle. The nutrient status of water in respect of silicate, nitrate-N, and phosphate-P ranged from 1.5 to 4.4 mg/l, 0.323 to 0.69 mg/l and 0.002 to 0.61 mg/l, respectively. The gross primary productivity and the net primary productivity ranged from 44.4 to 97.2 mgC/m^3/hr and 27.77 to 69.45 mgC/m^3/ hr, respectively.

Macrobenthos consisting of four species of Gastropoda, one of Bivalvia, two of Insecta, and one of the Oligochaeta with abundance ranging from 266 (in Kitamantal) to 630 (in Ramgarhtal) no./m^2 were recorded from the wetlands of Uttar Pradesh. In wetlands of Madhya Pradesh also 10 species of benthos (gastropod 06, bivalves 02, and insects 02) with abundance ranging from 20 to 20-230 no./m^2 were recorded.

A total of 94 plankton species belonging to Bacillariophyta, Chlorophyta, Charophyta, Cyanobacteria, Euglenozoan, Myozoa, Ochrophyta, Cryptophyta, and Ciliata in the selected wetlands of Uttar Pradesh with abundance ranging from 130060 to $28x10^6$ u/l were observed, whereas only 19 species of plankton were recorded in the wetlands of Madhya Pradesh belonging to Bacillariophyceae, Chlorophyceae, Myxophyceae, Euglenophyceae and Rotifera with abundance ranging from 80000 to $1.2x10^6$ u/l. Chlorophyll ranged from 10.68 (Kitamantal) to 987.9 (Jatiya) mg/m^3 in the wetlands of Uttar Pradesh, while it ranged from 3.78 (Nirpat Sagar) to 6.75 (Devender Nagar) mg/m^3 in the wetlands of Madhya Pradesh.

A view of the Ramgarh Tal

A view of the Govindgarh Lake



Relative abundance of fishes in selected wetlands of UP and MP

Project Title: Fish health management and antimicrobial resistance in inland open waters

Project Code : FREM/17-20/14

Duration : 2017-2021

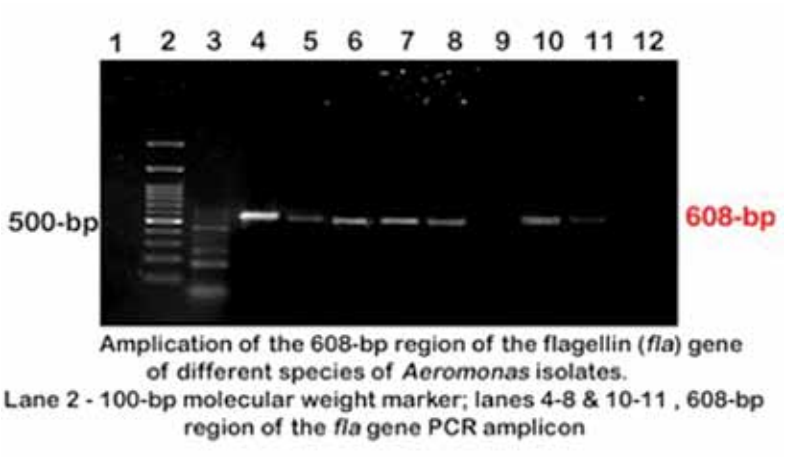
Project personnel: B.K. Das (P.I.), S.K. Manna, B.K. Behera, R.K. Manna, H. Chowdhry, A.K. Bera, A.K. Sahoo, D.J. Sarkar, R. Baitha, Vikas Kumar, D.K. Meena, H.S. swain, D. Das, M. Shaya Devi, S. Das Sarkar, Santhana Kumar V. and V. Kumar

Bacterial association in TiLV infection in Tilapia

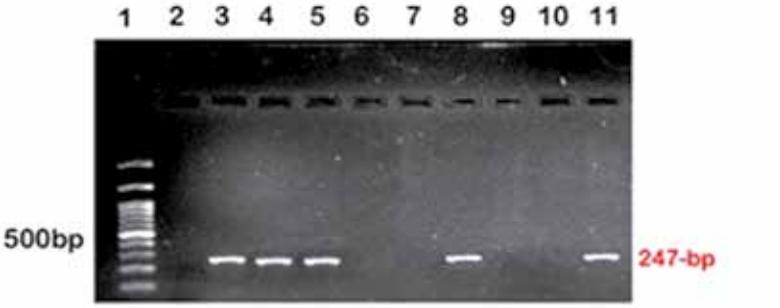
Concurrent infection by more than one pathogens make disease management difficult. To understand combined infection of virus and bacteria a detailed investigation of disease outbreak in a farm in East Midnapore, West Bengal in summer of 2021was conducted. The diseased fishes developed hemorrhagic lesions at ventral and anterior aspects, protruded eyes, circling movement, lethargy, reduced feed intake and death. In the polyculture system, mortality was highest in Tilapia (*Oreochromis niloticus*) and 60% of Tilapia stock died in a month. Laboratory screening for TiLV using nested PCR revealed that 75% (18/24) of tested fish were positive for the viral infection. Moribund fishes were also examined for bacterial infection through standard isolation and identification from 16S rDNA gene sequence. The study revealed simultaneous presence of *Aeromonas hydrophila, A. caviae, Klebsiella pneumoni, Pseudomonas aeruginosa* and *Edwardsiela tarda* in TiLV infected fishes. In pathogenicity study, all these bacteria proved their virulence at moderate to high degrees suggesting that mortality in TiLV infection might be aggravated due to concurrent presence of virulent bacterial pathogens. Hence, preventive measures against both bacteria and virus are suggested for management of TiLV disease in Tilapia.

Molecular detection of virulence genes in *Aeromonas* spp. isolated from diseased fishes

Understanding the virulence genes in bacteria pathogens are of utmost importance for pathogenesis study as well as therapeutic management of fish diseases. In this study PCR assays were performed for the detection and amplification of aerolysin (*aer*A; 431 bp), lipase (*lip*; 247 bp) and the structural gene flagellin (*fla*; 608 bp) in



Amplication of the 608-bp region of the flagellin (*fla*) gene of different species of *Aeromonas* isolates.
Lane 2 - 100-bp molecular weight marker; lanes 4-8 & 10-11 , 608-bp region of the *fla* gene PCR amplicon



Amplication of the 608-bp fragment of the lipase (*lip*) gene of different species of *Aeromonas* isolates.
Lane 1, 100-bp molecular weight marker;
lanes 3-5, 8 & 11, 608-bp region of the *lip* gene PCR amplicon

Detection of flegelin (*fla*) and lipase (*lip*) gene in *Aeromonas* isolates from diseased fishes

Aeromonas isolates. The study showed that 80% of the *Aeromonas* isolates were carrying the *aer*A gene (amplicon length: 431bp), 43.3% isolates were positive for the *fla* gene (amplicon length: 608bp) and 56.6% of the isolates carried the *lip* gene (amplicon size: 247bp).

Pathogenic *Vibrio cholerae* strain EMM1 isolated from *Labeo rohita*

Occurrence of fish disease caused by zoonotic pathogens is a serious concern along with antimicrobial resistance development. A fish disease survey was conducted in natural wetlands of Moyna, West Bengal, India based on informed mass mortality of *Labeo rohita*. Moribund fishes showing clinical signs of hemorrhagic patches on the body were studied for bacterial pathogens. *Vibrio cholerae* was isolated from diseased fish and the bacterial species of was confirmed through culture in specific media, biochemical characterization, and 16S rRNA sequencing. The strain was named as *V. cholerae* EMM1. It produced flat yellow colonies on TCBS Agar. Antibiotic sensitivity assay showed that this strain was resistant to dicloxacillin (D/C) but susceptible to ampicillin (AMP), amoxylac (AMX), ceftazidime (CAZ30), cefepime (CPM30), cefixime (CFM5), colistin (CL10), ciprofloxacin (CIP5), chloramphenicol (C30), doxycycline, (DO10), erythromycin (E10), fosfomycin (FO200), gentamicin (GEN10), imipenem (IPM10), nalidixic acid (NA30), netilmicin sulphate (NET30), nitrofurantoin (NIT), ofloxacin (OF2), piperacillin (PIT100/10), polymyxin B (PB300), rifampicin (RIF5), streptomycin (S25), trimethoprim (TR5), tetracycline (TE) and tobramycin (TOB10). This strain exhibited β-hemolysis on agar. Liquid phase hemolysis assay showed that there was complete hemolysis at 16h of incubation. The strain possessed virulence genes like hemolysin (*hlyA*) and repeats in toxin *(rtxA*) but other virulent genes like *O1-rfb*, *O139-rfb*, *ctxAB*, *ctxA*, *tcpA*, *tcpA(c)*, *zot* were absent. *In vivo* toxicity study revealed 100% mortality of *L. rohita* after 84h of injection with 1.04×10^7 CFU/ml of *V. cholera* EMM1. Histopathological changes in diseased *L. rohita* consisted of breakdown of intestinal epithelium, degenerated hepatocytes, degeneration of renal tubules and muscle bundles. EMM1 is a non-choleragenic *V. cholera* but has pathogenic potential to *L. rohita*. This report on new pathogen of *L. rohita* draws attention for proper management of fisheries in natural wetlands.

Fish health investigation in freshwater cages of Madhya Pradesh

A study was undertaken in more than 300 cages in 8 reservoirs/lakes of Madhya Pradesh. Pangasius (*Pangasianodon hypophthalmus*) was the major cultured species, followed by common carp and tilapia. Suboptimal water quality including low dissolved oxygen (DO) levels due to city sewage pollution was a major problem in Halali dam and Lower Lake. Mass mortality of fish, especially common carp, was reported from Halali dam due to severe fall in oxygen levels. Fishers/cage fish farmers had to regularly apply a large amount of lime and potassium permanganate to improve water quality of the Lower Lake.

Fish mortality from infectious diseases such as septicaemia, fungal infections were reported from majority of the cage sites. A septicaemic condition in Pangasius, with signs of petechial haemorrhages, intra-abdominal gas accumulation and small nodule formations in kidneys, and about 25% fatality rate was recorded in cages in Yaswant Sagar dam. Following culture isolation the causative agents of the disease outbreak were identified as *Edwardsiella ictaluri* and *Klebsiella pneumoniae*.

Molecular identification of endoparasites from different inland open waters

Endoparasite infestation has substantial adverse impact on fish

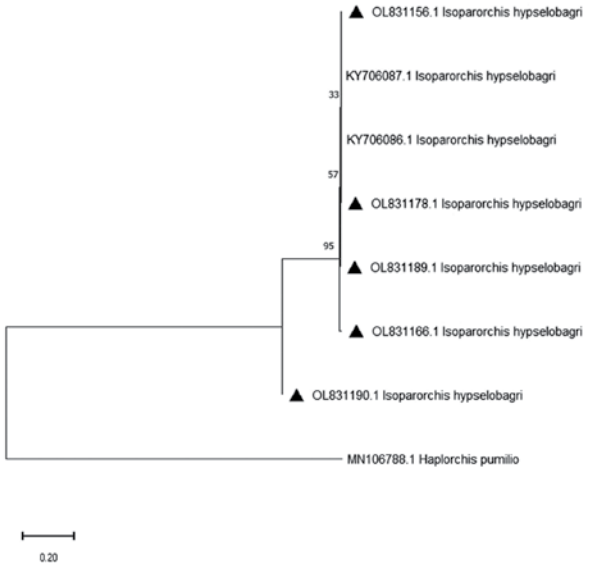
Pangasius with mild petechial haemorrhage and gas formation in the abdomen

health and production but most of the times these effects are ignored. The presence of metacercarial stage of *Isoparorchis hypselobagri* was observed in different fishes such as *Mastacembelus armatus* (OL831156.1), *Ompok bimaculatus* (OL831166.1, OL831178.1), *Sperata seenghala* (OL831189.1) and *Wallago attu* (OL831190.1). The parasites were identified using cytochrome oxidase subunit I gene sequencing. A phylogenetic tree was inferred using Neighbor-Joining method in MEGA X software and sequence homology was compared.

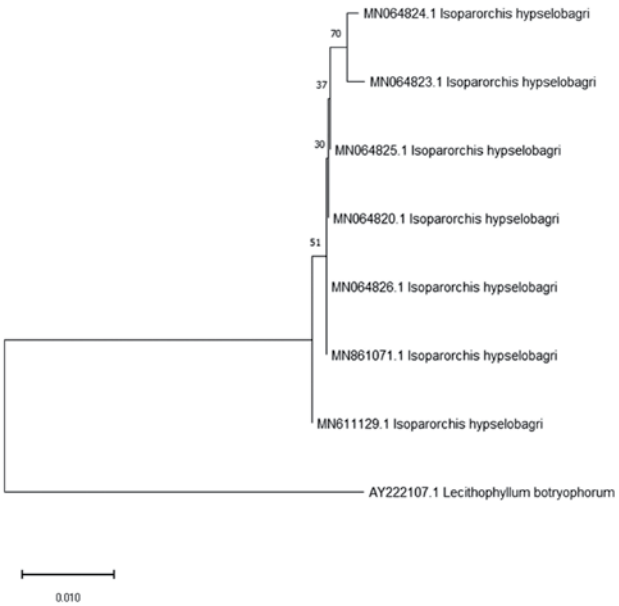
The parasites were also identified using 18S rRNA gene sequencing. The sequence generated (633-704 bp) were submitted to GenBank and accession number were obtained. A phylogenetic tree was inferred using Neighbor-Joining method in MEGA X software.

In-silico interaction study of plant compounds with aerolysin

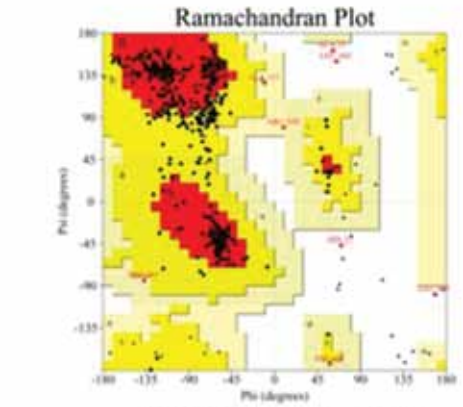
Plant derived compounds are effective against various pathogens through various biochemical and molecular mechanisms. Before *in vivo* trial of such compounds, it is wise to predict the probable lead molecules and their mechanistic pathway of effectiveness. In this direction, compounds belonging to esters and ketones were isolated from the aquatic macrophyte, *Cyperus rotundus*. The 3D structure of aerolysin with 493 residues was done by homology modelling using MODELLER 9.24 program. The energy minimization was performed by GROMOS 96 force field and visualized in Swiss PDB viewer 4.1.0.The Ramachandran plot analysis showed that 71% of the residues were in the most favored region and 28.1% in allowed regions with only 1% in disallowed regions. Various physicochemical parameters were predicted using the ProtScale server and ExPASyProtParam Tool. The molecular weight (54598.11 Dalton), Theoretical Iso-electric point, pI (5.75), number of atoms (7591), residual properties (negatively charged 52 & positively charged 46) were calculated. The instability and aliphatic index are 25.92 and 77.89 which classifies the protein to be stable with a grand average of hydropathicity (GRAVY) (-0.430). The results of sequence-based profile analysis show the values of hydrophobicity are -2.867 (359 aa) to 2.544 (15aa), polarity 6.344 (15 aa) to 16.267 (119 aa), bulkiness 8.661 (180 aa) to 18.469 (318 aa) and % accessible residues 3.833 (66 aa) to 7.911 (263



Cytochrome oxidase subunit I based phylogenetic tree of *Isoparorchis hypselobagri* metacercaria isolated from different fish species



18S rRNA based phylogenetic tree of *Isoparorchis hypselobagri* metacercaria isolated from different fish hosts



Ramachandran Plot of aerolysin protein.
[Core regions, most favored (red); additionally allowed regions (yellow); generously allowed regions (grey) & disallowed regions (white)]

Twenty pockets in the aerolysin protein.
The three pockets which had a large volume, have been represented using three colour, namely, red, blue, and violet.
The other smaller pockets have been shown in pink colour.

Validation of aerolysin using Ramachandran plot and visualization of it's binding pockets by CASTp

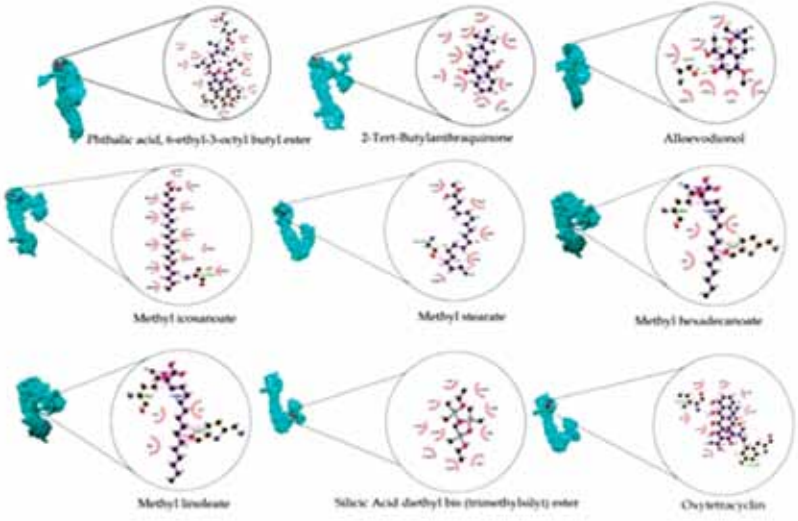
aa) respectively. The parameters with higher scores project the characteristics of aerolysin.

The CASTp server identified twenty pockets in the structure of the aerolysin protein. The largest pocket in the aerolysin protein had a volume of 2158.884 Å3 and was composed of 45 amino acids. The smallest pocket within the protein structure had a volume of 0.782 Å3, with only 8 amino acid residues.

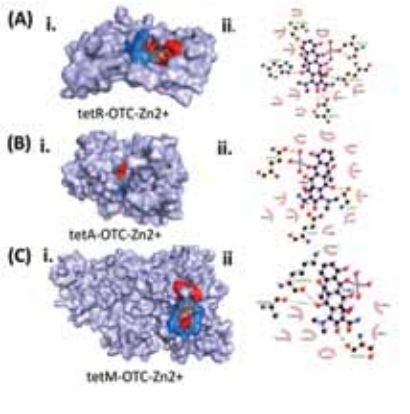
Molecular Docking: The ligands and the flexible molecular docking interaction with aerolysin protein was visualized using UCSF CHIMERA software. A significant interaction was observed in the binding pockets. The intermolecular docking complex revealed non-covalent hydrophobic interactions and hydrogen bonding. The interacting amino acid residues prospectively forming the complexes were identified. Six out of eight isolates had higher shape complementarity score than OTC, of which methyl icosanoateas was found to be the strongest. The AI score was highest for phthalic acid derivative followed by methyl hexadecanoate. The least ACE was observed in anthraquinone derivative followed by methyl icosanoate and phthalic acid derivative. Thus it could be assumed that anthraquinone derivative, phthalic acid derivative and methyl icosanoate constituted the active compounds of the plant extract with activity against *Aeromonas* spp. and could be used in formulation of natural drug substances or added to antibiotic oxytetracyclin to enhance antibacterial activity or reduce dose.

Docking simulation of nano-OTC against resistant genes of *Aeromonas hydrophilla*

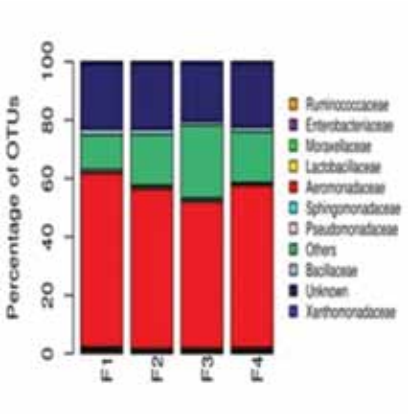
Nano-formulation of conventional antibiotics are useful for bacterial disease management and addressing antimicrobial resistance. Previous *in vitro* studies had showed that oxytetracycline (OTC) encapsulated into ZnO nanoparticles (nano-OTC) had better antibacterial efficacy against oxytetracyline resistant *A. hydrophilla*. Hence an effort was taken to deduce the molecular mechanism of nano-OTC activity against resistant *A. hydrophilla*. Protein-ligand docking simulation (AutoDock-4) showed that nano-OTC had very high ligand binding energy (> -5.00 kcal/mol) against *tetR*, *tetA* and *tetM* genes of *A. hydrophilla* as compared to OTC (<-9.00 kcal/mol). Hence it could



Molecular docking of the ligands (plant compounds) with aerolysin



Molecular docking simulation of nano-OTC on tetracycline resistance genes (*tetR*, *tetA* and *tetM*) of *A. hydrophilla*



Comparative gutmicrobiome following in-feed administration of *Terminalia arjuna* bark powder

be postulated that nano-OTC can escape these resistance proteins and bind to respective ligand sites on 30S ribosomal subunit. Docking simulation also revealed that both OTC and OTC@nZnO are having very low ligand binding energy (< -13 kcal/mol) towards 16S rRNA of 30S ribosomal subunit.

Prebiotic characteristics of *Terminalia arjuna* bark powder (TABP) based fish feed

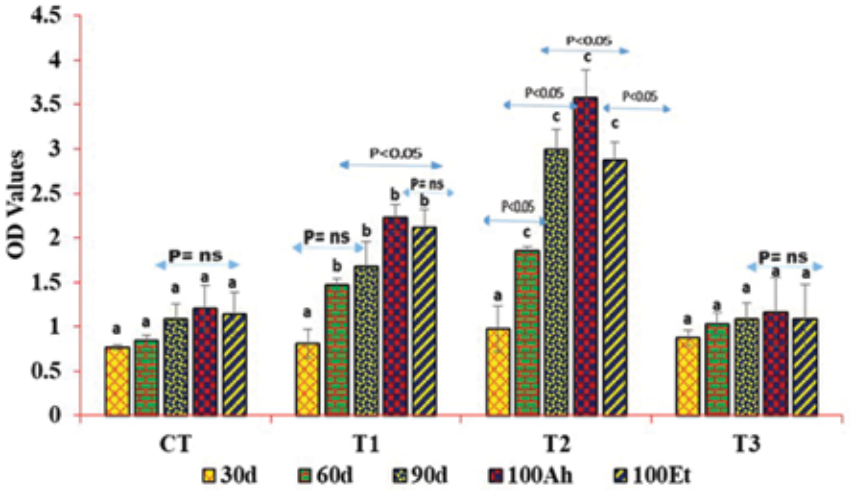
The dietary TABP based feed was fed to *Labeo rohita* at four inclusion levels (0 g TABP/kg of feed, 1g TABP/kg of feed, 10g TABP/kg of feed, and 15 g TABP/kg of feed) followed by Gut metagenomics. The result reveal that 10g/kg TABP could alter the gut microbial population, particularly probiotics bacteria. Gut microbiome study showed a better community structure and proved the hypothesis of "normobiosis" that illustrate about the increment in the numerical abundance of beneficial bacterial community which is an indication that TABP might have acted as prebiotic in fish.

Dietary TABP enhances immunoglobulin (IgM) levels in *Labeo rohita*

Herbal powders have potential to enhance fish immunity which can be monitored by evaluating immunoglobulin levels. The *Terminalia arjuna* bark powder was fed to *Labeo rohita* at four graded levels (0, 1, 10 and 15 g TBAP/kg of feed) for 90 days followed by challenge study for 10 days (represented as 100 days) with two pathogenic bacteria viz., *Aeromonas hydrophila* and *Edwardsiella tarda*. Serum IgM levels of fishes were examined. Results showed no significance difference among the treatments in IgM level at 30 days, however at 60 days a significant change ($p<0.05$) was observed. Among the treatments maximum value was recorded at 10 g TABP/kg of feed as compared with other treatment groups. During challenge study the IgM level differ significantly ($p<0.05$) between and within the treatment groups. The study showed more IgM level against *A. hydrophila* as compared to *E. Tarda* challenged fish.

Terminalia arjuna bark extract enhances disease resistance in fish

A 15-day intraperitoneal inoculation experiment followed by challenge study for 10 days against *A. hydrophila* and *E. tarda* was performed to evaluate the effects of fractionated ethanolic bark extract of *T. arjuna* on disease resistance. *T. arjuna* extract at concentrations above the minimum inhibitory concentration (MIC) of the corresponding extract (7.02±0.20 µg/ml) at doses of 0, 80, 100 and 120 µg/ml (CT, T1, T2, and T3, respectively). The fixed volume of 50 µL was inoculated intraperitoneally to each fish. The relative percent survival (RPS) of fish was significantly ($p<0.05$) higher among the T1 and T3 treatments. The RPS can be represented as T3>T2>T1>CT in



Variations in serum immunoglobulin M levels in indoor feed trial and challenge study

both *A. hydrophila* and *E. tarda*. The highest value of RPS was reported at T3 treatment (120 µg/ml) when fish was challenged with *A. hydrophila* (86.25%) and *E. tarda* (78.75 %).

Immunomodulatory potency of extract of *Eclipta alba* (Bhringaraj) leaf

Immunopotentiation may be helpful in control of ectoparasite infection in fish. With this aim a herbal extract was evaluated against *Ichthyophthirius multifiliis* infection in Pangasius (*Pangasianodon hypophthalmus). I. multifiliis* infected Pangasius (weight: 15.83 ± 2.8 g) were collected from ICAR-CIFRI culture facility. Examination of wet mounts of disloged parasites from skin and gills revealed oval to round shape large ciliated parasites (trophont) with horseshoe-shaped or sausage shape macronucleus which is pathogenic sign of *I. multifiliis* infection. Group of 10 *P. hypophthalmus* fingerlings were randomly put in glass aquaria containing 20 litres of water. The aquaria were supplemented with increasing concentrations of methanolic leaf extract *viz*., 5 (T1), 10 (T2), 25 (T3), 50 (T4), 75 (T5) and 100 mg/l (T6) for 168h. The non-exposed fingerlings were maintained as controls. Analysis of blood showed significant change in protein, serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT), superoxide dismutase (SOD), catalase (CAT) and HSP70 in the Bhringaraj leaf extract treated fish, as compared to control. Overall, the results revealed that *E. alba* methanolic leaf extract could be used as a potential immunomodulatory agent to enhance the immune reactivity and protect *P. hypophthalmus* from *I. multifiliis* infection.

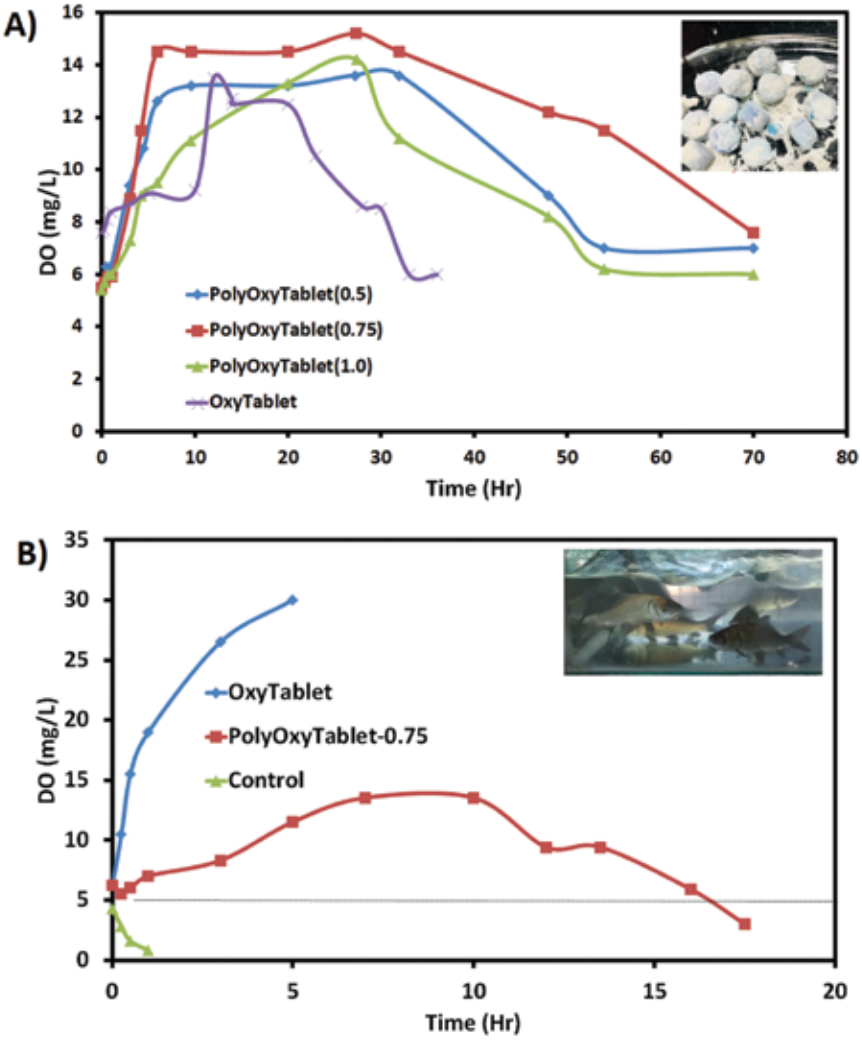
Development of a slow release oxygen formulation

Maintaining optimum dissolved oxygen (DO) in aquatic environment is critical for fish health and growth. Effort was made to develop a slow release oxygen formulation by encapsulating CaO_2 tablets with biopolymer solution. Encapsulation with biopolymeric solution resulted in coating of solid polymer over the tablet (PolyOxyTablets) and penetration of water through the coating was restricted resulting in slow dissolution. Hence, the oxygen release from reaction of CaO_2 and water was also delayed. In all the cases of PolyOxyTablets, oxygen release rate was slower as compared to bare tablet (Oxytablet). It was seen that concentration of polymeric solution (0.5, 0.75 and 1 g/l) has effect on the rate of oxygen release. A very slow release was observed with high conc. of polymer (1.0 g/l), whereas relatively fast release was observed with low polymer conc. (0.5 g/l). Thus oxygen tablet with polymer conc. 0.75 g/l was optimized for *in vivo* condition with 10 fish in 20 litre water. It was observed that in case of negative control the DO level reached a critical level (<5 mg/l) at fast rate (<30 min), whereas positive control (Oxytablet) showed very fast release of oxygen within 5h at upper critical limits (>20 mg/l) where fishes were jumping due to irritation. However, the PolyOxyTablet-0.75 performed better by maintaining oxygen level between 5-15 mg/l for extended period of time (>15 hs).

Effect of *Eclipta alba* methanolic leaf extract in *P. hypophthalmus* against *I. multifiliis* infection. A: Pangasius fingerlings in control group showing white spots on the body surface (arrow head). B: Pangasius in treatment group receiving methanolic leaf extract of *E. alba* were healthy with very few clinical white spots.

Development of a plant extract based fish sedative/ anaesthetic

Use of safe sedative/anaesthetic during fish transport and handling will lead to reduced stress and mortality. An herbal product christened as "CIFRI Fish Tanavhari" as a water dispersible unique sedative/ anaesthetic formulation was developed. This is an effective formulation without any side effect on fish health. The product is easy to apply in water, induces quick anesthesia/ sedation with quick recovery and no mortality. Product has sufficient shelf life. It is effective at a dose of 25-40 µl/l or 3-5 drops in 5



Oxygen release study in 20litre of water without fish (A) and with 10 fish (*L. catla*, 60 g each) (Tablets: 10 no., 15-17g) (B)

litre of water for sedation for 6 h. By replacing water after every 6 h and adding half of the initial dose fishes could be transported to a distance covered in 24 h. At 125-200 µl/l or 13-20 drops in 5 litre of water the formulation could induce anaesthesia very quickly with a sufficiently long anaesthesia duration and quick recovery without any mortality. Beside anaesthetic effect, immunostimulatory properties of the plant extract would help fishes prevent microbial infection when released in natural environment after transportation. The invention is under process of patenting.

Plant extract for harvesting fish/killing weed fishes

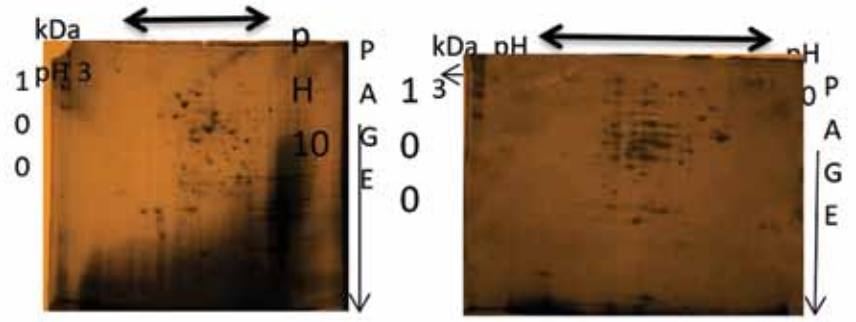
Use of Mahua oil cake is widely used for killing of weed fish in aquaculture practices. However, the cake is becoming costly and scarce. In present study, a water soluble formulation of a plant extract with fish stupefying property has been developed. The formulation quickly dissolves in water, can drag out fishes to the surface of water, and arrest their movement within half an hour at a low dose (10 mg/l) so that the fisherman can easily collect the fishes. This formulation may be helpful in easy, convenient and eco-friendly fishing. This can also be useful for killing weed fishes. Further experimentations are needed to develop this plant extract as a cheaper alternative of *Mahua* cake.

Protein characterization of *F. columnare* and *A. hydrophila* using 2D and LCMS/MS spectra

Outer membrane proteins (OMPs) of bacteria are key molecules that interact with the host environment. Considering potential of OMP components in vaccine development, the sarcosine-insoluble membrane fraction of the OMPs was characterized using 2D and LC MS/MS. The individual peptide MS/MS spectrum was matched to the database sequence for protein identification on PLGS software, WATERS. Different fractions of the OMP from *F. columnare* and *A. hydrophila* were studied which may serve as abasis for understanding the pathogenesis of these bacteria and further selection of immunodominant components for vaccine development.

Development of an innovative culture medium for microalgae-based biodiesel production

Culturing economically important microalgae in large scale is a challenge. For development of nutrient rich culture media an in-house prepared vermicompost extract was tested as nutrient source to enhance growth performance and lipid production from a freshwater microalga (*Graesiella emersonii*). Garden wastes were first converted into vermicompost manure and its extract (aerobic and anaerobically digested) was prepared. The mixotrophic cultivation of microalgae in anaerobically digested



2D-PAGE profile of the sarcosine-insoluble membrane fractions of the OMPs *F. columnare*. First dimension (IPG 3-10; NL; Biorad) and second dimension (15% SDS-PAGE run at constant 90V) gel performed by standard method.

vermicompost extract at 50:50 combination with BG11 medium enhanced cell morphology (bright green, spherical, yellowish-green, and ellipsoid cell) and cell size (~10 µm), cell biomass (0.64 g d.w./l) and lipid production (3.18 mg/l/day) of microalgae by two times.

The FAME profile of the best combination (T4, extract: BG 11 in 1:1) was analyzed using GC–MS which showed a higher percentage of monounsaturated fatty acids (MUFA) and saturated fatty acids (SFA). SFA content varied from31.5 to 56% of total fatty acids, indicating that biodiesel produced from test combination possess better oxidative stability.

The vehicular properties of extracted biodiesel have been calculated. The saponification value (SV) of the biodiesel obtained was 130.63 mg KOH/g. The Cetane Number (CN) values of the test combination had satisfied the ASTM standards (≥47) and the EN standards (≥51) of biodiesel. The test combination and control showed higher iodine value (IV) which is in agreement with the European standards. However, the cold filter plugging property (CFPP) of test combination (~24.22°C) was significantly ($p < 0.01$) lower than control (45°C) which denotes the potential of the medium combination to be used for microalgae biodiesel production. The present study concludes that 50% supplementation of vermicompost extract with BG11 medium significantly improved the lipid productivity and the biodiesel quality of *G. emersonii*.

***Project Title* : Ecosystem health risks and food safety assessment in relation to chemical contaminants in inland aquatic environment**

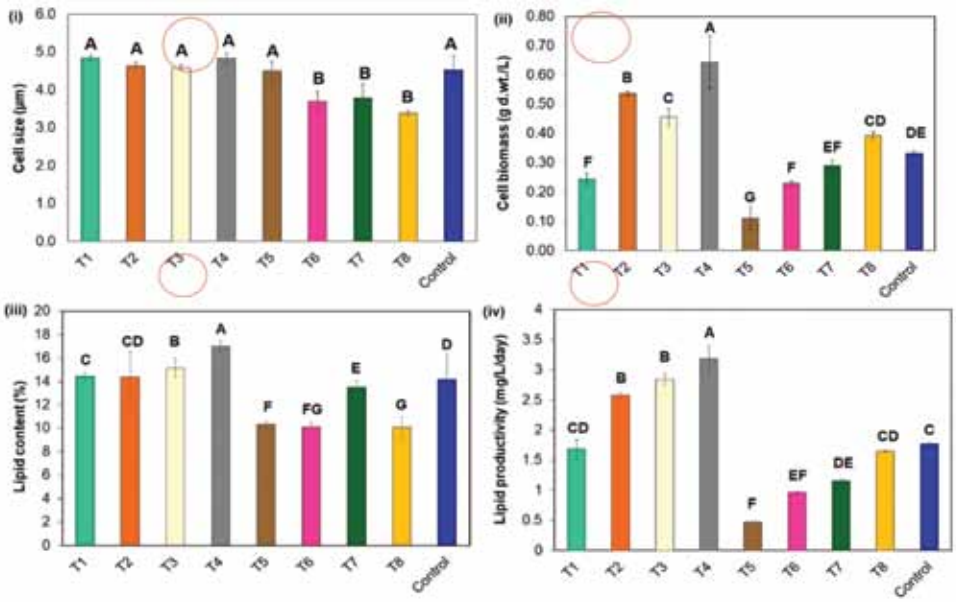
Sub-project 1: Monitoring of targeted pesticides and emerging contaminants in selected water bodies

Sub-project 2: Monitoring of heavy metals and arsenic in selected inland water bodies

Project Code : FREM/20-23/16

Duration : 2020-23

Scientific Personnel : S.K. Nag (P.I., and Sub-project 1 Leader), S.K. Manna, Md. Aftabuddin, S. Das Sarkar, A. Saha, K. Kumari, D.J. Sarkar (Sub-project 2 Leader), S. Samanta, Santhana Kumar V., P.R. Behera, T. Bera, A.K. Bera (w.e.f. 01-04-2021)



(i) Cell size, (ii) cell biomass, (iii) lipid content, (iv) lipid productivity of *G. emersonii* in different treatments. Bar (mean value) that do not share a letter are significantly different from rest treatments.

Sub-project 1: Monitoring of targeted pesticides and emerging contaminants in selected water bodies

Standardization of analytical method and recovery experiment for analysis of *Bisphenol A*

Bisphenol A (BPA) is a synthetic organic plasticizer compound used in production of polycarbonates for food storage containers and kitchen items, epoxy-based resin for manufacture of lacquers, inner coating of food cans and thermal papers, and for personal care products, etc. BPA is a category-I endocrine disruptive chemical (EDC) and is acutely toxic to living organisms. The plastics and containers used for foods and beverages can release BPA during production, handling, storage and transportation exposing humans to this EDC. In the aquatic environment, the major sources of EDC are domestic and industrial sewage water effluent, and agricultural runoff. To estimate its residual presence in the water and fish tissue, the extraction and recovery of BPA from water using solid phase extraction (SPE) and liquid-liquid partitioning (L-L partitioning) and from fish tissue (modified HPLC method) have been standardized. The recovery from water was 92% and 88% in both SPE and L-L partitioning methods, respectively. Good recovery (> 89%) was also obtained for the studied compound in tissue.

Table 3. Fatty acid profiling of *G. emersonii* grown in best combination medium and BG11 medium

Fatty acid	Combination	BG-11
Saturated fatty acids		
Methyl pentadecanoate	0.5±0.06	0.3±0.04
Methyl palmitate	26.6±1.6	23.3±1.8
Methyl octadecanoate	18.5±0.7	31.3±2.2
Methyl nonadecanoate	-	-
Methyl heneicosanoate	1.5±0.07	1.0±0.02
Lignocerate	-	-
Palmitoleate	3.9±0.07	1.5±0.02
cis-6- methyl petroselinate	-	-
cis-Oleic acid	10.6±0.9	-
cis Vaccenic acid	0.8±0.04	0.8±0.06
Trans 9- elaidic methyl ester	-	11.2±0.8
Polyunsaturated fatty acids		
Methyl linoleate	1.6±0.06	-
Linolelaidic acid, methyl ester	-	-
Methyl linolenate	36.0±1.6	30.5±2.0
% of saturated fatty acids	47.1±0.59	56±1.1
% of unsaturated fatty acids	52.9±0.82	44.0±0.76
SFA/UFA	0.89±0.06	1.27±0.04

Extraction of BPA from aqueous medium and fish tissue

Water and fish samples were collected from various inland open waters such as sewage-fed wetlands (Bheri no. 4, Badachoinabhi), floodplain wetland (Bortibeel),

Table 4. Biodiesel quality of *G. emersonii* MN877773 grown in combination medium and BG11 medium

Physical properties	Combination	BG11	BS I	BS A	BS E
Saponification value (mg KOH/g)	130.63±1.0^{c}	135.31±1.1^{b}	NA	NA	NA
Iodine value (g Iodine/100g)	126.43±0.4^{d}	117.90±0.7^{e}	NA	NA	≤120; ≤130*
Cetane number	55.84±1.32^{a}	56.57±0.74^{a}	NA	≥47	≥51
Degree of unsaturation (% wt)	90.50±0.95^{c}	74.50±1.0^{d}	NA	NA	NA
Long chain saturation factor (% wt)	11.91±0.78^{b}	17.98±1.07^{a}	NA	NA	NA
Cold filter plugging properties (°C)	24.22±0.50^{b}	44.96±0.54^{a}	NA	NA	≤5≤-20
High heating value (MJ/kg)	42.18±0.65^{a}	42.11±0.79^{a}	NA	NA	≥35*
ln (Kinematic viscosity) (mm^2/sec)	6.14±0.52^{a}	6.22±0.42^{a}	2.5-6.0	1.9-6.0	3.5-5.0
Density (g/cm^3)	0.95±0.08^{a}	0.90±0.03^{a}	0.86-0.9	0.86-0.89	0.86-0.9
Oxidative stability (h)	5.73±0.73^{a}	6.46±0.29^{a}	≥6	>3	≥6; ≥4*

BS I- Biodiesel Standard India; BS A- Biodiesel Standard ASTM D6751-02; BS E- Biodiesel Standard EN 14213*& 14214; NA- not available; different small letter alphabets given as superscript indicates the significant difference ($p<0.05$).

sewage canal (Choubhaga) and reservoir (Sunei dam) for extraction of BPA. Replicate water samples did not reveal presence of BPA in the ecosystem except in Bheri no. 4 where a level of 73.43 µg/l was detected. Edible muscle tissue of 16 fish species viz., *Anabas testudineus, Cyprinus carpio, Cirrhinusmrigala, C. reba, Chanda nama, Channa punctata, Labeo rohita, Mystus cavasius, Ompok bimaculatus, Osteobrama cotio, Oreochromis niloticus, O. mossambicus, Puntius sarana, P. sophore, Sperata seenghala, Trichogaster fasciata* and one snail (*Bellamya bengalensis*) were examined and total of 68 (fish~64 and snail~4) samples were analysed. Residues of BPA have not been detected in any of the samples.

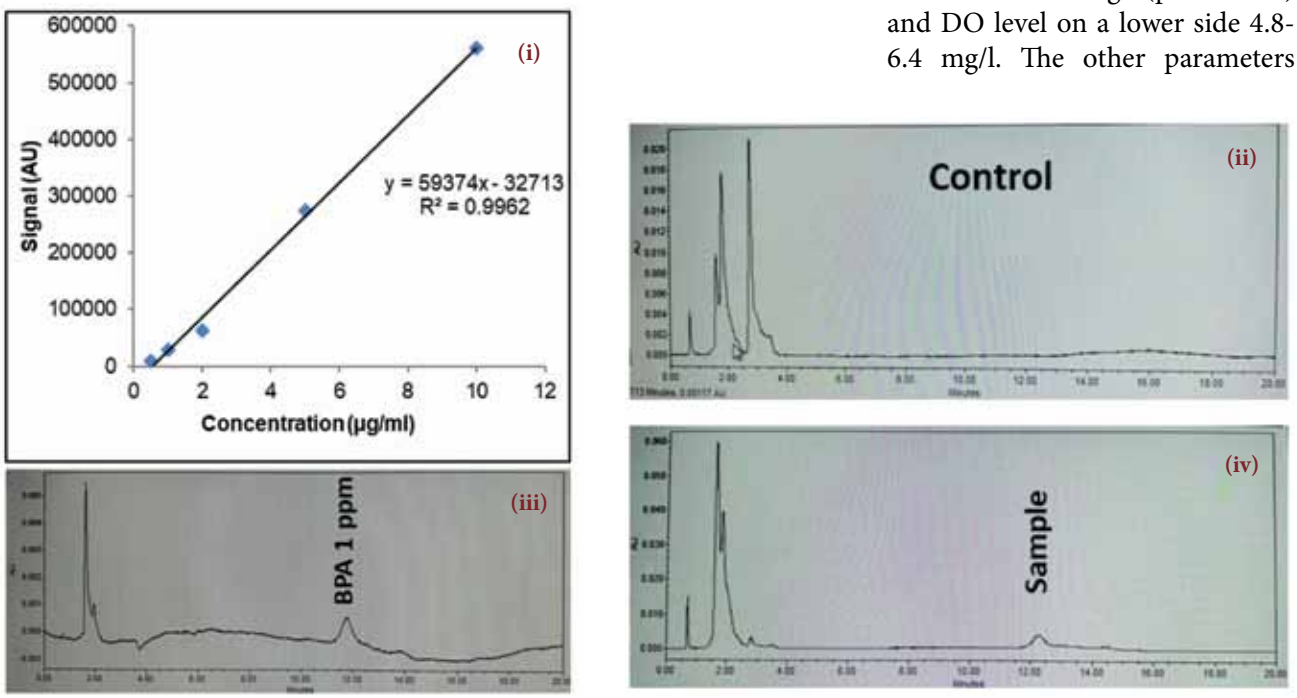
Standardization of analytical method and recovery experiments for analysis of phthalate esters

Phthalate esters (PE) are commonly used as plasticizers and in many personal care products. These are also known as endocrine disrupting chemicals and distributed in many environments including air, water, sediment and in fish. Method standardization of phthalate esters viz., diethyl phthalate and diethyl hexyl phthalate (DEHP) was done in GC-MS. Average recovery was 65-70%. Samples of fish (Tilapia) collected from East Kolkata wetland were analysed and none of the samples were positive for the targeted phthalate esters.

Physico-chemical properties of water and soil of the studied wetlands

Borochoinavi (22°32'13.44" N, 88°26'33.48" E) and Bherino.4 (22°33'23.66" N,88°25'19.18" E) are sewage fed East Kolkata wetlands where semi-intensive aquaculture is practiced. The water of the wetlands was slightly alkaline in reaction (pH 8.4-8.7), and optimum dissolved oxygen (6-10 mg/l). The dissolved salt content was on a higher side (average specific conductance 512-608 µS/cm). Total alkalinity (94-121 mg/l) and hardness (116-144 mg/l) were in the optimum ranges for fisheries and aquaculture. Other water quality parameters were also in the normal range, though nitrate and phosphate loads were high. The soil was sandy loam (in Borochoinavi) to loamy sand (in Bherino.4) in texture, slightly acidic to neutral in reaction (pH 6.4-6.9) and containing 4.5-5.7% oxidizable organic carbon. The specific conductance was quite high (1492-2182 µS/cm).

Borti beel is a stretch of marshland crept up on several agricultural and fishing area which is a network of several canals previously connected to Vidyadhari River and also included in the riverine network of Ganga in North 24 Parganas district of West Bengal. It's a seasonal wetland and remains dry during winter and summer months. The Beraberia sector of the beel (22°47'2.99" N, 88°26'11.82" E) was studied for physico-chemical and pollution status in water and soil. The water of the wetland was in the neutral range (pH 6.9-7.2) and DO level on a lower side 4.8-6.4 mg/l. The other parameters



Analytic method standardization for Bisphenol A: i) Linearity of BPA in Methanol by using HPLC-PDA system; ii-iv) BPA chromatograms in HPLC

were: TDS 200-249 mg/l, free CO_2 1-11 mg/l, alkalinity 98-156 mg/l and hardness 96-116 mg/l. The soil is sandy loam with neutral (pH7.0-7.2) and 2-4% oxidizable organic carbon content. The average specific conductance was 874 µS/cm.

Raja beel is a fresh water wetland located by the side of Barrackpore-Kalyani expressway in North 24 Parganas district of West Bengal. It is connected to the Ganga river through canal. The water quality was in the acceptable range for most of the parameters like pH (7.7-8.1), free CO_2 (10 mg/l), DO (6.7-10 mg/l), alkalinity (170-180 mg/l), hardness (116-128 mg/l), and TDS (415-429 mg/l). The soil is loamy sand to sandy loam containing 3.8-5.3% oxidizable organic carbon and high salt content (specific conductance 1675 µS/cm).

Occurrence of pesticide residues in water, sediment and biota Borochoinavi beel and Choubaga canal

The water collected from Chowbaga storm water canal, one of the important waste water canal in East Kolkata wetland ecosystem, was analysed for pesticide residues. Cypermethrin, a pesticide widely used in agriculture, aquaculture and fisheries was detected at alarmingly high concentration (12356 µg/l). The compound was also detected in water (1.3-8.2 µg/l) and fish flesh and gill (~0.1 mg/kg) of Borochoinavi wetland located at few kilometers downstream of the canal.

Wetlands and reservoir

In Bheri no. 4 residue of cypermethrin was detected in water (0.75-2.5 µg/l) and, fish flesh and gill (0.18-0.63 mg/kg) of. Among the OP pesticides, chlorpyrifos (0.216 mg/kg) was detected in gill tissue of Tilapia. In Raja beel residues of no targeted pesticides were found in water and soils samples. In Borti beel, cypermethrin residues were recorded in fish tissue (0.028-0.42 mg/kg) and in soil (0.03 mg/kg). In water samples of Sunei the reservoir no residue of any pestcide could be detected but residue of cypermethrin was recorded in flesh of *Labeo catla* (0.084 mg/kg) and *Labeo bata* (0.136 mg/kg).

Sub-Project II: Monitoring of heavy metals and arsenic in selected inland water bodies

Method optimization for multi-element analysis in ICP-MS

Environmental pollution by heavy metals is becoming a concern due to their toxic effects on aquatic biota and human health. These inorganic pollutants are discharged or leached in to water bodies from rapidly growing agriculture and metal industries, etc. Effort has been taken to estimate these toxic heavy metals at very trace level (<1 µg/l) in water, sediment and fish using ICP-MS (Inductively Coupled Plasma emission Mass Spectrometer). Standard solution mixture (1-1000 µg/l) of 24 elements (Al, B, Ba, Bi, ca, Cd, Co, Cr, Cu, Fe, Ga, K, Mg, Na, Ni, Pb, Se, Sr, Te, Tl and Zn) was prepared using MilliQ water and tested using ICP-MS (NexIOn 1000, PerkinElmer). The ICP-MS instrument was run in ($He+H_2$) KED mode (Gas flow 0.5 ml/min, RPq 0.25) with a cyclonic spray chamber and Meinhart nebulizer (nebulizer gas flow rates: 1.04 l/min, auxiliary gas flow: 1.2 l/min, plasma argon flow: 15 l/min, deflector voltage: -15 V, ICP RF Power: 1600 W, CeO/Ce = 0.018, $Ce^{++}/Ce+ = 0.028$).

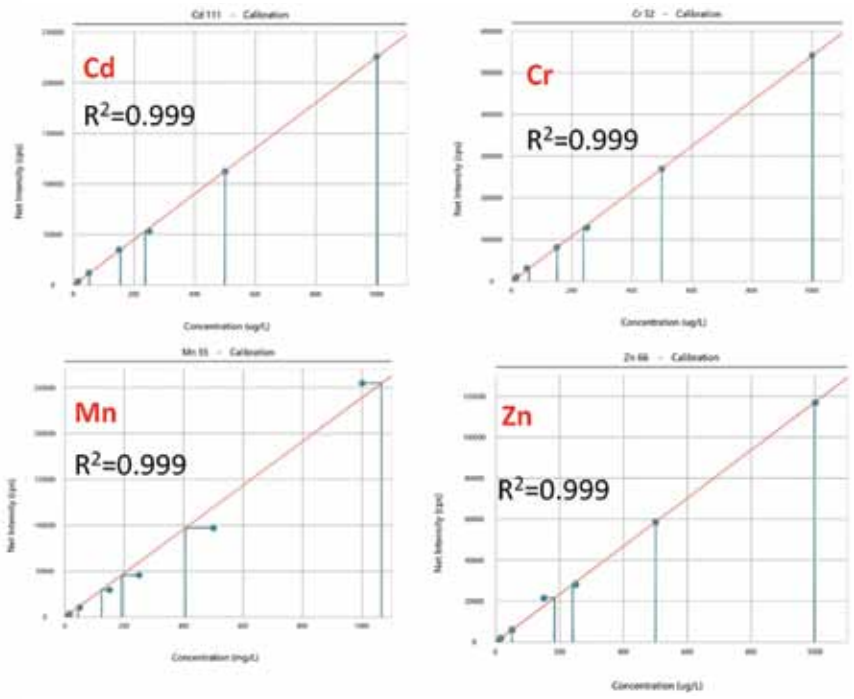
Metal pollution in water, sediment and biota of selected wetlands

Bheri No. 4

In water phase of Bheri no. 4 heavy metals like Cd (0.016-0.167 µg/l), Cr (5.77-13.66 µg/l), Cu (1.15 – 3.0 µg/l), Zn (4.47 – 35.4 µg/l) were present at levels lower than CMC (critical maximum concentration) and CCC (criterion continuous concentration) values recommended by the USEPA for aquatic life. Copper was also present at a very low level (1.15-3.0 µg/l). However, Pb was detected at concentration (1.45-92.3 µg/l) higher than its CCC (1.8 µg/l), and CMC (65 µg/l) values in one instance. In wetland soils Cd and Pb were detected at an average concentration of 2.64 and 7.85 µg/g indicating no serious pollution as per the USEPA limits. However, Cr (average concentration 96.17 µg/g) was present at high levels. The level of Cu (59.05-133.78 µg/g) and Zn (149.6-708.19 µg/g) in some cases also exceeded the recommended safe limits. The toxic metalloid arsenic (As) was also recorded in soil (9.5-17.35 µg/g) of the wetland. Cd was not found but Pb (0.03-5.25 µg/g) and Cr (0.97-4.16 µg/g) were detected in flesh and gills of *Cirrhinus mrigala*, *Oreochromis mossambica*, *O. nilotica*. The FAO and USFDA recommended limit of Pb (0.5 µg/g) and the FAO recommended limit of Cr (0.15-1.0 µg/g on wet weight basis) were exceeded in many samples. In gill of *C. mrigala* and flesh of *O. nilotica* accumulation of As was detected at concentration 1.36 µg/g and 0.105 µg/g respectively.

Borochoinavi beel

The toxic metals Cd and Cr were present in water phase at levels below the USEPA criteria values



Standard curve of metals (Cd, Cr, Mn and Zn) in ICP-MS

but Pb (1.5-78.9 µg/l) was found to exceed the CCC values in most of the samples and CMC in one samples. Metals like Cu, Zn and Mn were also present at low levels. In wetland soils Cd and Pb were at very low levels, but Cr concentration (104.5 µg/g) was high. Arsenic (18.7-19.1 µg/g) was also detected in soil. The average concentrations of other elements like Cu, Zn and Mn were at levels not indicating pollution. Accumulation of Cd and Pb was not observed in flesh of fish (*Labeo rohita*) but Cr (2.405 µg/g) was present at concentration surpassing the safe limit. Arsenic accumulation (0.973 µg/g) was also found in flesh of *L. rohita*.

Borti beel

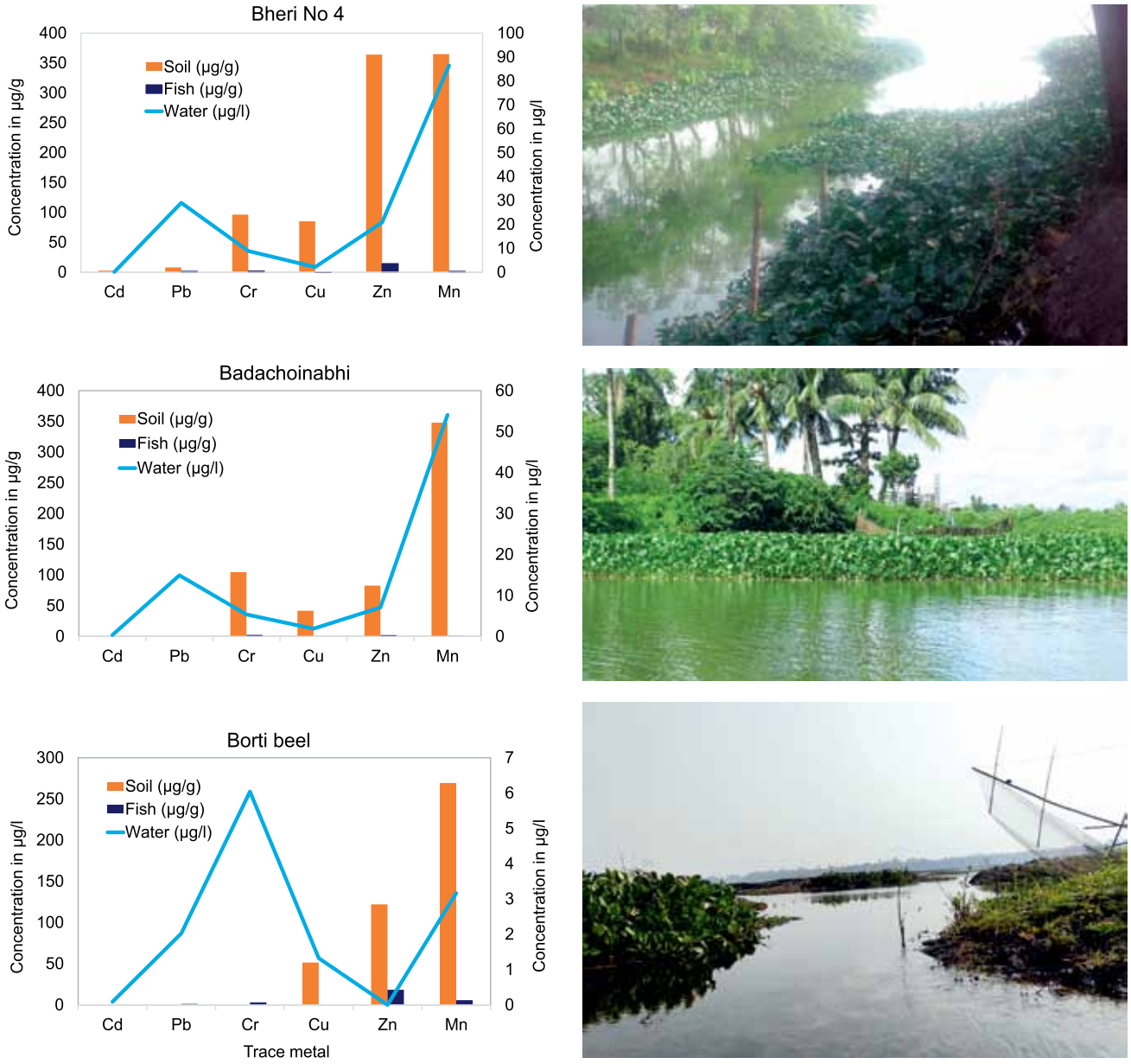
The levels of toxic heavy metals Cd (0.089 µg/l), Pb (0.91-5.03 µg/l) and Cr (3.85-6.99 µg/l) in water phase were much below the USEPA criteria values recommended for aquatic life. Cu and Mn were also present in minute concentrations (<6 µg/l). So the fishes and other aquatic biota in the wetland were not exposed to the stress caused by metals. In soils too, levels of the targeted metals elements were within prescribed limits, except Zn (113-135 µg/g) which was present at USEPA recommended moderate pollution level (90-200 µg/g). In fishes collected from the wetlands accumulation of Cd was not observed, but Pb was present in *A. mola, Esomus danricus, Puntius sophore, Trichogaster fasciata, Channa punctatus* at an average concentration of 1.212 µg/g (range 0.13-3.5 µg/g). So, the permissible limit of Pb (0.5 µg/g) recommended by FAO and USFDA was exceeded in few samples. Cr detected at levels 0.07-2.24 µg/g in fish flesh and at 18.28 µg/g in the gill of *C. puntatus* was higher than the FAO recommended limit (0.15-1.0 µg/g) on wet weight basis. Arsenic accumulation was noted in *P. sophore* (0.608 µg/g) and *C. punctatus* (0.14-1.84 µg/g).

Loktak Lake, Manipur

Loktak Lake in Manipur is one of the largest natural freshwater lakes in India with mean surface area of 287 sq km. Considering the ecological status and its biodiversity values, the lake was designated as a wetland of international importance under the Ramsar Convention. However, waste water and runoff from agricultural land are reaching to this wetland though rivers (Imphal river and Nambul river) from Imphal city area and numerous natural streams. Water and sediment samples were collected from 13 locations out of which 5 sites are chosen from associated rivers to understand the contribution of these rivers as source of heavy metals. It was found that heavy metal concentrations in the river and wetland water are lower than standard US EPA values and the Lake can be considered as non-polluted. However, the mean values of heavy metal concentrations in the river samples are higher than wetland water samples indicating wastewater flow through these rivers as a major source of heavy metals to the wetland. Further analysis found that the average heavy metal concentrations in river and wetland sediments are same and some heavy metals (like Cr, Cu, Ni and Zn) are present in alarming concentrations.

Method optimization for arsenic speciation in LC-ICP-MS

Exposure to arsenic through contaminated drinking water and food items including fish is a global public health concern. More than 100 arsenic compounds are reported in the environment and biological systems and among them inorganic As(+3) is the most toxic while organoarsenic compounds are least toxic. Different toxicity potential of different forms of As highlights the importance of quantifying



Metal accumulation in water, soil and fish tissue

individual arsenic species for better understanding of their distribution, transformation in the environment, toxicity, metabolism, and health effects. In this context, a method was standardized to detect and quantify various toxic arsenic species like, arsenate (As5), arsenite (As3), dimethyl arsenate and arsenobetaine using LC-ICP-MS. The HPLC with analytical column (C18, 4.6x 250mm, 5µm) and a gradient mobile phase (octanesulfonic acid, 2mM + malonic acid, 2mM + methanol 1% and pH adjusted to 4.0, flow rate 1.5 ml/min) was used to carry the sample. ICP-MS (NEXION 1000, PerkinElmer, Inc., USA) was operated in Oxygen DRC mode (oxygen flow: 0.5 ml/min, Pulse stage voltage: 900 V, ICP RF Axial field voltage (AFT): 250 V, RF voltage applied to reaction cell: 0.25 V, RF Power: 1600W, CeO/Ce=0.018, Ce++/Ce+=0.028). The ICP-MS instrument was used with a cyclonic spray chamber with a peltier cooler (15 °C) and Meinhart nebulizer (nebulizer gas flow rates: 1.04 L/min, auxiliary gas flow: 1.2 L/min, plasma argon flow: 15 L/min). The method show clear separation of test arsenic species.

Pattern of arsenic deposition in Indian major carp: A wet lab experiment

Arsenic (As) is a carcinogenic metalloid. Some published reports indicated that among the IMCs *Labeo catla* has higher tendency to

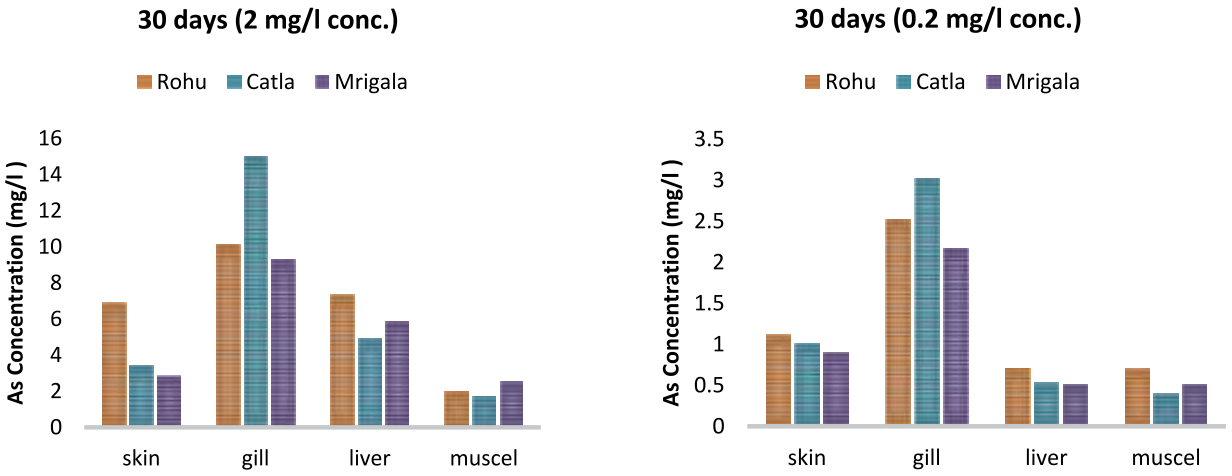
Sampling sites in the Imphal river and Loktak lake

Table 5: Levels of different heavy metals (µg/g) in Loktak lake water

	Cd	Cr	Cu	Fe	Ni	Pb	Mn	Zn
River	0.03 ±0.03	0.79 ±0.27	3.41 ±0.71	567.44 ±612.77	9.90 ±3.55	2.02 ±1.37	36.61 ±36.19	7.41 ±3.41
Wetland	0.025 ±0.06	0.51 ±0.41	2.08 ±2.34	408.55 ±553.92	10.46 ±17.37	1.19 ±1.29	29.58 ±46.28	8.52 ±8.11
Status (as per US EPA)	Non-polluted	Non-polluted	Non-polluted	--	Non-polluted	Non-polluted	--	Non-polluted

Table 6: Heavy metal (µg/g) distribution in sediments of river and Loktak lake

	Cd	Cr	Cu	Fe	Ni	Pb	Mn	Zn
River	0.21 ±0.17	217.53 ±83.68	71.29 ±26.67	77764.94 ±34186.6	227.29 ±76.76	27.06 ±14.75	276.10 ±154.38	578.48 ±371.06
Wetland	0.15 ±0.07	260.82 ±64.54	78.06 ±17.36	87188.92 ±20200.57	288.08 ±60.97	24.69 ±7.92	231.77 ±35.05	596.56 ±238.80
Status (US EPA)	Non-polluted	Heavy pollution	Heavy pollution	--	Heavy pollution	Non-polluted	--	Heavy pollution



Accumulation of As in tissues of IMC after exposure at different concentrations for 30 days

accumulate As than other species. To validate this, a renewal wet lab study was set up to find out the differential pattern of distribution and accumulation of As in different tissues (skin, gill, liver and muscle) of IMCs, and more specifically, to check whether *L. catla*is the highest accumulating species or not. IMCs, viz., *Labeo rohita, L. catla* and *Cirhinus mrigala* were exposed to 2 mg/l and 0.2 mg/l concentrations of As. The study revealed highest As levels in gills of *L. catla*, followed by gills of other species. In exposure at lower concentration the pattern of the deposition of As was: gill > skin > liver > muscle, whereas at higher concentration the deposition pattern was: gill> liver > skin > muscle. Among all the tissues tested, lowest accumulation was noted in flesh, which is encouraging from human food safety point of view.

Arsenic accumulation in fish in aquaculture ponds

Arsenic content in aquaculture pond waters was found to be in the range of 10.44-126.32 µg/l in Daulatpur and Meena villages of As-endemic Habra-II block of North 24 Parganas district of West Bengal. In flesh of *Labeo bata* (Bata), *Labeo catla* (Catla), *Labeo rohita* (Rohu), Roopchanda and Tilapia As concentration varied from 0.11-0.83 mg/kg. However, in gills the accumulation was many times higher (1.08-14.82 mg/kg) with highest level in Catla followed by Tilapia, Roopchanda, Bata and Rohu.

Comparative effect of organic and synthetic substrate grown microalgae biofilm on arsenic bioremediation

Although there are a few methods of As remediation available for drinking water, such technologies are not available to reduce As load or toxicity in surface water bodies. Use of microalgae has been suggested for As bioremediation in aquatic ecosystem but its use is still in infancy due to the lack of techno-economic feasibility. To address the issue, the present study utilized banana pseudostem (BS) waste, generated in huge quantity (80 million t/year) in India, as an organic substrate for growing microalgal biofilm (BSB) and the same was compared with the synthetic net substrate grown biofilm (NMB) for As remediation. The experiment was conducted for 15 days. After 5 days of exposure, BSB completely removed (97.6 ± 1.5%) As from water whereas NMB removed 74.1 ± 12.2% from water suggesting that banana stem adsorbs more arsenic from the water. After 15 days, the microalgae biofilm desorbed the arsenic back into the water.

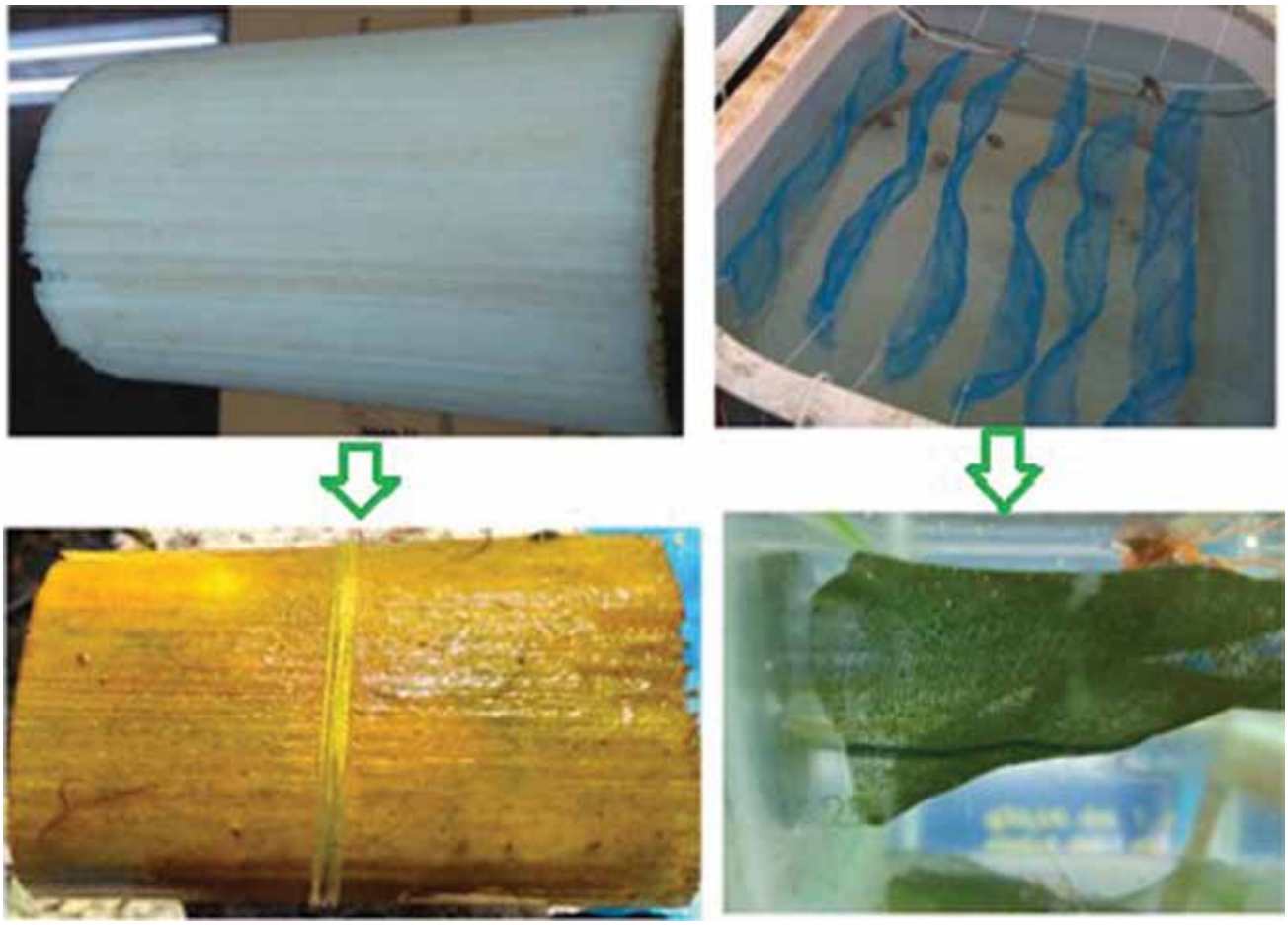
Project Title : Fisheries resource assessment and prediction in inland open water under AI and Big Data platform

Project Code : FREM/20-23/18

Duration : April 2020 to March 2023

Scientific Personnel : M. Naskar (P.I.), B.K. Das, A.K. Das, S.K. Sahu, C. Jana, N. Chanu, A. Pandit, S.N. Singh

Data on Inland water bodies were collected from published documents of ICAR-CIFRI, specifically bulletins and research papers published in the Journal of the Inland Fisheries Society of India. The ICAR-CIFIR published 194 bulletins during 1963 to 2020, which were segregated according to water resources. Among these vast documents, 20 bulletins on reservoirs, 10 on wetlands, and 17



Substrate used for arsenic bioremediation experimentation and biofilm formation over the substrates

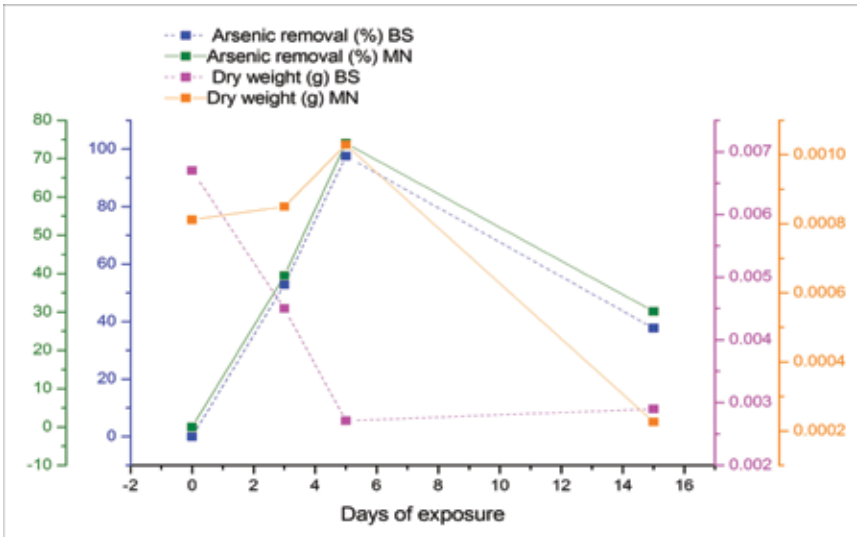
on rivers and estuaries contain data worth mining. All the research papers of IFSI between 1990 and 2020 were scrutinized, which resulted in 24 research papers on reservoirs, 38 articles on river and estuaries and eight research papers on wetlands that contain useful data on water quality, fish species distribution, physical habitat, etc. All those data and information are being digitized.

Geo-referencing of sampling stations

The water quality data of 10 perennial rivers were collected from the completed projects and published documents of ICAR-CIFRI. Sampling stations were digitised, and the latitude and longitude of every sampling station were placed using 'google earth' and corrected based on the name of the sampling station approach road and *ghats*. Thus, a total of 180 sampling stations were digitised.

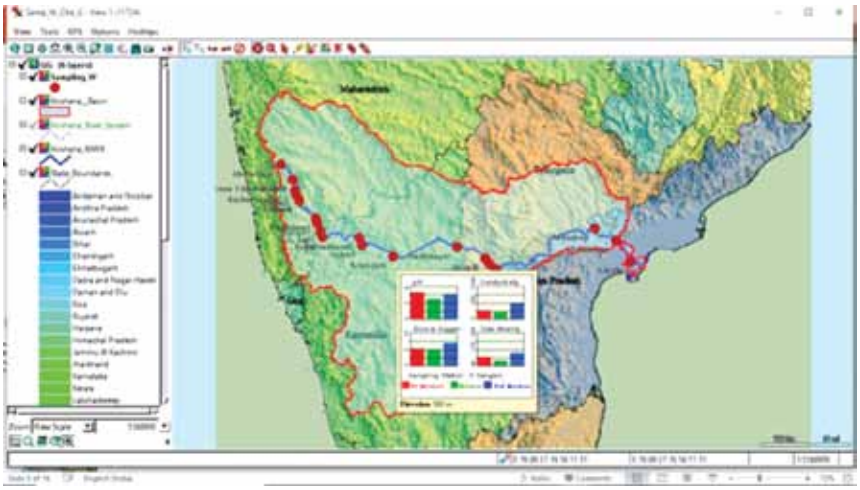
Standalone e-maps

An e-Atlas is a map-based electronic tool to present different information themes on a map.



Interactive effect of arsenic removal and dry weight biomass of microalgae biofilm grown on banana stem (BS) and nylon mesh net substrate (MN)

One e-Atlas was developed for the river Krishna displaying water and sediment quality information. Six layers viz., digital elevation, state boundary, river basin, Krishna basin, Krishna river and sampling station were used for the individual theme preparation.



eAtlas for navigating environmental data of the River Krishna

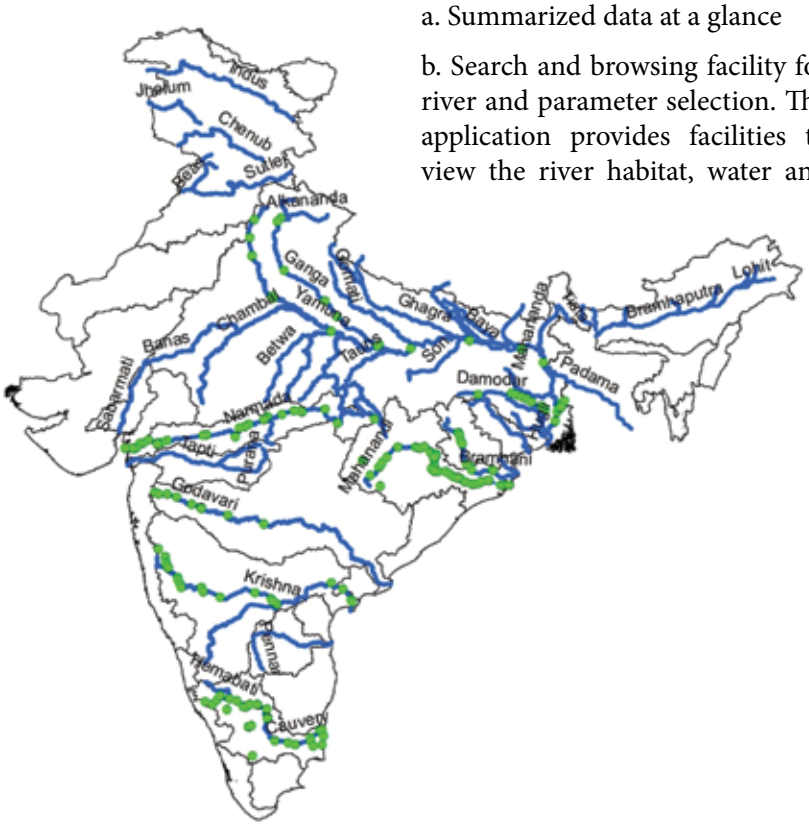
Design and development of Web-GIS portal

The project aims at creating a big data analytic for inland open water systems. The fundamental element is data, especially of the inland fisheries domain, and its dissemination technique to the end-users. To this end, a data-driven Web-GIS application was designed and developed. Presently it includes rivers and can disseminate various information such as water quality, sediment quality, physical habitat, etc. about the river. The portal supports visualizing the scenarios of spatio-temporal patterns of different river environment parameters and their inter-relationships on the online GIS platform. The portal has a rich database and a utility to extract customized reports that will facilitate researchers, planners and policymakers to make prudent planning /strategies for betterment of the fisheries resources in coming days. The following key features are included in the portal:

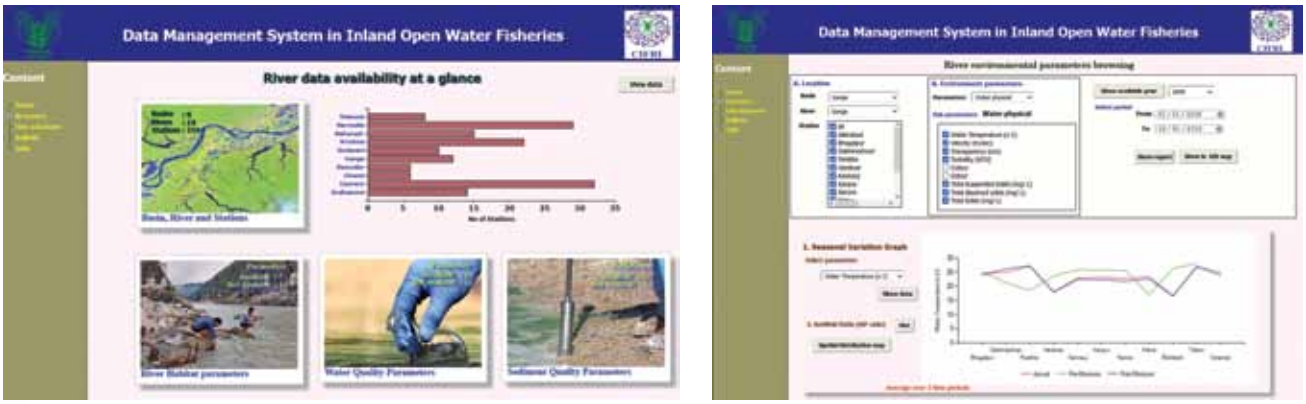
a. Summarized data at a glance

b. Search and browsing facility for river and parameter selection. The application provides facilities to view the river habitat, water and sediment parameters at different stations and time and to generate a report. Spatio-temporal variation of different parameters is presented in graphical form to understand the changing scenario.

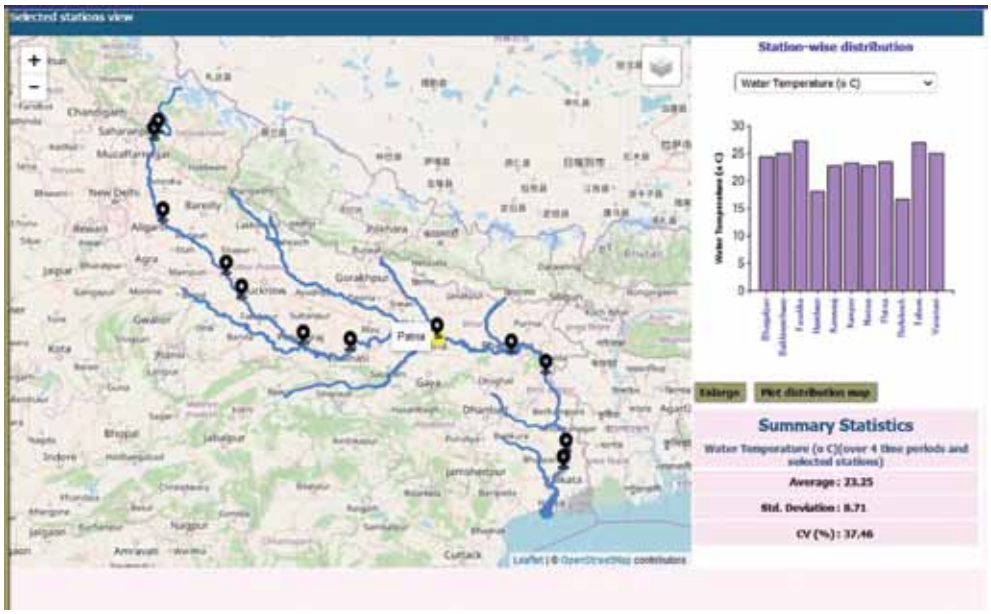
c. Data representation in GIS platform: Selected stations can be plotted and visualized directly on a dynamically loaded map. Temporal river habitat, water and sediment information can be retrieved on any selected sampling station, typically through online GIS navigation within the developed Web-GIS portal.

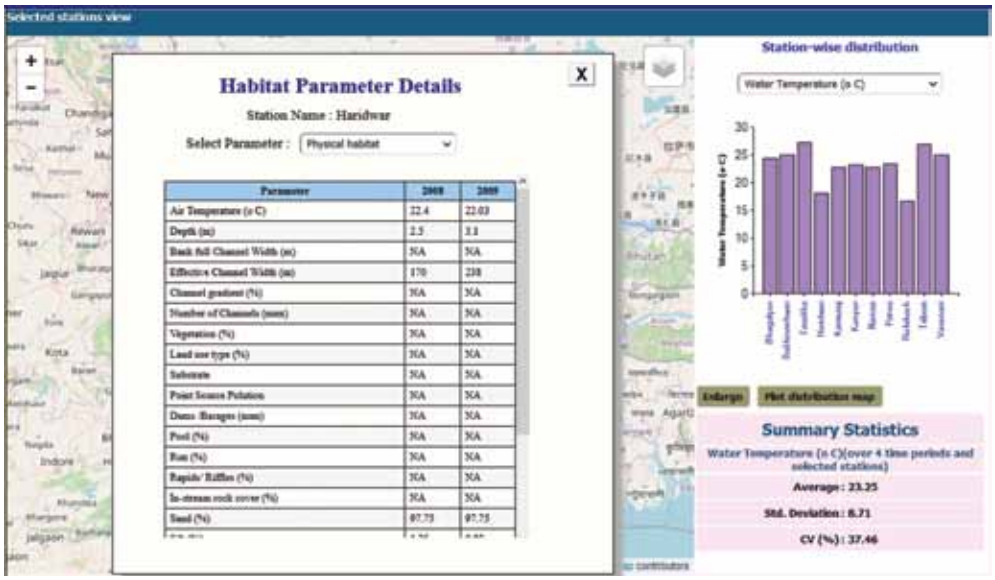


GIS map of data availability locations of 10 major rivers in India.



Data availability and river environment parameter search window





Analysis output in GIS and tabular form

Project Title: Diversification of fish species for enclosure culture in reservoirs and wetlands

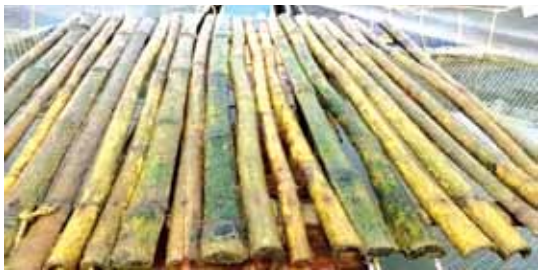
Project code: RWF/17-20/09

Duration: April 2017 to March 2022

Scientific Personnel: B.K. Das (P.I.), A.K. Sahoo, M. Ramteke, U.K. Sarkar, S. Kumari, Mishal P., D. Das, M.A. Hassan, R. Das, G. Karnatak, H.S. Swain, T. Tayung, S.P. Kamble, A.K. Das, V.R. Thakur, D. Debnath, S. Yengkokpam, P. Das

Periphyton based cage culture of *Systomus sarana* in inland open water cages

The culture of *Systomus sarana* in cages in Salia reservoir, Ganjam, Odisha was incorporated with three different periphyton substrates to examine the efficiency of periphyton based fish production. *S. sarana* fingerlings (20.87 ± 1.13 g) were stocked in four treatments i.e., control (without any periphyton substrate), T_1 (bamboo as the periphyton substrate), T_2 (sugarcane bagasse periphyton substrate) and T_3 (mosquito net as periphyton substrate). Each treatment comprises of two rectangular HDPE cages (6 m x 4 m x 3.5 m) representing two replicates, with respective periphyton substrates. Bamboo splits were joined to make square frames of 1 m^2 size. Similarly, sugarcane bagasse was bound in bundles and mosquito nets were cut into square frames. The surface areas for periphyton growth in each cage were uniformly maintained. Fishes were also supplemented with formulated floating feeds (CageGrow® feed) twice daily. After four months of culture, highest final body weight (159.40 ± 14.63 g) was obtained in T_1 (bamboo substrate), followed by T_3, T_2 and control group. Mean weight gain was highest in T_1 (138.53 ± 14.63 g), followed by T_3 (113.73 ± 15.26 g), T_2 (106.53 ± 13.45 g) and control (102.63 ± 16.35 g). Highest absolute growth rate was recorded in T_1 (1.15 ± 0.04) and subsequently it declined following the order T_3 >T_2 >control. Feed conversion ratio (FCR) was lower in T_1 (1.50 ± 0.01) whereas, control group displayed lowest FCR of 1.67 ± 0.02. A significantly higher protein efficiency ratio (2.192 ± 0.04) and FCR (0.66 ± 0.01) was obtained in bamboo substrate (T_1). The above study indicates the efficiency of bamboo substrate for periphyton production and along with culture of *S. sarana* in tropical inland open water cages.



Bamboo based periphyton

Net based periphyton

Use of sugarcane waste for periphyton growth

Haul of *S. sarana* in cage

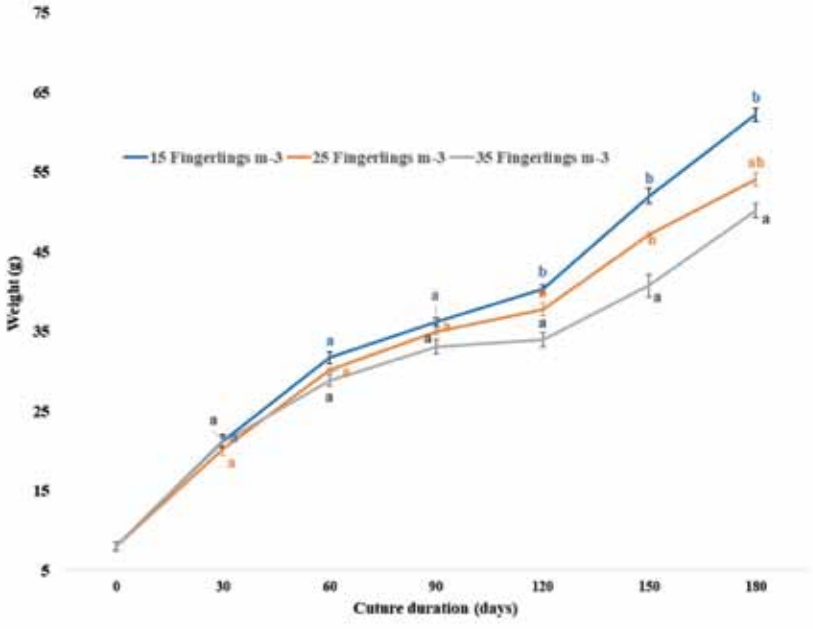
Evaluation of growth performance and survival of Amur carp *Cyprinus carpio* var. *haematopterus* (Martens, 1876) in inland nursery cages

Amur carp is the genetically improved breed of common carp suitable for low-input aquaculture systems due to its better growth performance. Hence, it is a potential candidate for species diversification in inland cage culture. A study was conducted with the aim to evaluate the growth performance of Amur carp in nursery cages in Maithon reservoir, Jharkhand. The early fry of Amur carp (3.10 ± 0.10 cm, 0.47 ± 0.05 g) were stocked in e-CIFRI GI® model cages (5 m x 5 m x 2.5 m) in triplicate at three different stocking densities viz. 100, 200 and 300 no./m^3 designated as low, medium and high stocking density. The fishes were fed with commercial feed @ 3-6% of body weight twice a day. The growth of the fishes was recorded on monthly basis. The average size attained by fishes during 90 days of culture was 45.07 ± 4.55 g, 40.09 ± 2.49 g and 38.05 ± 2.00 g at the stocking densities of 100, 200 and 300 no./m^3, respectively. No significant difference ($p>0.05$) has been observed in water and sediment quality at the cage site compared to reference sites.

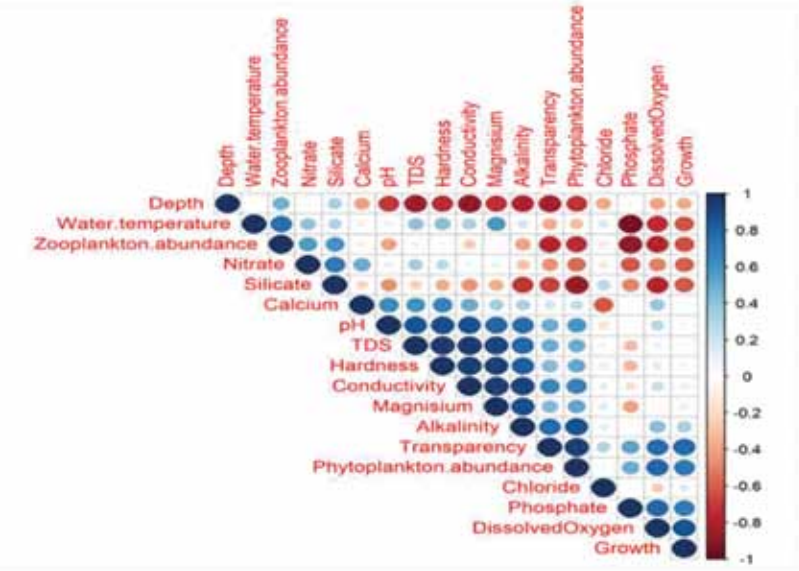
Growth and feed utilization of butter catfish, *Ompok bimaculatus,* in floating net cages

A growth trial was conducted to assess the influence of stocking density on growth, survival, feed utilization, and economic feasibility of a high value butter catfish, *Ompok bimaculatus* in floating cages at Maithon Reservoir for 180 days. The fingerlings (8.05±3.27g) were stocked at three stocking densities, viz., 15, 25 and 35 no./m^3 in GI cages in triplicates. The fishes were fed with commercial floating pellets @ 3-5 % of the body weight. The analysis of data indicated that the fishes at the lowest stocking density of 15 no./m^3 had significantly higher ($p<0.05$) growth in terms of weight gain (717.67 ± 39.10%) and specific growth rate (1.14 ± 0.05). Survival was also significantly higher ($p<0.01$) at lower stocking densities. Feed conversion efficiency (FCE; (0.423±0.025), protein efficiency ratio (PER; 1.37±0.15) and feed conversion ratio (FCR; 2.37±0.16) were significantly better at 15 no./m^3. The fish growth and feed utilization efficiency did not vary significantly ($p>0.05$) between stocking densities of 15 and 25 no./m^3. The condition factor was close to 1 and insignificantly higher at lower densities indicating congenial ecosystem for overall well-being of this species. The highest benefit cost ratio (1.77) was achieved at the lowest stocking density. The present study indicated better growth and economic returns at stocking densities of 15-25 no./ m^3. The nutrients level and plankton abundance were higher at cage site, however, they did not vary significantly from reference sites throughout the culture period. Among the environmental parameters, dissolved oxygen showed significant positive relation (r = 0.86) with the growth of the fish.

Nursery rearing of Amur carp in cages



Growth trend of *O. bimaculatus* at different stocking densities



Correlation between water quality and growth of *O. bimaculatus*

Over-wintering of *Heteropneustes fossilis* in circular tanks

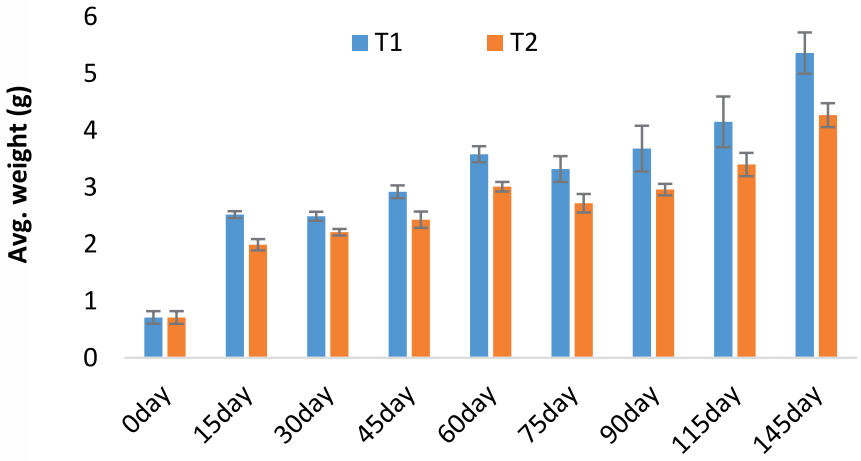
An experiment was conducted to evaluate the suitability of circular tanks for over-wintering and to assess the growth performance and survival of *Heteropneustes fossilis*, locally called Singi, at different stocking densities. Singi (avg. wt. 0.71±0.12g) was stocked in densities @ 1 no./l (T_1) and 2 no./l (T_2) in circular tanks (5000 litre capacity) in duplicates. The fishes were fed with floating pellet feed (0.8 mm; CP: 40% and CL: 6%) @ 8-4% of the body weight 4 times (9:00, 12.00, 15.00 and 18:00 hr) a day for 145 days. Water quality parameters were monitored on weekly basis and hideouts were provided in the tanks to control cannibalism. Singi achieved an average weight of 5.36 ± 0.36 g and 4.27 ± 0.21g in T_1 and T_2 respectively in 145 days. The weight gain (%) achieved were 654 % and 501 % respectively for T_1 and T_2 in 145 days. The findings of the study indicate that Singi can be overwintered successfully in circular tanks and stocking density of up to 2 no./l can be maintained. The overwintering and raising of Singi will ensure the availability of the seed of required quantity and size at right time for stocking in cages for better production.

Growth and survival of *Heteropnuestes fossilis* in cages

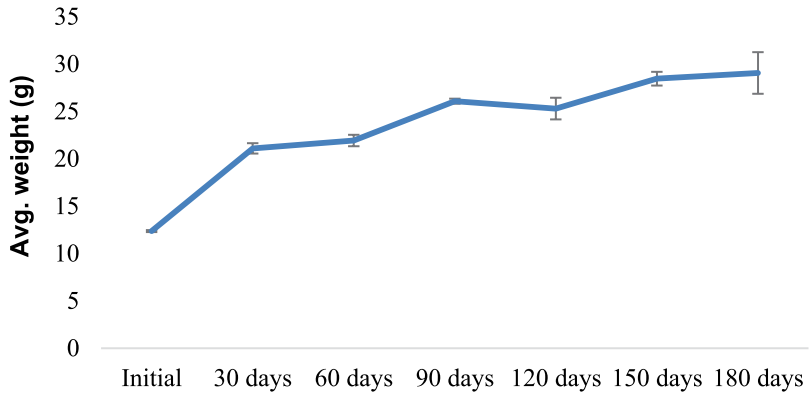
A study was conducted to investigate the overall performance and effect of stocking densities on growth and survival of Singi (*H. fossilis*) in cages. Singi fingerlings raised in circular tanks in captivity were stocked in cages in Maithon reservoir of Jharkhand in four densities, *viz.* 10, 20, 30, 40 no./m^3 in 1st week of April 2021. Fishes were fed with commercial floating pellet (crude protein 32%, crude lipid 5%, fiber 5.5%) twice daily at 3% body weight. At the end of the 180 days culture period fishes in stocking density of 20 no./m^3 gave the highest average body weight gain with highest survival rate of 69%.

A closer look at the growth curve indicated fast growth and better survival in initial one month, subsequently growth rate decreased and mortality increased.

Haul of *H. fossilis* raised in circular tanks



Average weight of *H. fossilis* in circular tanks during the experimental trial



Growth pattern of *H. fossilis* in cages (stocking density 20 no./m^3)

Low grade mortality continued till the end of experiment more or less uniformly in all the cages and stocking densities despite several antimicrobial and nutritional interventions. Some of the dead and moribund fishes developed desquamation and superficial skin ulcers, generally at hind part of the body, while other fishes did not show any external lesion.

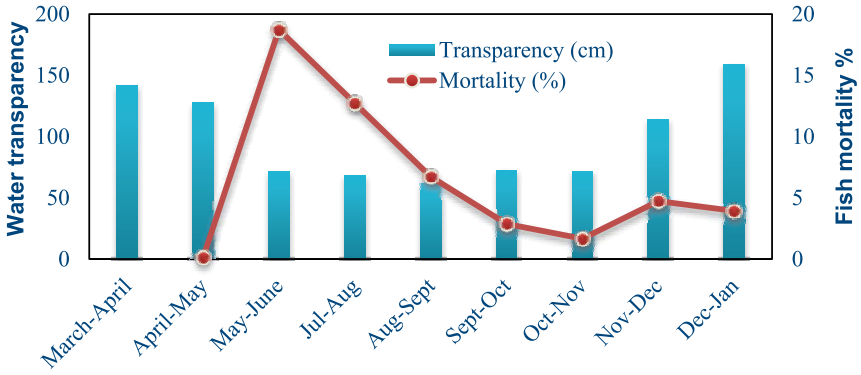
Microbiological and parasitological investigations carried out on moribund fishes excluded parasite as a causative agent of death. Microbiological study could isolate few strains of *Aeromonas veronii*, *A. punctata*, *A. enteropelogenes* from skin lesions and blood of only a few fishes suggesting either localized skin infection or low-grade systemic infection. Experimental pathogenicity study in *Pangasianodon hypophthalmus* and *Labeo rohita* showed that the bacterial isolates were non-pathogenic in nature and mortality might not be primarily caused by bacteria. Whether some unidentified chronic stress is associated with low grade mortality and predisposing Singi in cages to secondary infections needs further investigation.

The disease onset started with ingress of storm water in the reservoir and the mortality was correlated with water transparency suggesting water turbidity might be a stress for the fish. In conclusion, further studies are needed for the development of culture practices of Singi in cages.

Optimization of stocking density of *Cyprinus carpio* (Amur carp) fingerlings in ICAR-CIFRI GI cages for production of table sized fish

A cage aquaculture experiment was carried out to optimize the stocking density of *Cyprinus carpio* (Amur carp) fingerlings for table fish production. Sixteen units of cages (individual cage dimension: 5 x 5 x 2 m^3 each) were installed in Samaguri beel (floodplain wetland) of Nagaon district, Assam. The cages were

A moribund *H. fossilis* with skin lesion from cage



Mortality trend of *H. fossilis* in relation to water quality of the reservoir

stocked with *C. carpio* fingerlings (avg. length 8.44 cm; avg. weight 9.23 g) at five different stocking densities, viz. 5 (S_1), 10 (S_2), 15 (S_3), 20 (S_4) and 25 (S_5) fingerlings/m^3, in triplicates. Fishes were fed with floating feed containing 32% protein @ 3-5% body weight twice-a-day for six months. Growth and water quality parameters were studied bimonthly. Water quality parameters monitored inside and outside the cages at 1 m and 5 m away from the cages were similar in all the sites in a particular sampling time. Results of the experiment indicated that the growth rate of *Cyprinus carpio* decreased with the increase in stocking density, however, differences were not significant (P = 0.171). The specific growth rate at different stocking densities were: 1.94 (S_1), 1.92 (S_2), 1.87 (S_3), 1.85 (S_4) and 1.77 (S_5). Therefore, Amur carp can be stocked at a stocking density of 25 fingerlings/m^3 or above for producing table size fish in ICAR-CIFRI GI® cages in the beels of Assam. However, it was observed that the serrated dorsal spine of Amur carp sometimes got entangled with the net cages leading to mortality. Proper care and monitoring are needed to prevent such situation.

Amur carp grown in cages

Effects of stocking density on fish physiology, growth and flesh quality of *Labeo rohita*

The present study was conducted for a period of 240 days to evaluate the effects of stocking density on growth attributes, digestive enzymes, muscular composition, biochemical and physiological responses of *Labeo rohita* fingerlings in tropical inland open water cages. *L. rohita* (30.35±1.08 g) were randomly distributed into three treatments, namely low stocking density (LSD, 10 no./m^3), medium stocking density (MSD, 20 no./m^3) and high stocking density (HSD, 30 no./m^3), in triplicates. Fishes were fed twice daily with CIFRI CageGrow® floating feed (crude protein 28%, crude fat 4%). Fish growth and feed efficiency was higher (P<0.05) in LSD, however MSD registered higher yield. Amylase and protease activities were low whereas lipase activity increased with increasing stocking density. Muscle crude protein and crude fat formed inverse correlation. Fillet quality was deteriorated at higher stocking densities based on muscle pH, drip loss and frozen leakage rate. The stress biomarkers level (glucose, cortisol, superoxide dismutase and catalase) increased in serum under crowding condition. Glutamate oxaloacetate transaminase and glutamate pyruvate transaminase in serum were significantly increased in HSD. Serum protein level decreased with increase in stocking density. Body ionic imbalance (Na^+, Cl^- and K^+) were observed under crowding stress. Based on growth attributes and multiple biomarker responses, *L. rohita* @ 10 no./m^3 found to be optimum density for inland open water cage culture.

Project Title: Sustainable Production enhancement and livelihood improvement through technological intervention (pen culture) in selected reservoirs and wetlands of India

Project Code: RWF/21-24/14

Duration: 2021-24

Scientific Personnel: M. A. Hassan (P.I.), S.K. Manna, D. K. Meena, R. Baitha, H.S. Swain, S. Kamble, R. Das

Fisheries potentials of reservoirs and wetlands have not been fully utilized. Integrated development involving seed production and rearing through pen/cage culture, culture based fisheries and good governance can help realize the potential of these resources. Till date, research on pen culture has focused on standardizing

protocol of seed raising from fry to fingerling/advanced fingerling as stocking material for culture-based fisheries in reservoirs and wetlands. The present technology package of HDPE pen with FRP poles is effective in most of the wetland ecosystems. However, the furies of environmental extremities such as flood, storm have challenged present pen culture technology and improvement of pen material and design was felt necessary. In addition, development of package of practices for long duration table fish production need research attention to meet consumer demand. The present research aims at developing pen culture technology protocols for appropriate species and system diversifications in reservoirs and wetland ecosystem.

To study the feasibility of system diversification a site has been selected in Maithon reservoir, Jharkhand and hydrography of the selected site has been monitored in different seasons The selected site is more than 2 km upstream of the dam, at the mouth of a bay on the western bank linked through approach road and have active fishers community, long duration water availability (8-12 months), flat and muddy bottom and a nearby market.

The selected habitat parameter was collected and found to be suitable for culture and growth of fish. The average height of the water column

Selected pen culture site near Gogna Basti, Maithon reservoir

in the selected site at Full Reservoir Level (FRL) during September was recorded at 14.3 m and during the onset of summer in March it was 10.6 m.

A new design of pen has been developed for system diversification in pen culture. The proposed new pen design has been aimed at overcoming the wide fluctuation of water depth in reservoir ecosystem. In addition, pen material has also been changed for sustaining prolonged culture duration.

Table 7. Selected habitat parameters of the proposed site

Water quality parameter	Range
Location	23°47'33" N, 86°47'30" E
pH	8.0-8.2
DO (mg/l)	5.93-6.02
TDS (mg/l)	102-113
Conductivity (µS/cm)	204
Transparency (cm)	80-114
Water temperature (°C)	26.2
Air temperature (°C)	28.7
Water depth (m)	1.2-1.3(margin); away from margin (3.6-6.8); selected site (9.5-11.8)

Project Title : Evaluation and management of environmental health through omics technologies

Sub-project 1 : Metagenomic profiling of floodplain wetlands for ecosystem health formonitoring

Sub-project 2 : Stock characterization of two bagrid species (*Mystus cavasius* and *M. gulio*)fisheries management

Sub-project 3 : Efficacy of fish epidermal mucus as a biomarker for the environmental stress and potential antimicrobial agent against fish pathogens using 'omics' technologies

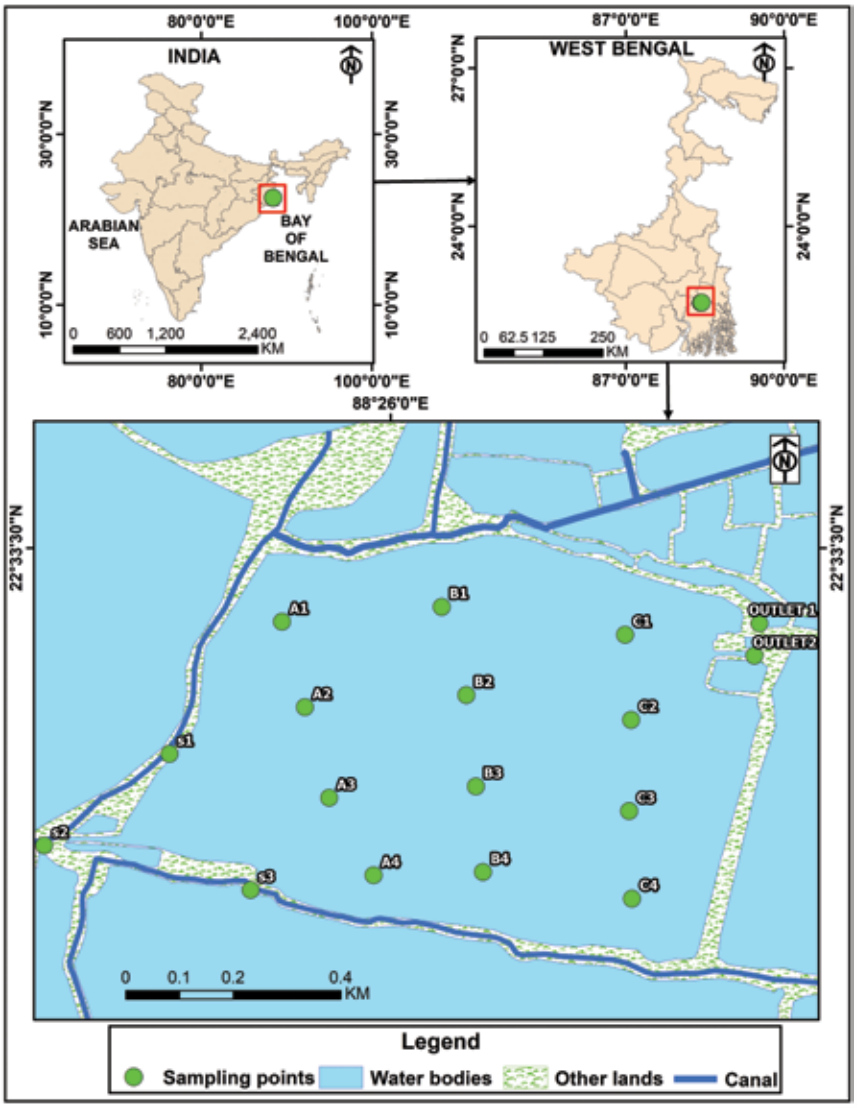
Project Code : FREM/20-23/17

Duration : April 2020 to March 2023

Scientific Personnel : B.K. Behera (P.I. and Sub-project 1 Leader), V. Kumar (from 1.4.2021), T. Bera, N. Sharma, P. Maurye (Sub-project 2 Leader), P.K. Parida (Sub-project 3 Leader), D. Bhakta, V.L. Ramya, K. Kumari, M. Shaya Devi, Santhana Kumar V.

Sub-project 1: Metagenomic profiling of floodplain wetlands for ecosystem health monitoring

East Kolkata wetlands (EKW) are natural sewage fed wetlands of area about 125 sq. km, bounded by latitude 22˚25'N to 22˚40'N and longitudes 88˚20'E to 88˚35'E, and situated in Eastern part of Kolkata, West Bengal. Among several wetlands the Sardar *bheri*, one of the most polluted wetlands in the region, was selected for study. To examine the impact of anthropogenic pressure generated from urban wastewater 51 sediment samples were collected from 17 sampling sites (3 samples/ site) in sewage canal (SC), wetland site A, B, C and outlet canal (OC). The direction of the water flow is from sites SC to OC. Samples were analyzed for heavy metals (HMs) by ICP-MS to characterize their spatial distribution, potential risk, and potential sources. Besides sediments, 45 water samples and 7 fish species were studied to understand the distribution pattern of HMs from soil to water and water to fish. The geostatistical prediction map of sediment samples showed that levels of Cr, Fe, Cu, Co, Zn, Cd, Ni, Pb and Mn in sampling stations were 27.3-84.1 µg/g, 7281-30193 µg/g, 50.6-229.7 µg/g, 4.8-15.3 µg/g 113.4-776.9 µg/g, 10.0-26.9 µg/g, 23.8-55.7µg/ g, 9.5-39.3 µg/g and 188.6-448.5 µg/g, respectively. The results of the



GIS based map of study area and sampling locations

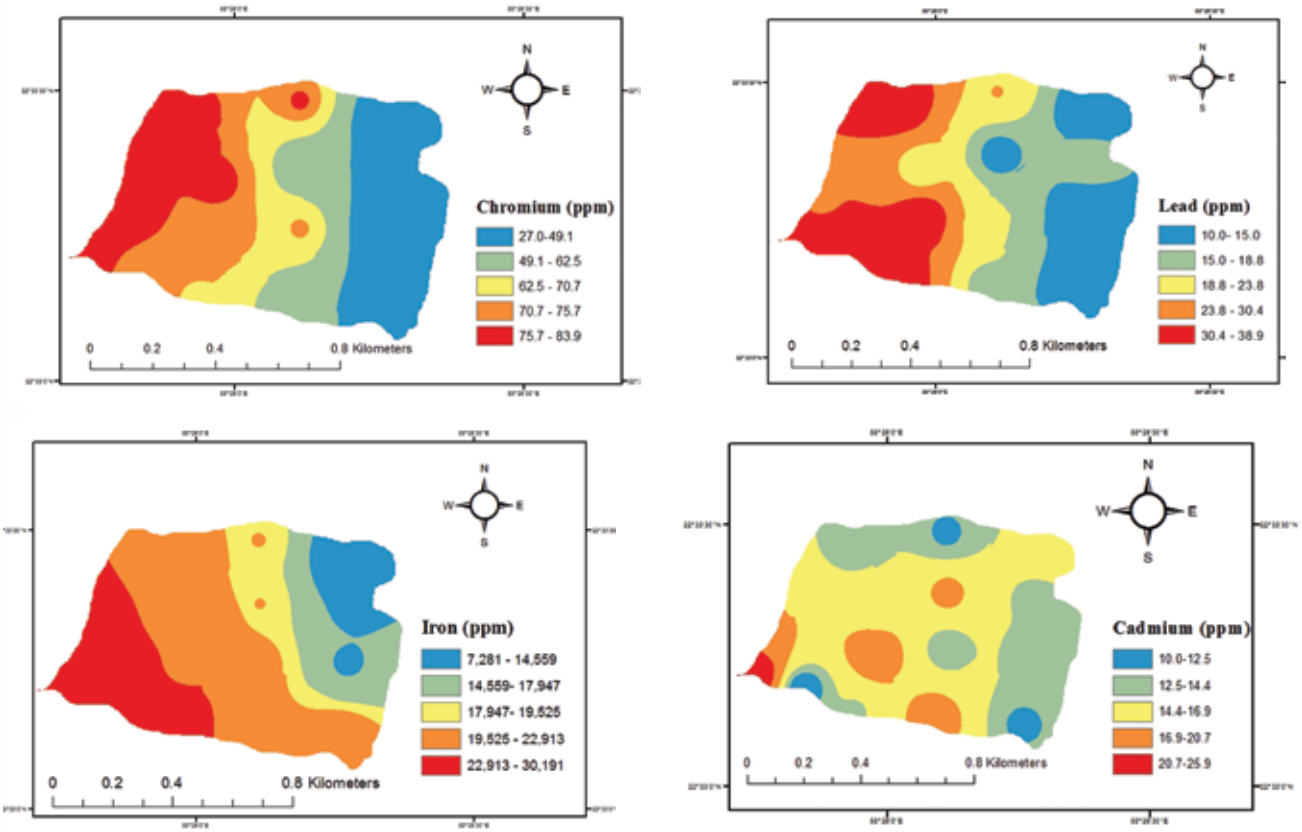
risk assessment of different hazard indexes (Geoaccumulation index, Contamination Factor, Ecological Risk Index, etc.) showed that sediment samples were severely polluted by Cd, followed by Zn. The study revealed that though HM status of water and fish were within considerable limits, pollution is most alarming in sediment since all the studied heavy metals exceed the threshold effect levels according to sediment quality guidelines.

The Sardar *bheri*, a natural wetland receiving urban wastewater and located in Eastern part of Kolkata city, has around 140 ha area. Sampling was done from sewage canal (SC1-SC3), wetland site A (A1-A4), B (B1-B4), C (C1-C4) and outlet canal (OC1-OC2) of the wetland.

Bacterial diversity, community composition and their possible functional properties of microbial communities isolated from the EKW were explored. Following isolation, 32 bacterial strains have been identified and their functional properties have been studied. Interestingly, eight strains were highly pathogenic to fish, causing 100 % mortality within 12-24 h post challenge. The remaining 24 strains were non-virulent. Among non-pathogenic isolates, 8 strains demonstrated antimicrobial properties against fish bacterial pathogens.

In Assam, Borsola beel, situated at the heart of the Guwahati city, has been undertaken for the study. The beel has a total length of around 1.5 km and average width of 50 meters, covering an area of 10.117 ha. However, due to poor waste management and absence of sewerage treatment network, the wetland has become a dumping ground resulting in rapid shrinking of the wetland. During our initial study, it was observed that the wetland has

A glimpse of Sardar bheri, Kolkata



Geo-spatial distributions of chromium, lead, iron and cadmium in Sardar bheri

Inlet and outlet points of Borsola beel, Guwahati

Table 8. Water quality parameters of Borsola beel, Guwahati

Parameters	Inlet (ZMean ± SE)	Middle (Mean ± SE)	Outlet (Mean ± SE)
Water temperature (^{0}C)	23.3 ± 0.20	23.7 ± 0.21	24.3± 0.16
pH	9.31 ± 0.112	9.29 ± 0.14	8.70 ± 0.005
Dissolve Oxygen (mg/l)	2.15 ± 0.162	2.70 ± 0.129	3.025 ± 0.217
Electrical conductivity ((µS/cm)	60.6 ± 1.749	52.28 ± 1.948	41 ± 0.57
Total Dissolve Solids (mg/l)	38.8 ± 1.240	33.28 ± 1.322	44 ± 1.20
Total Alkalinity (mg/l)	197.4 ± 3.68	139.14 ± 4.743	177.5 ± 1.45
Free CO_2 (mg/l)	6.84 ± 0.365	5.72 ± 0.213	8.06 ± 0.384

approximately ten numbers of inlet and outlet connections protected by lock gates, preventing ingress of bigger size wastes in to beel and escape of fishes to outlet channel. Water and soil sediments have been collected from inlets, middle and outlet area of the wetlands for studying the physico-chemical parameters, heavy metal analysis and metagenomics analysis. The analysis showed that overall water quality of the wetland is very poor (Table 8). Fish species, *viz*., *Wallago attu*, *Channa striata*, *C. punctatus*, *C. gachua*, *Clarias magur*, *C. gariepinus*, *Heteropneustes fossilis*, *Anabas testudineus* and *Colisa fasciata* have been collected from the wetland.

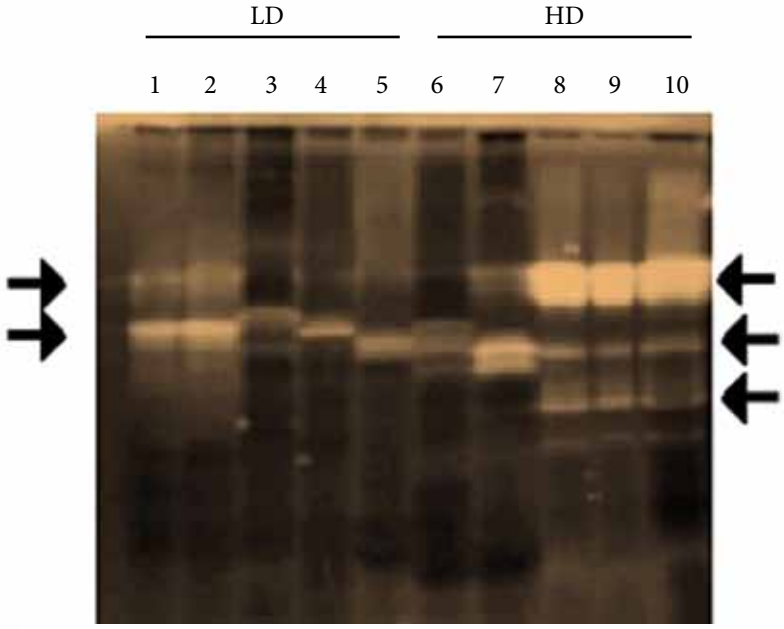
The sediment samples from both West Bengal and Assam wetlands were collected and send for metagenomics analysis. This will provide a comprehensive representation of microbial community composition of the studied aquatic ecosystem.

Sub-project 2 *:* Efficacy of fish epidermal mucus as a biomarker for the environmental stress and potential antimicrobial agent against fish pathogens using 'omics' technologies

Acclimatized *Labeo rohita* was challenged by bath treatment with a pathogenic strain of *Aeromonas veronii* at 2.08 $\times 10^3$ CFU/ml and 4.17×10^3 CFU/ml of bacteria along with negative control. Afterwards, the fish skin and mucus were collected for analysis.

Proteomics of fish skin mucus in search of environmental stress biomarker

Experimental fish mucus samples were used for isolation and characterization of antimicrobial peptides. Protein samples were dialyzed, desalted, precipitated-down, and made in to aliquots. For identification, characterization and analysis of some putative antimicrobial peptides (AMPs) 1D protein linear PAGE (11%, 12% and 15%) gel electrophoresis technique was used. The inhibitory activities of AMP against the opportunistic pathogen were analyzed by zymography technique using universal substrates. The 1D PAGE results confirmed that the mucus samples were rich in proteins and



Zymogram of skin mucus protease activities of the *L. rohita*. LD-low dose and HD-high dose. Arrows indicate inhibitory effects of the enzymes present in the fish mucus.

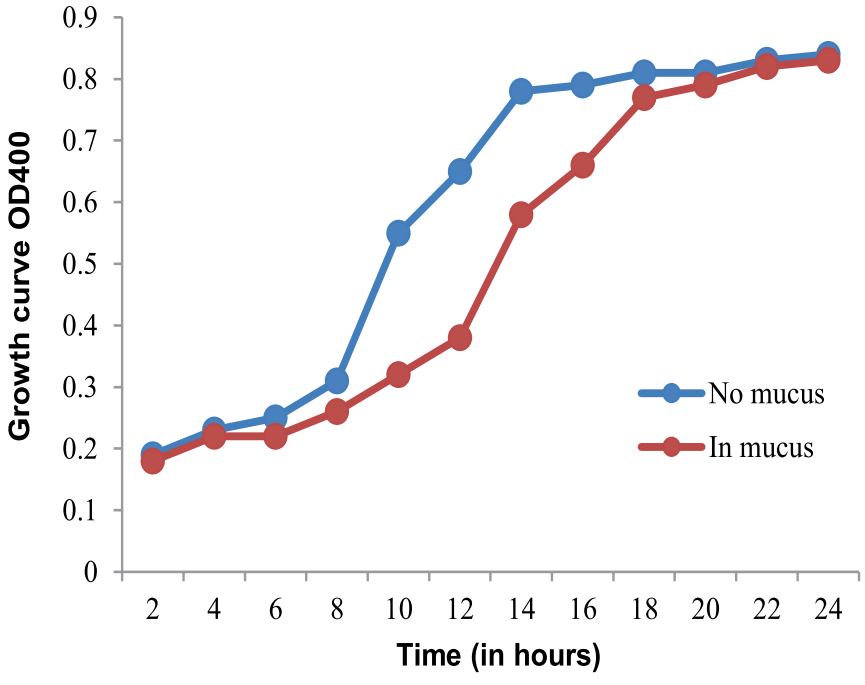
lipids. Wide range of extracellular proteases induced in the fish skin mucus has shown activities against selected pathogenic bacteria. These AMPs share significant protease activities among the experimental samples (with low and high dose) as compared to the control. It has been observed that high dose of pathogen exposure triggers high expression of AMPs in the fish skin mucus whereas low dose delayed the AMPs expression. The zymogram also revealed the presence of different bands with proteolytic activities in the presence of three universal substrates. The exposure of *A. veronii* to *L. rohita* confirmed that the mucus protease activity is dependent on exposure dose, and expression of these proteases in fish is specific and rapid for particular pathogen.

Estimation of antibacterial properties of epidermal fish mucus

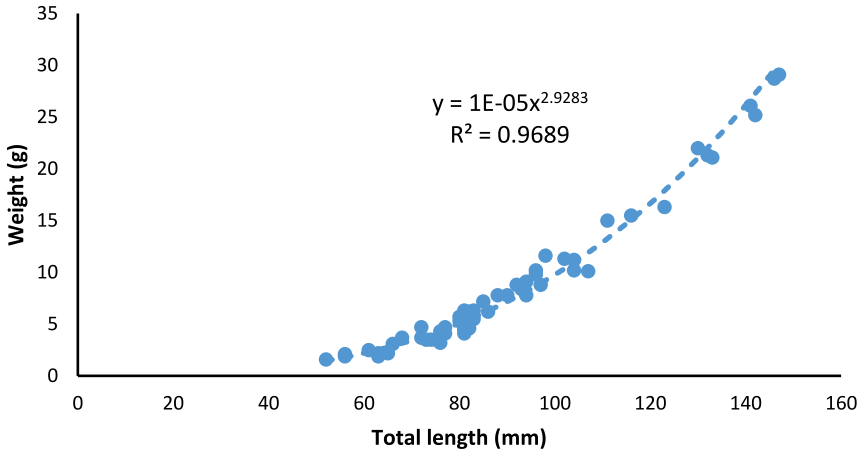
Antibacterial activity of the fish skin mucus was examined by well/disc diffusion method. Collected mucus samples were homogenized and centrifuged to get clear supernatent. In Mueller Hinton agar (MHA) and nutrient broth incorporated with 1% agarose, the bacterial culture (*Vibrio cholerae;* 10^8 CFU/ml) was spread on each plate and different concentrations of mucus (100%, 50%, and 25%) were added to punched wells. After overnight incubation, the zone of inhibition was recoreded to analyse the antibacterial properties of the mucus components. Similarly, the discs were prepared with above concentration of mucus samples and placed on the TSB plates. After incubation, no zone of inhibition around the discs were recorded with same bacterial culture. When co-culture of bacterial strain and mucus samples (1:1 in control) was analysed to record the growth curve of the bacteria, growth of bacteria was inhibited during the log phase which shows that fish skin mucus exhibited inhibition to the growth of *V. Cholerae.*

Sub-project 3: Stock characterization of two bagrid species (*Mystus cavasius* and *M. gulio*) for fisheries management

Mystus gulio (Hamilton, 1822), locally called "nuna-tengra", is a Least Concern (LC) species as per IUCN Red List status. It is primarily a brackish water species and contribute significantly to small-scale and artisanal fisheries.



Antibacterial activity of mucus against *Vibrio cholerae*



Length-weight relationship of *M. gulio* from the Hooghly-Matlah estuary

During 2021, a total of 55 fresh samples of *M. gulio* (size: 52-147 mm, 1.6-29.1 g) were collected from Hooghly-Matlah estuary (Nischintapur, Jharkhali, Sandeshkhali, Pathar Pratima, etc.). The established length-weight relationship shows a negative allometric growth pattern for the species in the said environments. Similarly, 12 specimens of *M. gulio* were collected from river Ganga and river Mahanadi.

Similarly, 43 numbers of *M. cavasius* samples (size: 14.2-22.5 cm, 16.9-74.9 gm) were collected from River Cauveri and Ganga. The established length-weight relationship (b = 3.071, R^2 = 0.939) study showed a positive allometric growth pattern of the species. Environmental factors might have also greatly determined the fecundity of *M. cavasius* in different habitats. The mean fecundity of *M. cavasius* was 8798±417. The average number of eggs per g of ovary and body weight were 8798 and 548, respectively.

Cytochrome b gene amplification and sequencing

For genetic study, a piece of dorsal fin sample from each individual fish was collected and preserved in 95% of ethanol and transported to laboratory using ice pack. Total genomic DNA was extracted from fin samples. The mitochondrial *Cytochrome b* (*cyt b*) partial gene was amplified, sequenced and 16 such sequences have been submitted to NCBI.

A total of 10 Cyt b gene sequences (1140bp) of *M. cavasius* (Accession no. MZ191061, MZ191062, MZ436919, MZ463197, MZ568802, MZ574438, MZ501209, MZ516518, MZ540027 and MZ546614) and 6 sequences of *M. gulio* (Accession no. MZ229470, MZ229471, MZ998905, MZ998906, MZ998907 and MZ998908) have been submitted to NCBI GenBank.

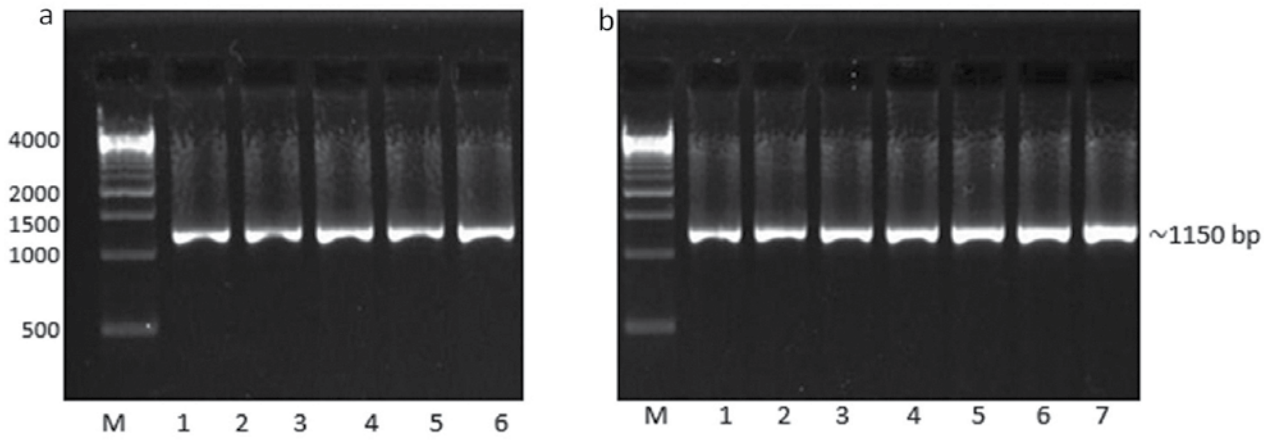
Project title : Development of ammonium and phosphate remediation techniques using nanostructured materials for restoration of polluted water bodies

Project Code : FREM/21-24/19

Duration : April 2021 to March 2024

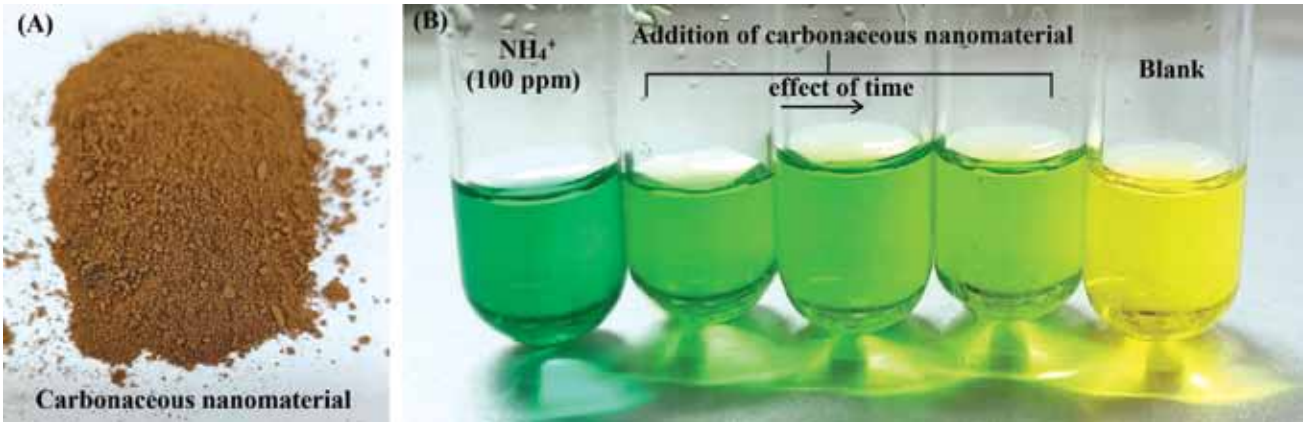
Scientific Personnel : D.J. Sarkar (P.I.), T. Bera, Santhana Kumar V.

Anthropogenic activities are polluting fisheries resources at an accelerated pace threatening ecosystem functions, fish and fisheries. Hence managing pollution in aquatic resources



Gel image showing the Cyt. b gene amplification of *M. gulio* and *M. cavasius*. Lane 1-6 and 1-7 showing positive samples for Cyt. B

through technical interventions is of utmost importance. Though there are several methods available for managing water quality in the small water bodies, such as application of lime, zeolite, etc., managing pollution in the large water bodies like river, reservoirs, lakes is difficult. The present project aims to develop nanotechnological interventions for remediation of large polluted waters. Carbonaceous nanomaterial was synthesized through hydrothermal carbonization of cellulosic biomaterials with varied temperature regime (100-200°C). The synthesized material showed high cation exchange capacity (50-90 $cmol_c/kg$) and high surface area. The material was a free flowing powder of slightly acidic nature (pH5-7). The initial batch adsorption study showed that the synthesized material has high sorption ability towards ammonium ion. A concentration dependent sorption capacity was observed with a fixed amount of the synthesized material. At 1 mg/l of NH_4^+, 83% removal was observed whereas at 100 mg/l 26% removal was observed and at 500 mg/l it was 30%. The ammonium sorption capacity of the synthesized material ranged from 0.42-222.42 mg NH_4^+/g at initial ammonium concentrations of 1-1000 mg/l. Further evaluation of tested material is going on.



A glimpse of the carbonaceous nanomaterial and its ability of ammonia quenching

FISHERIES SOCIO-ECONOMICS

Project Title : Sustainable Inland Fisheries Development Pathways to Ensure Sustainable Development Goals

Project Code : FSE/20-23/04

Duration : April 2020 to March 2023

Scientific Personnel : B.K. Das (P.I.), A.K. Das., M.A. Hassan, A. Pandit, G. Chandra, A. Roy, Lianthuamluaia, P.K. Parida, Th. Nirupada Chanu, P. DebRoy, H. Swain, M. Ramteke, S.K. Koushlesh, P.R. Behera (w.e.f. 01.12.2021)

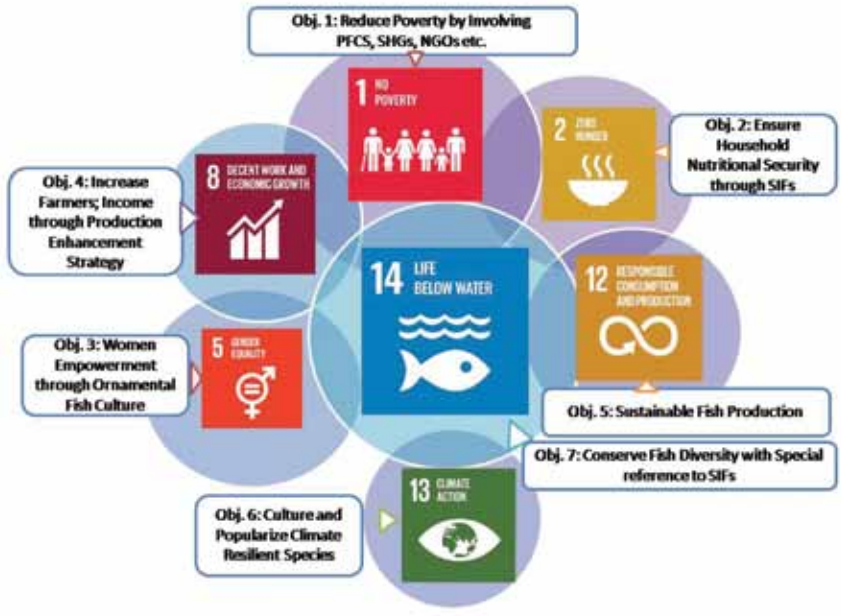
The project envisages to empower fishers and other stakeholders in the inland fisheries sector of India towards fulfilling the goal of SDGs. More specifically, the SDG # 1, 2, 5, 8 and 14 have been addressed in the first year of the project in West Bengal, Odisha and Jharkhand states where research and development activities of ICAR-CIFRI are being carried.

Socio-economic status of fishers in wetlands of Murshidabad (for SDG 1: No Poverty)

The study was conducted by taking 64 sample households from Asandighi, Andiran, Shaktipur, Sagarpara, Rangamati wetlands of Murshidabad. Majority (50%) of the respondents was in the age group of 35-50 years and SC category (90.62%). Nearly 40% fishers are more than 50 years in age. Regarding literacy, 25% of fishers can read and write, another 23.44% can only read; 18.75% each were primary educated and secondary educated and only 3.1% had college education. Occupation-wise, fishery and fish marketing was the primary occupation of 93.75% respondents. Among them 67.19% respondents have enclosure culture in wetland fisheries as their primary occupation which they carry out through Primary Fishermen Co-operative Societies (PFCS). The secondary occupations of the respondents were doing small business of fast-food, vegetable sale, garment, furniture, fish, fishing gear, masonry, agriculture, fishing, *e-rickshaw* driving and daily wage agricultural labourer.

Forty-four per cent of the households has family size of 3-5; 73.44% of the households were nuclear in nature. Around 90% (90.63%) of the households were under BPL category and 56.62% of the respondents were the members of SHGs. Almost half the households had *kachha* house. Around 51.56% and 28.13% of the respondent households possessed fishing crafts and gears, respectively. The fishing crafts were mainly dug-out canoes. Different fishing gears owned by the fishers are *khapla*, *phas jal*, *tana jal*, *khe jal* and *kochal jal*.

The problems encountered by fishers in Murshidabad are eutrophication and delay in wetland lease process. Many fishers are in search of additional livelihood opportunities as income from fisheries is dwindling. The fishers have also spoken about other infrastructural problems in their district and lack of access to educational opportunities for their children. Further, wetland Andiran falls in arsenic affected area and people are worried about using this wetland for fishery and other use.



Project objectives to address SDG 1, 2, 5, 8, 12, 13 and 14 of the United Nations

Ensuring household nutritional security through SIFs (SDG 2: Zero Hunger)

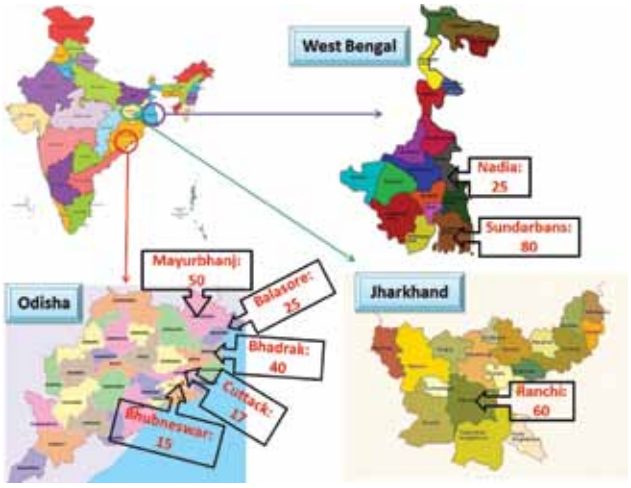
Consumption of Small Indigenous Fish (SIFs) supplies essential proteins and micro-nutrients and several vitamins. The Institute has taken up initiatives such as demonstration of pen culture for SIFs, mass awareness and sensitization programmes for conservation and culture-based fishery of SIFs. In this regard, 'Sarana Model' was implemented in some of the wetlands wherein 50,000 fingerlings of *Puntius sarana* were stocked in installed pens. This has contributed to nutritional security of fisher households as well as some additional income from sale of the produce.

Women empowerment through ornamental fish culture (SDG 5: Gender Equality)

ICAR-CIFRI has been promoting ornamental fish farming by providing hands-on-training and various inputs to women fishers so that they can adopt ornamental fish farming successfully and earn a profitable income. Nine clusters (four from West Bengal and five from Odisha) have been selected where groups of women are provided with inputs like FRP tanks, fish feed, fish seed and accessories (blower, aquarium plant, etc.).

The Institute has provided training and hand-holding support to 342 rural women, mostly from Scheduled Caste and Scheduled Tribe communities. The beneficiaries were selected on a cluster basis in Sundarban and also through the recommendation of the State Fisheries Department from amongst SHGs, NGOs and active members of Rotary Clubs. The majority of beneficiaries are in the age group of 25-45 years.

Women fisher beneficiaries under ornamental fishery enterprise



The location of beneficiaries in West Bengal, Odisha and Jharkhand

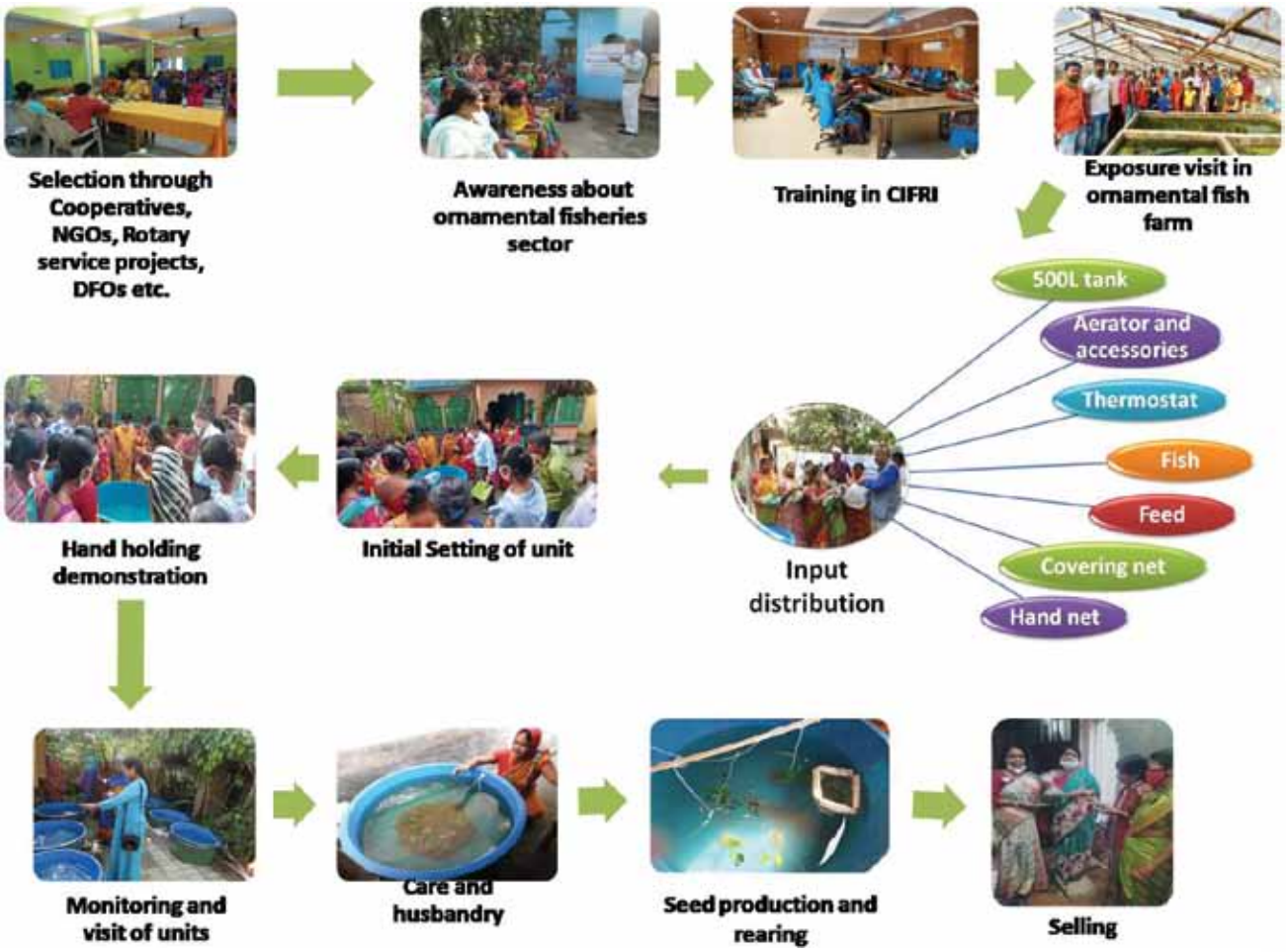
Ms. Manjulata Hembram from Chunakoli, Khurda, Odisha

Ms. Anima Kayal from Kultali, Sundarbans

Success stories

"I am very much interested to expand my business, and I am thankful to ICAR-CIFRI" - said of Ms. Manjulata Hembram of Chunakoli, Khurda, Odisha who earned ₹3,150 from sale of ornamental fish within 8 months of unit establishment.

Ms. Anima Kayal from Kultali, Sundarbans earned ₹1,500 from the ornamental fish unit within 6 months of unit establishment. She also started to promote ornamental fisheries in her neighborhood.



Process of ornamental fisheries unit establishment with hand-holding support from ICAR-CIFRI

Increase in farmers' income through production enhancement strategy (SDG 8: Decent Work and Economic Growth)

The institute has been working in several wetlands and small reservoirs in West Bengal, Odisha, Jharkhand and other states where supports, both technology and knowledge, are being provided to the fishermen associated with the water bodies. Most of the inputs are also given to them without any cost. Besides, time to time training, awareness camp and technology demonstrations have been arranged both in on-campus and off-campus modes. In this case, ICAR-CIFRI has been working with hand-holding support to the inland fishers so that they can adopt scientific fish farming practices appropriate for inland fisheries management to enhance fisheries production and thereby their income. The Primary Fishermen Cooperative Society of Beledanga wetland of West Bengal after ICAR - CIFRI's intervention has been able to increase their fish catch from 24,271 kg in 2019-20 to 32,817 kg in March, 2020-21 which, consequently, has led to the increment in the income from the sale of the fish from ₹23,34,450 to ₹29,14,974 respectively.

Conservation of fish diversity with special reference to SIFs (SDG 14: Life Below Water)

In India, the flood plain wetlands and the reservoirs have a huge scope of fish production enhancement. But, irresponsible fishing practices, habitat loss, climate change, water abstraction, dam construction and pollution are causing substantial decline in inland fishery resources. These have resulted in the loss of fish diversity, more particularly the small indigenous fish (SIF) species. ICAR-CIFRI has developed different technologies through which fish production from these water bodies can be enhanced. The present average production of wetlands and reservoirs are 350 kg/ha and 150 kg/ha, respectively. ICAR - CIFRI has emphasized on the conservation of the SIFs. The Sarana Model of pen culture technology has been demonstrated in different floodplain wetlands for growing SIFs which are becoming endangered or threatened day-by-day. On-field or in-house training, mass awareness and sensitization programmes have also been conducted to upgrade their knowledge and skill to adopt various fish conservation technologies suitable for open waters.

Project Title: Breeding of indigenous fish species of ornamental value from West Bengal and Assam

Funding agency: ICAR

Scientific Personnel : U.K. Sarkar (P.I. w.e.f. 01.06.2021), A. Sinha (P.I. till 30.9.2020), S. Kumari (P.I. during Oct. 2020-May 2021), S. Yengkokpam, H.S. Swain, N. Sharma (w.e.f. 01.09.2021)

Breeding and culture status of *M. aral*

Published literature on breeding and culture of *Macrognathus aral* and *Macrognathus pancalus* are limited, however, available reports indicated that the first induced breeding of *M. aral* with pituitary extract was carried out more than a decade ago in Bangladesh (Chakraborty, 2008) with partial success but the details of breeding protocol and larval rearing of the species were not systematically documented. In India, to the best of our knowledge, no reports are available on induced breeding and captive propagation of *M. aral* in the Gangetic floodplain areas and supply of this ornamental fish is solely dependent on natural fish stocks. Therefore, one of the objectives of the project is to breed and rear *M. aral* in captivity.

Collection and captive rearing of *Macrognathus aral* and *M. pancalus*

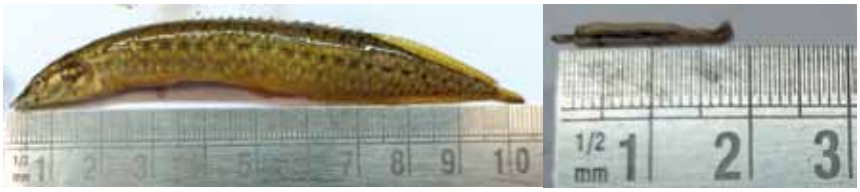
Live *M. aral* and *M. pancalus* fishes were collected throughout the year from freshwater ponds, six wetlands in North 24 Parganas, one wetland in Nadia, River Ganga at Tribeni and Balagarh in Hooghly district, and a river canal at Diamond harbor in South 24 Parganas district, West Bengal. The fishes were also collected from Brahmaputra river and its tributaries (Digaru and Puthimari) and reared in captivity.

Gonadal maturation of *M. aral* and *M. pancalus*

The fishes attained maturity within 6-7 months of rearing in captive condition. Tubifex was offered to promote gonadal development. The matured female gonad is elongated, dark green in colour and has asymmetric lobes. The male testis is milky white, elongated and asymmetric lobbed. The breeding season of the fish is from July to September. The gonadosomatic index (GSI) ranged from 0.75 to 8.30. In fully matured ovary the average ova diameter was recorded to be 0.94 mm. The absolute fecundity of the fish varied between 775 and 2250 numbers during the breeding season.

Female *M. pancalus* and matured ovary

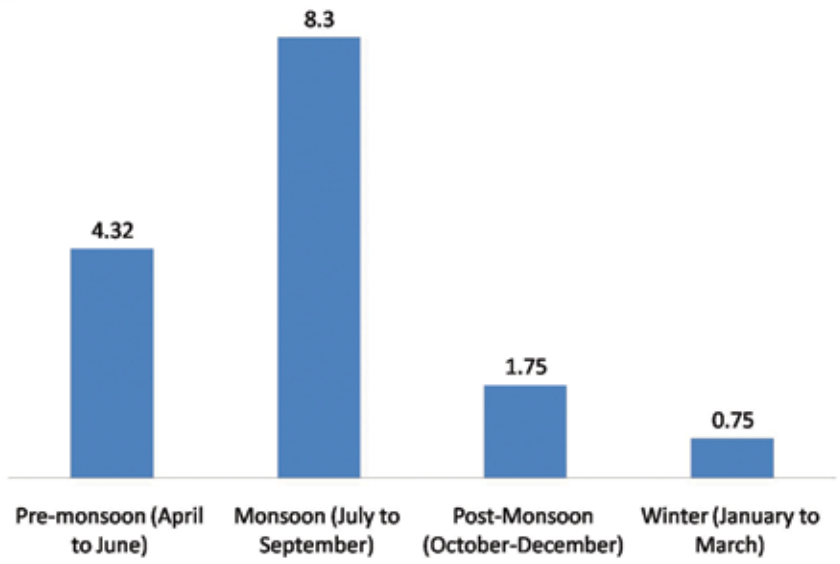
Male *M. pancalus* and matured testis



Female *M. aral* and matured ovary

Male *M. aral* and matured testis

Matured *M. pancalus* and *M. aral and their* gonads



Seasonal change in GSI of *M. aral*

Induced breeding and larval rearing of *M. aral*

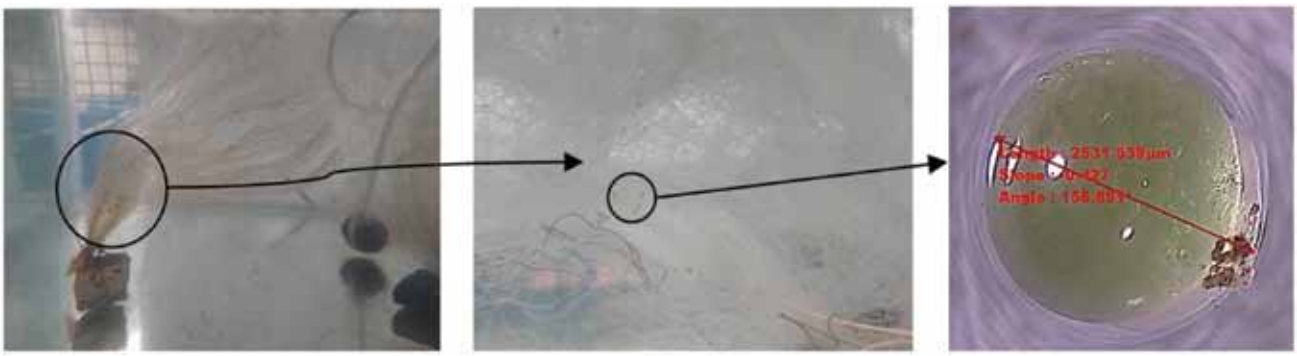
In matured fish, breeding behavior was noted from the end of July. However, no natural spawning was observed in females. Fishes were bred successfully with administration of hormone Spawn Pro and at a 1:2 female-male ratio. The optimum water quality parameters during the breeding time recorded were: temperature 30.2-32.5 °C, pH 7.6-7.8, alkalinity 144-150 mg/l, dissolved oxygen 8.9-9.5 mg/l. The spawning behavior of the fish starts after 3-8 h of the hormone injection. During courtship the male chases the female. Then, male and female fishes get entangle each other around the bushy substratum and release the eggs and milt. The sticky fertilized eggs get attached to the nylon thread or bushy substratum. The latency period varied up to 12-14 h from injection. The breeding efficiency significantly varied with the hormonal dose. A fertilization rate of 72.62 % and highest hatching rate of 77.86 % were achieved with 0.05 mg/10g hormone dose.

The yolk sac is absorbed after 55-60 h of hatching. After yolk sac absorption, the larvae were fed with mixed infusoria and artemia larvae for 15-20 days. The larvae reached 10-25 mm in length within 15 days when they were fed with small, cleaned tubifex. Water quality parameters were monitored daily during larval rearing. Ocelli were clearly visible after 25-30 days of hatching. In four months, the fingerlings of average size of 7.5 cm in length and 3.4 g weight were raised.

Study of biometric, morphometric and biology of indigenous *Badis blosyrus* (Kullander & Britz, 2002)

Badis blosyrus (Kullander & Britz, 2002) is a freshwater fish belonging to the family Badidae and is commonly known as Dwarf Chameleon fish and locally referred as 'Dum bhecheli'. It is distributed in Brahmaputra River drainage, Assam. The fish exhibits prominent dark blotch poster dorsally on operculum and two rows of irregular blackish blotches alongside. The fish is orange-reddish in colour with irregular scattered bluish-blackish blotches on the lateral side. The fins are hyaline with the dorsal, anal and caudal fin origins having the orange-reddish. The dorsal fin has a large black blotch located on first few rays, and another large black blotch is present at the centre of the caudal peduncle. Due to attractive and colourful pattern, it is used as an ornamental fish species and exploited in the aquarium trade.

A total of 30 numbers of *B. blosyrus* were collected for domestication

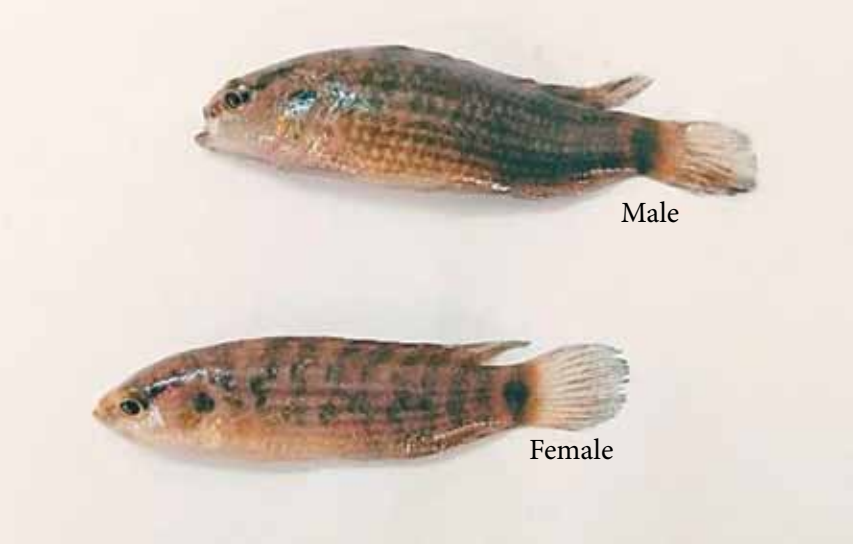


Fertilized eggs of *M. aral* attached to substratum and their size

Table 9: Morphometric and meristic characteristics of *B. blosyrus*

Morphometric traits	Minimum	Maximum	Average	Meristic characteristics	Range
Weight (g)	0.54	1.27	0.87	Dorsal fin spine count (no.)	16-17
Total length (cm)	3.6	5.1	4.57	Dorsal fin soft rays count (no.)	8-11
Standard length (cm)	3.1	4.2	4.05	Pectoral fin ray count (no.)	6-7
Head length (cm)	0.8	1.2	1.075	Anal fin rays count (no.)	8-10
Body depth (cm)	1.1	1.3	1.2	Caudal fin rays count(no.)	12-14
Eye diameter (cm)	0.21	0.28	0.23	Scales in lateral line (no.)	24-26
Snout length	0.2	0.25	0.22		
Dorsal fin length (cm)	2.0	2.2	2.1		

and breeding purpose. The total length and weight of the fish ranged from 3.6-5.1 cm and 0.54-1.27 gm, respectively. Standard length, head length, snout length, body depth, eye diameter, pre-dorsal length and length of caudal peduncle are found to be highly correlated with increasing total length and body weight. The meristic counts showed 16-17 dorsal fin spine, 8-11 dorsal fin soft rays, 6-7 pectoral fin rays, 8-10 total anal fin rays, and 12-14 caudal fin rays. The fish exhibits sexual dimorphism and females are smaller in size, more round in shape and have duller pattern as compared to males.



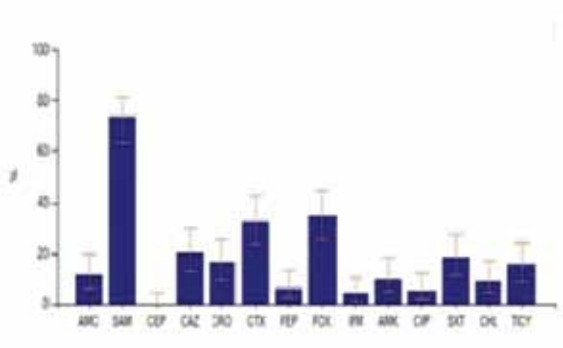
Sexual dimorphism of the brooders of *B. blosyrus*

Project Title: Network project on Antimicrobial Resistance (AMR) in Fisheries and Aquaculture

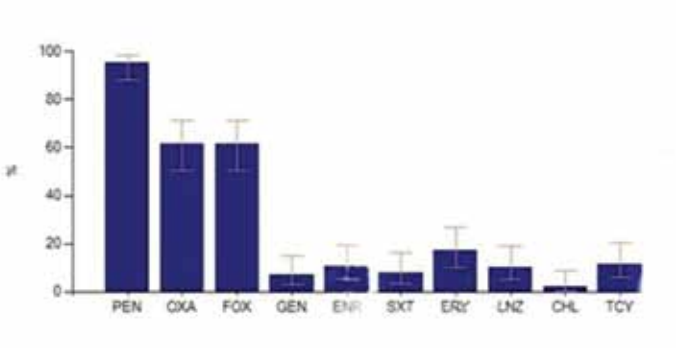
Funding agency: ICAR

Scientific Personnel: A.K. Sahoo (P.I.) and A.K. Bera

India has one of the highest antibiotic resistance rates among bacteria causing infections in the community, agriculture including aquaculture and healthcare facilities. Resistance to the broad-spectrum antibiotics fluoroquinolones and third generation cephalosporin were more than 70 % in *Acinetobacter baumannii*, *Escherichia coli*, and *Klebsiella pneumonia* and more than 50 % in *Pseudomonas aeruginosa*. Realizing the importance of AMR in aquaculture, three bacteria, viz., *E. coli*, *Aeromonas* spp. and *Staphylococcus* spp. from fish farms were selected for screening of antibiotic resistance. In 2021 a total of 98 *E. coli*, 92 *Aeromonas* spp. and 58 *Staphylococcus* spp. were isolated from fishes from Burdwan, North 24 Parganas, Hooghly and Howrah districts of West Bengal. Out of 98 *E. coli* isolates, 55 were screened and 38 were found positive for AmpC type β lactamase production; 64 isolates were screened for TEM (resistance gene for Ampicillin) and 48 isolates were detected positive. Out of 92 *Aeromonas* isolates 10, 18 and 54 isolates were studied and 2, 12 and 41 isolates were found to be positive for bla_{CTXM}, Tetracycline resistance gene and bla_{TEM}, respectively. The bla_{CTX-M} and bla_{TEM} genes indicate Class A type of broad spectrum β lactamase production which is mediated by either plasmid or chromosome. More than 70% of isolates were resistant to ampicillin-sulbactam. Out of 58 *Staphylococcus* isolates 4 were *Staphylococcus aureus* and others were coagulase-negative Staphylococcus (CONS). Antimicrobial susceptibility testing of these isolates revealed that more than 95 % isolates were penicillin resistant and 60 % were resistant to antibiotic oxacillin and cefoxitin.



Antibiotic resistance pattern of *Aeromonas* spp.



Antibiotic resistance pattern of *Staphylococcus* spp.

Awareness on AMR at Moyna

Project Title: Fish stock enhancement including Hilsa and livelihood improvement for sustainable fisheries and conservation in River Ganga

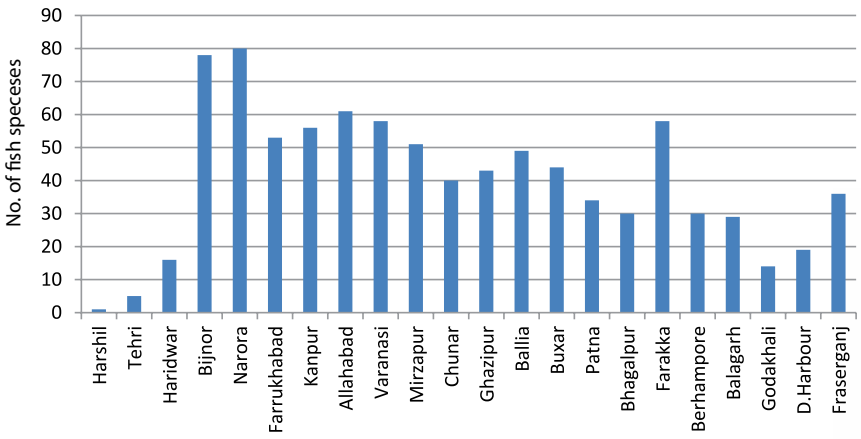
Funding Agency: National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti, Government of India

Scientific Personnel: B.K. Das (P.I.), R.K. Manna, D.N. Jha, A. K. Sahu, D.K. Meena, S.C. Sukla Das, R. Baitha, J. Kumar, T.N. Chanu, H.S. Swain, M.H. Ramteke, M. Gupta, C. Johnson, T. Bera, Santhana Kumar V., S. Kundu (Project Scientist)

Assessment of fish and fisheries of River Ganga

The study conducted during 2021 recorded a total no. of 139 fish species including 131 native and 8 exotics belonging to 44 families from Harshil to Frasergunj stretch of the river.

The highest number of fish species was recorded at Narora (80) fish landing center, followed by Bijnor (78), Allahabad (61), Varanasi (58), Kanpur (56), Farrukhabad (53), Mirzapur (51), Ballia (48), Ghazipur (43), Chunar (40), Haridwar (16), Tehri (5) and Harshil (1). The high species richness indicates a positive influence of open wetlands, streams and rivulets along with the aquatic macrophytes which created added niches for fish assemblage. Both pre-monsoon and monsoon seasons marked the availability of 68 and 66 fish species from the freshwater section of river Ganga. Farakka had the highest species richness with availability of 42 and 29 species in pre-monsoon and monsoon season, respectively. The dominant species included *Puntius sophore* (7.42%), *Corica soborna* (5.81%), *Cabdio morar*(5.33%) and *Ailia coila* (5.21%) in pre-monsoon season, and *Eutropiicthys vacha* (8.81%), *Puntius sophore* (7.81%), *Clupisoma garua* (7.18%) and *Rita rita* (4.54%) in monsoon months.



Fish diversity in River Ganga from Harshil to Frasergunj

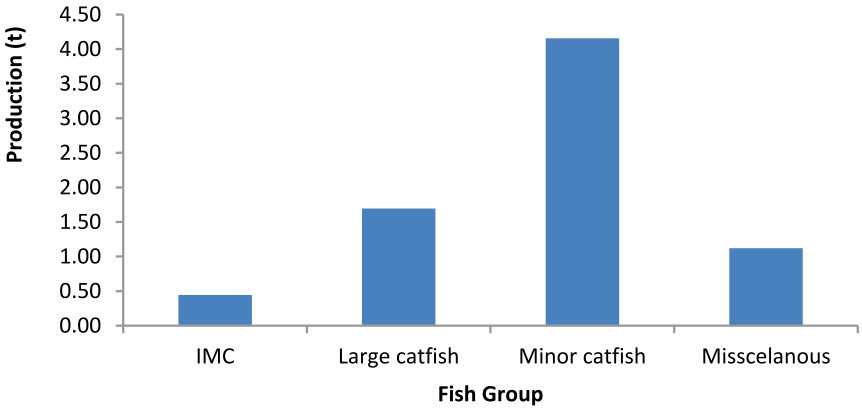
Table 10. Diversity indices at different sites and seasons along River Ganga

	Pre monsoon 2021				Monsoon 2021			
Site	**No. of taxa**	**Dominance_D**	**Shannon_H**	**Evenness_ e^H/S**	**No. of taxa**	**Dominance_ D**	**Shannon_ H**	**Evenness_ e^H/S**
Buxar	15	0.07	2.89	0.44	18	0.13	2.34	0.51
Patna	11	0.15	2.25	0.35	18	0.18	2.08	0.40
Bhagalpur	22	0.09	2.57	0.59	20	0.11	2.35	0.61
Farakka	42	0.05	3.24	0.51	30	0.08	2.77	0.50
Berhampore	25	0.16	2.33	0.41	13	0.18	1.93	0.53
Balagarh	22	0.18	1.99	0.66	21	0.11	2.50	0.55
Godakhali	13	0.46	0.96	0.65	5	0.13	2.21	0.70
Diamond Harbour	12	0.49	0.96	0.65	10	0.21	2.06	0.79
Fraserganj	11	0.44	0.90	0.67	21	0.16	3.40	0.88

Hilsa Shad, *Tenualosa ilisha*, is one of the most important commercial fishes of the Indo-Pacific region. The Hilsa population showed a steep decline in the middle stretch and maximum decline in the stretch above Farraka barrage. To increase Hilsa population in upstream of Farakka barrage, ranching of wild caught Hilsa seed/ juveniles was performed along with artificial breeding and culture of Hilsa. Migration of the fish was monitored using Floy tagging and other advanced techniques. The study observed that the specially designed net is appropriate for catching Hilsa up to 350gm size. After documenting the length and weight of individual fishes, they were released about 15-30 km upstream of the Farakka barrage.

Table 11. Species-wise landing of IMCs at Prayagraj

IMCs	Quantity (t)	% Contribution
Labeo catla	2.16	19.00
Labeo rohita	2.50	22.00
Cirrhinus mrigala	5.46	48.00
Labeo calbasu	1.25	11.00



Catch of major fish groups at Patna stretch of River Ganga

Diversity indices

The resource group data for the freshwater section were analyzed using the diversity indices to measure the species abundance, richness, and evenness in the ecosystem both during pre-monsoon and monsoon months (Table 10).

The Shannon index revealed high species richness from Farakka covering both pre-monsoon (3.24) and monsoon (2.77) seasons indicating a healthy and positive environment with minor alterations throughout the year. The F-value for comparing between seasons (1.212) and between sites (0.441) was found to be non-significant at 0.05 level indicating no significant difference in the dominance index between sites and between seasons.

Dominance of exotic fishes in lower part of river Ganga

The fish diversity atBuxar (Bihar) was characterized by high number of exotic fish species. Exotic fishes like *Cyprinus carpio* (Common carp) and *Oreochromis mossambicus* (Tilapia) were recorded about 3.47% and 2.67% during pre-monsoon while 2.29% and 1.68% of the total catch during monsoon season. The mean length and weight of *C. carpio* was recorded to be 352.82 mm and 738.47 g respectively. Prolific breeding nature helped Tillapia and Common carp to establish breeding territories in Buxar stretch of river Ganga.

IMC Landings during January to December 2021

Prayagraj

A total annual IMC landing from Prayagraj landing site of the river Ganga during January to December 2021 was estimated to be 11.37 t. The overall IMC landing was contributed by *Cirrhinus mrigala*(48%), followed by *Labeo rohita* (22%), *Labeo catla* (19%), and *Labeo calbasu* (11%) (Table 11).

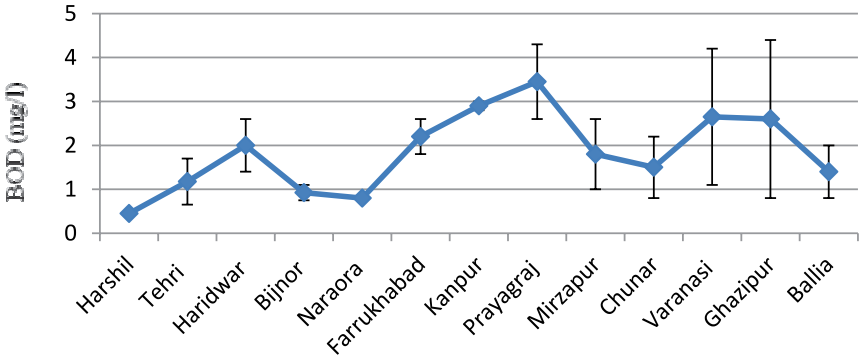
Patna

The total fish catch from Patna stretch (from Dighaghat to Gaighat) of the Ganga River System has been estimated to be 7.41 t. The contribution of Indian Major Carp was recorded to be 0.44 t.

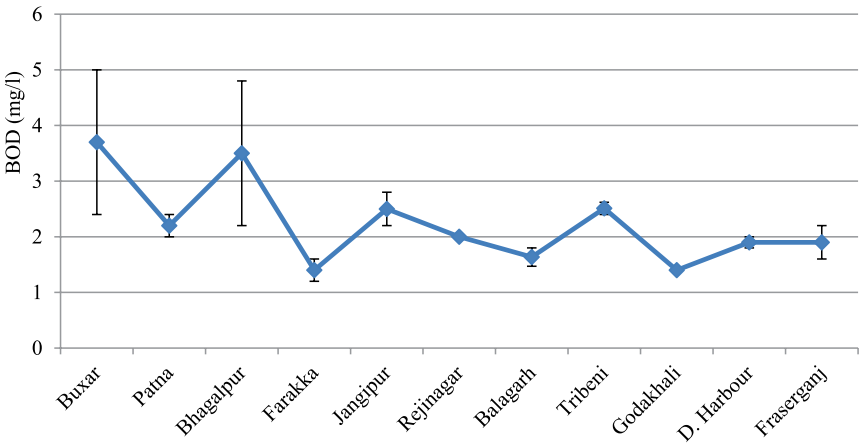
Among the Major carps, the percent share of *L. rohita* was highest (0.167 t; 2.25%), followed by *C. mrigala* (0.157 t; 2.12%) and *L. catla* (0.118 t; 1.60%).

Barrackpore

The total fish catch at Barrackpore stretch (from Nawabgunj to Dhobighat) of the Ganga River System during the year 2021 has been estimated to be 0.29 t. *Tenualosa ilisha* was found to contribute the highest with 0.15 t (52.73%) during the period. Among large catfishes, *Pangasius pangasius* shared maximum with 0.067 t (21.04 %) followed by *Rita rita* (0.47 t; 16.30%). The total production of the miscellaneous fish group



Average BOD from upper to middle stretch of River Ganga



Average BOD from middle to lower stretch of River Ganga

comprising of *Rhinomugil corsula*, *Setipinna phasa*, *Cynoglossus cynoglossus*, etc. was estimated to be 0.013 t only. On the other hand, the landing of exotic silver carp (*Hypophthalmichthys molitrix*) was estimated to be 0.006 t, with highest catch in monsoon season.

Assessment of key habitat variables

Specific Conductivity and Biochemical Oxygen Demand (BOD)

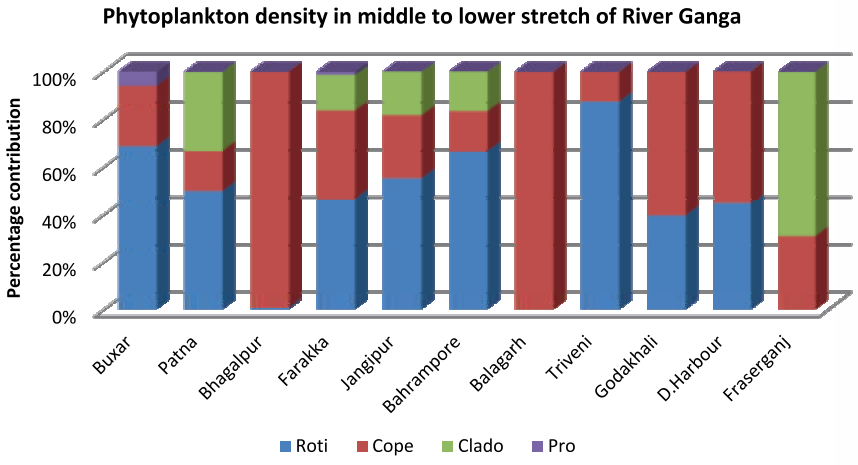
Average annual BOD of the entire river water was 1.83 mg/l. Highest average annual BOD value of 3.45 mg/l was recorded at Prayagraj. The average BOD concentration in the river water during pre-monsoon and monsoon season were 2.2 mg/l and 1.39 mg/l, respectively. The average BOD ranged between 1.6 mg/l and 5 mg/l in the middle to lower stretch of river Ganga. Highest average BOD was 3.7 mg/l at Buxar, whereas lowest was at Farakka (1.4 mg/l).

Other water quality parameters such as temperature, dissolved oxygen, sulfate, free carbon dioxide, total nitrogen play a major role in aquatic living resources in River Ganga and the recorded values were at optimum for survival of aquatic organisms.

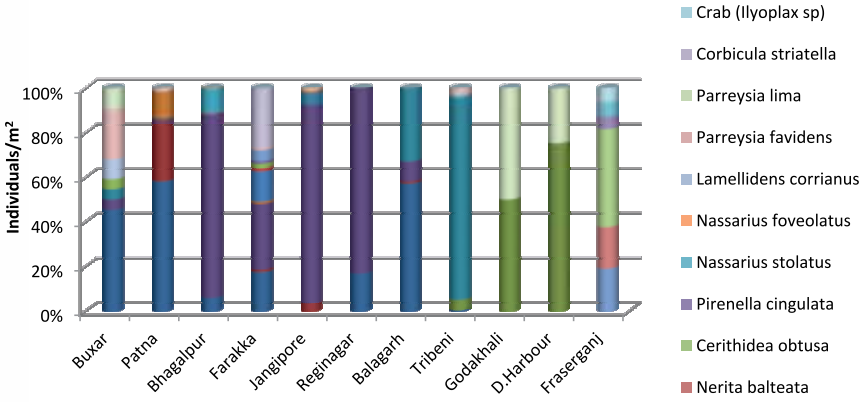
Plankton, periphyton and benthos status of River Ganga

A total of 63 genera of planktons belonging to 12 groups were recorded from upper to lower stretch of river Ganga. Chlorophyceae was the dominant group followed by Cyanobacteria, Charophyta, and Rotifera. Cyanobacteria, represented by the genera *Oscillatoria, Microcystis, Lyngbya,* and *Dolichospermum,* recorded higher abundance during the study period. Phytoplankton density was highest at Bhagalpur (178794 cells/l) and lowest at Fraserganj (119 cells/l).

A total 67 genera of periphytons belonging to 10 groups were recorded from upper to lower stretch of river Ganga. The abundance ranged from 831-10365 u/cm^2 with highest abundance at Varanasi and lowest at Harshil. Periphytic population was dominated by Bacillariophyceae (576 u/cm^2 at Harshil to 6250 u/cm^2 at Narora) and recorded in the upper and middle stretches. Highest



Phytoplankton density recorded in middle to lower stretch of river Ganga



Relative abundance of benthic species in middle to lower stretch of River Ganga

Induced breeding of carps caught from River Ganga

abundance of Chlorophyceae was recorded at Kanpur (1667 u/cm²); highest abundance of Cyanobacteria was recorded at Varanasi (4595 u/cm²). Dominated taxa of Bacillariophyceae were *Nitzschia, Navicula, Melosira, Gomphonema, Cymbella. Cyclotella* and *Pinnularia*, while *Chlorella* were dominant among Chlorophyceae.

The benthic biodiversity of river Ganga comprised of 40 species: 19 species belonged to class Gastropoda, 9 to Bivalvia, 9 to Insecta, 2 to Clitellata and 1 to Polychaeta. A dominance of gastropods, *viz. Filopaludina bengalensis* and *Tarebia granifera,* was observed in the entire stretch from Harshil to Fraserganj, whereas amongst the bivalves *Corbicula striatella* and *Parreysia favidens* dominated in the whole stretch. Chironomid larvae belonging to class Insecta dominated the upper stretch of the river. *Physella acuta* was dominant from Narora to Ghazipur indicating moderately clean status of the river. The highest average abundances (ind./m²) of the benthic species were recorded from Ghazipur (430) and the lowest from Tehri (5). The highest abundance of benthic species ranged between 30-335 ind./m² at Ghazipur and lowest of 18-168 ind./m² at Bijnor.

In-situ seed production of selected fish species and ranching in depleted river stretches

Successful breeding of wild IMC germplasm (*L. rohita, C. mrigala* and *L. catla*) have been undertaken. A total of 75 lakhs of spawn was produced with 99% fertilization rate and 96% hatching rate. Spawns were reared in nursery of ponds up to fingerling and advanced fingerling sizes (>10 cm) and then ranched in different depleted stretches of river Ganga.

Fish tagging, ranching & awareness programmes

To study the pattern of fish migration, the Institute tagged 650 adult IMCs and released in river Ganga. Further, 22 river ranching and mass awareness programmes were organized with release of 11,35,000 numbers of

Fish tagging before release in the river

Fish ranching at different places in River Ganga

Generating peoples' awareness on dolphin conservation

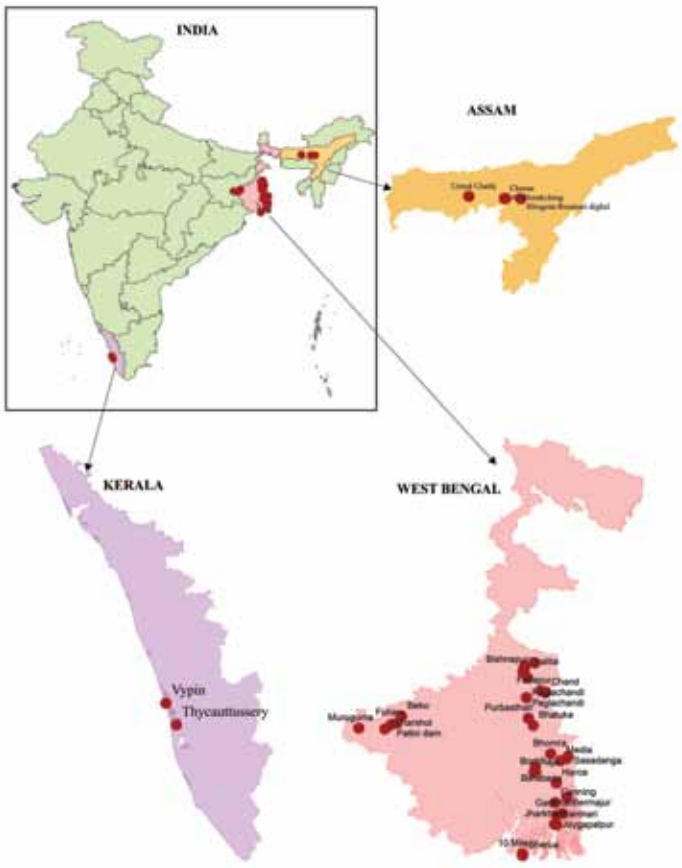
IMC fingerlings in 13 different depleted stretches of river Ganga from Prayagraj to Barrackpore in the states of Utter Pradesh, Jharkhand and West Bengal. A total of 27173 Hilsa brood fish were also ranched in the upstream of the Farakka barrage. Of these, 1503 brood fish were tagged to understand their migration pattern and 45 tagged Hilsa were recovered from Murshidabad, Malda, Jharkhand and Uttar Pradesh. During the study period, more than 3850 fishermen from Jharkhand and West Bengal were made aware about Hilsa fishing.

Programmes were also organized to create awareness among fishers about dolphin conservation and importance of dolphin as national aquatic animal of River Ganga.

Project Title: Impact of climate change in inland fisheries and development of adaptation strategies

Funding Agency: NICRA, ICAR

Scientific Personnel: U.K. Sarkar (P.I.), B.K. Bhattacharjya, S.K. Nag, M. Naskar, D. Debnath, S. Das Sarkar, T.T. Paul, S. Kumari, L. Lianthuamluaia, P. Mishal, G. Karnatak, K. Kumari, C. Johnson



Study area under the NICRA project

Global climate change is considered as one of the worst threats to the economy, environment, and livelihood of people dependent on inland fisheries. Research works were undertaken on various aspects of climate change in inland fisheries such as assessment of ecosystem services, ecological and stakeholder driven vulnerability, impact of climate on fisheries, reproductive vulnerability, development and demonstration of climate smart adaptation strategies and carbon sequestration in floodplain wetlands of Assam, West Bengal and Kerala.

Ecosystem services of floodplain wetlands of West Bengal in reference to climate change

Study on the impact of climate change on ecosystem services was carried out in 15 different wetlands of Nadia, North 24 Parganas and Murshidabad district of West Bengal during 2020-2021. The maximum Ecological Services Index (ESI) was for Purbastali beel of Bardhaman district and Chand beel of Nadia district (ESI=94), followed by Fataipur (Nadia) and Bhandardaha (Murshidabad) beels, whereas Raja beel of N-24 Parganas has the lowest ESI (54). Through Rapid Assessment of Wetland Ecosystem Services (RAWES) approach, it is found that most ecosystems are vulnerable to climate change, even under low- and medium-range scenarios of global warming. They are likely to be affected by gradual changes in temperature or precipitation and climate-related disturbances (e. g., flooding, and drought), in association with other threats (e.g., land use change, pollution, over exploitation of resources).

Trend analysis of rainfall

Rainfall data collected for the period from 1901 to 2020 at 122 locations were divided into 4 regions, namely, Northern India, Eastern India, Western India and Southern India. The analysis showed a decreasing trend of rainfall in Northern India whereas Eastern and Western India showed an increasing rainfall trend in the last decade; Southern India showed an irregular pattern of rainfall with a steady trend line from 1901. The data were also analyzed for prediction of rainfall pattern in Northern India up to 2060 by exponential triple smoothing method using the FORECAST.ETS function.

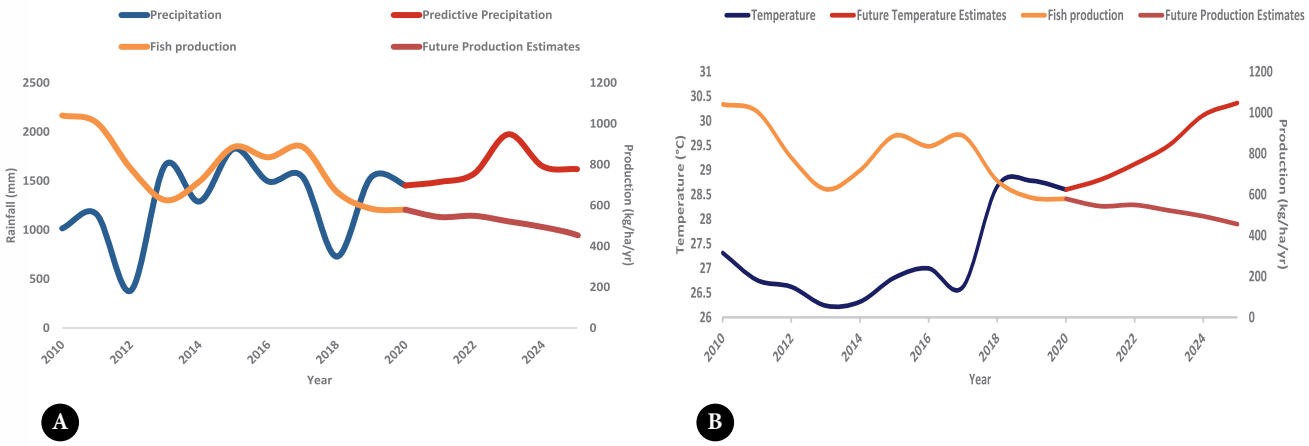
Prediction of fish yield based on rainfall and temperature patterns

Fish production data from floodplain wetlands of lower Gangetic basin of West Bengal were collected during 2010 to 2020 and rainfall and temperature data were collected from Indian Meteorological Department (IMD) and Customized Rainfall Information System (CRIS). The analyses of data showed an irregular rainfall pattern as well as an increasing trend of temperature with declining fish yield in the last decade.

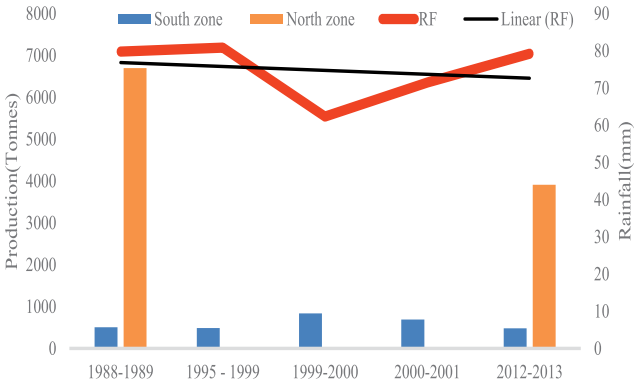
Assessment of climate induced vulnerability of Vembanad Lake, Kerala

Study indicated that with decrease in rainfall @ 0.8% per year in this region, the fish production across the zones in the lake declined with the tune of 4.56%. Similarly, with increase in temperature @ 0.02% per year in this region, the fish production across the zones in the lake declined to the tune of 4.56%.

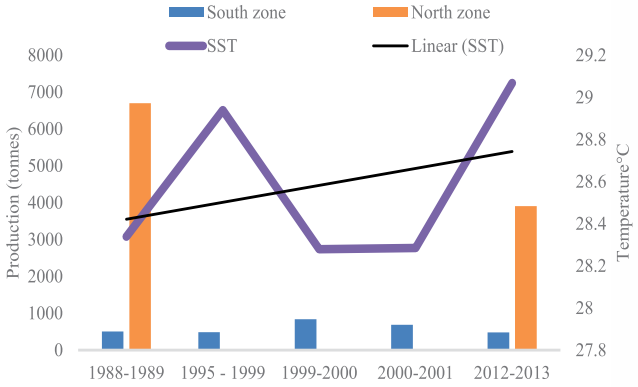
Climate associated variability in species composition study indicated that with increase in temperature, there is a shift in fish/shellfish species composition of the lake. Crustaceans, especially penaeid prawns, contributed predominantly to the fish production from Vembanad lake in 2020 (58%) as compared to 1988-1989 (22%).



Prediction of fish yield in relation to rainfall (a) and temperature (b) up to 2025 of lower Gangetic basin



Rainfall trends and fish production at Vembanad Lake



Temperature and fish production trends of Vembanad Lake

Climato-hydrological influences on population and breeding phenology of *Nandus nandus*

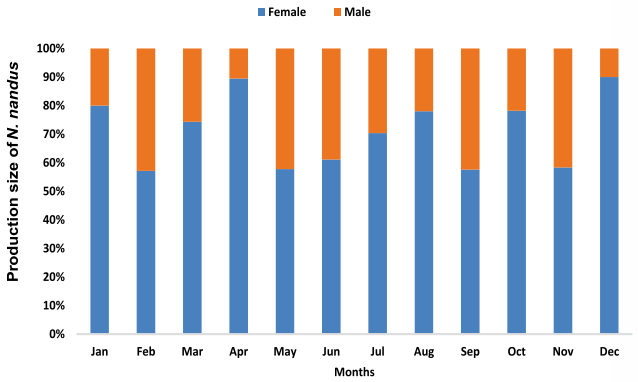
A study was undertaken to assess the breeding phenology as well as population dynamics of *Nandus nandus* from selected wetlands of West Bengal. The Length-Frequency Distribution (LFDs) of *N. nandus* showed that the smallest and largest individuals were 4.6 cm and 17.5 cm in total length (TL) respectively, and the body weight (BW) ranged from 1.51-76.17 g. Females dominated the population. The natural mortality (M_w) of *N. nandus* population was 1.33. Lenth at First Sexual Maturity (L_m) of *N. nandus* was estimated as 10.45cm, and absolute fecundity was in the range of 8,040- 54,075. The spawning season of the fish extended from early June to end of September with a peak in July. The average female Gonado Somatic Index (GSI) ranged between 4.34-7.88 with a peak GSI of 7.88 in the month of July associated with the rainfall of 335.27 mm and the temperature of 29.82°C which may be considered as the right climatic condition for spawning.

Assessment of reproductive vulnerability of *Etroplus suratensis*

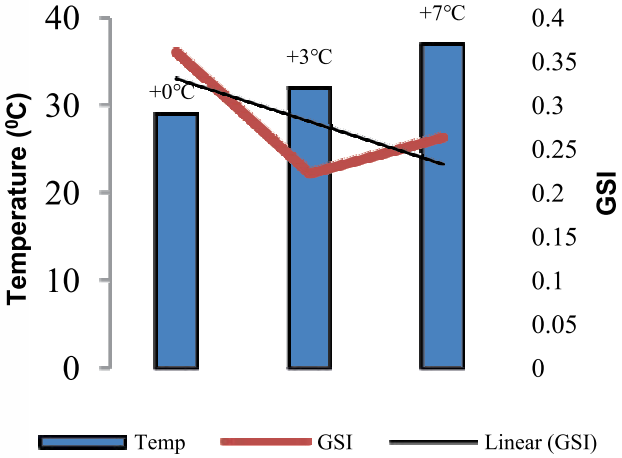
Temperature simulation experiment was conducted in NICRA Lab of the Institute on *E. suratensis* at ambient+0°C, ambient+3 °C and ambient+7 °C.

The study indicated that with increase in temperature by 3 °C, the GSI of male and female fishes reduced by 38% and 80.2%, respectively which indicates reproductive vulnerability of *Etroplus* sp. and a probable decline of the wild population in near future. The study identified that the species is vulnerable to climate change (at +3 °C increase in temperature), but assumes resilience when the temperature stress is increased by +7 °C (36-37 °C). A slight increase in GSI in males and females may be considered as a strategy the fish assumes to ensure the species survival with temperature stress. Month-wise study of reproductive vulnerability indicated that the species has protracted spawning season in February-April (28-30 °C). Comparative assessment of GSI of *E. suratensis* with natural environment indicated that with climate change the fishes attain low GSI and delayed maturation. The egg size of matured *Etroplus* usually ranges from 0.25-2.75 mm in natural environment. The treatments showed range of 0.64 -1.12 mm for maturing fishes

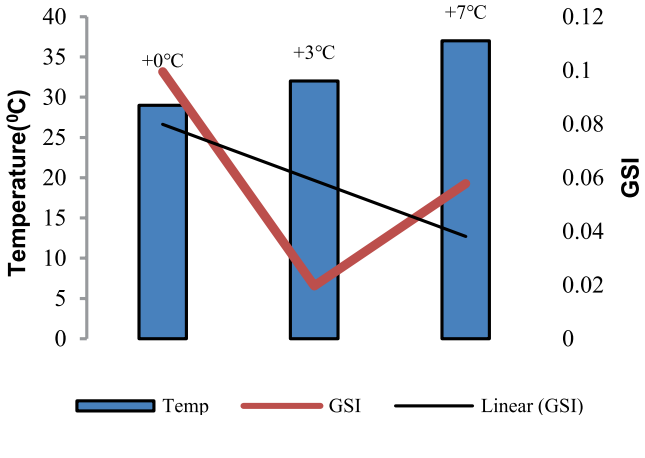
Nandus nandus



Female and male proportion of *Nandus nandus* sampled throughout the year



Simulated impact of climate change on *E. suratensis* (Male)



Simulated impact of climate change on *E. suratensis* (Female)

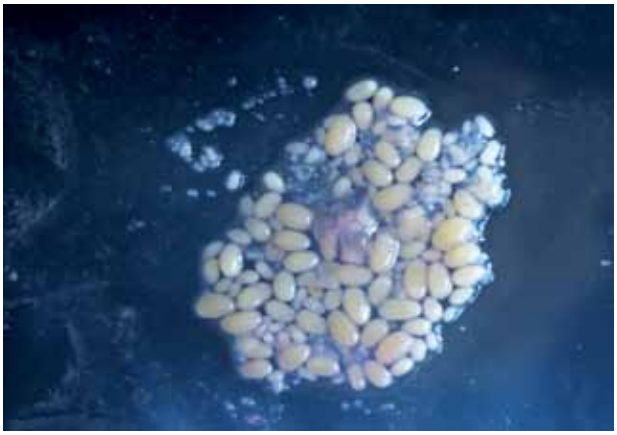
(mode = 0.69) alone for the same span of growth. This indicated that increasing water temperature delays egg maturation, hampers spawning periodicity and divert its energy for survival.

Vulnerability of floodplain wetlands of lower Ganges basin using new approach

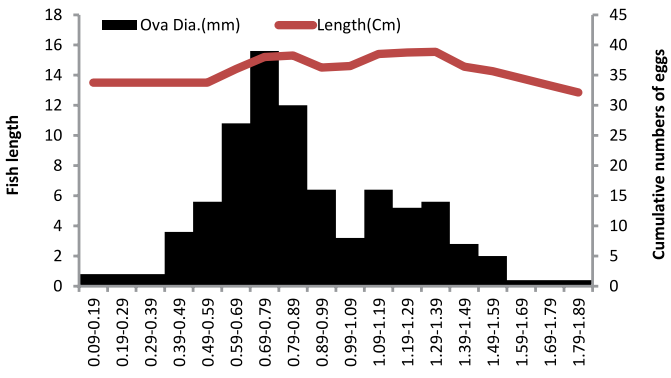
Vulnerability assessment was carried out in nine floodplain wetlands from three districts of West Bengal using stakeholder perception and ecological conditions. Analysis of climatic variables for the last three decades revealed a warming trend and decreasing rainfall in the studied areas in last three and a half decades. The temperature anomaly ranged from +0.07 to +0.31°C while rainfall anomaly ranged from -61.41 to -372.62 mm. Respondents showed high level of consensus (75.3%) on climate change awareness. The respondents, with consensus ranging from 67.8% to 94.7%, were aware of the fact that climate anomaly affects ecology and fisheries of wetlands. The studied wetlands showed 2-81.28% reduction in depth, 21.52-61.29% reduction in species diversity and 30-95% macrophyte infestation. The stakeholder perception-based vulnerability scores ranged from 18-31 and 6 out of 9 wetlands were highly vulnerable. The ecological vulnerability scores ranged from 17-21 with 5 out of 9 wetlands as highly vulnerable. Although, both the approaches used in the present study categorize the studied wetlands as moderately to highly vulnerable, the category of some wetlands varied in both approaches.

Impact of extreme environments in coastal wetlands

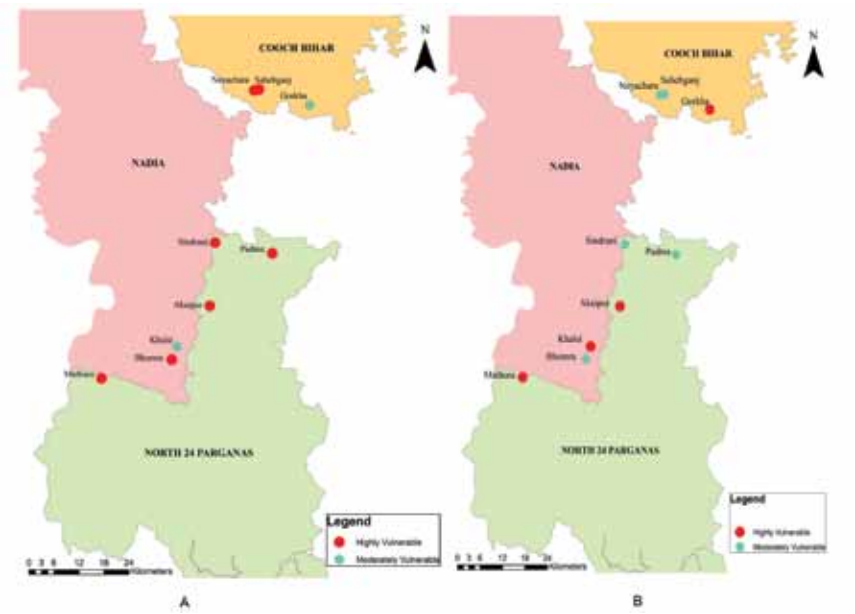
West Bengal has three coastal districts, namely, North 24-Parganas, South 24-Parganas and East Medinipur with a coastline of 158 km with 49 fish landing centres and 171 fishing villages which contribute about 6-8% of the total marine fish landings of India. Vulnerability assessment of the surveyed estuarine wetlands (Kanmari, Beremajur, Joygopalpur, Jharkhali and Canning) revealed declining fish production due to increased frequency of the extreme events. It is observed that the numbers of fish species decreased in these wetlands by 14.33%. The



Maturing eggs of *E. suratensis*



Ova dia vs body length of *E. suratensis*

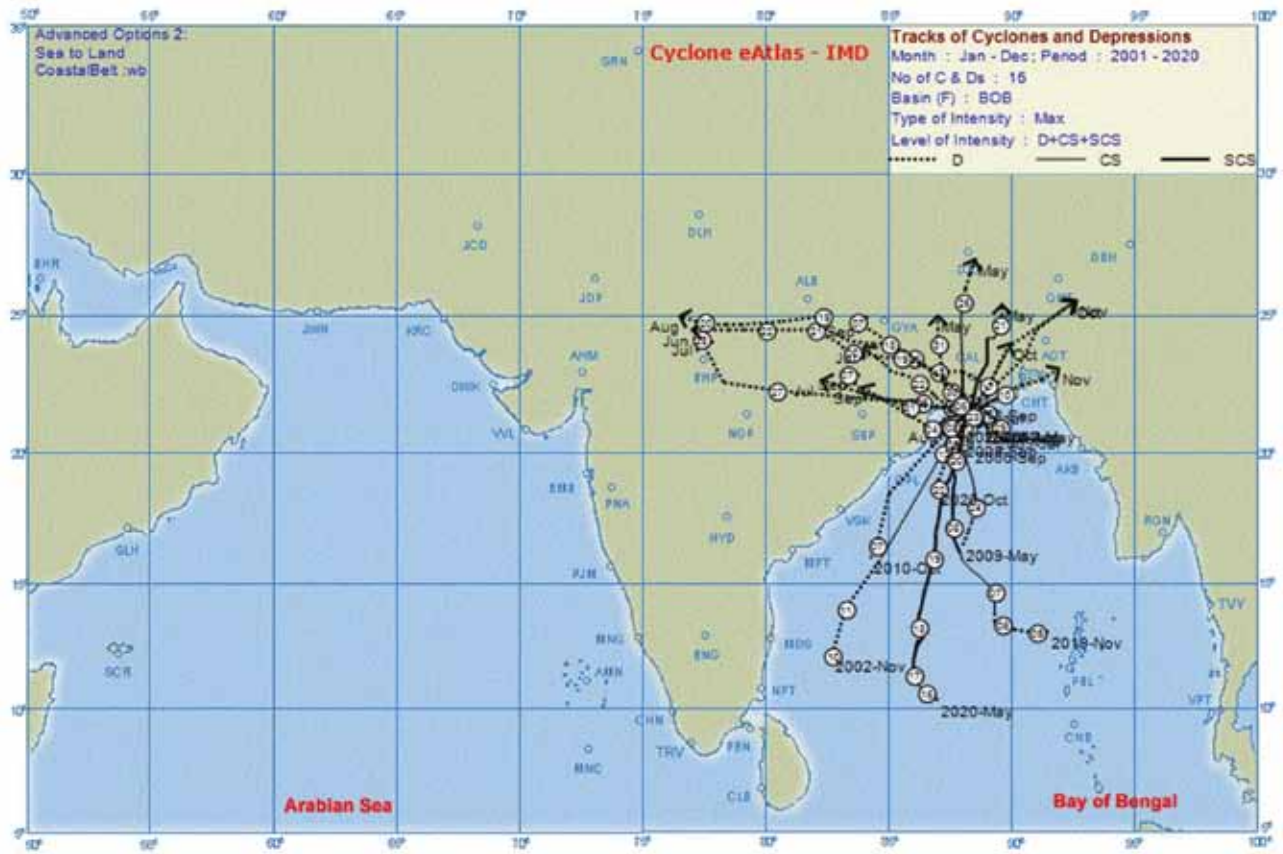


GIS based map of wetlands depicting stakeholder driven (a) and ecological vulnerability (b) assessment

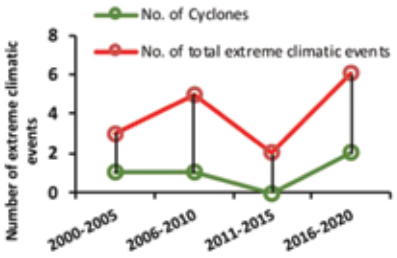
frequent extreme climatic events (i.e., cyclone Amphan in 2020 and Yaas in 2021) adversely impacted the bheries and caused escape of fish stocks (*Lates calcarifer*, *Mugil cephalus*, *Macrobrachium rosenbergii*, *Penaeus monodon*, etc.) into adjacent rivers.

Climato-hydrological influence on phototrophic micro-players in wetlands

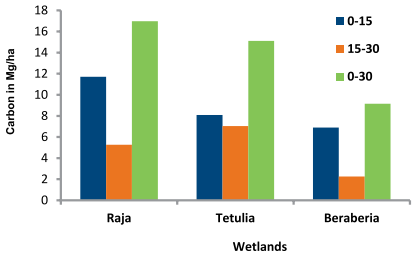
The spatio-temporal heterogeneity of tiny plankton community and their possible correlations with environmental traits of two anthropogenically stressed wetlands (Bhomra and Mathura) of West Bengal were assessed. Study revealed occurrence of harmful cyanobacteria *Anabaena* sp. and zooplankton, *Brachionus forficula* with higher occurrence towards water depth in Mathura, a hydrologically closed wetland. Further, the cyanobacterial *Phormidium* sp. in the seasonally open Bhomra wetland have shown more gradient towards water depth and nitrate, whereas water temperature, rainfall and total phosphate were found to be the most influential factors for the occurrence of *Brachionus*



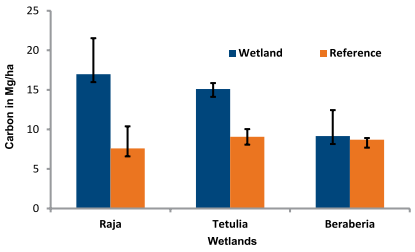
Track of Cyclones and Depressions during 2000 to 2020 showing high number of extreme climatic events (Source: IMD website)



Total count of climatic disturbance including depressions, cyclonic storms and sever cyclonic storms over the coastal belt of West Bengal from 2001 to 2020



Carbon accumulation in soils of selected wetlands of West Bengal



Carbon content upto 30cm depth in different wetlands and the corresponding upland reference

sp., *Filinia* sp., *F. terminalis*, *Keratella tropica*, *Hexarthra* sp. The study showed water depth as the influential hydrological factor in the Indo-gangetic floodplain wetlands.

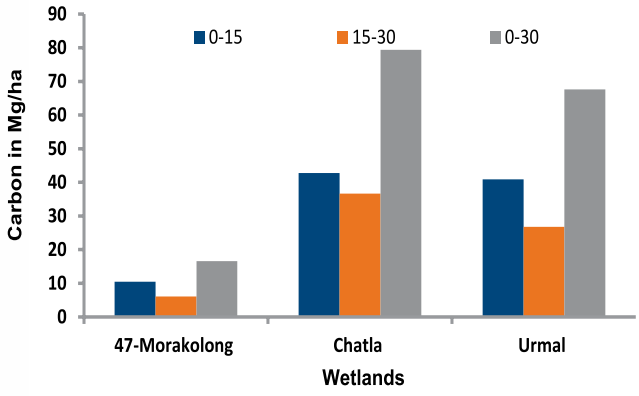
Carbon (C) sequestration and GHG emission in wetlands

Three wetlands, *viz*. Raja, Tetulia and Beraberia in North 24 Paraganas District of West Bengal were studied for C accumulation and storage in their soil vis-a-vis in soils of reference upland sites. The average C content of the wetland soil was 1.78-3.59% in 0-15 cm and 0.49-2.41% in 15-30 cm depth whereas in reference upland sites these were 0.37-0.58% in 0-15 cm and 0.11-0.44% in 15-30 cm depth. Thus, it was estimated that up to 30 cm depth of wetland soil 17.44 Mg C (1Mg=1 t) in Raja beel, 15.85 mg C in Beraberia, and 15.11 mg C per ha in Tetulia wetland were accumulated. The estimated C accumulation in reference upland sites of Raja, Beraberia and Tetulia were 7.59 Mg, 8.69 Mg and 9.07 Mg/ha. The wetlands have accumulated higher quantity of C which varied from 1.67 times (Tetulia) to 2.3 times (Raja) of the C content of their corresponding upland sites.

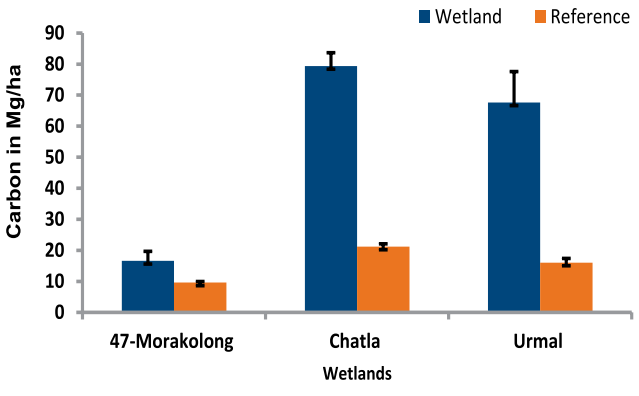
Similar study conducted in three wetlands of Assam revealed that C storage was highest (79.36 Mg/ha) in Chatla wetlands, followed by Urmal (67.62 Mg/ha), but in 47-Morakolong wetland only 16.57±3.1 Mg/ha was accumulated up to 30 cm depth. The corresponding reference upland sites contained 21.18 mg, 16.02 Mg and 9.6 Mg/ha respectively. Thus, in all the wetlands C deposit up to 30 cm depth of soil was quite higher (1.7 to 4.2 times) than the carbon deposited in the reference upland sites. Thus, it is evident that wetlands are effective C-sinks and can help in mitigating global warming.

Greenhouse gas emission from wetlands

Greenhouse gas (CH_4 and CO_2) emission was measured in two floodplain wetlands (Khalsi and Bhomra) in West Bengal in summer season (water temperature 31-33°C). The emission of CH_4 was more from Khalsi (24-79 mg CH_4-C/m²/h) than Bhomra (19-52 mg CH_4-C/m²/h). However, CO_2 emission was higher from Bhomra wetland (18-44 mg CO_2-C/m²/h) than Khalsi (6-20 CO_2-C/m²/h). From the corresponding reference upland sites, CH_4 emission was



Carbon accumulation in different wetlands



Carbon accumulation in wetlands of Assam and corresponding reference sites

very less (0.04-0.07 mg CH_4-C/m^2/h) but CO_2 was emitted at a higher rate (46-85 mg CO_2-C/m^2/h).

Community composition of methanogens and methanotrophs in different wetland

Anaerobic methanogenesis is carried out by the Euryarchaeotain kingdom Archaea. In the present study methanogens were the most dominant archaeal groups in the Bhomra wetland, population of which decreased sharply in the East Kolkata Wetlands (EKW) and became least abundant in the Malancha wetland. The most abundant methanogens in freshwater were *Methanothrix*, which decreased sharply in coastal wetland. Most of the produced methane is oxidised to CO_2 during its transfer from sediment to water column by methane-oxidizing bacteria (methanotrophs). In the present study methanotroph abundance dominated in EKW, followed by in Bhomra and Malancho. Among the methanotrophs, *Methylocystis* dominated in all the three wetlands. The Genus community composition dissimilarity pattern of methanogens and methanotrophs reveals that Malancha is distinct from the other two wetlands.

GHG emission study in wetland

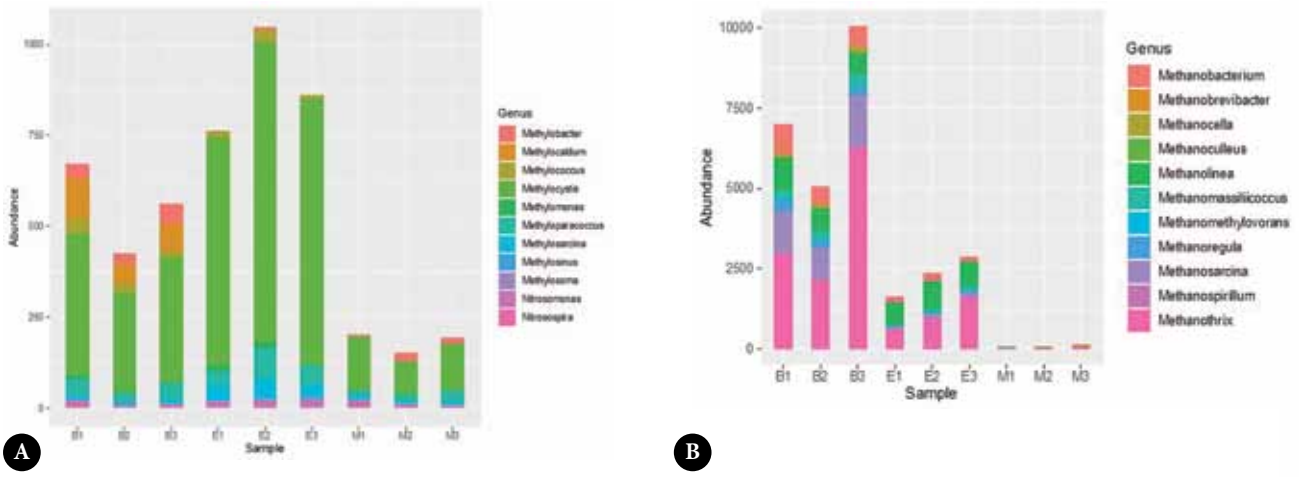
Climate Smart Adaption Technologies

Climate resilient pen system (CRPS)

The CRPS was conceptualized and developed to culture the fish during flood season, encouraging growth of carps and recruitment of SIF. To demonstrate CRPS, a study was carried out in 47-Morakolong beel located in Morigaon district, Assam where five different species combinations viz., P1 (IMC only), P2 (IMC + *A. mola* @ 30 no./m^2), P3 (IMC + *G. chapra* @ 20 no./m^2), P4 (IMC + *P. sophore* @ 20 no./m^2) and P5 (IMC + all three SIFs @ 1/3 of stocking density of each species) were stocked. The IMC (*Labeo catla, L. rohita and Cirrhinus mrigala*) were stocked @ 3 no./m^2 in all the pens. After 5 months, highest fish production was obtained from P2 (124.86 kg/pen) followed by P3 (120.19 kg/pen), P5 (105.15 kg/pen), P1 (89.91 kg/pen) and P4 (87.38 kg/pen). Economic feasibility analysis of the pen culture operation indicated that culturing IMC with *G. chapra* or *A. mola* was more profitable compared to other combinations, studied.

Climate resilient culture-based fisheries (CRCBF)

The CRCBF was demonstrated in Media wetland, West Bengal. Selected climate smart fish species *viz.*, *Systomus sarana* (L=15.13±1.43 cm, W=4.45±1.60 g), *Mystus gulio* (L=3.21±0.13 cm, W=7.05±0.34 g), *Labeo bata* (L=6.1±0.25 cm, W=9.00±0.75 g) along with IMCs were stocked. It was found that the fish production increased considerably after adopting CRCBF. Prior to this intervention, the wild stock of *S. sarana* and *M. gulio* were depleted in the wetland. However, after



Methanogen (A) and Methanotroph (B) abundance pattern in different wetlands

implementation of CRCBF these species have shown the sign of recovery in the wetland.

In order to increase the adaptive capacity of the fishers, demonstration of culture-based fisheries has been initiated under extensive fish farming systems associated with Vembanad wetland. Six thousand *Etroplus* seeds were stocked in 1 acre of pond as initial stocking phase of culture. The programme envisaged multi-stocking and multiple harvesting strategies for sustained livelihood to the farmers associated with wetland. The strategy ensures a year-long assessment of the reproductive and feeding variations of Pearlspot in a changing climate scenario.

Climate resilient cage culture system (CRCS)

Demonstration of CRCS has been initiated in Media wetland for fish seed raising and table fish production in 6 GI CIFRI Model Cage (5m x 5m x 4m). The indigenous fish species *viz. L. bata and S. sarana* were stocked along with IMCs to enhance fish production, conserve selected indigenous fish species and to increase the adaptive capacity of fishers in the climate change scenario.

Selection of climate smart species based on their biological characters

A total number of 66 fish species of the Gangetic floodplain wetlands were screened based on their recent abundance and biological characteristics to identify climate smart species. Some key features like feeding habit, trophic level, fecundity, thermal tolerance level, doubling time, pH tolerance level, peak production seasons, breeding seasons and presence of accessory respiratory organ were selected to estimate their resiliency. The preliminary assessment indicated fish species like *Anabas testudineus, Channa punctata, Channa striata, Clarias magur, Heteropneustes fossilis, L. bata, Mystus cavasius, Pethia ticto, Puntius sophore, C. mrigala, Amblypharyngodon mola, Eutropiichthys vacha, Glossogobius giuris* as climate resilient species.

Demonstration of climate resilient pen system at 47-Morakolong beel, Assam

Climate resilient fish species (*Labeo bata* and *Systomus sarana*)

Success Story

Culture of black clam in pens

The institute successfully raised and harvested black clam, *Villorita cyprinoides,* in CIFRI HDPE CRPS

Climate resilient cage system in Media wetland

Partial harvesting of *Villorita cyprinoides* at Thycattussery

Harvest of *Villorita cyprinoides* at Thycattussery

(Climate Resilient Pen System) in Vembanad Lake ofThycattussery, Kerala. The pen was stocked with black clam seeds (TL: 1 cm; average weight: 1 g) collected from wild (Poochakkal) @ 2.9 kg/m^2, in collaboration with Thycattussery black clam industrial co-operative society. A total of 460 kg of clam seeds was stocked in a pen of 160 m^2 area anticipating a harvest of nearly 3 t. Partial harvesting of 1 t clam with sale price of about ₹25,000 was done on 10 March 2021. Clams achieved an average final weight of 13 g. Women and men clam collectors actively participated in the harvest programme. The successful demonstration proved that clam culture can be taken up as an alternate livelihood option or as a switch over livelihood option for inland open water fishers of the Vembanad Lake.

Project Title: Fisheries development in Kothia *maun* of Bihar - A pilot project

Funding Agency : NFDB, Hyderabad

Scientific Personnel : B.K. Das (P.I.), G. Chandra and R. Baitha

Implementation of fisheries enhancement programme

Species enhancement and stocking enhancement activities are the major technological interventions in wetlands for augmenting fish production and said interventions were made in Kothia *maun* located in East Champaran district of Bihar. The *maun*, seasonally connected to River Burhi Gandak, has maximum water spread area of 60 ha and the depth ranged between 2-7 m. Stock enhancement activity in the *maun* with advanced fingerlings (weight: 25-70 g) of IMCs (catla, rohu, mrigal) and exotic carps (common carp and grass carp) was undertaken in a staggered manner. The size at stocking of fish seeds was increased progressively from 25 g to 70 g due to availability of larger size fish seeds, higher survival in open wetland, and for counteracting slow growth and disease related mortality during winter. A total of 3,210 kg fish seeds have been stocked in the ponds and open *maun* and 2,323

Stocking of fish (A) Harvesting of stocked fishes(B)

Fish harvesting from land based nursery

kg of stocked fish species were harvested from the maun in 20 for. Additionally, bumper catch (2,707.1 kg) of wild or indigenous fishes was also recorded benefitting the fishers.

Fish seed/table fish production in pond

Nursery ponds are integral parts of culture based fisheries in wetlands and ensures timely availability of quality seeds of desired size at low cost. Land based nursery facility in the proximity of Kothia *maun* was created for raising fry to fingerlings/advance fingerlings and for table size fish production during vacant period. All the four ponds were stocked with IMCs & exotic carps, and Amur carp seeds in January and harvested after one month culture and transferred to cage culture system. In May 2021, the total volume of available fish stock (IMCs & exotic carps) was estimated at 2,160 kg (average body weights: 370-730 gm).

Amur carp production in cages

Six numbers of "CIFRI GI Cage" were installed in Kothia *maun* at a suitable site having water depth ≥5 meter. A total of 370 kg seed of Amur carp, a Hungarian strain of common carp (*Cyprinus carpio*), was stocked in six cages for table fish production. However, there was theft of fish from cages and loss fish were recovered after 3 months of culture.

Project Title : All India Network Project on Fish Health

Funding Agency : ICAR

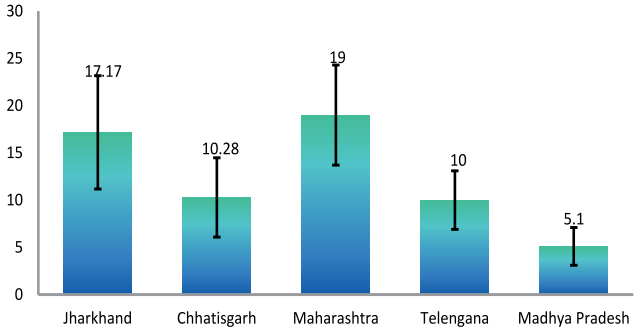
Scientific Personnel : S. K. Manna (P.I.), S.K. Nag, P. Panikkar, A. K. Bera, D. Debnath, R. Baitha

Assessment of economic loss from disease in inland cage culture

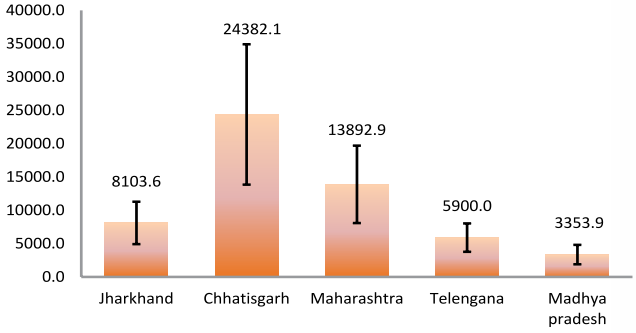
Cage culture is gaining fast momentum in the country. A study was conducted to identify fish health problems and their economic impact in about 3000 cages functional in different reservoirs and lakes of Maharashtra, Jharkhand, Chhattisgarh, Telangana, and Madhya Pradesh. More than 80% of cage farms reported disease outbreaks, especially in winter. Bacterial septicaemia, tail and gill rot and superficial mycosis were the major diseases causing 14.11% mortality of the stocked fishes. Economic loss from diseases that included direct mortality loss, cost of chemicals, health management etc. was estimated at ₹4881.75/t produce or ₹13069.75 per cage. Almost all the cage farms used potassium permanganate, table salt, and lime for health management. On an average, 1.35

Stocking of fish seeds in cages

Monitoring of fish growth in cages



Fish mortality (%) due to diseases in major cage culture states of India



Economic loss (₹) from fish diseases in major cage culture states. Values are ₹ loss per ton of fish produce

kg of the said chemicals and plant products such as garlic, turmeric were used incurring a cost of ₹738.25/t of production. Use of antibiotics and other potentially harmful chemicals was meager indicating safe nature of fish produced in cages.

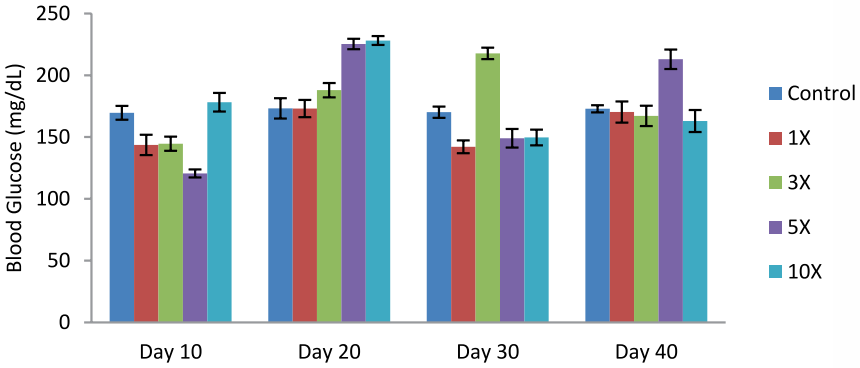
Assessing safety of antibiotic florfenicol in Pangasius

Pangasianodon hypophthalmus is widely cultured in cages in reservoirs, lakes, etc. and antimicrobials are used for health management of the fish. Safety of florfenicol, an antibiotic approved for aquaculture, used in several countries, was assessed in the catfish. The antibiotic was administered at doses, viz., 10 mg/kg (1X), 30 mg/kg (3X), 50 mg/kg (5X) and 100 mg/kg (10X) body weight (b.w.) of fish through medicated feed daily for 30 days. Study of haematological, blood biochemistry parameters showed insignificant increase in blood glucose, globulin, aspartate and alanine transaminases, and alkaline phosphatase levels at higher doses of the antibiotic. Although the antibiotic showed some toxicity at very high doses, it may be used for control of bacterial diseases in the catfish species at a recommended dose of 10 mg/ kg fish biomass daily for 10 days.

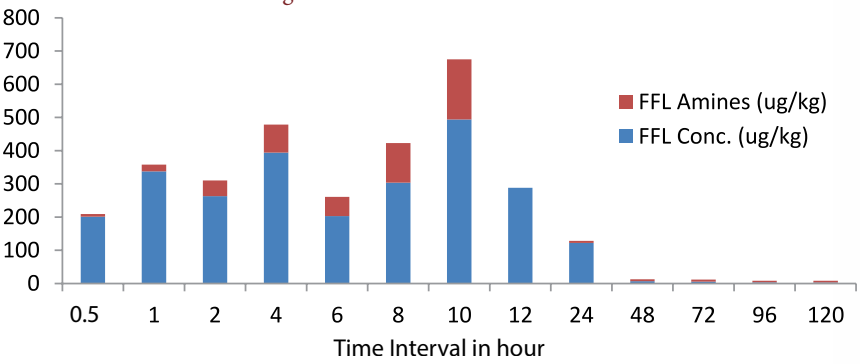
Determination of bioavailability and withdrawal period of florfenicol

For successful use of any drug it is essential to know its pharmacokinetic behavior, bioavailability and withdrawal period. To study the kinetics of florfenicol, the antibiotic was administered @ 10 mg/ kg b.w. with feed and by intramuscular (I.M.) injection and quantified in blood by GC-MS/MS at different time intervals. After obtaining the AUC0→∞ values for I.M. and oral use, the bioavailability of florfenicol was estimated to be 21.58% which is much higher than that of oxytetracycline (<1%).

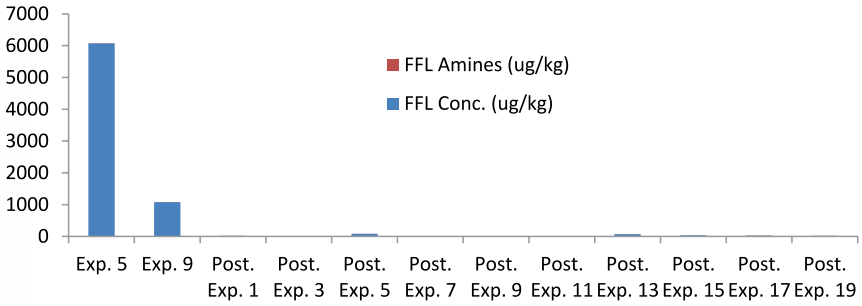
Withdrawal period of the antibiotic was tested following oral administration of the drug at the therapeutic dose of 10 mg/ kg b.w. of fish for 10 days. Monitoring of the drug residue in blood, liver and flesh by LC-MS/MS established rapid clearance of the chemical from body requiring only one day of withdrawal period for food safety purpose.



Alteration in blood glucose level after administration of florfenicol



Florfenicol residue level (µg/kg) in blood at different time intervals after single in-feed administration



Residue of florfenicol (µg/kg) in flesh at different days of post-administration

Project title: Up-scaling of climate-friendly pen aquaculture technology for improved livelihood, employment generation and enhanced income of wetland fishers of North-eastern India

Funding Agency: National Mission on Himalayan Studies, Ministry of Environment, Forest and Climate Change, Govt. of India.

Scientific Personnel: B.K. Bhattacharjya (P.I.), S. Yengkokpam, D. Debnath and S.C.S. Das

Project partners:

1. Director of Fisheries, Directorate of Fisheries, Govt. of Manipur, Lamphelpat, Imphal, Manipur
2. Director of Fisheries, Directorate of Fisheries, Govt. of Meghalaya, Clive Colony, Shillong, Meghalaya
3. Director of Fisheries, Directorate of Fisheries, Govt. of Arunachal Pradesh, Itanagar

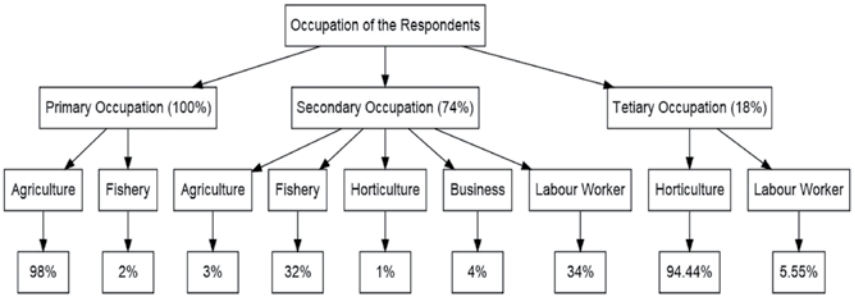
Pen culture demonstration in Bor Beel, Namsai District, Arunachal Pradesh

Bor beel, located in Namsai District of Arunachal Pradesh, has heavy macrophyte infestation making fisheries operations difficult. The average fish production of the beel is 155 kg/ha/yr which is very low compared to its potential of 1000 kg/ha/yr in similar beels of Assam. Under this project, pen culture was initiated in Bor beel to convert macrophyte infested area to fish production area (waste to wealth). A suitable site for pen culture was selected based on water depth, water quality, ease of monitoring, etc. Macrophyte clearance was done by using both machinery (JCB) and manual labour. Five pens, 0.1 ha area each, were constructed in the beel using net (LDPE) lined *bana* screens and bamboo poles. The beel has turtles which can cut off net material of pens, and hence, split bamboo screen (*bana*) was used in the pen construction to ward off turtles. The pens were stocked with fingerlings of Rohu (*Labeo rohita*), Silver carp (*Hypophthalmichthys molitrix),* Mrigal (*Cirrhinus mrigala),* Common carp (*Cyprinus carpio),* Kuri (*Labeo gonius)* and Bhangon (*Labeo bata)* which have a high local demand at a stocking density of 5 no./ m^3 in March 2021. The fish were fed with floating pellet feed, CIFRI CageGrow containing 28% crude protein at 5% of body weight of the stocked fish. After 6 months of culture, the fish grew to an average size of 120-817 g.

Assessments of economic conditions of fishers of Bor beel through participatory approach

A study was conducted to assess the socio-economic condition of fishers residing in the village Jona III, bordering Bor beel. Households deriving their income and livelihood from fishing and allied activities were selected randomly for the study. A structured questionnaire was developed based on relevant socio-economic aspects of the wetland fishers. A total of 100 respondents were visited and primary data was collected during August 2019 to August 2021.

The study revealed that average family size was 5 in a household. The sex ratio was 904 females per 1000 male which is less than Indian average (940 female per 1000 male) and also less than Arunachal Pradesh (938 female per 1000 male). The households comprised of 4 caste-based communities, mainly other backward caste (66%), followed by scheduled tribe (30%), scheduled caste (3%) and unreserved (1%) households. The occupations were categorized in 3 sections according to their weightage in income – primary



Occupation of the Respondents of Bor beel, Namsai Dist., Arunachal pradesh

ITK-based floating circular pen in Takmu pat, Manipur

Fish harvested from the circular pens

occupation, secondary occupation and tertiary occupation. Among the households 74% were involved in primary as well as secondary occupation and 18% of the households were involved in all 3 categories of occupation. It was observed that 34% of the respondents practiced fishery as their occupation. The average income of the household survey was ₹8170. About 22%of the respondents were illiterate, 17% had primary education, 28% had upper primary education, 31% completed high school, 1% went to higher secondary and 1% was graduate. 97% of the respondents had kacha house and 3% had their own boat. Preliminary data analysis showed poor socio-economic status of the households of Bor beel.

Pen aquaculture using ITK-based technology in Takmu pat, Manipur

Two floating pens of 3240 m^2 and 3600 m^2 area were constructed using the floating dense macrophyte mass (phumdi) as the platform in Takmu pat in Bishnupur district of Manipur. Phumdis were cut and used to form a circular floating structure to which the nets were attached and hanged using ropes. The ropes were inserted to the bottom soil using sinkers. At every 6 feet interval, ropes with anchors were used to tie the *phumdi* so that the pens remain in place. The height of the net wall was kept sufficient so that the structure can float up with the increase in water levels during rainy months. The pens were stocked with Catla (*Labeo catla*), rohu (*Labeo rohita*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*) and kuri (*Labeo gonius*) at a stocking density of 1 no./ m^2. After 6 months of rearing, grass carp attained the highest growth (1.68 kg), followed by common carp (1.10 kg), rohu (0.85 kg), kuri (0.60 kg) and catla (0.55 kg). Net fish production of 0.89 kg/ m^2 was obtained.

Project title: Empowering women of wetland-dependent fisherfolk community of lower Gangetic plain through cost-effective technologies

Funding agency: DBT, Govt. of India

Scientific Personnel: A. Roy (P.I.), A. K. Bera, A. Pandit, P. K. Parida

Women population around the Khalsi beel, a shallow, seasonally open ox-bow lake spread across 62 ha area in Haringhata block of Nadia District in West Bengal were selected for empowerment using cost effective technologies under the project. The beel is surrounded by eight villages, out of which five were selected including one control, namely, Khalsi, Mathpara, Uttar Brahmapur, Kanapukurdanga and Satshimulia. Being a multi-component collaborative project, four cost-effective technologies have been introduced under this project.

Participatory demonstration of pen culture technology

Wetland fishery is an indispensable source of livelihood to the people inhabiting these villages. In consultation with fishers and cooperative society members, CIFRI HDEP Pen technology has been introduced. About 265 kg of IMC fingerlings were stocked in 5 pens in April 2021. With active participation of the beel fishers a total of 487 kg of fishes were harvested and released in the beel in middle of July 2021 with an average survivability of 62%. Again, on 24th September socking of 420 kg of IMC fingerlings was done in 4 pens. Majority of the fishers (53%) watched and learned the pen culture technology implementation process. About, 17% of the fishers paid their labour for pen demonstration. The women beneficiaries of the project monitored the pen and were also involved in management process. However, only 4% of the fishers, particularly the Cooperative Society Governing body members participated in decision making.

Backyard poultry farming

For generation of alternate livelihood opportunity and to



IMC fingerling raising in pens with community participation

ensure nutritional security sixty women beneficiaries were given twenty eight-days old chicks under the backyard poultry farming component. Initially, 820 birds were given to 39 women in the 1st year. Further, a total of 441 chicks were distributed among the 20 beneficiaries from four villages in October, 2021. The benefit cost ratio of a single unit backyard poultry farm in first year was estimated to be 1.6. However, excluding the family labour the B:C ratio went up to 7.6. So, the women involved in backyard poultry farming can get a net economic benefit of ₹11992 (excluding family labour) in a year. Since the women member looks after the poultry birds in their leisure time, the opportunity cost is almost nil, and hence the net return was also calculated without accounting their labour cost.

Kitchen gardening

Kitchen gardens provide fresh crops and vegetables for family consumption and help increase household income from sale of the excess produce. Besides, this initiative promotes entrepreneurship, especially among women. The earning from the sale of kitchen garden produce and the savings from consuming home-grown food products create an increased amount of disposable income for the beneficiary families, who invest the surplus to fulfill other essential needs such as children education, etc.

Since marketing could not be taken up substantially due to COVID-19 restrictions, family savings equivalent to the local market price/ farm gate price was derived from the produce which were mostly consumed at home.

Implementation of innovative extension approach: Fisher Field School

The first step to any developmental programme or introducing any innovation is to create awareness and sensitize the target populace that such possibilities exist. In Khalsi beel area Farmer Field School (FFS) approach was adopted for diffusion of farm innovations along with awareness and sensitization, group meetings, exposure visit, on-farm training and demonstration. Two FFS groups were formed with 25 members in each and regular gathering on every fortnight was ensured for problem solving interactions. Several such programmes were conducted in collaboration with other partner organizations.

Table 12. Average production (kg/family) of vegetables in kitchen gardens

Winter vegetable	Khalsi	Kanapukur danga	Uttar Brahmapur	Mathpara
Tomato	5.2	4.5	10.0	2.5
Chilli	0.5	1.5	1.0	0.5
Brinjal	4.5	12.1	7.5	4.5
Dolichos Bean	2.5	2.0	1.5	-
Carrot	2.5	-	-	-
French bean	4.5	3.0	3.5	8.5
Peas	7.0	5.5	2.2	2.0
Spinach	2.5	3.5	15.5	3.5

Table 13. Programmes conducted for human resource development in the Khalsi beel area

Date	Topic	No. of beneficiaries
11.02.2021	Training on mushroom cultivation at KVK Nadia	24
26.03.2021	Exposure visit cum awareness on poultry farming at RKVY, Haringhata	46
01.04.2021	Sensitization cum monitoring programme for mushroom and vegetable component	25
10.07.2021	Management of sustainable fisheries- online	44
18.08.2021	Sensitization cum monitoring programme for backyard poultry component	21
01.09.2021	Enclosure culture for fish production enhancement in Inland open waters	52
24.09.2021	'Field day' at Khalsi and fish seed stocking	24
08.11.2021	Awareness programme on fish and poultry disease management cum input distribution	37
18.11.2021	Hands on training on mushroom and input distribution	25

Various extension activities

Project title: Assessment of endocrine disruption in fish reproduction

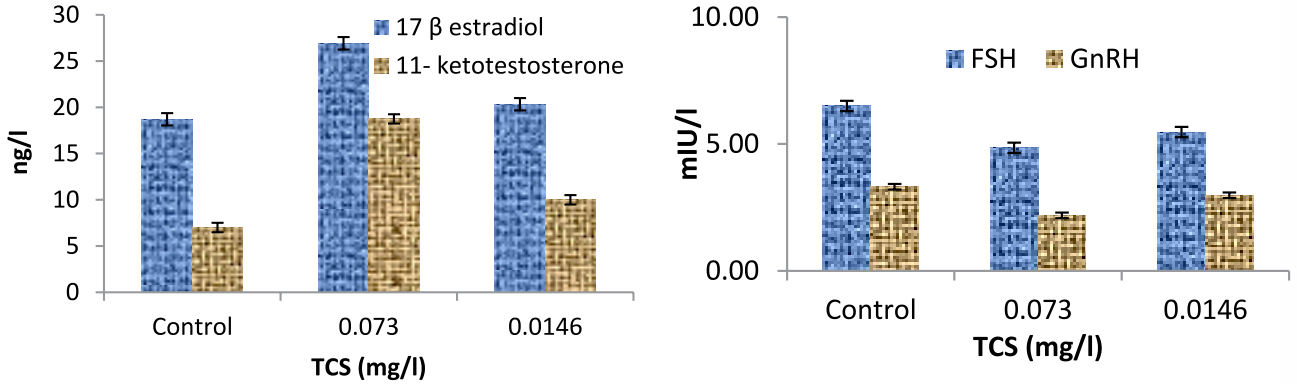
Funding Agency: DBT, Govt. of India

Scientific Personnel: B. K. Das, S.K. Nag, K. Kumari

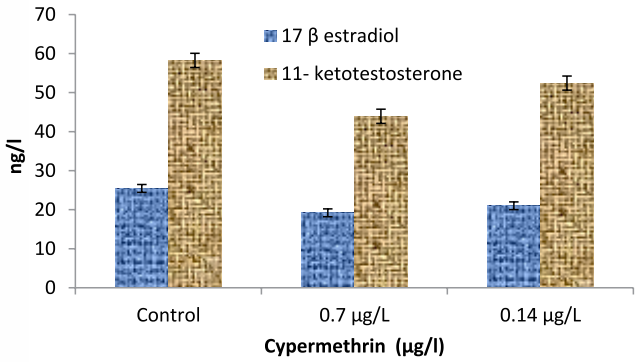
The effects of exposure of triclosan, an emerging contaminant in the aquatic environment, originating from various personal care products, and cypermethrin, a synthetic pyrethroid pesticide frequently used in agriculture and aquaculture, were investigated through chronic exposure at sublethal concentrations to fry /fingerlings of catla (*Labeo catla*). Both the compounds were administered at two different concentrations, *viz.* 1/10th and 1/50th of respective LC_{50} doses on a static renewal basis to *L. catla*. Significant changes at both biochemical (catalase, superoxide dismutase, glutathione peroxidase, 17-β estradiol and 11-ketotestosterone) and at molecular level (*GnRH, FSH, Kiss1, Kiss2* and *Vtg*) were detected.

Chronic exposure to triclosan (TCS)

Sublethal exposure of TCS at dose rate of 1/10th (0.073mg/l) and 1/50th (0.0146 mg/l) of LC_{50} dose for a period of 30 days to *L. catla* resulted in higher abundance of reproductive hormones such as 17β estradiol, 11-ketotestosterone, FSH and GnRH in a dose dependent manner. Up-regulation of genes associated to hypothalamic pituitary-gonadal (HPG) axis



Serum sex steroids and FSH and GnRH levels in brain tissue of *L. catla* exposed to TCS



Serum sex steroid levels of L. catla exposed to cypermethrin

(*FSH*, *Kiss1*, *Kiss2* and *Vtg*) were observed by qRT-PCR as compared to control. However, no significant change was observed in *GnRH* expression.

Chronic exposure to cypermethrin

Exposure of *L. catla* to sublethal concentrations of cypermethrine at dose rate of 1/10th (0.0007 mg/l) and 1/50th (0.00014 mg/l) of LC_{50} dose) for 30 days resulted in increase in SOD activity whereas no significant change was observed in catalase activity in serum, liver and kidney tissues. Decrease in concentration of reproductive hormones, *viz.*, 17β estradiol and 11 ketotestosterone were observed in a dose dependent manner.

Project Title : Investigation on fisheries and ecological status, threats, and remedial measures for enhancement of fish productivity of Gobindsagar reservoir, Himachal Pradesh

Funding Agency : Department of Fishery, Govt. of Himachal Pradesh

Scientific Personnel : U. K. Sarkar (P.I.), A. K. Das, Lianthuamluaia, Mishal P.

The Gobindsagar reservoir (31°25' N and 76°25' E) on river Sutlej is a large reservoir located in Himachal Pradesh. The fish production from the reservoir has been showing a declining trend in recent years despite stocking measures adopted by the fisheries department of Himachal Pradesh. Systematic assessment was required to determine the ecological process and establish a strategic management plan for fisheries development in order to increase and sustain fish production in the reservoir.

Ecological parameters

The physico-chemical characteristics of the Gobindsagar reservoir indicated medium productive nature from fisheries point of view. The majority of the

Location of Gobindsagar reservoir

water and soil characteristics were in optimal ranges for fish production. Dissolved oxygen level was within the suitable range for fish (5-9 mg/l). The pH was slightly alkaline (8.15–8.68). The conductivity (229-390 µS/cm) demonstrated a high level of productivity. The reservoir's nitrate and phosphate levels also suggested productive nature of the reservoir. The total alkalinity revealed that the water has a high pH buffering capability, which is a good sign of the reservoir's water quality. The reservoir's bottom soil is slightly alkaline. The bottom sediment is dominated by sand.

Fish diversity

The fish diversity of the reservoir was represented by presence of only 15 species in the commercial catches. Most of the species richness was represented by the orders Cypriniformes and Siluriformes. The species richness in the lentic zone of the reservoir was relatively higher than intermediate and lotic zones. However, the spatio-temporal survey during 2021 indicated a decline in the previously recorded species diversity from the reservoir. The exotic *Hypopthalmichthys molitrix* and *Cyprinus carpio* were recorded as the most dominant taxa contributing to nearly 80% of the catch, while *Sperata seenghala* and *Labeo dyocheilus* were found most abundant among native fish fauna.

Contrary to this, the abundance of golden Mahseer, *Tor putitora,* was meagre and warrants additional measures for its conservation and enhancement. The time series data also showed that silver carp as the most dominant fish in the reservoir despite the steep decline in catch of this species.

Spatial and temporal variations in fish catch

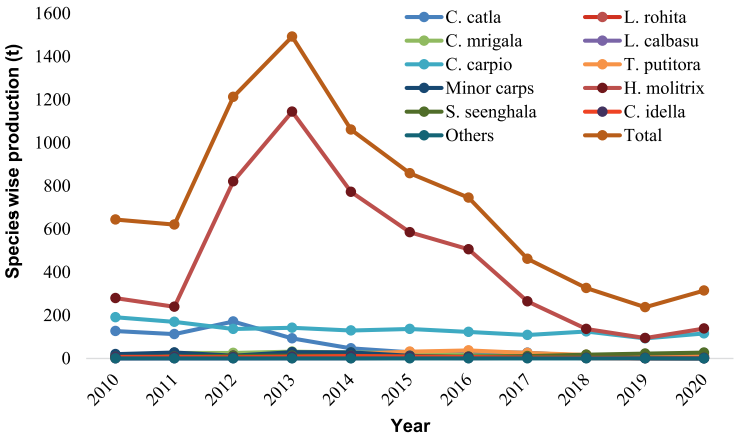
The fish catch analysis during the last decade (2010-20) indicated that the exotic fish *H. molitrix* and *C. carpio* led the percentage fish catch followed by *Catla catla*. The time series data also indicated that *H. molitrix* was the most dominant fish although the fish was not stocked in the reservoir. However, the catch of *H. molitrix* decreased drastically after 2013. The spatial variation of fish production during the last decade indicated that the highest fish production was obtained in lentic zone followed by intermediate and lotic zone, might be due to accumulation of nutrients in the lentic zone. The regression analysis of the fish production and precipitation indicated a positive relation between rainfall and fish production.

Project title : Microbiome metatranscriptomics assessment of Indian river basins for ecosystem health monitoring

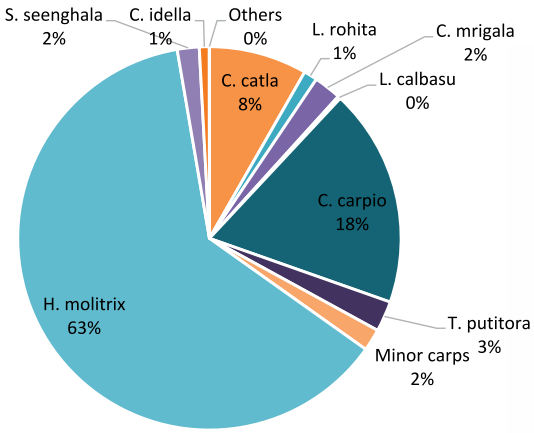
Funding Agency : CABin, ICAR, New Delhi

Scientific Personnel : B.K. Behera (P. I.), B.K. Das, D.J. Sarkar, P.K. Parida

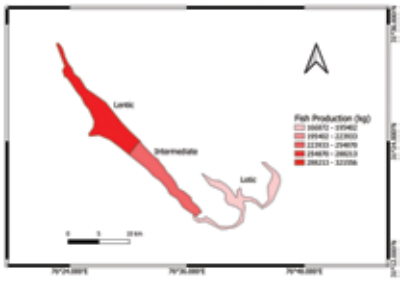
The Ganga is a major riverine system of India providing ecosystem services to millions of households. However, this river is under stress from various anthropogenic activities. River sediments harbour a variety of microorganisms which have tremendous influence on the river health. In present study, a shotgun metagenomic sequencing in NGS platform was carried out for microbial community characterization of three sediment samples collected from river Ganga at three sites (F1, F2, F3) of Farakka stretch. Taxonomical classification study showed that the occurrence of bacteria is higher than the other group of microbes. The bacterial Class Betaproteobacteria, Deltaproteobacteria, Gammaproteobacteria, and Archaeaphyla Thaumarchaeota and Crenarchaeota were relatively higher than the other communities. KEGG pathway analysis revealed that the number of genes associated with environmental information processing is higher in the Lalbag



Production trend of different fish species in Gobindsagar reservoir during 2010-20

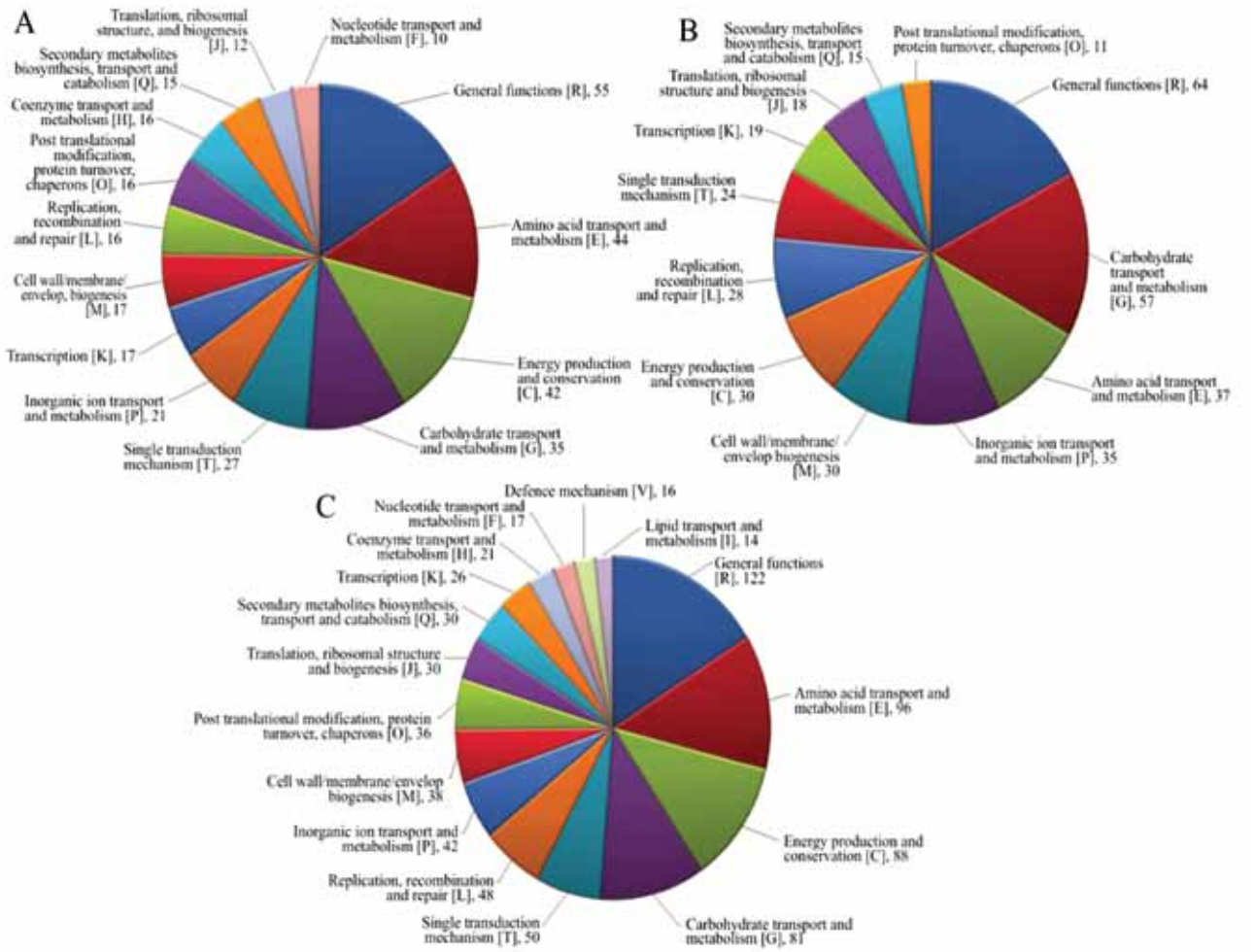


Fish catch composition during 2010-20 in Gobindsagar reservoir



Map showing the spatial variation of annual fish production in Gobindsagar reservoir

Fish catch of Gobindsagar reservoir



Abundances of several COG categories for Sample F1 (A), Sample F2 (B), Sample F3 (C)

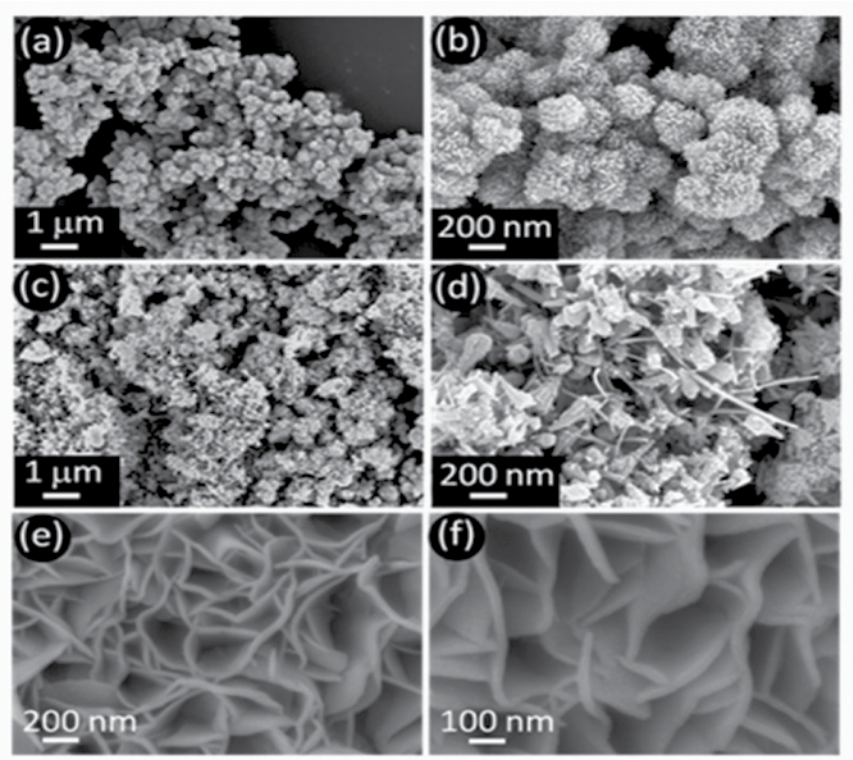
sample in comparison to Farakka barrage and Dhulian samples. Both COG and SEED analysis revealed that genes associated with carbohydrate metabolism are higher than other functional categories. The genus-level study confirms the higher occurrence of *Pseudomonas* which corresponds to anthropogenic activities like mass bathing; presence of bacterial genus *Nitrospira* and archaea phylum *Thaumarchaeota* confirms a healthy nitrogen cycle in the environment. The generated information would help in understanding the importance of microbial communities and their imperative functions in river ecosystem functions and health.

Project title : Development of biosensors for detection of fish pathogenic bacteria and hazardous metalloids in selected water bodies

Funding Agency : NASF, ICAR

ScientificPersonnel : B.K. Behera (P.I.), P.K. Parida, D.J. Sarkar, B.K. Das

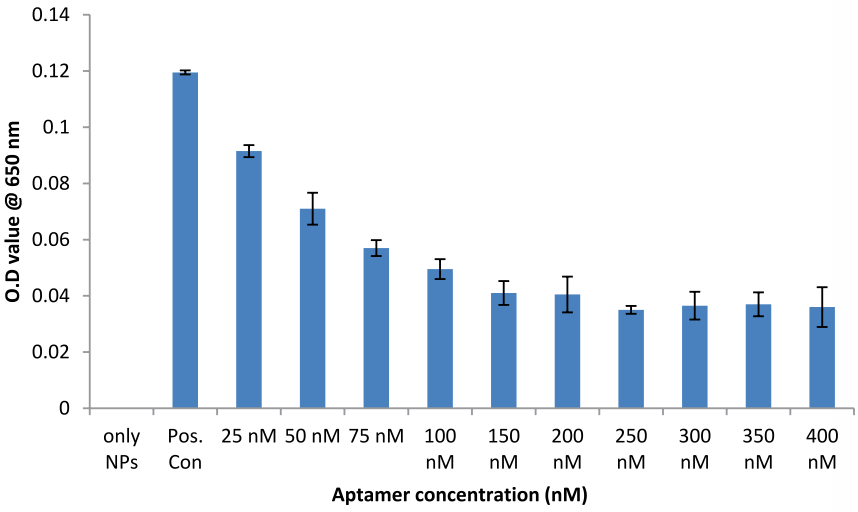
Gold (Au) and silver (Ag) nanoparticles (NPs) with different capping agents (citrate, and tyrosine) were synthesized and characterized for MRE development of the biosensor. Manganese oxide nanoparticle was also prepared using soution-based technique. The agglomerated structure of size 400-500 nm composed of finer particles of size <20 nm. By adding 8 ml HCl, nanowires were prepared. The cobalt hydroxide nanostructures were prepared at room temperature using electrochemical deposition technique. The 300 s electrodeposited $Co(OH)_2$ film composed of vertically aligned sheet-like structure with thickness <30 nm. The Tyr-Au and Tyr-Ag NPs were used for aptamer-based biosensor development for detection of As(III), Cr(VI) and *Aeromonas veronii*. Basic optimization of both Tyr-Au and Tyr-Ag NPs, substrates (TMB: 3, 3', 5, 5'- Tetramethyl benzidine, H_2O_2), were demonstrated by



FESEM images of MnO_2 nanoparticles (a, b) MnO_2 nanowires (c, d), and $Co(OH)_2$ nanosheets (e, f)

using different concentrations of NPs (10-400 µM) and substrates (TMB; 25-400 µM, H_2O_2; 1-400 mM). Aptamer based inhibition of nanozymes activity was executed at different concentrations of Ars-3 aptamer (25-400 nM). With increased concentration of Ars-3 aptamer, inhibition of GNPs nanoZyme activity was observed. Based on the aptamer based inhibition study Ars-3 aptamer at concentration of 150 nM was used for recovery study. Further, SELEX method was used to identify novel Aptamer for Cr(VI). After 10^{th} round of SELEX, the selected ssDNA pool was cloned and individually sequenced and analyzed for binding specifically to Cr(VI). The DNA aptamers identifying and binding specifically to Cr(VI) in solution were developed.

For development of a field-portable instrument based on a uniform illumination imaging system, various image processors such as portable scanners, camera modules are being assessed. The scanned images are being captured and analyzed through MATLAB. In parallel, towards electrochemical detection a three-electrode system has been designed for current-voltage measurement with various electrical circuits, OA-amps, and microcontrollers. Initial experimentations for parameter optimization through the electrochemical prototype are being performed with Chromium samples.



The changes in the peroxidase-mimic nanoZyme activity of Tyr-capped Au NPs as function of increasing Ars-3 aptamer concentration

Project Title : MEAN: Measuring EDCs and aquatic diagnostics through biosensor networks with special reference to NE India

Funding Agency : Ministry of Electronics and Information Technology, Govt. of India

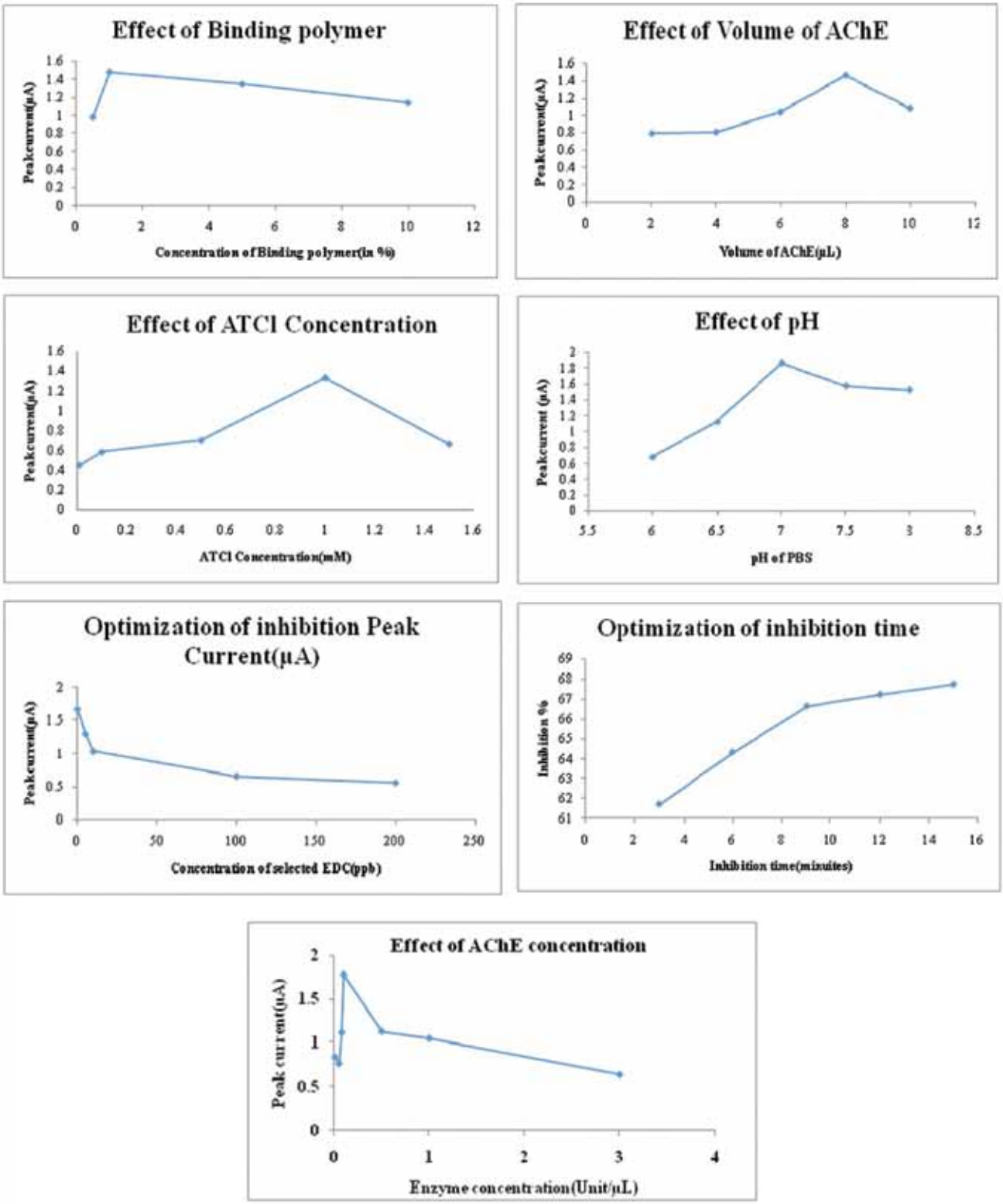
Scientific Personnel : B.K. Behera (P. I.), S.C.S. Das (P. I., NE Component), B. K. Das, D. J. Sarkar, P. K. Parida

Electrochemical detection of OP pesticides

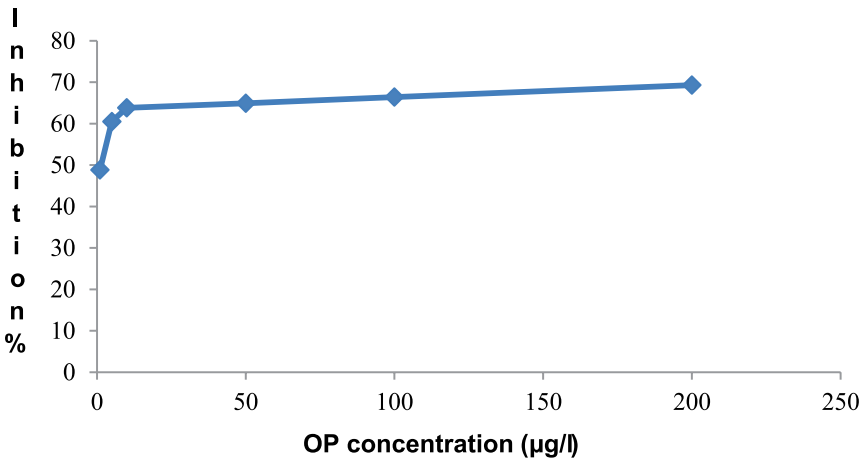
OP pesticides are well recognized as endocrine disrupting chemicals (EDC) for fishes and trace level analysis of OP pesticides is very important. Hence, besides colorimetric estimation, efforts were taken to develop sensing system for the same at trace level (<10 µg/l). In the present study acetylcholine esterase-based electrode was prepared by immobilizing the same using nanosilver encapsulated hydrophilic polymer followed by cross-linking using glutaraldehyde.

Fabrication of the electrode

The electrode was prepared by taking a thoroughly cleaned glassy carbon electrode (GCE, 3mm) and drop casting it with a 10 µl solution of 1% conducting binding polymer followed by air drying at room temperature for 30 minutes. After that 8 µl of prepared 0.1 U AChE was drop casted on the polymer coated GCE and followed by mixing with 6 µl of 5% glutaraldehyde and the optimized working electrode was kept under 4°C for 1 h. Then the working electrode was purged by nitrogen gas to make it proper dry.



Optimization of test parameters



Inhibition study of Organophosphate in Electrochemical Workstation

Electrochemical measurement

Three electrode systems were used where Ag/AgCl was used as a reference electrode, functionalized carbon electrode was used as working electrode and platinum electrode was used as counter electrode. The peak current at optimum voltage was found from the cyclic voltametry (CV) study. To test the electrochemical differential pulse voltammetry (DPV) response, the obtained conducting polymer/AChE/GLA/GCE was immersed in PBS solution containing different concentration of selected EDC for 9 minutes. It was transferred to an electrochemical cell consisting 10 ml PBS (pH7) containing 1 mM acetylthiocholine chloride (ATCl) solution as a substrate for AChE. The inhibition rate of selected EDCs was calculated as follows:

$$\text{Inhibition (\%)} = (I_{p,control} - I_{p,exp}) / I_{p,control} \times 100\%$$

Where $I_{p,control}$ and $I_{p,exp}$ are the peak currents of ATCl on the conducting polymer/AChE/GLA/GCE without and with EDCs inhibition, respectively. Inhibition (%) was plotted against the concentration of the pesticide to obtain a linear calibration curve.

Effect of various test parameters, viz. effect of binding polymer, volume of test enzyme, pH effect, peak current, inhibition time and enzyme concentration were tested. It was found that after certain optimum value the peak current obtained from DPV remained same or reduced a bit. Hence these optimum values are taken further to calculate the limit of detection of the test OP pesticide.

The inhibition study at different pesticide concentration found that the electrochemical analysis gave linear relationship in the test concentration between 10 and 100 µg/l.

ICAR-CIFRI in association with C-DAC, Kolkata, and IIT, Hyderabad developed a prototype for detection of EDCs like Organophosphate pesticides (OPs) from inland open waters. The biosensor was deployed at the five different sites (Borsola beel, Bharalu river, Samaguri beel, Charan beel and Damal beel) of Assam for field validation. Preliminary observations suggest high levels of pesticide pollution in Bharalu River and Borsola beel.

Project title: National Surveillance Programme for Aquatic Animal Diseases

Funding Agency: DoF, Govt. of India

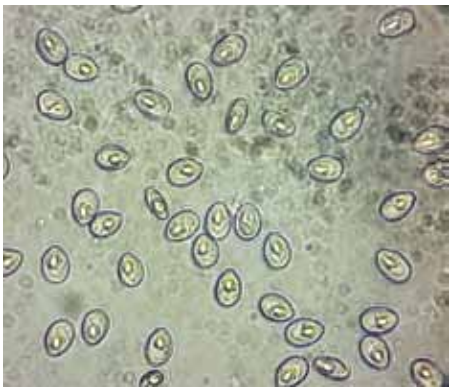
Scientific personnel: B.K. Behera (P.I.), B.K. Das, B.K. Bhattachariya, P.K. Parida, P. Das

Surveys have been conducted in the farmers' field of East Medinipur, Nadia, North 24 Parganas, and Bardhaman districts of West Bengal for fish diseases. Fish pathogenic bacteria *viz. Bacillus cereus*, *Aeromonas veronii*, *Citrobacter freundii*, *Klebsiella pneumoniae* were identified from the diseased fish samples (*Ctenopharyngodon idella*, *Labeo rohita*, *L. catla* and *Cirrhinus mrigala*), respectively.

Tilapia infected with TiLV

Bacterial infection in *Cirrhinus mrigala*

Fish parasite, *Myxobolus* spp. identified from the gills of *Labeo rohita*



Fish parasite, *Thelohanellus* spp. identified from caudal fin of *L. rohita*

The fish parasites *viz. Myxobolus* spp., *Ichthyophthirius multifiliis*, *Thelohanellus* spp., *Henneguya* spp., *Chaetogaster* spp., *Chilodonella* spp. and *Argulus* spp. were also recorded from different diseased fishes (*Labeo catla*, *Macrognathus pancalus*, *Ctenopharyngodon idella*, *L. rohita*, *Pangasianodon hypophthalamus* and *C. mrigala*) in West Bengal. The Tilapia Lake Virus (TiLV) was also reported from the diseased Tilapia samples in South 24 Praganas of West Bengal.

During survey in the farmers' field of Kamrup, Barpeta and Cachar district of Assam, fish pathogenic bacteria *Aeromonas hydrophila* was identified from the diseased *L. rohita*. Fish parasites, *viz. Saprolegnia parasitica* and *Argulus* spp. were also recorded from diseased *L. catla* and *Cyprinus carpio* in Assam.

Project title : Utilization and diversification of silkworm pupae products for human & animal consumption and composting

Funding Agency : Central Silk Board (CSB), Ministry of Textiles, Govt. of India

Scientific Personnel : B.K. Das (P.I.), M.A. Hassan, D.K. Meena, R. Das

Estimation of nutrient composition, anti-nutritional factors, and nutraceutical values of the Vanya (*Antheraea mylitta*) and Mulberry (*Bombyx mori*) silk worm pupae

Proximate composition of dry pupa meals of *Antheracea mylitta* and *Bombyx mori* were analysed following standard methods (Table 14). The study revealed presence of high levels of crude protein (65.04 ± 0.21%and 56.50 ± 0.28% respective) in these pupae meals. The crude lipid contents were as high as 15.45 ± 0.14% and 32.15 ± 0.20%, respectively. The low chitin (6.32 ± 0.08% and 3.71 ± 0.12 %) and ash (7.5 ± 0.1%and 5.57 ± 0.19%) contents of these pupae meals make them suitable for inclusion in fish feed. Study of anti-nutritional factors showed presence of high levels of oxalate, alkaloid, and saponin in both the pupae meals, whereas tannin and phytate levels were within the permissible limits. However, after preparation of feed using these pupae meals at maximum inclusion level of 25%, levels of the ANFs reduced to safe limits for fish diet. A good amount of total flavonoid was also obtained in both the pupae meals and can acts as a nutraceutical.

Antheracea mylitta pupae

Bombyx mori pupae

Feeding trial of Pangasius and Tilapia using *Antheraea mylitta* pupae meal

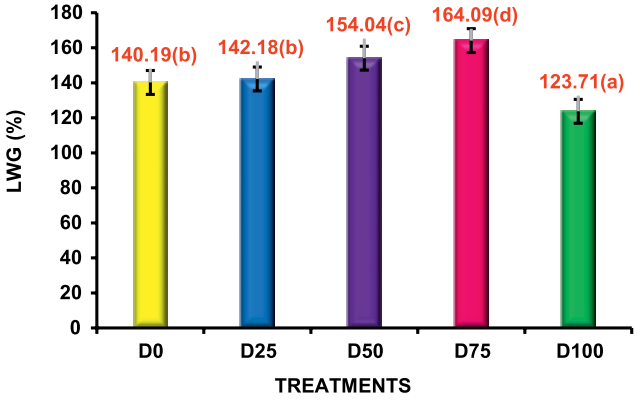
Pangasionodon hypophthalmus

Experiments were conducted for 8 weeks to study the extent to which fish meal can be replaced by Vanya silkworm pupae meal in fish feed for advanced fry of *Pangasionodon hypophthalmus*. Five experimental diets (D0, D25, D50, D75 and D100) were formulated using various oil cakes with sequential

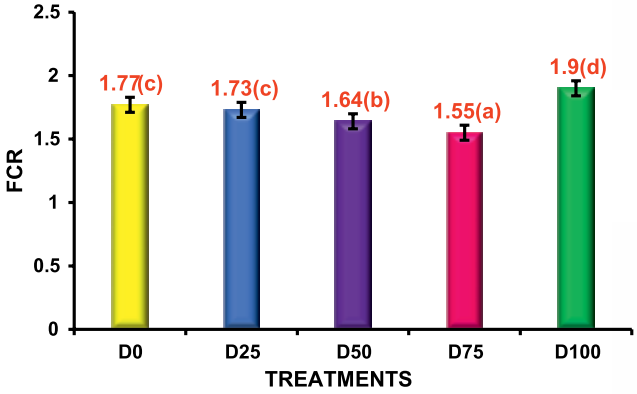
Table 14. Proximate composition and anti-nutritional factors in *Antheraea mylitta* and *Bombyx mori* pupae meals

	Parameter	*Antheraea mylitta*	*Bombyx mori*
Proximate composition (% dry matter)	Moisture	4.39 ± 0.13	2.16 ± 0.11
	Crude protein	65.04 ± 0.21	56.50 ± 0.28
	Crude lipid	15.45 ± 0.14	32.15 ± 0.20
	Chitin	6.32 ± 0.08	3.71 ± 0.12
	Total ash	7.5 ± 0.1	5.57 ± 0.19
	Nitrogen-free extract	5.63 ± 0.15	2.07 ± 0.57

Anti-nutritional factors (mg/100g)	*Antheraea mylitta*	*Bombyx mori*	Permissible limit in fish diet (mg/100g)	
Tannin	22.43 ± 0.66	128.05 ± 3.39	2000	(Prusty et al., 2007)
Phytate	3.62 ± 0.08	38.11 ± 0.33	500	(Francis et al., 2001)
Total flavonoid	37.67 ± 2.68	594.20 ± 7.35	Acts as nutraceutical	(Kaleem and Ahmad, 2018)
Total oxalate	2862.96 ± 21.60	6174.56 ± 166.89	2500	(Focken et al., 2015)
Alkaloid	1037.85 ± 86.94	1771.52 ± 93.26	10	(Glencross et al., 2006)
Saponin	613.58±43.83	971.55±12.97	100	(Francis et al., 2001)



Live weight gain (%) of *P. hypophthalmus* fed with different experimental diets for56 days. Bars with different superscripts differ significantly (p<0.05); value (123.71 to 164.09) represents the LWG (%).

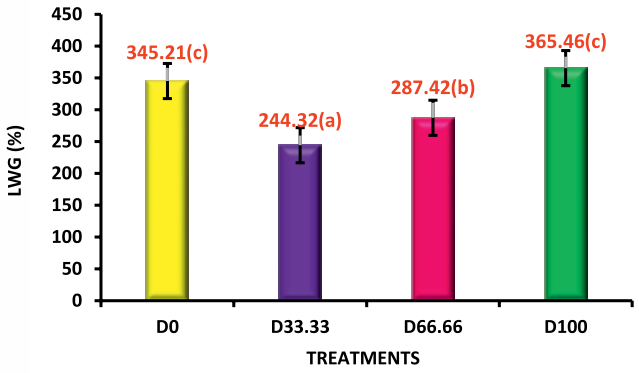


Feed conversion ratio of *P. hypophthalmus* fed with different experimental diets for 56 days. Bars with different superscripts differ significantly (p<0.05); value (1.55 to 1.9) represents the FCR.

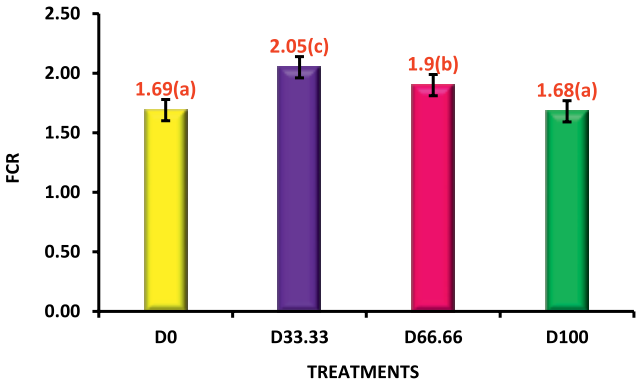
replacement of fish meal with pupae meal. Three hundred *P. hypophthalmus* fish (2.51 ± 0.01 g) were divided in to 5 dietary groups in duplicate by keeping 30 fish per 330 litre fibre-reinforced plastic circular experimental tanks with round the clock aeration. Each fish group was fed with experimental diets on satiation basis thrice daily at 08:00, 12:00, and 16:00 h. Based on weight gain, nutrient utilization, flesh quality, and survivability of fish after 56 days of trial, it was observed that 75% of fish meal protein can be replaced by *A. mylitta* pupae meal in the diet of *P. hypophthalmus* without any detrimental effect.

Oreochromis niloticus

Two hundred *O. niloticus* fish (0.72 ± 0.02 g) were arbitrarily divided into four groups viz., D0, D33.33, D66.66, and D100 (*Antheraea mylitta* pupae meal-based diet) in duplicate by keeping 25 fish per 250 L fibre-reinforced plastic circular experimental tank with round the clock aeration. Fish in different tanks were fed different feed formulation up to 56 days. Based on fish growth, nutrient utilization, flesh quality, and survivability of fish, it was observed that fish meal protein can be replaced completely (100%) by the *A. mylitta* pupae meal (AMPM) in the diet of *O. niloticus* without any deleterious effect.



Live weight gain (%) of *O. niloticus* fed with different experimental diets for the period of 56 days; Bars with different superscripts differ significantly ($p<0.05$); value (244.32 to 365.46) represents the LWG (%).



Feed conversion ratio of *O. niloticus* fed with different experimental diets for the period of 56 days. Bars with different superscripts differ significantly ($p<0.05$); value (1.68 to 2.05) represents the FCR.

Project Title: Captive breeding of Hilsa, *Tenualosa ilisha*: Phase II

Funded by: National Agricultural Science Fund (NASF), ICAR

Scientific Personnel: S. Samanta (Consortium P.I.), B.K. Behera, R.K. Manna, A.K. Sahoo

Partner Institutes: ICAR-CIBA, ICAR-CIFA and ICAR-CIFE

Captive breeding and rearing of highly prized Indian Shad are major objectives of the project. In this endeavor, breeding on boat was performed, together with ICAR-CIFA, Rahara, at Godakhali utilizing wild Hilsa brood fishes. This yielded a huge number of spawns which are being reared in grow-out pond of ICAR-CIFA facility at Rahara.

To set up more number of experimental ponds for rearing, Hilsa pond rearing facility (0.4 ha) has been established at Kolaghat, West Bengal. The pond has been stocked with 239 fingerlings (22.84 ± 1.56 g) collected from river Roopnarayan and also local ponds. Fishes are regularly fed with Hilsa^{Plus} twice a day. Mass culture facilities for *Chlorella* and mixed zooplankton have been developed at pond site and are supplemented in the pond at weekly basis. In order to maintain the plankton density in the rearing pond, Plankton^{Plus} is being applied at regular intervals. Two separate experiments have been conducted with *Chlorella vulgaris* to standardize its optimum growth conditions. The water quality parameters of Hilsa pond are monitored at regular intervals to maintain a uniform environmental condition for the stocked Hilsa.

Transportation of live Hilsa is a challenge since the fish die soon after catching. With objective to enhance the fish survival, three experiments on live Hilsa transportation were conducted using specially designed structure. In the 1st experiment, live Hilsa fingerlings survived for about 3 hours; in the 2nd experiment, Hilsa collected from river at Godakhali survived for about 1 hour 35 minutes, while in the 3rd experiment, Hilsa collected at Godakhali survived a maximum of 3 hours 15 minutes.

Beside ponds, attempt will be made for rearing the fish in cages. In this direction, a suitable site at upstream of Farakka Barrage on river Ganga has been selected for installation of circular cages. For this, discussion with Farakka Barrage Authority & Inland Waterways Authority of India is under progress.

Pond culture facilities of Hilsa at Kolaghat

Project Title: A Study on Input Cost and Farm Gate Prices in Inland Fisheries of India

Funding agency: Ministry of Statistics and Programme Implementation, Govt. of India

Scientific Personnel: B.K. Das (Project Coordinator), A. Pandit (P.I.), P. Panikkar, M. Karthikeyan, P.K. Parida. A. Saha, S.P. Kamble, D.N. Jha, T.T. Paul, V.R. Thakur, A.K. Yadav, S. Borah, R.K. Raman (up to 30.11.2019) and S. Som (up to 17.05.2020)

According to the Department of Animal Husbandry, Dairying and Fisheries (DAD&F), availability of accurate data on fishery resources and their potential in terms of fish production are some of the major challenges in fisheries sector of the country. Attention of the nodal national level data collection agencies like CSO/ NSSO could not be adequately leveraged to include fisheries sector as one of their focus areas. Lack of data on cost of production in the inland fisheries sector affects the compilation of gross value added by the sector as well as the policy formulation for its development. The study is a step in this direction to estimate the input cost and farm gate prices of inland fisheries.

The study was carried out in 12 states covering fresh and brackish-water aquaculture, capture fishing in rivers, estuaries, wetland, reservoirs, backwaters and lagoons. Data were collected from West Bengal, Odisha, Chhattisgarh, Uttar Pradesh, Karnataka, Andhra Pradesh, Assam, Tripura and Kerala for fresh water aquaculture; from West Bengal, Odisha, Gujarat, Kerala and Andhra Pradesh for brackish water aquaculture; from West Bengal, Uttar Pradesh, Assam and Gujarat for riverine fisheries. Similarly, the reservoir component has been done in Odisha, Chhattisgarh, Madhya Pradesh and Karnataka. For wetland fisheries Assam, West Bengal, Bihar, and Uttar Pradesh were taken into account. Chilika and Vembanad lakes have been covered for lagoon and backwater fisheries, respectively. Different factors of intermediate consumptions were taken into account for estimating the input cost. Labour cost was also excluded. Gross value of output depend on species and quantities caught and prices obtained, which again depend on seasonal fluctuations and other factors. Gross value of output (GVO), Gross value added (GVA) and input-output ratio have been estimated for all the sectors. The input-output ratios were estimated both for selected state as well as for the national level. For culture fishes (both FWA and BWA) weighted averages were used.

Capture fisheries

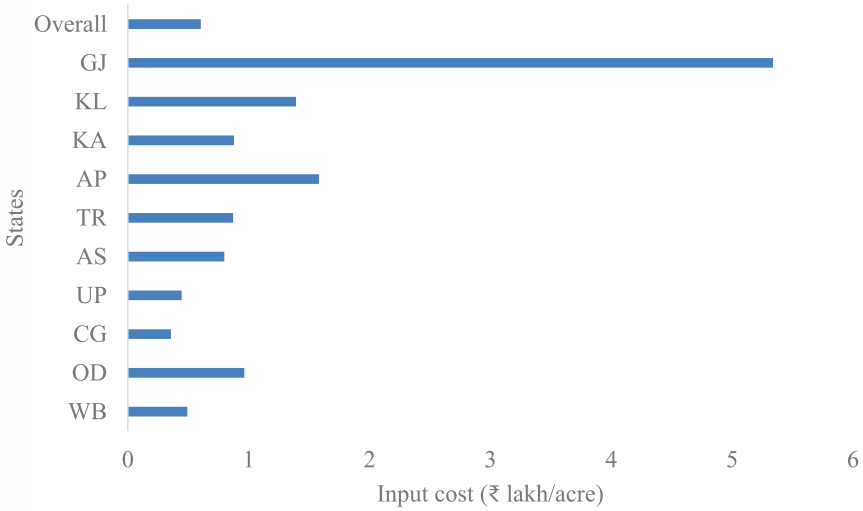
Capture fisheries, for the present study, involved fishing in rivers, estuaries, reservoirs, flood plain wetlands, backwaters and lagoon. Reservoirs and wetlands were of unstocked type. It was found that the input cost was ranged from ₹3,929 in reservoir to ₹47,582 in lagoons and backwaters per fishermen per year (Table 15). The gross value of output by a fisherman per year ranged from ₹ 1,04,064 in wetlands to ₹ 5,98,172 in backwaters and lagoons. The GVA-GVO trend was opposite to that of input-output trend.

Table 15: GVO-GVA and input-output ratio in capture fishing

Ecosystem	Input cost (₹/fisherman/year)	Gross Value of output (₹/ fisherman /year)
Riverine fisheries	13715	231101
Estuarine fisheries	40959	235699
Unstocked reservoir	3929	134696
Unstocked wetlands	4508	104064
Backwaters and lagoon	47582	598172

Aquaculture

In freshwater aquaculture input costs were ranged from around ₹ 0.87 lakh to ₹1.50 lakh in southern states (Fig. 1). In West Bengal and Odisha they were almost similar (about ₹0.49 lakh/acre). At national level the input cost in freshwater aquaculture was found to be ₹ 0.53 lakh/acre. Seed, feed, chemicals and fertilizers, lime and gypsum, fuel charges were the major items of input costs. In brackish water aquaculture the study showed that a farmer household incurred input cost worth ₹ 2.69 lakh per acre per year, of which the costs on feed was major item. The seed, medicine, lime/gypsum, electricity were the major items of input cost of fish farming in the country. The cost was highest in Gujarat (around ₹5.3 Lakh/acre), followed by Andhra Pradesh, Odisha and. In overall aquaculture the study revealed that the input cost was highest in Gujarat and lowest in Chhattisgarh. Only brackish water aquaculture was considered for Gujarat. Similarly, only freshwater aquaculture was included for Chhattisgarh, Karnataka, Tripura, Assam, Uttar Pradesh states. In West Bengal, Odisha, Andhra Pradesh and Kerala both the aquaculture practices were taken into account.



Input cost in aquaculture (fresh and brackish water)

The study showed that in fresh water aquaculture the gross value of output was highest in Tripura (around ₹2.87 lakh/ acre/year). Higher farm gate prices are the reasons behind this. For overall aquaculture it was found to be around ₹ 1.34 lakh per acre/year, being highest in Gujarat (around ₹ 7.5 lakh) as only brackish water aquaculture was considered for this state. The GVA-GVO ratio was more than sixty per cent in MP, Bihar, Karnataka, Tripura, Assam, UP and Chhattisgarh. In freshwater and brackish water aquaculture the gross value of output was found to be ₹ 1.20 and ₹ 5.45 lakh, respectively. The input–output ratio in this sector is much higher than the capture fisheries.

Glimpses of Survey

CONSULTANCY PROJECT

Project Title: Assessment and impact study on biodiversity, eco-hydrology, fish population dynamics and livelihood of fishers in Narmada River with special focus on downstream of Sardar Sarovar Dam and Bhadbhut Reservoir

Funding Agency: Govt. of Gujarat, Narmada Water Resources, Water Supply and Kalpasar Department

Scientific Personnel: B. K. Das, S. Samanta, A. Pandit, G. Chandra, A. K. Sahoo, S. P. Kamble, D. Bhakta, L. Kumar

Biodiversity assessment in the river Narmada was carried out considering fish, plankton, and benthic community in the selected stretches from Garudeshwar to Luwara point covering 13 stations. Biotic and abiotic parameters were analyzed for two years in pre-monsoon, monsoon, and post-monsoon seasons.

Fish and shellfish diversity

A total of 79 finfish species belonging to 13 orders, 34 families, and 66 genera was recorded. Order Perciformes was found to be the most dominant group with 41 species (51.90%), followed by Cypriniformes with 13 species (16.46%), Siluriformes with 7 species (8.86%), etc. Family wise, the highest number of species was observed in Cyprinidae with 13 numbers (16.25%), followed by Gobiidae (10 numbers), Mugilidae (6 numbers), etc. Beside finfish species, 9 species of shellfish under Class Malacostraca (3 crabs, 5 shrimps, and 1 mantis shrimp), 1 Cephalopoda (Old woman octopus), 1 Elasmobranchii (Arabian carpet shark), and 1 Scyphozoa (common jellyfish) have been recorded.

New records in the river

As many as 16 fish species *viz.*, Yellow tip halfbeak (*Hemiramphus marginatus*), Slender thryssa (*Thryssa stenosoma*), Indian frogfish (*Antennarius indicus*), Greenback mullet (*Planiliza subviridis*), Highfin glassy perchlet (*Parambassi slala*), Yellowtail scad (*Atule mate*), *Caranx nobilis,* Scribbled goby (*Awaous grammepomus*), Walton's mudskipper (*Periophthalmus waltoni*), Indian threadfin (*Leptomelanosoma indicum*), Spangled emperor (*Lethrinus nebulosus*), Rice-paddy eel *(Pisodonophis boro),* Seven finger

Lethrinus nebulosus

Periophthalmus waltoni

Caranx ignobilis

Atule mate

Gill net operation for catching Hilsa in river Narmada

threadfin (*Filimanus heptadactyla*), Goatee croaker (*Dendrophysa russelii*), Striped eel catfish (*Plotosu slineatus*), Lattice blaasop (*Takifugu oblongus*) were found as new records in the studied river stretches.

Fishing gears and CPUE

Among different fishing gears gillnet, bagnet, and hook and lines were found to be the main gears operated downstream of Sardar Sarovar Dam in the river Narmada. Catch per unit efforts (CPUE) varied widely in different seasons, *viz.,* 2.0-6.0 kg/bagnet/day (in pre-monsoon), 0.50-7.5 kg/ bagnet/day (in monsoon) and 1.25-17.0 kg/ bagnet/day (in post-monsoon) for bagnet fishery. Gillnets are most commonly used to catch target species like Hilsa (*Tenualosa ilisha*), Pama (*Otolithoides pama*), other sciaenids, mullets, etc. Gillnets with mesh size of 50-60 mm and 100-130 mm are used for catching males and females of Hilsa.

Migratory fish/shellfish

Hilsa (*Tenualosa ilisha*) was found to be the major migratory fish species with maximum abundance in monsoon season and highest catch at Bhadbhut. The species migrated up to Jhanor and Sisodra during monsoon months with peak migration occurring during June to August. In addition to Hilsa, Giant freshwater prawn *Macrobrachium rosenbergii* and Flathead grey mullet *Mugil cephalus* were recorded with significant production. In Narmada estuary *M. rosenbergii* showed two recruitment patterns in a year: one during January to February and the other, which is also the major recruitment, during May to August. The recruitment pattern of *Mugil cephalus* also follows two recruitment patterns in a year: one from February to May and the other from August to October.

Juvenile fisheries

The Narmada estuary supports a wide variety of juvenile fisheries due to its highly productive habitat. The commercially important juvenile fisheries in the Narmada estuary are: Hilsa (*Tenualosa ilisha*), Mullet (*Mugil cephalus*), Bombay-duck (*Harpodon nehereus*), Barramundi (*Lates calcarifer*), Fourfinger threadfin (*Eleutheronema tetradactylum*), Bengal tongue sole (*Cynoglossus cynoglossus*), Threadfin sea catfish (*Arius arius*), etc., while prawn comprised mainly of Giant freshwater prawn (*Macrobrachium rosenbergii*) and Indian white prawn (*Penaeus indicus*); *M. rosenbergii* formed the prime juvenile fishery of the estuary. Harvesting of the finfish and shellfish juveniles with small meshed nets (such as bag net with 10 mm cod-end mesh size) was one of the major reasons of depletion of the commercially important species such as *T. ilisha*, *M. cephalus*, *Harpodon nehereus*, *Latescal carifer*, *Eleutheronema tetradactylum*, and *M. rosenbergii*

A mixed catch of Hilsa juveniles from river Narmada

in downstream of the dam in the river Narmada.

Macrobenthic invertebrate diversity

Fifteen species of benthic organisms, belonging to six groups *viz*., gastropods, oligochaetes, polychaetes, bivalves, crustaceans, and insects, were recorded from the studied stretch of river. Benthic organisms are considered as the best bio-indicators owing to their sessile nature. Benthic population was more abundant in stations below the proposed barrage site. Polychaetes, oligochaetes and insect larvae were dominant in the lower stations suggesting possible pollution of industrial effluents in the estuarine region. Benthic groups such as gastropods, bivalves, etc. were dominant in the stations above Bhadbhut. In pre-monsoon season the benthic population was dominant in the upstream of Bhadbhut, while in monsoon the estuarine region was dominated by the gastropods and polychaetes. The other groups were dominant in the upstream of Bhadbhut barrage site.

Plankton diversity

During the study period, a total 42 genera of phytoplanktons belonging to 9 classes (Bacillariophyceae, Coscinodiscophyceae, Cyanophyceae, Chlorophyceae, Conjugatophyceae, Xanthophyceae, Trebouxiophyceae, Mediophyceae and Euglenophyceae) were recorded. A total of 11 genera of zooplanktons, under 4 classes (Eurotoria, Maxillopoda, Hexanauplia and Branchipoda) were recorded. The study did not exhibit significant spatial patterns in the spatio-temporal diversity and abundance of phyto- and zooplanktons across stations and seasons. Plankton diversity was higher in the lean season and may be related to low flow rate in the river.

Water quality

The river water discharge and availability in the upper stretch from Garudeswar to Panetha was very low. Water quality analysis showed relatively higher salinity in the stretch up to Bharuch. The nutrients, viz. nitrate (average 0.1 mg/l) and phosphate (average 0.09 mg/l) were mostly in lower levels indicating unpolluted status. However, in Sakkarpura-Amlakhadi stretch higher phosphate-P content up to 0.21 mg/l was recorded suggestive of pollution. In addition, wide variability in sediment organic carbon contents was recorded with relatively higher values in the upper stretch at Garudeswar (average: 0.76%) and Sisodra (average: 0.80%) due to anthropogenic effects. Although the industrial effluents enter the Bharuch to Amlakhadi stretch, the strong tidal influence in the estuary prevented any major accumulation of organic matter in the sediment. The sediment total nitrogen and available phosphorus levels were low. The river sediment was dominated by sand, however, clay fraction dominated in some seasons due to washings from clay dominated catchment.

Socio-economics of fishers

Socio-economic and livelihood analysis both at upstream and downstream of the proposed barrage was conducted. A total of 190 randomly selected fishermen were interviewed and data were collected through interview schedules. About half of the respondents were secondary (Class 6-10) level educated and 21% were illiterate. Overall, 80% respondents were dependent on fisheries alone as primary occupation. Labour, jobs in private factories, driver, and missionary were some of the other primary occupations of the respondent fishers. The average family size of fisher's households was estimated to be around 5. About 79 % of the total respondents were landless. Majority of the families fell in the category of ₹1-2 lakh per annum income category. The gill net was used by most of the respondents, in above barrage (97%), below barrage (97%) and overall (97%). About 23% and 43% of respondents owned non-motorized and motorized boats, respectively. On an average, fishers spent 8 hours per day for fishing and they went 12 days for fishing in a month during summer. Declining fish availability, low return and high risk were the major reasons for non-continuation of the fisheries. Overall, disruption in hilsa fishery, less fish availability, loss of livelihood, no fish migration were the major perceived threats by the fishers due to dam construction.

Hilsa fishing is the most important economic activity for fishers in downstream of Narmada estuary. Declining Hilsa availability over the years was found to be one of the major concerns of the fishermen in the entire study area. Majority of respondents from above barrage (around 30%) would like to shift to factory job as alternative livelihood in absence of fishery. Labour and aquaculture were the other preferred avocation. Aquaculture was also one of the most preferred alternative livelihood plans. Overall, 43% of the fishers wanted help for establishing aquaculture facilities. Government may provide them water bodies on lease/permanent tenure basis. About one-third

respondent wanted appointment in Govt or private jobs as per their qualification. About one-fifth of the fishers wanted grant/subsidy for establishing fish marketing business. Monthly compensation, fishing rights in the reservoir, easy loan for small business were the other major areas of help the fishers wanted.

Hilsa shad *Tenualosa ilisha* was recorded as a major migratory fish species during monsoon and post-monsoon months indicating the established life cycle in the selected river stretches. Determination and strict implementation of environmental-flow requirements for the species is critically important for breeding migration and maintenance of Hilsa fishery in the river.

Fishing crafts in river Narmada

The following research and development activities, in form of a comprehensive project, were carried out by the Institute under the NEH programme:

Project Title: Refinement of management strategies for open water fisheries of Northeastern region through location and ecosystem-based approaches

Project Coordinator: B.K. Das, Director

Project Code: NEH/20-23/03

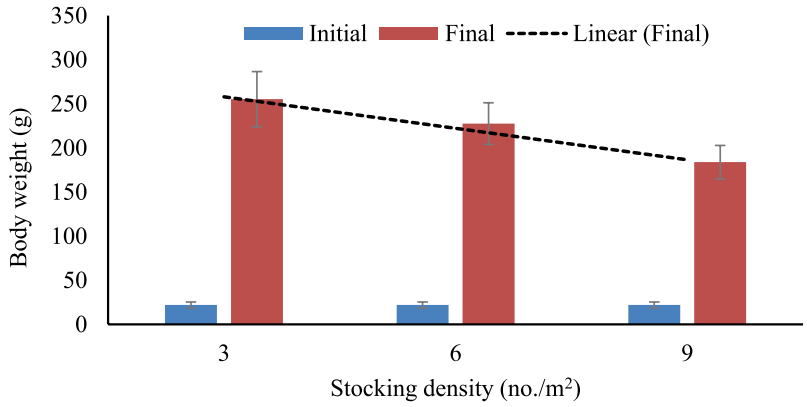
Project Principal Investigator: B.K. Bhattacharjya

Scientific personnel: S. Borah (Sub-project 1 Leader), S. Yengkokpam (Sub-project 2 Leader), S.C.S. Das (Sub-project 3 Leader), D. Debnath (Sub-project 4 Leader), P. Das (Sub-project 5 Leader), A.K. Yadav (Sub-project 6 Leader), N. Sharma (w.e.f. 01.4.2021), N. Samarendra Singh, R. Baitha, Mishal P., N. Chanu, M. Shaya Devi, Lianthuamluaia L., T. Tayung and D.K. Meena

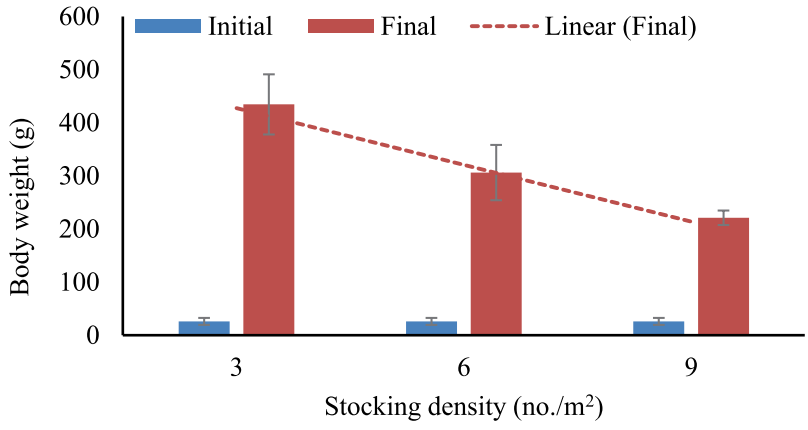
Sub-project 1: Sustainable utilization of openwater fisheries in Assam and Nagaland through community participation

Pen culture for livelihood improvement of tribal fishers in beels of Assam

Pen culture using CIFRI HDPE Pen was carried out in five beels located in three districts of Assam for livelihood improvement of tribal fishers. Pen culture of *Cirrhinus mrigala* as candidate species was carried out in Charan beel located in Baksa district, *L. Rohita* as candidate species in pens in Bamuni beel in Kamrup Rural district and *Labeo catla* as candidate species in pens in Urpad beel in Goalpara district. In all the experiments fishes were stocked @ 3, 6 and 9 no./m^2 in triplicates in pens, each having an area of 500 m^2. Fishes were cultured for a period of six months and were fed CIFRI CAGEGROW feed @ 3-5 % body weight. At the end of the culture period it was observed that body weight (mean ± SE) of *C. Mrigala* increased from 21.95 ± 4.17 g to 195.63 ± 23.02 g, 147.19 ± 20.27 g and 112.13 ± 16.54 g at stocking densities of 3, 6 and 9 no./m^2 respectively. Fingerlings of *L. Rohita* grew from 22.05 ± 3.39 g to 255.27 ± 31.25 g, 227.63 ± 23.61 g and 183.91 ± 18.90 g; *L. Catla* fingerlings grew from 26.05 ± 6.57 g to 434.61 ± 56.65 g, 306.15 ± 52.06 g and 221.13 ± 13.54 g in above-said stocking densities respectively. In all three experiments growth rate of fishes declined with increase in stocking densities. In addition, pen culture demonstrations were also carried out with Indian major carps in Saren (Baksa district) and Dhamal (Goalpara district) beel of Assam for benefit of tribal fishers belonging to Bodo and Rabha communities, respectively. Further, six CIFRI HDPE pens, each of



Growth performance of *L. rohita* in pens at different stocking densities



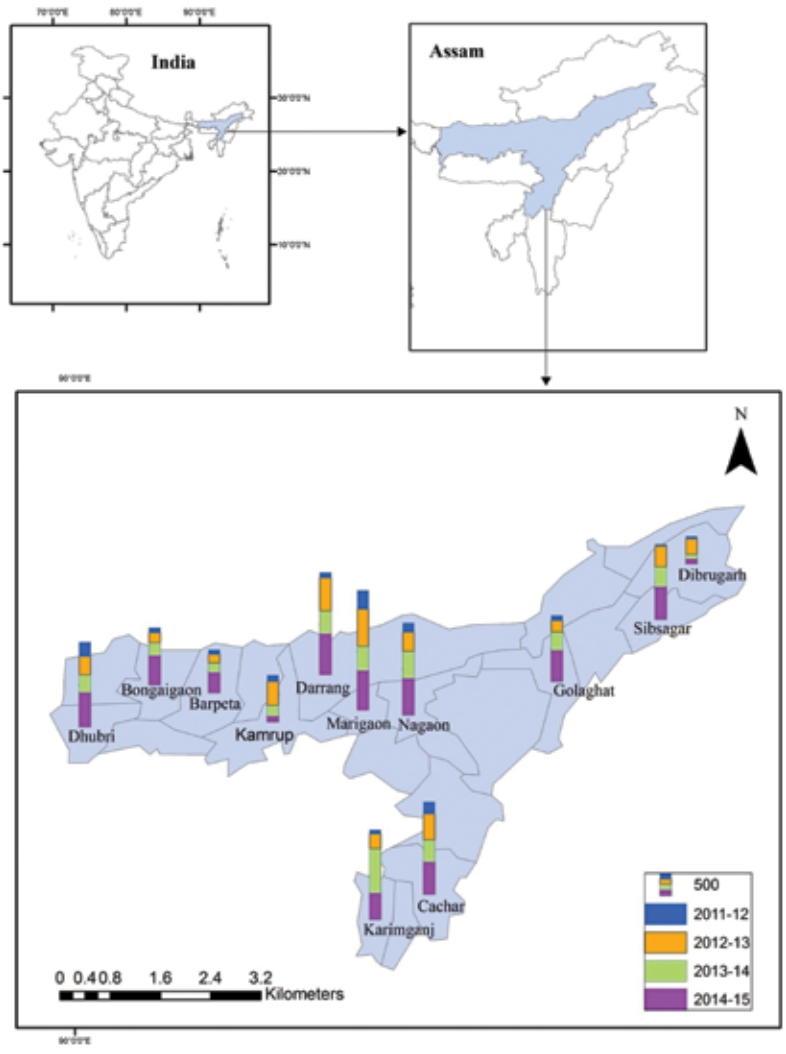
Growth performance of *L. catla* in pens at different stocking densities

Fish harvest from pens installed in beels of Assam

size 0.1 ha, were supplied for pen culture in Rupahi beel, Nagaon, and 34 t of CIFRI CAGEGROW feed was also supplied to 6 beels located in 5 districts of the state for benefit of the fishers.

Study on impact of culture-based fisheries in beels of Assam

A study was conducted to assess the effectiveness of stocking of Indian major and minor carps in 37 floodplain wetlands in Assam. Data on culture-based fisheries (CBF) including stocking of fish fingerlings and fish production were collected from AFDC Ltd., Guwahati and analyzed for a period of five years. The results indicated that adoption of CBF management regime resulted in significant increase in mean yield of fish from 234.51 kg/ha/year during 2011-12 to 704.60 kg/ha/year during 2014-15 (p<0.05). Fish production per capita also recorded significant increase (p<0.05) from 119.40 kg/fisher/year (2011-12) to 358.46 kg/fisher/year (2014-15) benefitting 2262 fisher families. Mean fish yield increased from 234.51 kg/ha/year in 2011-12 to 443.65 kg/ha/year in 2012-13, 452.43 kg/ha/year in 2013-14 and 704.60 kg/ha/year in 2014-15. Mean fish production has increased from 8.85 t during 2011-12 to 18.08 t, 18.50 t and 31.63 t during 2012-13, 2013-14 and 2014-15, respectively. About 40 %, 37 % and 78 % of the studied wetlands showed two times increase in mean fish yield during the period of supplementary stocking *viz*. 2012-13, 2013-14 and 2014-15, respectively as compared to pre-stocking period 2011-12. District-wise analysis showed an increase in mean fish yield during supplementary stocking (2012-13, 2013-14 and 2014-15) as compared to pre-stocking period (2011-12) in all the 12 districts except for Kamrup district, where mean fish yield during 2014-15 was lower than that in 2011-12. Comparison of district-wise fish yield between 2011-12 and average yield for three years (2012-13 to 2014-15) showed increase of fish yield ranging from 65.38 % (in Dhubri district) to 1491.11 % (in Sivasagar district).



District-wise impact of culture based fisheries on fish yield in floodplain wetlands of Assam

Awareness-cum-fish seed stocking programme in beels of Assam

Fish stock enhancement in beels

Fish stock enhancement activities were carried out in 11 floodplain wetlands of Assam. Among these, three beels located in Goalpara district were dominated by tribal populace. For fish stock enhancement, seasonally open beels, preferably with area > 15 ha were selected. These 11 beels were located in seven districts of middle and lower Assam region. A total of 4.29 lakh advance fingerlings of Indian major carps and minor carps were supplied at beel site.

Culture based fisheries for livelihood improvement of fishers in beels of Assam

To create awareness on culture based fisheries in closed beels among fishers, supplementary stocking of advance fingerlings of IMCs and minor carps were carried out in 4 beels located in 4 districts of middle and lower Assam. Out of these, one beel has larger population of tribal fishers belonging to Bodo community. A total of 1.46 lakh fingerlings were released in these four beels. For CBF regime, closed beels having smaller areas, preferably <15 ha were selected.

Sub-project 2: Enclosure culture in open waters of Manipur incorporating locally important fish species for stock replenishment and table fish production

Demonstration of cage culture technology with endemic *Osteobrama belangeri* in Takmu pat of Manipur

The minor carp *Osteobrama belangeri* (locally called *Pengba*) is endemic to the state of Manipur. This state fish of Manipur with considerable importance in the social and cultural life of Manipuri people is currently classified as 'Near Threatened'. With the success of induced breeding technology, culture of the fish is carried out in many aquaculture farms of the state. However, its population in the wild is still negligible. Pen culture of *Pengba* along with Indian major and minor carps was successfully demonstrated by ICAR-CIFRI in Takmu pat during 2012-13 and 2018-19. For the first time, rearing of *O. belangeri* was carried out in HDPE cages (each cage: 6 x 4 x 2.5 m^3) in Takmu pat, a part of Loktak lake, in collaboration with the Department of Fisheries, Govt. of Manipur with the objective of stocking in the open wetland for species conservation. Fingerlings of *O. Belangeri* (weight: 13.18 ± 1.79 g) were stocked at five different

Stocking of *Osteobrama belangeri* in cages in Takmu pat

Field-day and release of *Pengba* in Takmu pat

stocking densities, viz., 10, 20, 30, 40 and 50 no./m^3 in 10 net cages. Fish were fed CIFRI CageGrow feed @ 5-3% of body weight. The range of water quality parameters in the cage were: temperature 21.3-27.1^{O}C, Secchi disc visibility 85-95 cm, pH6.5-6.8, dissolved oxygen 5.6-7.8 mg/l, undetectable level of free carbon dioxide and total alkalinity of 28-40 mg/l $CaCO_3$. After 8 months of rearing, the growth performance of the reared fish was found to be inversely proportional to the stocking density. The final weight of the fish ranged from 62.7-154.6 g. The harvested fish (approximately 10,000 numbers) were released in the wetland for stock enhancement.

Field-day at Takmu pat after demonstration of cage aquaculture

On the occasion of final harvesting of fish from cages and their release in Takmu pat, a field-day was organized on 28.10.2021 at the cage culture site to share the results with the fishery officers, fishers and other participants on cage farming of indigenous fishes. The programme was attended by Shri K. Dineshwar Singh, DFO Bishnupur district, Manipur; other staff (K. Rajiv Singh, O. Maipak Singh, T. Joykumar Singh) of Department of Fisheries, Govt. of Manipur; Scientists from ICAR-CIFRI and more than 50 fishers. Shri K. Dineshwar Singh urged the farmers to harness the potential of cage aquaculture in wetlands/lakes of Manipur.

Fisheries of the Mapithel dam

Mapithel dam, located in Kamjong district, is a medium reservoir with a total water-spread area of 1182 ha and is the largest reservoir of Manipur. A survey on ecology and fisheries of Mapithel dam was conducted in 2021. Water quality parameters analyzed indicated productive environment for fisheries. A total of eight water quality parameters were assessed and the values observed were: temperature 21-26.5^{O}C, pH7.4-7.7, conductivity 150-153.5 µS/cm, TDS 105-110 mg/l, Turbidity 1.49-2.12 NTU, dissolved oxygen 9.2-10.4 mg/l, total alkalinity 84-89 mg/l and total hardness 74-82 mg/l. A total of 32 fish species were recorded from the reservoir, out of which three species were exotic viz., *Cyprinus carpio, Hypophthalmichthys molitrix* and *Oreochromis mosambicus*. Small indigenous fishes such as *Puntius* spp., *Mystus ngasep, Gagata* sp. were dominant in the catch and *C. carpio* was the most abundant exotic carp in the reservoir. The local fishers initiated cage culture in the dam using wooden frame and net cages. At present a total of 126 cages are installed in the reservoir, however, cage farmers do not have much knowledge about the technology. The fish production from the dam is about 25 t during 2020-21.

Awareness programme on enclosure culture at Mapithel dam

An awareness programme on 'Enclosure culture for fish production in reservoir' was

A view of cage culture in Mapithel dam

Awareness programme on enclosure culture at Mapithel reservoir, Manipur

organized by ICAR-CIFRI in collaboration with Department of Fisheries, Govt. of Manipur at Mapithel dam, Kamjong district, Manipur on 29.10.2021. The main purpose of the programme was to create awareness about enclosure aquaculture as a livelihood option for the displaced farmers of the region and to educate them on the subject. The awareness programme was attended by 38 fishers, Mr. Kamshing Ahum, Additional Director of Fisheries, Manipur; Mr. Y. Nabachandra Singh, DFO, Ukhrul district, other fishery officials and a team of scientists of ICAR-CIFRI.

Sub-project 3: Refinement of cage culture and species enhancement in Dumbur reservoir of Tripura

Fisheries and ecology of Dumbur reservoir

Dumbur reservoir is located around Gomti and Dhalai districts of Tripura with a water-spread area of 3049 ha. A total of 51 finfish species belonging to 7 orders, 21 families and 37 genera were recorded from Dumbur Reservoir of Tripura during the study period. Order-wise, Cypriniformes contributed 41%, followed by Perciformes (24%), Siluriformes (20%), Synbranchiformes (8%) Osteoglossiformes (4) and Beloniformes & Clupeiformes (1.5% each) to the reservoir fish diversity. Long-term average (2001-2020) annual fish yield rate of the reservoir is 119 kg/ha/yr based on data maintained by DoF, Govt. of Tripura. Annual fish catch from Mandirghat fish landing centre during 2015-16 to 2020-21 indicated that the bulk of the catch was contributed by small indigenous fishes (SIFs), dominated by *Amblypharyngodon mola*, and minnows & barbs (83.4%). Murrels, featherbacks, large and small cat fishes formed about 9.6 % of the total catch. The dwindling Indian major carps fishery that constituted only 7 % of the total catch is a major concern in this reservoir. A total of 11 macrobenthic fauna comprising of 2 insects, 4 bivalves, and 5 gastropods were recorded from different sampling stations. The Macrobenthic populations ranged from 343-518 no./m^2.

The physico-chemical parameters of the reservoir showed healthy water quality regime for fisheries in all the seasons. The water pH was slightly acidic in nature (6.24 ±0.2) in all the seasons. Important water quality parameters like specific conductance (67.2 ±16.2 µs/cm), dissolved oxygen content (8.1 ± 0.3 mg/l), total dissolved solids (43.2 ± 8.2 mg/l) and total alkalinity (44.9 ±1.8 mg/l) were recorded.

Fish catches from Dumbur Reservoir, Tripura

Stocking of fish in the Dumbur reservoir

Demonstration of cage culture technology in Dumbur reservoir

The average yield from the Dumbur reservoir is 119 kg/ha/yr and there is enough scope of enhancing fish yield through stock enhancement and cage culture. In this context ICAR-CIFRI, in collaboration with Department of Fisheries, Govt. of Tripura has initiated experimental culture of common carp (*Cyprinus carpio*) in cages in the reservoir. A total of 20,000 fingerlings of *C. carpio* (weight: 1.62 ± 0.12 g) were stocked in ten cages (6 x 4 x 4 m^3 dimension each) installed in the reservoir. The stocked fishes were fed twice-a-day with CIFRI CageGrow floating pellets @ 7% body weight for initial 3 months; afterwards it was reduced to 5% of body weight. The health and growth of stocked fishes are being monitored. Presently, Dumbur reservoir has 180 cage installations. With this demonstration of cage culture by the Institute, it is expected that the fishers will take up the technology as a profitable enterprise in near future.

Sub-project 4: Sustainable utilization of reservoir fisheries of Meghalaya through community participation

Ecology and fisheries of Umiam reservoir, Meghalaya

A study was made to assess the ecology and fisheries of Umiam reservoir. Located in Ri-Bhoi District of Meghalaya (25°39'30"N and 91°43'51"E) at 900 m above MSL it is a small reservoir with water spread area 500 ha. There is no organized fishery in this reservoir and it has remained an open-access capture fishery. Subsistence fishing and limited commercial fishing (using gill nets) by some local people belonging to Khasi tribe in an unorganized manner is being carried out in the reservoir. The common carp (*Cyrprinus carpio*) has established in the reservoir and dominates fish catch with indigenous chocolate mahseer (*Neolissocheilus hexagonolepis*) occurring in low numbers. A total of 30 fish species have been documented from primary and secondary sources and Cypriniformes contributed the maximum. Water quality parameters were recorded in post monsoon and winter seasons. Most of the critical parameters including pH, temperature, dissolved Oxygen, total alkalinity, cholorophyll, and specific conductivity were in favourable ranges for fish production. Sediments are sandy loam in nature with acidic pH. Phytoplankton population was dominated by Bacillariophyceae (47.15%), followed by Chlorophyceae (29.73%), Desimidaceae (14.11%) and Myxophyceae (9.01%). Net primary productivity (mgC/m^3/day) assessed using light and dark bottle method indicated productive ecosystem for fisheries.

Cage culture of carps in the Umiam reservoir

A battery of six CIFRI-GI cages with total cage water volume of

A view of the Umiam reservoir

Cages in Umiam reservoir

540 m^3 (90 m^3/cage) were installed in the reservoir. Fingerlings of *Labeo rohita* (40 %), *Cyprinus carpio* (40 %) and *Barbonymous gonionotus* (20 %), brought from Fish farm of ICAR Research Complex for NEH Region, Umiam, were stocked in the cages with 3 stocking densities viz., 10, 15 and 20 no./m^3 in the December 2021. Fishes were fed twice daily with CIFRI-CageGrow (Crude protein 28 %) floating feed @ 5-2 % of their body weight. Growth and water quality were monitored by ICAR-CIFRI Regional Centre, Guwahati and ICAR-RC-NEHR, Umiam whereas daily feeding was done by the local fisherwomen. The final harvests of the cages will directly benefit the fifty local tribal fishers belonging to Ri-Bhoi Farmers' Union.

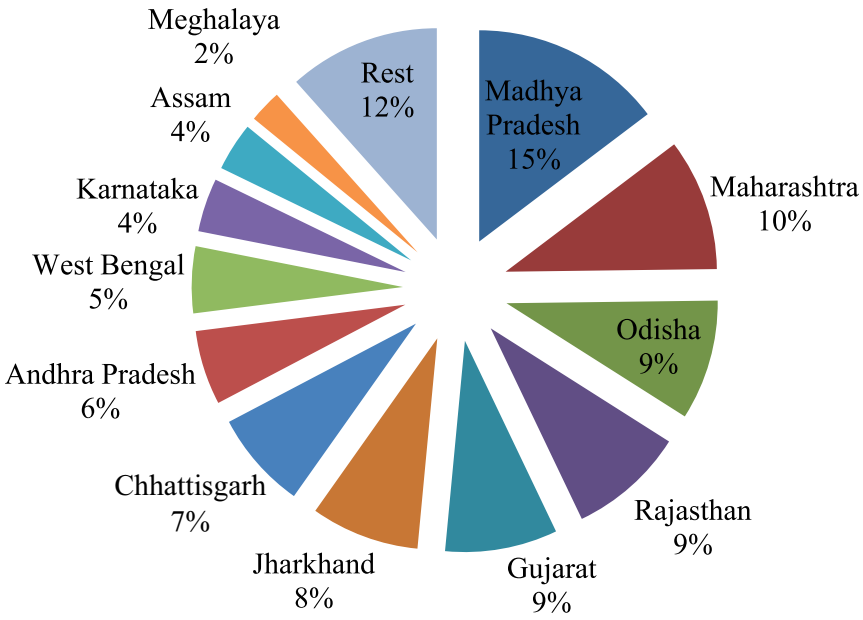
Interactive workshop on 'Cage culture in Umiam reservoir Meghalaya'

An Interactive workshop on 'Cage culture in Umiam reservoir, Meghalaya' was organized by the Institute in collaboration with ICAR Research Complex for NEH Region, Umiam at Umniuh Khwan village of Umiam, Meghalaya on 21.12.2021. The programme was attended by 55 tribal farmers (including 25 women) under the Ri-Bhoi Farmers' Union led by Mr. D. Mazzao (President) and Mr. Brightstar K (Secretary). Welcoming the guests and participants, Mr. D. Mazzao thanked both the ICAR Institutes for their initiatives on Cage culture in the reservoir. Dr. S. K. Das, Principal Scientist, ICAR RC for NEH Region, Umiam informed that cage culture in Umiam reservoir was initiated for the first time during 2019 by ICAR-CIFRI RC, Guwahati in collaboration with the ICAR RC for NEHR and Ri-Bhoi Farmers' Union. Dr. S. Hazarika, Principal Scientist, ICAR RC for NEHR outlined major activities initiated by complex in the NEH region for livelihood improvement of tribal communities. Dr. B.K. Bhattacharjya, Head (Acting), ICAR-CIFRI, thanked the Director of the Institute for sanctioning CIFRI-GI cages and CIFRI-CageGrow feed for initiating cage culture in the reservoir. He urged the local communities to take utmost interest for making the collaborative cage culture a success even beyond the project period. On the occasion, a leaflet on *"Management of openwater fisheries in Meghalaya: ICAR-CIFRI interventions"* was released for the benefits of different stakeholders. Resource persons from the two Institutes interacted with the participants on different aspects of cage culture. A total of 9000 fish fingerlings were stocked in cages installed in the reservoir and 4 t CIFRI-CAGEGROW feed was distributed to the beneficiaries.

Participants of the Interactive workshop

Release of fish seed in cage in the Umiam lake

SCHEDULED TRIBE COMPONENT (STC) PROGRAMME



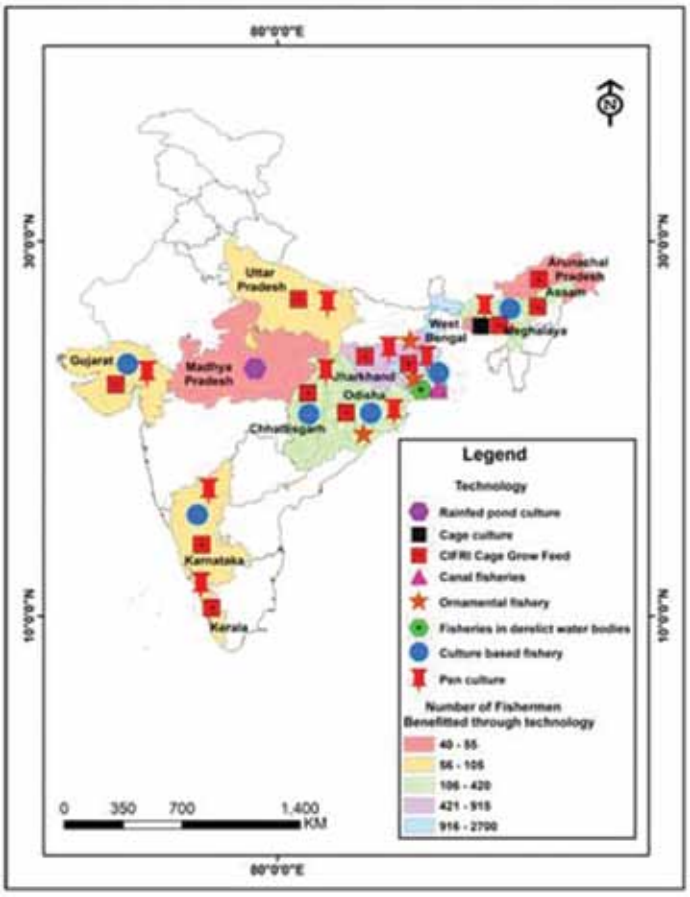
Statewise distribution of Scheduled Tribe population by States
(Source: Census Report 2011)

India has the largest tribal population in the world along with Africa. There are 533 different tribes that constitute about 10% of India's population. Majority of the tribes live in central India, followed by in western and North East India and few of them lives in southern states of India.

Livelihood of tribal communities greatly dependents on natural resources. However, fast degradation of natural resources is resulting in widespread poverty among the tribal populace. In every state, human development index of the tribal populace are at the bottom. There is an urgent need on integrated socio-economic development of the Scheduled Tribes. The objectives of the Scheduled Tribe component, funded by ICAR, are (i) to support the livelihoods of the rural tribal populace, and (ii) to enhance the economic profitability of tribal farmers. ICAR-CIFRI is working with the tribal populace to support their life and livelihoods through inland fisheries.

Activities in West Bengal

The unique delta of the Sundarbans is resource poor and people endure additional burdens caused by poor communications due to presence of innumerable number of creeks, canals and tidal rivers separating the islands from each other and from the mainland. Tribal population specially, Santhal and Munda community are found in Sagar, Gosaba, Bali islands.



ICAR-CIFRI's initiatives for tribal development in different states

Awareness and input distribution for Yaas affected fishers of Sagar Island

Awareness and input distribution programme for Yaas affected fishers of Sagar Island

The cyclone Yaas has badly affected the Sagar Island. With the objective to support the livelihoods of the Yaas affected tribal populace an awareness-cum-input distribution programme was organized on 20 October 2021 in Sagar Island. Fish seed, feed, lime were distributed to 98 tribal fishers of the Sagar Island. Sri B. C. Hazra, Hon'ble Minister, Sundarbans affairs, Govt. of West Bengal highly appreciated the initiative of the Institute towards livelihood of the tribal populace.

Livelihood support through sustainable fisheries development at Palot Ghat, Kakdwip

Majority of the Scheduled Tribe community living in Kakdwip block, South 24 Parganas district, West Bengal are economically backward. Further, COVID-19 pandemic and frequent occurrences of natural disasters like cyclone, flood, etc. have severely impacted their livelihood. ICAR-CIFRI distributed fisheries inputs to 146 ST beneficiaries of Kakdwip block on 15 December 2021 for livelihood development through fisheries. Each beneficiary was given 3 kg of fish seed, 20 kg of lime and 105 kg of fish feed. A locally active NGO, named SKSVYCS, had also extended its support in conducting the programme.

Input support for fish production enhancement of ST fishers of Gosaba block

The Institute organized a sensitization-cum-input distribution programme for sustainable fisheries development towards livelihood security for ST beneficiaries of Rangabelia village of Gosaba block in Sunderbans on 17 December 2021. Institute staff members sensitized the local people about potential of fisheries development in improving their livelihood and the nutritional security. They also discussed on various aspects of scientific fisheries management such as fish nutrition, feed, fish health, etc. On this day, each of the 50 ST beneficiaries was given 3 kg of fish seed, 20 kg of lime and 105 kg of fish feed. SKSVYCS, a local NGO, extended its support to make the programme successful.

Input distribution at Palot ghat for livelihood support

Input support for production enhancement at Gosaba

Initiative for empowerment and nutritional security of tribal women of Malda district

Malda district is endowed with a vast water resource in the form of rivers, beels, canals, ponds and tanks and has the potential for fish farming. The Institute, in collaboration with CHIS Regional Research Station and Krishi Vigyan Kendra, Malda, took initiative for capacity building of the tribal women. A training program on "Inland Fisheries Management" was organized by the Institute at its HQ during 21-25 September 2021 for 39 tribal fisherwomen from the aspirational district. In this programme, the knowledge and skill were imparted on various topics of fish rearing such as pond construction and preparation, water quality management, induced breeding techniques, composite fish culture, nursery and rearing pond management, polyculture of fish with small indigenous fishes (SIF), fish disease management, feed preparation and ornamental fish culture techniques, etc. for fisheries enhancement in a sustainable way. A strategic plan has been developed to support a group of 40 tribal women in of Habibpur block, Malda for economic and nutritional upliftment.

Frontline demonstration of fish production enhancement in community waterbody in Birbum

The Institute, in collaboration with Rathindra Krishi Vigyan Kendra, Visva-Bharati, Sriniketan, Birbhum, conducted a frontline demonstration of fisheries development on in a water body managed by "Chandu Rakab", a Tribal Women SHG group in Ashadulla village, Sriniketan with active participation of tribal women members of the group. Director, ICAR-CIFRI, with a team of scientists visited the demonstration field and also stocked fish in the pond.

Scientists-Women SHG Group members'-interface meet and input distribution programme in Sriniketan, Birbhum

ICAR-CIFRI, in collaboration with Rathindra KVK, organized Scientist-women SHG interface meet at Sriniketan, Birbhum on 07 December 2021to sensitize the participants about inland fisheries management for livelihoods and

Training programme and capacity building of tribal women of Malda district

Demonstration of production enhancement in community water body at Birbhum

nutritional security. A total of 72 ST beneficiaries from 7 SHGs of Birbhum district participated in the interface meet. The beneficiaries also discussed about various constraints faced in inland fisheries management. Fisheries inputs like fish seed, feed, lime were distributed to support their livelihoods through fisheries development.

Activities in Jharkhand

About 30 different tribes reside in Jharkhand. ICAR-CIFRI has taken initiatives to support livelihoods of the tribal fishers living on small and medium reservoirs of Jharkhand.

Frontline demonstrations of Pen culture

ICAR-CIFRI extended its technical knowhow and necessary inputs for fisheries development by the SC and ST fishermen communities for their livelihood improvement. A total of 18 CIFRI HDPE Pens were distributed in Ranchi, Hazaribag, Simdega, Lohardaga, Khunti districts of Jharkhand to support livelihoods of 300 tribal fishers of small reservoirs. The pens were installed and stocked with IMC seed for *in situ* raising of advanced fingerlings in reservoirs. The pens were maintained and managed by the fishermen's cooperatives associated with the reservoirs. The extensive programme has been designed to harness 180 t of fish from eight reservoirs.

Empowering women of tribal community through ornamental fisheries

ICAR-CIFRI has initiated backyard ornamental fish culture to empower the ST women folks. An off-campus training was organized on 17 November 2021 at Department of Fisheries HQ, Ranchi to upgrade the skills of the fishers. About 35 ST women participated in the training programme. Ornamental fish culture kits were also distributed to the beneficiaries.

Demonstration of culture of *Puntius Sarana* in Getalsud reservoir

ICAR-CIFRI had planned to introduce *Puntius sarana* in pens in the reservoirs of Jharkhand to popularize the concept of 'Nutri-fish'. On 17 November, 2021 Dr. H.N. Dwivedi, Director Fisheries, Govt. of Jharkhand had joined hands with ICAR-CIFRI in this endeavour. Dr. B.K Das, Director, along with a team of scientists and technical officers visited the pen culture site at Getalsud reservoir to demonstrate the pen culture operation and also did stocking

Scientist- SHG members interface meet and input distribution at Birbhum

Demonstration of pen culture for tribal farmers at reservoirs of Jharkhand

Distribution of ornamental fish culture kits at Ranchi

Pen culture demonstration and stocking of *Puntius sarana* at Getalsud reservoir

of *Puntius sarana* in the pen. The programme would help ST fishers of Jharkhand to upscale their livelihood in a sustainable way.

Activities in Odisha

A total of 62 distinct tribes are found in Odisha, thirteen out of those belong to "Particularly Vulnerable Tribal Groups" (PTGs). The tribes constitute more than 22.5 % of the state's total population. ICAR-CIFRI has taken some initiatives for livelihood improvement of rural tribal populace.

On-campus training for tribal beneficiaries of Rishia Dam

Two on-campus training programs on "Production enhancement through Reservoir Fisheries management," and "Opportunity of Inland open water Ornamental fisheries management for income generation" were conducted by ICAR-CIFRI during 20-22 February, 2021 at ICAR-CIFRI for tribal fishers of Rishia Dam, Balasore. On 20 February 2021 Farmer-Scientist-I interface meet was organized at the Institute HQ where 42 tribal fishers participated. Training Neads of the tribal beneficiaries were identified and based on that the training programmes were designed. A total of 20 tribal fishermen were trained on reservoir fisheries management, culture-based fisheries, and pen

On-campus training of tribal beneficiaries of Rishia dam

Establishment of ornamental fish unit in Odisha

culture and 25 fisherwomen were trained on ornamental fish culture, breeding and aquarium fabrication for their livelihood improvement. A field exposure visit was also organized for the beneficiary trainees to the wetlands and to the Ornamental fish village in Howrah.

Establishment of ornamental fish unit in Odisha for empowering tribal women

The Institute took initiative to develop ornamental units in tribal villages of Odisha, with the primary aim is to empower tribal women and to make them self-employed in fisheries. Awareness-cum-demonstration programmes were organized at Risia Nilagiri village in Balasore district and Chunakuli, Damana village in Bhubaneswar, Odisha for the tribal women on 26 and 27 February 2021. Director, ICAR-CIFRI distributed the 35 ornamental fish units in Rishia, Nilagiri village and 15 units in Chunakuli, Damana village to the tribal beneficiaries in presence of members of Rotary Club of Bhubaneswar Royal Odisha and Rotary Club of Bhubaneswar Ekamra Khetra. On the same day off-campus trainings were organized. Eachs ornamental fish unit consisted of 350 litre capacity FRP tank, aerator, heater, aquatic plant, medicines, feeds, covering nets, extension wire and ornamental fish. The ornamental fish units were installed and demonstrated in the villages. The women from both the villages were trained on ornamental fish keeping and breeding to strengthen the theoretical and practical skill for ornamental fish culture at ICAR-CIFRI Barrackpore prior to the establishment of the unit.

Pen culture demonstration in Rishia reservoir

ICAR-CIFRI demonstrated CIFRI HDPE Pen culture technology in Rishia reservoir situated in Balasore, Odisha for *in situ* advance fingerling production and stocking in the reservoir. There are about 150 tribal fishers actively involved in fishing from the reservoir. The Institute recommended stocking of more than 80-100 mm size of fish seeds for higher production from the reservoir. For production of large size fish seeds for stocking in open reservoir, the Institute has introduced low-cost *in-situ* fish seed production technology through CIFRI HDPE Pen. Three pens of 0.1 ha each have been installed and stocked with 48,000 fish seeds for fingerling raising.

Penculture demonstration and fish seed stocking at Rishia reservoir

Pen installation and awareness programme at reservoirs of Odisha

Pen culture-cum-reservoir fisheries enhancement programme at Baldiha and Badjod dams

Union Minister of State for Jal Shakti and Tribal Affairs, Shri Bishweswar Tudu inaugurated the ICAR-CIFRI Pen Culture Demonstration-cum-Reservoir Fisheries Enhancement Programme at Balidiha and Badjod Dam in Mayurbhanj District, Odisha on 11 and 31 December, 2021 respectively. The Institute installed two pens in the reservoir and stocked 50,000 advance fry for fingerling raising. An awareness camp was also organized. The Minister stressed on disseminating the benefits of the reservoir fisheries development programme to the local community. He desired that the Department of Fisheries, Government of Odisha and the fishers should join hands with the ICAR-CIFRI for holistic development of the Reservoirs in Odisha. Dr. B.K. Das, Director, briefed about the activities being carried out by the Institute in Odisha. He also urged to fishers of Balidihadam to work together in a participatory mode for successful reservoir fisheries production enhancement. The programme was witnessed by Odisha state fisheries department officials. About 250 Fishermen participated in each programme.

Activities in Gujarat

A tribal cooperative, Songadh Taluka Matsya Udyog Sahakari Mandali, with 870 members has been identified as beneficiary for TSP interventions such as pen culture for raising fingerlings as stocking material in Ukai reservoir of Gujarat. Similarly, in Panchmahal district of Gujarat, the Dev Dam Asargrast Matsya Udyog Cooperative Society, a tribal cooperative with 112 members has been identified as beneficiary for pen culture for raising fingerlings in Dev dam.

Activities in Kerala

ICAR-CIFRI Kochi Centre demonstrated the culture of pearl spot (Etroplus suratensis) in CIFRI HDPE Pens in Vazhani Dam on 4 January, 2021. Fishermen belonging to ST community of Vazhani Dam Harijan- Girijan Fisheries Co-operative Society (Vazhani, Thrissur) participated in the programme. The fishers were provided with 3 CIFRI HDPE Pens (1000 sq. ft each), 7500 number of fish seeds and 100 kg feed for pen culture of pearl spot. This enhancement strategy would ensure more catch and better catch per unit effort giving higher income to the fishers.

Demonstration of pearl spot culture in Vazhani Dam

Release of pearl spot in the reservoir

Awareness and input distribution programmes

ICAR-CIFRI Kochi Centre organized seed ranching and awareness programme on 'Sustainable fisheries for livelihood enhancement in reservoirs' in Vazhani Dam on 10 July, 2021 on the occasion of National Fish Farmers' Day. The fishermen belonging to ST community of Vazhani Dam Harijan-Girijan Fisheries Co-operative Society (Vazhani, Thrissur district) participated in the programme. The fishers were provided with 2500 pearlspot (*Etroplus suratensis*) seeds of 3-5 cm size, which were released in the reservoir. This would help in enhanced production and higher income of fishers.

The Institute also distributed two fibre glass fishing coracles to the tribal fishers of Vazhani Dam, Vazhani, Thrissur on the occasion of National Fish Farmers' Day. Two more coracles were distributed to the tribal fishermen of the Kanjirapuzha SC/ST Fisheries Co-operative Society, Kanjirapuzha, Palakkad district on 1September, 2021.

Distribution of fiberglass fishing coracles to the tribal fishers of Vazhani Dam

Capacity building of ST fishers

SCHEDULED CASTE SUB-PLAN PROGRAMME

Activities under the "Scheduled Cast Sub-Plan (SCSP)" have been implemented with the goal of improvement of socio-economic status of backward people belonging to Scheduled Castes by providing fishery-related inputs and enhancing their skill through various capacity-building programs.

Wetland fisheries enhancement through pen culture and culture-based fisheries

Culture-based fisheries through "pen culture" is one of the best production enhancement technologies suitable for inland open water bodies. ICAR-CIFRI is promoting this technology for the uplifting of the socio-economic status of the SC community. In continuity of the previous year activities, this year "pen culture" technology was demonstrated in 13 wetlands of West Bengal (Murshidabad, North 24 Parganas, Nadia) and 2 wetlands (Keshapura and Paikashidha) of Odisha. Indian major carps (IMCs; Catla, Rohu, Mrigala), and grass carp were raised in the HDPE pens. Besides, additional fish seeds were also distributed to enhance fish yield of these wetlands.

The institute has also supported development of the fisheries in 8 swage-fed wetlands of the East Kolkata Wetlands (EKW) by providing necessary inputs such as 8 No. HDPE Pen culture kit, 8 coracles and 30 t of fish feed were provided to PFSC members of EKW.

Fish seed release in different wetlands of West Bengal

Captive nursery raising of climate smart fish species

ICAR-CIFRI has taken initiative to enhance the production of minor carps and climate-smart fishes through stocking of climate-smart fish species such as *Systomus sarana* in all the wetlands adopted under the SCSP program. This fish species is an auto breeder and can breed in the wetland itself. Around 50,000 fingerlings of *S. sarana* of average size of 8.02±0.98 g were stocked in captive nursery of Beledanga wetland, West Bengal. The fingerlings were stocked in the captive nursery for a period of 6-7 weeks and released to the open wetland once they attained average size of 16.05±0.98 g.

Reservoir fisheries production enhancement

The institute is working on fisheries enhancement in 9 reservoirs: 7 in Jharkhand, 1 in Odisha and 1 in Karnataka. In Odisha, pen culture demonstration was made in Baghua reservoir (in Nayagarh district) and 3 lakh seeds were reared for 3 months in pens and then released into the reservoir. Fish feed of 6 t was provided for pen culture.

After successful demonstration of fish seed raising in the Odisha reservoir, the Institute has extended its support, in collaboration

Meeting with the fishers of Duma wetland

Stake-holder meeting at Ranchi for fisheries development in Jharkhand reservoirs

Pen culture demonstration in Gitalsud reservoir, Jharkhand

with the fisheries department, Jharkhand, to the SC fishers of Jharkhand for their livelihood improvement from reservoir fisheries. Inputs like 14 pens, 28 t fish feed, fish seeds, and boats were distributed in seven reservoirs of Jharkhand. *In-situ* rearing of fish seed is a new experience for the SC fishers of Jharkhand, who wholeheartedly participated in the reservoir fisheries development programme.

The fishermen of Gayathri reservoir in Chitradurga district of Karnataka were sensitized for fish production enhancement from the reservoir by scientists of the Bengaluru Regional Centre. Besides training, coracles were also distributed to the PFCS members of Vanivilasasagar Fishermen Cooperative Society, Chitradurga, Karnataka.

Women empowerment through ornamental fisheries

Ornamental fish culture is one of the best platforms for women empowerment. Women can generate auxiliary incomes through breeding, culture and sale of ornamental fishes. ICAR-CIFRI is promoting ornamental fish culture among SC fisherwomen by extending support towards establishment of ornamental fish culture units in West Bengal, Jharkhand and Odisha. Rural women were trained on ornamental fish keeping and breeding prior to establishment of the units.

In 2021, an ornamental cluster consisting of 15 culture units was established in Satyabhamapur in the Cuttack district of Odisha; another cluster comprising of 30 women was developed in the Ranchi district of Jharkhand. Each ornamental culture unit consists of FRP tanks, aerator, heater, aquatic plant, medicines, feeds,

Coracle distribution to the fishers of Gayathri reservoir, Karnataka

Hand-holding support to the ornamental fish entrepreneurs at the field level

Distribution of fisheries inputs for hill fisheries development at Kalingpong, West Bengal

covering nets, extension wire and ornamental fishes. Besides, need-boasd supports are also provided to 5 ornamental clusters previously developed in Amatali, Kochukali, Kulna, Kultali and Khalsi by the Institute.

Socio-economic development of hill fishers through coldwater fish farming

The Institute took initiative for upliftment of socio-economic conditions of the hilly people of Darjeeling and Kalimpong districts of West Bengal through scientific fish culture practices. In this regard, two mass awareness-cum-input distribution programs were organized for the rural SC fishers. In Kalimpong district 50 fishers from Pemling and Gidang villages (Kalimpong block) and in Mirikin Darjeeling district, 50 fishers from Manju Dara Gaon, Manju Gauri Gaon, Lepcha villa, Amalbotey, Soureni busty, Bungkulung (Mirik block), Gopaldhara village (Sukhia block) attended the programs. Besides awareness generation, 12000 no. of Amur carp and grass carp fingerlings and 7000 kg feed were distributed among 100 fish farmers of both the district.

Restoration of the cyclone affected fish culture units in Sunderbans

The cyclone *YAAS* caused massive devastation in Sunderbans affecting fishers and fish farmers severely. To strengthen their livelihood the institute supported the farmers by providing fishery inputs to restore the fishing and other pisciculture activities in the affected areas. In Sahebkhali and Amtali areas of Sundarbans 4000 kg lime, 42000 kg feed, 2200kg fish seed and 80 liters of fish medicine were distributed among the 400 SC fish farmers. Additionally, 200 kg fish seed was released in two canals of these areas for sustainable canal fisheries development in Sunderbans. On this occasion, two awareness camps were also organized.

Fisheries awareness and input distribution programmes were organized in *YAAS*-devasted Sagar Island of Sunderbans. Nearly, 250 SC fish farmers had participated, and 3 bags of fish feed and 3 kg of fish seeds and 10 kg lime were distributed to each of them. Fishers were also encouraged to do fish culture activity in a sustainable way.

Fisheries awareness and input distribution programme were also organized in Kultoli area. About 500 SC fish farmers participated and 52.5 t fish feed, 3.3 lakhs

Distribution of fisheries input to the *Yass* affected fishers of Ganga Sagar

Director ICAR-CIFRI addressing SCSP fishers

Fish seed distribution among the fishers

Capacity building training of ornamental fishers of Satyabhamapur, Odisha

Trainees in the practice of aquarium maintenance

Mass awareness programme for wetland fishers of Murshidabad

fish seeds, and 10 t lime were distributed among them.

Capacity building of fishers

For capacity development of fishers and improvement of their livelihoods three off-campus and on-campus training programmes were conducted by the institute. A total of 55 fishers were trained by the institute on ornamental fisheries and 40 were trained on fish production enhancement from inland water bodies. Besides these, 20 mass awareness programs and two stakeholder meetings were organized for fisheries development in inland waters.

Project on "IoT based precision enclosure culture and fisheries management in inland open waters"

Farming system is reforming day by day keeping in pace with the ever-increasing evolution of modern technologies *viz.* Internet of Things (IoT), sensors, drones etc. Precision farming is an important consequence of it. It is the adoption of highly precise set of practices that uses technology to cater the needs of individual farm. The purpose is to achieve more precise application of inputs, real time monitoring and management for quality parameters that help to reduce expenses, produce higher yields and create a more environment-friendly operation. In this direction, the Institute has taken initiatives to develop IoT based technologies for precision fish farming in Inland open water bodies. This project is aimed at to design and develop sensors / biosensors for estimation of dissolved oxygen and ammonia in inland open waters and culture-based fisheries. At the same time the Project will focus on to develop sensor-based fish diseases detection in enclosure culture and culture-based fisheries. Further, the design of a sensor based automated feed dispensing system in enclosure culture will be developed and post-harvest fish quality and adulteration will be estimated using near infrared (NIR) spectroscopy. Real-time monitoring of water bodies through various water quality sensors, UAV based water sampling as well as aerial imaging, ROV based underwater inspection would help water quality as well as fish health management in timely manner to avoid fish mortality. IoT based system would play a significant role to bridge between the IoT systems for devising efficient management strategies for harvest optimization using Bigdata and AI techniques.

Collaboration with NEEPCO, Shillong, for planning and design of fish hatchery at Bichom dam site along with study on reproductive biology of Snow Trout *Schizothorax richardssonii* for conservation and ratification propagation in River Bichom, Arunachal Pradesh

Under this collaborative programme, ICAR-CIFRI will study breeding season and maturity stages of the targeted fish species, *Schizothorax richardssonii*, in river Bichom, water availability and quality of water at Bichom Dam site. Findings would help in improving Snow Trout (*S. richardssonii)* population in the river stretch.

Development of unique sedative for fish transportation

The Institute initiated research for the development of sedative for fish transportation and has come out with a product, Fish Tanavhari™ is unique anaesthetic formulation developed for hassle free fish handling and transportation under laboratory and field conditions. The herbal formulation is environmentally safe and does not possess any side effect on fish health with quick recovery after drug withdrawal. "CIFRI Fish Tanavhari" formulation was released by Dr. Trilochan Mohapatra, Secretary DARE and DG, ICAR on 6 October 2021.

Setting up of new laboratory for environmental and aquatic animal health monitoring at Hirakud reservoir, Odisha

Under this initiative, ICAR-CIFRI will monitor the soil and water quality parameters in the Hirakud reservoir keeping in view the need for long term environmental health of the reservoir. The institute will also conduct aquatic animal health surveillance in the cage culture and in the wild population of the reservoir. Institute will also conduct environmental impact assessment with an aim to protect aquaculture operations from detriment due to excessive nutrient load in water and sediment and to protect the environment from the harmful effect of cage culture.

Collaboration with C-DAC, Kolkata for research on bioelectronics

Under this new collaboration, C-DAC and ICAR-CIFRI will work jointly for capacity building of faculty members in their specialized fields related to artificial intelligence, machine learning, cloud computing, big data analysis, etc.; research collaborations in the field of sensors for monitoring of aquatic pollution, disease occurrence, physiochemical parameters estimation, etc.; lay out or plan

for establishing IOT (Internet of Thing) based inland fisheries management; improvement of the Acoustics set-up and Mobile app (E-DAS) developed by ICAR-CIFRI; sharing of accessibility in the supercomputing facility at C-DAC-Kolkata and development of small scale supercomputing facility at ICAR-CIFRI.

Development of ornamental fish culture clusters for women fisherfolks under SCSP-STC

Ornamental fish culture is considered one of the best platforms for women empowerment. Women can generate auxiliary income by utilizing leisure time in this culture practice. ICAR-CIFRI is promoting the ornamental fish culture as an opportunity for additional income generation and extending support to the SC/ST fisherwomen through establishment of successful ornamental unit in Eastern India (West Bengal, Jharkhand and Odisha). The rural women were trained in ornamental fish keeping and breeding to strengthen the theoretical and practical skills for ornamental fish culture prior to the establishment of the units. In 2021-22, two ornamental clusters at Satyabhamapur in Cuttack district of Odisha and a cluster of 30 women in the Ranchi district of Jharkhand were developed. A total of 15 culture units (Satyabhamapur) were distributed in these clusters. Besides, need-based supports were provided to five (Amatali, Kochukali, Kulna, Kultali and Khalsi) ornamental clusters previously developed by ICAR-CIFRI.

Waste to wealth: development of insect meal-based feed

India is annually producing about 2,11,129 MT cocoon, of which nearly 60% of this cocoon biomass comes as silkworm pupae waste. ICAR-CIFRI has undertaken a project in collaboration with CSRTI, Mysore and CTR&TI, Ranchi of Central Silk Board, Ministry of Textiles, Govt. of India to utilize waste from the silk industry for fish feed development. Four different floating feeds having different sizes and nutrient compositions have been developed for various life stages of different fish species after confirming their efficacies at laboratory and farmers field conditions. The outcome of this project will play a vital role in the value chain of silk industry in waste management and livelihood enhancement of silk producers vis-a-vis will help reduce pressure on fish meal and soybean as protein source.

New approach in pen farming

Technological interventions are to be comprehensively utilized for harnessing fish production potential from vast inland fisheries resources, such as, reservoirs and wetlands of India. The country is looking towards these vast resources for fish production through technological interventions, especially improved pen design/material and refined pen culture technology, in combination with cage culture and culture-based fisheries. The new initiative aimed at developing package of practices for long duration table fish production and system diversification in pen culture for harnessing natural productivity of littoral zones of reservoirs and wetlands. The outcome of the project will boost the momentum of fish production from open water resources of the country.

Water sampling using drone

STATE-WISE AND RESOURCE-WISE REACH OF ICAR-CIFRI IN 2021

State	Resource	Activity
Andhra Pradesh	River	• Pollution benchmarking, monitoring and fish biodiversity study for IBI and health assessment of river Godavari
	Aquaculture farms	• Assessment of input cost and farm gate prices in fresh and brackish water aquaculture
Arunachal Pradesh	HRD	• Capacity building of the state officials of the Dept. of Fisheries
	Wetland	• Assessment of fisheries and ecology in Bor beel, Namsai district. • Cage culture in Arunachal Pradesh. • Wetland of Namsai district for up-scaling of climate-friendly pen aquaculture technology • Ecology and fisheries potential, and socio-economics in Bor beel
Assam	River	• Ichthyofaunal diversity of River Brahmaputra. • Assessment of input cost and farm gate prices in Bramhaputra and Kolong • Fish catch estimation in river Barak and fish diversity study in selected stretches of river Brahmaputra
	Wetland	• Standardization of stocking densities for cage culture of Amur common carp (*Cyprinus carpio*) in Samaguri beel, Nagaon district. • Pen aquaculture as climate resilient technology in 47-Morakolong beel, Morigaon district. • Ecology and fisheries of Dandua and 46-Morakolong in Morigaon district and Rupahi and Lakhanabanda beels in Nagaon district. • Supplementary stocking for stock enhancement in 18 beels located in 8 districts. • Pen culture using CIFRI HDPE pens in 6 beels in Baksa, Goalpara and Rupahi beels. • 24 Awareness programmes on fish stock enhancement and pen culture. • 9 Training programmes on beel fisheries management. • Carbon sequestration and reproductive vulnerability studies in 47 Morakolong, Chaltia, Urmal and Charan beels of Morigaon and Kamrup districts • Rearing of *Labeo bata* and *Labeo gonius* in CIFRI-GI Cages as a winter crop in Samaguri beel • Risk assessment of Tilapia with special emphasis on GIFT in Morigaon, Sonitpur, Dhuburi and Cachar districts of Assam • Breeding of indigenous fish species of ornamental value • Pen culture under TSP Scheme at Goalpara, Kamrup and Baksa District • Cage culture of *Labeo gonius* in Samaguri beel, Nagaon district • AMR exploratory survey • Exploratory surveys in floodplain wetlands for ecological assessment in relation to climate change. • Demonstration of Climate Resilient Pen Systems (CRPS) in 47-Morakolong beel • Forecasting of Hilsa catch in river Brahmaputra

		• Assessment of fish stock enhancement protocol on increased fish production in the state wetlands. • Impact of fish stock enhancement on increased fish production in 183 wetlands under administrative control of AFDC Ltd. • Vulnerability assessment of wetlands from climate change in Dhubri district. • Fish stock enhancement with indigenous fish species in Samaguri beel. • Awareness and training on livelihood improvement through fisheries; distribution of CIFRI CageGrow feed in in Baksa and Goalpara districts. • Awareness on Community based management of pen culture using CIFRI-HDPE net pen in Bezera, Kamrup (R) districts • HDPE pen culture demonstration; socio-economic study in Borbila beel, Nalbari district. • Carbon sequestration studies in 47-Morakolong, Charan, Chatla, Urmal beel. • Assessment of input cost and farm gate prices in wetland fisheries taking 10 wetlands
Bihar	River	• Assessment of fish and fisheries of the Ganga river system • Breeding of wild fish germplasm and ranching in depleted stretches of river Ganga • Hilsa fisheries awareness and activities in Patna, Bhagalpur, Sahebganj
	Reservoir	• Exploratory survey and assessment of fish diversity in two protected habitats -Nagi Bird sanctuary and Nakti bird sanctuary, Jamui district • Assessment of ecological and fisheries status of Jargo reservoir
	Wetland	• Exploratory survey on aquatic biodiversity in protected wetlands of Kusheshwar Asthan Bird Sactuary, Darbhanga • Fisheries development in Kararia, Majharia, Rulhi, Sirsa and Kothia wetlands of Motihari region • Assessment of input cost and farm gate prices in wetland fisheries taking 10 wetlands
Delhi	River	• Eco-variability study of river Yamuna
Chhattisgarh	Reservoir	• Investigation on status of fisheries in Kodar reservoir • Collection of data related to fish production of 40 reservoirs • Assessment of economic loss from diseases in cage culture • Assessment of input cost and farm gate prices in pond culture in Durg, Raipir and Dhamtari districts and in 10 reservoir fisheries.
Goa	Estuary	• Assessment of the Mandovi-Zuari estuarine fishery resources
Gujarat	River	• Fish catch estimation at river Tapti • Assessment and spatial database for ecology, biodiversity, ecohydrology of river Narmada • Fish pass design on the river Narmada • Assessment of input cost and farm gate prices in Narmada and Mahi rivers and in brackish water aquaculture in Surat, Navsari and Bharuch districts
	Reservoir	• Assessment of ecology and fisheries of Panam reservoir • Cage culture activity in different reservoirs • Pen culture under TSP programme • Impact assessment of hydro ecological changes on fisheries and socio-economy of Sardar Sarovar Dam in Narmada Basin

Haryana	River	• Eco-variability study of river Yamuna
Himachal Pradesh	Reservoir	• Assessment of ecology and fisheries of Gobind Sagar reservoir • Impact of stocking in Gobind Sagar reservoir • Exploratory survey on status of fish and fisheries of Koldam reservoir
Jharkhand	River	• Fish diversity studies of major waterfalls (Dassam, Hundru, Johna and Panchghagh) in Jharkhand
	Reservoir	• Assessment of economic loss from diseases in cage culture • Demonstration of Electronic Data Acquisition System (e-DAS) for fish catch data collection from reservoirs (at Patratu Dam site) • Efficacy of floating feed CIFRI-CAGEGROW was tested in a farmer's cage installed in Chandil reservoir • Fish disease investigations in Patratu, Tenughat, Chandil and Getulsud reservoirs • Assessment of fisheries potential, socio economic study of Patratu reservoir
Karnataka	River	• Pollution bench marking of river Cauvery • Investigation on genetic stock characterization of *Mystus cavasius* in River Cauvery
	Estuary	• Assessment of Netravati-Gurupur estuarine fishery resources
	Reservoir	• Tropho-dynamic modelling of Gayatri reservoir for ecosystem based fisheries management • Exploratory survey on status of fish and fisheries, including habitat characteristics and fish assemblage of Gayathri reservoir • Sensitization programme and distribution of fishing implements and mass awareness program on culture based fisheries at Gayathri reservoir, under SC-SP programme. • Awareness programme on "Reservoir Fisheries Management for Sustainable Development" at Manchanabele reservoir, Ramanagara district • Sensitization of inland fish farmers and fishers on the "Antimicrobial Resistance in Culture-based Fisheries" at Vanivilassagar and Gayathri reservoir. • Survey to select suitable sites for cage culture at Krishnarajasagar (KRS) reservoir and Almatti reservoir • Habitat characteristics and fish assemblage of Harangi reservoir • Study on potential fishery zones using hydro-acoustics in KRS reservoir • Assessment of input cost and farm gate prices in 10 reservoirs and aquaculture systems of Shimoga, Mysore and Ramnagara districts • NFDB sponsored Skill development programme on "Reservoir fisheries management for employment generation" in Harangi and Manchanbele reservoirs • Mass awareness and pen culture demonstration in Harangi reservoir under TSP program
	Estuary	• Assessment of Netravathi - Gurupur estuarine fisheries resources for sustainable management
Kerala	Fish feed	• Demonstration on mass production of Black Soldier Fly for utilization as fish feed at Govt fish seed hatchery, Peechi, Kerala
	Estuary	• Temporal assessment of Vembanad estuarine fisheries resources

	Reservoir	• Status on fisheries, fish assemblage structure and ecological status of Idukki reservoir • Established linkages with major stakeholders of Idukki reservoir for implementing fisheries enhancement practices • Distributed coracles, fish seed and feed for fishers of Vazhani reservoir under TSP programme • Distributed coracles for fishers of Kanchirampuzha reservoir under TSP programme • Created awareness about reservoir fisheries and cage culture among fishers of Vazhani and Kanchirampuzha reservoirs • Assessment of ecology and fisheries of Mangalam reservoir
	Wetland	• Study on impact of climate change and development of adaptation strategies in Vemanand lake • Pen culture activities in Thycauttuserry and Muhamma in the Alleppy district • Exploratory surveys in coastal backwaters for ecological assessment in relation to climate change • Demonstration of Climate Resilient Pen Systems (CRPS) for fish raising in Vembanad lake
	Backwaters	• Demonstrated Climate Resilient Culture based Systems with *Etroplus suratensis* (Pearlspot) and *Villorita cyprinoides* (Black clam) in Vembanad • Assessment of input cost and farm gate prices in Vembanad backwaters and pond aquaculture of Kasaragod, Thiruvananthapuram and Ernakulam districts; and brackish water aquaculture of Alappuzha, Kollam districts • Ranching of Pearlspot in Vembanad • Culture Based Fisheries in farms associated with Vembanad • Awareness programme on Integrated, multi-trophic aquaculture practice using Pearlspot and Black clam for backwater fishers
Madhya Pradesh	River	• Fish catch estimation in river Tapti • Study of fisheries and socioeconomics of river Tapti • Ecology, fisheries and water management for Tamas river
	Wetland	• Resource assessment and pen culture in Loni wetland of Rewa district
	Reservoir	• Fish disease investigation in cage culture • Assessment of economic loss from diseases in cage culture • Status of fish diversity, abundance and population dynamics of tilapia in Halali reservoir • Investigation on ecological status, conservation and enhancement of fisheries in Madhya Pradesh part of Sardar Sarovar reservoir • Impact of fingerling stocking in enhancing fish yield in Indirasagar, Bansagar, Barna, Halali reservoirs • Assessment of input cost and farm gate prices in 10 reservoirs
Maharashtra	River	• Fish catch estimation in river Tapti • Pollution benchmarking, monitoring and fish biodiversity study for IBI and health assessment of river Godavari • Investigation on habitat characterization, fisheries and socioeconomics of River Tapti
	Reservoir	• Disease investigations in Pench and Bor reservoirs • Assessment of economic loss from diseases in cage culture

Manipur	River	• Monitoring of heavy metals in Imphal river.
	Wetland	• Ranching of the *Osteobrama belangeri* in Loktak lake for augmenting its natural stock. • Cage culture of *Osteobrama belangeri* in Takmu pat. • Ecological profiling of Takmu pat • Monitoring of heavy metals in Loktak lake • Evaluation of pen culture technology in Loktak lake and Takmu pat • Study of socio-economics of wetland fishers of Takmu pat • Guidelines for the productivity enhancement of Loktak lake • Farmer awareness programme at Loktak lake • Awareness programme on pen aquaculture in Moirang, Bishnupur district
	Reservoir	• Survey on ecology, fisheries and cage aquaculture of Mapithel dam, Kamjong district. • Awareness on cage aquaculture as means of livelihood for fishers of Mapithel dam.
Meghalaya	Reservoir	• Studies on ecology, fisheries and cage culture demonstration at Umiam reservoir.
	Wetland	• Ecological profiling of Boro, Katuli and Kumligaon wetlands • Pen culture demonstration under TSP in Tura district • Road map for fisheries development in Meghalaya • Capacity building and brain storming session of the officials of the Dept. of Fisheries, Govt. of Meghalaya • Up-scaling of climate-friendly pen aquaculture technology for improved livelihood, employment generation and enhanced income of wetland fishers • Awareness generation on fisheries enhancement in derelict water bodies in Ri-Bhoi district • Distribution of CIFRI CageGrow feed (25 beneficiaries) in Ri-Bhoi district
Mizoram	Reservoir	• Assessment of ecology, fisheries and feasibility of cage culture in Serlui-B and Tuirial reservoirs, Kolasib district.
Nagaland	Wetlands and rivers	• Interactive workshop on open water fisheries management with Dept. of Fisheries, Govt. of Nagaland and ICAR-NRC Mithun
	Reservoir	• Cage aquaculture in Doyang reservoir.
Odisha	River	• Assessment of pollution, water and sediment qualities and fisheries status in river Kathajodi • Estimation of environmental flows in river Kathajodi
	Estuary	• Study of ecohydrological dynamics in relation to fish fauna and their recruitment in Rushikulya estuary • Fish diversity study at selected stretches of river Brahmani and Baitarani estuarine complex (Bhitarkanika)
		• Fisheries and ecological status of Hirakud reservoir • Impact of stocking and effectiveness of CBF practices in Hirakud reservoir. • Fish diversity and status of fisheries in Sunei and Kalo reservoirs of Mayurbhanj District • Impact assessment of stocking and effectiveness of CBF practices in Sunei reservoir • Assessment of ecology and fisheries and the trophic state index (TSI), fish production potential and impact of fish seed stocking on yield of Derjang, Salia, Kalo and Budhabudhiani reservoirs

	Reservoir	• Technical guidance on cage culture in Salia dam • Tribal Sub Plan activities with distribution of inputs, training to the fishers in Kalo reservoir • Circular cage installation in Hirakud reservoir • Cage culture and ecological assessment of Balimela reservoir • Demonstration of seed raising in pen in Salia and Kalo reservoirs • Demonstration of production enhancement in reservoirs of Kalo, Salia, Baghua • Assessment of input cost and farm gate prices in 10 reservoirs; fresh water aquaculture of Balasore, Anugul, Dhenkanal districts and brackish water aquaculture of Puri and Jagatsingpur districts • Training, awareness, installation and demonstration of pen culture in 67 reservoirs in 15 districts under World Fish project
	Wetland	• Demonstration of culture based fisheries and pen culture in Keshpura wetland, Jaleswar
	Ornamental Fisheries	• Distribution of FRP tanks to SC women of Bhadrak for ornamental fish culture
Pondicherry	River	• Pollution benchmarking, monitoring and fish biodiversity study for IBI and health assessment of river Godavari
Sikkim	River	• Fish passages and migration study in Teesta river
Tamil Nadu	River	• Pollution bench marking at river Cauvery • Monitoring of pesticides and emerging contaminants in River Cauvery
	Reservoir	• Assessment of ecological and fisheries status in Poondi reservoir • Evaluation of impact of stocking in 62 reservoirs in Tamil Nadu • Demonstration of Electronic Data Acquisition System (eMatsya) at Chennai • Assessment of ecological and fisheries status in Mettur, Krishnagiri reservoirs • NFDB sponsored Skill development programme on “Reservoir fisheries management for employment generation” in Mettur, Krishnagiri reservoirs
Telangana	River	• Pollution benchmarking, monitoring and fish biodiversity study for IBI and health assessment of river Godavari
	Reservoir	• Demonstration of cage culture in Palair reservoir, Khammam • Assessment of economic loss from diseases in cage culture • Collaborative cage culture programme with DoF, Telangana • Fish disease investigation in Sriramasagar reservoir • Implementation of eMatsya for fish catch data collection • Dissemination of in situ fish seed rearing technology in cages and pens
Tripura	Reservoir	• Assessment of ecology and fisheries of Dumbur reservoir, Gomti and Dhalai district. • Demonstration of cage culture at Dumbur reservoir. • Capacity building of the officials of the Dept. of Fisheries, Govt. of Tripura and fishers of Dumbur reservoir. • Awareness on fish production through cage culture for fishers of Dumbur reservoir, Dhalai district. • Assessment of input cost and farm gate prices in pond aquaculture of West Tripura and Gomati districts

Uttar Pradesh	River	• Hilsa fisheries awareness and activities at Varanasi, Prayagraj of river Ganga • Assessment of ecology and fish and fisheries of river Ganga • Breeding of wild fish germplasm and ranching in depleted stretches of river Ganga • Eco-variability and impact study of river Yamuna on river Ganga
	Reservoir	• Assessment of fisheries potential in Rihand reservoir • Socio economic study on Jargo reservoir
	Aquaculture systems	• Assessment of input cost and farm gate prices in 10 reservoirs, and aquaculture systems of Jaunpur, Prayagraj and Chitrakoot districts
	River	• Assessment of input cost and farm gate prices in Ganga and Tons rivers • Hilsa fisheries awareness and activities at Varanasi, Prayagraj of river Ganga • Assessment of ecology and fish and fisheries of river Ganga • Breeding of wild fish germplasm and ranching in depleted stretches of river Ganga
Uttarakhand	River	• Eco-variability and impact study of river Yamuna on river Ganga • Assessment of ecology and fish migration and suggestive measure for fish pass on river Tons • Study of fish diversity and breeding biology of migratory fish species for designing fish pass of Natiwar Mori HE project
West Bengal	River	• Investigation on emerging contaminants in river Torsa and Teesta • Assessment of fish and fisheries of the Ganga river system for developing suitable conservation and restoration plan • Breeding of wild fish germplasm and ranching in depleted stretches of river Ganga • Assessment of efficacy of fish passes provided across Teesta Low Dam Stage III and IV power stations • Hilsa fisheries ranching and awareness and activities under NMCG • Assessment of pollution status of the river Teesta and Torsa • Assessment of input cost and farm gate prices in Ganga and Torsa rivers • Investigation on fish diversity in river Torsa (Jaldapara stretch)
	Estuary	• Fish and shellfish assemblage study in relation to ecological variability at Hooghly-Matlah estuary
	Pond	• Study of arsenic contamination in nine ponds and six wetlands of North 24-Parganas district • Screening for selected pathogens for antibiotic resistance in fish culture farms • Assessment of input cost and farm gate prices in freshwater aquaculture systems of Purba Medinipur, Coochbehar and Hooghly districts and brackish water aquaculture of North 24 Parganas district
	Reservoir	• Exploratory survey in five small reservoirs of Purulia district, viz. Beko, Futiyari, Paltoi, Loharshol and Murguma to assess the ecology and fisheries potential

	Wetland	• Demonstration of Climate Resilient Culture based Systems of small indigenous fishes (SIF) along with Indian major carps in Media beel. • Exploratory survey, ecological characterization and vulnerability assessment of wetland fisheries to COVID-19 pandemic in Bhomra, Raja, Borty and Media wetlands in North-24 Parganas and Nadia districts • Vulnerability assessment of coastal wetlands of Sundarban area- Bermajur, in South 24 Parganas districts • Vulnerability assessment of Chand wetland in Nadia district and Katiganga, in Murshidabad district. • Stock enhancement of Chand beel of Nadia district by stocking Indigenous carps like *Labeo bata, Systomus sarana* and IMC. • Exploratory survey and stakeholder vulnerability assessment at four estuarine/ coastal sites (Sahidpur, Kulti, Diamond harbor, Madanganj, Bherua and Harwa). • Carbon sequestration and reproductive vulnerability studies in Katiganga, Motijhil, Paharpur, Bhandardaha of Murshidabad district • Study of temporal variations in abundance of key fish species like *Macrognathus aral* in Gangetic floodplain wetlands for assessing their conservation priority • Study of the emerging contaminants in East Kolkata Wetlands • Exploratory surveys in four floodplain wetlands for ecological assessment in relation to climate change. • Demonstration of Climate Resilient Pen Systems (CRPS) for fish raising in Mathura and Bhomra beels • Arsenic contamination in Khalsi and Chandania beels and Arsenic contamination in surface water and its accumulation in fishes in Daulatpur and Meena villages of Habra-II block of North 24 Parganas district. • Monitoring arsenic and other heavy metals in drinking water unit and in Media beel • Disease investigation in Khalsi, East Kolkata and Moyna wetlands • AMR exploratory survey • Assessment of input cost and farm gate prices in wetland fisheries taking 10 wetlands • Ornamental fish exploratory survey • Sensitization of SC women and distribution of FRP tanks and ornamental fish seed in Amtoli and Kachukhali in Indian Sunderban and Khalsi wetland • Assessment of fisheries potential at Nayachara, Sahebganj, Katiganga, Bishnupur wetlands • Climate resilient pen system and vulnerability assessment, trophic status studies on Mathura and Bhomra beel • Demonstration of culture based fisheries and seed raising of fish seed in pen in Beldanga, Chamardaha, Kumli, Panchita and Chamta wetlands • National campaign on antimicrobial resistance in fish for fishers of East Kolkata wetland • Monitoring aquatic environmental pollutants in water, sediment and biota of sewage fed East Kolkata wetalnds (Borochoinavi and Bheri no. 4) and freshwater wetlands (Borti beel and Raja beel). • Monitoring of heavy metals in Bheri No. 4, Borochoinavi beel and Borti beel • Carbon sequestration and green house gas (GHGs) emission study in Khalsi and Bhomra beel.

DEMONSTRATION AND TRANSFER OF TECHNOLOGY

Demonstration of black clam (*Villorita cyprinoides*) culture in CIFRI HDPE CRPS in Vembanad lake

The CIFRI HDPE CRPS (Climate Resilient Pen System) pen was installed and stocked with black clams in October 2019 in collaboration with Thycattussery Black Clam Industrial Co-operative Society in Vembanad lake, Kerala under the NICRA project. A total of 460 kg of clam seeds was stocked in a pen of 160 sq.m. area with an anticipated harvest of about 3 t. Partial harvesting of 1 t clam worth ₹ 25,000 was done on 10 March 2021. Clams achieved an average final weight of 13g. The demonstration proved that clam culture can be taken up as an alternate livelihood of inland open water fishers associated with of the Vembanad lake.

Demonstration of pearl spot culture in CIFRI HDPE pens in Vazhani Reservoir

The Institute demonstrated culture of pearl spot (*Etroplus suratensis*) in CIFRI HDPE pens in Vazhani reservoir, Kerala on 4 January, 2021. The fishermen belonging to ST community of Vazhani Dam Harijan-Girijan Fisheries Co-operative Society (Vazhani, Thrissur district) participated in the programme. They were provided with the technical inputs, 3 CIFRI HDPE pens (1000 sq. ft each), 7500 pearl spot seeds and 100 kg feed under the TSP programme by the Kochi centre. Fish seeds of 3-5 cm size were stocked in three pens. The species is expected to grow to 10 cm before stocking in the reservoir. This enhancement strategy would ensure better harvesting size and catch per unit effort for Vazhani reservoir fishers.

Fish seed stocking in pens in Vazhani reservoir

Black clam culture in pens

Stocking of Pearlspot seed in Vembanad wetland

Distribution of CIFRI-CAGEGROW feed to tribal fishers of Assam

Culture-based fisheries at Vembanad wetland system

ICAR-CIFRI Research Station, Kochi has taken up culture-based fisheries in extensive fish farming systems associated with Vembanad wetland as a part of the climate-resilient fisheries programme under NICRA. Six thousand seeds of Pearlspot (*Etroplus suratensis*) were stocked in the farming systems located at Elamkunnapuzha on 9 December, 2021. The programme envisages multi-stocking and multiple harvesting strategies for sustained livelihood to the farmers associated with the wetland.

Demonstration of CIFRI-CAGEGROW floating feed in derelict water bodies of Assam

With an objective to demonstrate CIFRI-CAGEGROW floating feed in derelict water bodies a total 4200 kg of the feed was distributed among tribal fishers at Chhatomatia village, Goalpara district on 19 September, 2020. A total of 40 tribal fisher families benefited from the programme.

Demonstration of climate-resilient technology for wetland fisheries in Assam

The Institute has been demonstrating pen culture as a climate-resilient technology for fishers in 47-Morakolong beel, Morigaon district, Assam during past two years under NICRA project. Under climate-smart inland fisheries initiative, a total of 6000 fingerlings of carps (comprising of *L. catla*, *L. rohita*, *C. mrigala*, *L. bata*, *L. gonius*, and *idella*) were stocked in a pen enclosure constructed in 47-Morakolong beel for raising advanced fingerlings as well as for table-fish production. This will increase the adaptive capacity of the fishers and provide

Fish seed stocking for climate-resilient wetland fisheries

Stocking for culture-based fisheries in beels of Assam

Stoking of Pengba seed in cages

Demonstration programme of mass production of fly for fish feed

additional livelihood security to the beel fishers in changing climate scenario.

Demonstration of culture-based fisheries (CBF) for livelihood improvement of beel fishers of Assam

Culture-based fisheries was demonstrated in seven closed beels (Charan, Saren, Bamuni, Go, Lakhanabandha, Sat Bhoni, and Borboi beels) of Assam. A total of 2.66 lakh advance fingerlings of Indian major carps and minor carps were released in these beels.

Demonstration of cage culture of *Osteobrama belangeri* in Takmu pat

For the first time in Manipur, ICAR-CIFRI, in collaboration with the Department of Fisheries, Govt. of Manipur, carried out cage culture of *Osteobrama belangeri*. The Institute provided 10 net cages, 4 t of CIFRI CageGrow feed and 17000 fingerlings of *O. belangeri*. After 8 months of rearing, fish attained weight of 62.7-154.6 g. The harvested fish (approximately 10,000 numbers) were released in the wetland for stock enhancement.

Demonstration on Electronic Data Acquisition System (eMatsya)

A demonstration programme for e-Matsya was arranged for the Department of Fisheries, Govt. of Tamil Nadu at the Office of the Commissioner of Fisheries, Chennai on 21 September, 2021. Forty fishery officers from different districts of Tamil Nadu attended the demonstration.

Demonstration of "Mass production of Black Soldier Fly for utilization as fish feed"

A demonstration programme was arranged on 'Mass production of black soldier fly for utilization as fish feed' on 16 December, 2021, at Peechi, Trissur, Kerala. The Officials of Department of Fisheries, Govt. of Kerala and fish farmers at Peechi, Trissur, Kerala attended the programme

Participants of the eMatsya demonstration

TRAINING AND CAPACITY BUILDING

Trainings Conducted

S. No.	Name of the training	Date	Venue	Participants
1.	Culture of pearlspot (*Etroplus suratensis*) in CIFRI HDPE pens under TSP	04 January, 2021	Vazhani Dam, Thrissur Kerala by ICAR-CIFRI, Kochi Centre	Fishermen of FCS of Vazhani dam
2.	Pen as a tool for beel fisheries management	08 January, 2021	ICAR-CIFRI, Guwahati Centre (online mode)	51 fishers/ farmers
3.	Fish & fisheries management for students of Cachar College, Silchar, Assam	19-24 January, 2021	ICAR-CIFRI, Guwahati Centre (online mode)	50 students
4.	Production enhancement through cage culture in inland open waters	29 January, 2021	ICAR-CIFRI, Bengaluru Centre (online mode)	110 beneficiaries
5.	Production enhancement through cage culture in inland open waters	29 January, 2021	ICAR-CIFRI, Barrackpore (Online mode)	110 fishers/ farmers
6.	Opportunities of inland open water ornamental fishes for livelihood enhancement and employment generation under TSP	11-14 February, 2021	ICAR-CIFRI, Barrackpore	23 fishers/ farmers
7.	Production enhancement through pen culture in inland open waters	19 February, 2021	ICAR-CIFRI, Guwahati Centre online mode	60 fishers/ farmers
8.	Opportunities of inland open water ornamental fishes for livelihood enhancement and employment generation under TSP	20-22 February, 2021	ICAR-CIFRI, Barrackpore	25 fishers/ farmers
9.	Reservoir fisheries management training for Odisha under TSP	20-22 February, 2021	ICAR-CIFRI, Barrackpore	25 fishers/ farmers
10.	Opportunities of inland open water ornamental fishes for livelihood enhancement and employment generation under TSP	26 February, 2021	Rishia, Odisha by ICAR-CIFRI, Barrackpore	25 fishers/ farmers
11.	Production enhancement through pen culture in inland open waters	01 March, 2021	ICAR-CIFRI, Barrackpore (Online mode)	50 fishers/ farmers
12.	Importance of river ranching for fish conservation and livelihood improvement of fishers. (Online)	02 March, 2021	ICAR-CIFRI, Allahabad Centre	50 fishers/ farmers
13.	Fisheries enhancement in wetlands	09 March, 2021	ICAR-CIFRI, Barrackpore (Online mode)	50 fishers/ farmers
14.	Wetland fisheries development in East Champaran district of Bihar	23 March, 2021	KVK, Piprakothi	500 fishers of East Champaran, Bihar

15.	Sampling methodologies for fish catch estimation from inland water bodies of India	23 March, 2021	ICAR-CIFRI, Bengaluru Centre and State Institute of Fisheries Technology (SIFT), Kakinada, DoF, Andhra Pradesh (Online mode)	450 Village Fisheries Assistants of Andhra Pradesh Fisheries Department
16.	One day training on GeM	23 July, 2021	ICAR-CIFRI, Barrackpore	2 staff from ICAR CIFE, Kolkata centre
17.	Enhancing reservoir fisheries for livelihood and nutritional security	29 July, 2021	ICAR-CIFRI, Barrackpore	50 participants
18.	Production enhancement through pen culture in inland open waters	29 July, 2021	ICAR-CIFRI RC, Guwahati	120 participants
19.	Collaborative training programme with MANAGE, Hyderabad on Nutrismart fish' to boost the nutritional security of the rural women	10-12 August, 2021	ICAR-CIFRI, Barrackpore	44 participants (Students, KVK personnel, Assistant Professor)
20.	Hilsa fisheries conservation and livelihood improvement in River Ganga	11 August, 2021	ICAR-CIFRI, Barrackpore	92 fishers and farmers
21.	Electronic Data Acquisition System (eMatsya)	21 September, 2021	RRC, Bengaluru	40 fishery officers from different districts of Tamil Nadu
22.	Fisheries enhancement options for beels	29 September - 1 October, 2021	46-Morakolong beel, Morigaon, Assam	33 fishers
23.	Estimation of fish productivity in inland open waterbodies	01 October, 2021	RRC, Bengaluru	31 Fisheries Development Officers of Kakinada, AP
24.	खुले जल में वैज्ञानिक हस्तक्षेप के माध्यम से मछुआरों की आय में वृद्धि	04-11 October, 2021	RRC, Allahabad	144 fishers, students, department officials, and entrepreneurs from UP, Bihar, Jharkhand, WB, Rajasthan, Haryana
25.	Impact of COVID-19 on ecology and fisheries of river Ganga	18 October, 2021	RRC ,Allahabad	100 participants including farmers, entrepreneurs, students and teachers from different Universities
26.	Strategies for enhancing fish production from beels	29-30 October, 2021	Lakhanabandhabeel, Nagaon, Assam	50 beel fishers
27.	Virtual training-cum-workshop on "Catch estimation methods for inland open waterbodies"	08 November, 2021	ICAR-CIFRI, Barrackpore	35 participants from 10 state fisheries departments of India
28.	Fisheries enhancement options for beels	09-11 November, 2021	Rupahibeel, Nagaon, Assam	25 beel fishers
29.	'Inland fisheries management' sponsored by Govt. of Bihar	17-23 November, 2021	ICAR-CIFRI, Barrackpore	29 fish farmers from Nawada dist., Bihar
30.	Strategies for enhancing fish production from beels	23-25 November, 2021	Danduabeel, Morigaon district	35 beel fishers

31.	Pen farming for production and livelihood enhancement in floodplain wetlands	24-26 November, 2021	Lakhanabandhabeel, Nagaon, Assam	58 beel fishers
32.	'Inland fisheries management' sponsored by Govt. of Bihar	30 November - 6 December, 2021	ICAR-CIFRI, Barrackpore	30 fish farmers from Mujaffarpur
33.	'Inland fisheries management' sponsored by Govt. of Bihar	14-20 December, 2021	ICAR-CIFRI, Barrackpore	30 fish farmers from Sitamarhi
34.	'Inland Fisheries Management' under ARYA farmers' training	27-31 December, 2021	ICAR-CIFRI, Barrackpore	40 fish farmers from Bhagalpur KVK, Bihar
35.	'Inland fisheries management' sponsored by Govt. of Bihar	28 December -03 January, 2022	ICAR-CIFRI, Barrackpore	30 fish farmers from East Champaran

Glimpses of few training conducted

Mass Awareness Camps

	Name of the Camp	Purpose	Venue and date	No. of participants
1.	Awareness on pearlspot culture in CIFRI HDPE pens under (TSP)	To create awareness on pearlspot culture in pens	Vazhani Reservoir, Kerala; 04 January, 2021	26
2.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on importance of fish stock enhancement in seasonally-open beels	Rupahi, Assam; 08 February, 2021	27
3.	Awareness-cum-supplementary fish seed stocking programme	To create awareness on culture based fisheries in closed beels	Charan beel, Assam, 17 February, 2021	20
4.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Kachadhara, Morigaon; 20 February, 2021	25
5.	Awareness-cum-fish seed stocking programmes for stock enhancement in Badhai beel	To create awareness on fish stock enhancement in seasonally-open beels	Badhai beel, Goalpara; 22 February, 2021	20
6.	Awareness-cum-supplementary fish seed stocking programme	To create awareness on culture based fisheries in closed beels	Bamuni beel, Assam; 23 February, 2021	21
7.	Awareness camps on Hilsa and dolphin conservation of Ganga	To create awareness on Hilsa and dolphin conservation	ICAR-CIFRI, Barrackpore; 24-25 February, 2021	75
8.	Stocking cum awareness programme on cage aquaculture in Dumbur reservoir	To encourage successful adoption of the cage culture technology	Dumbur reservoir; Tripura; 25 February, 2021	50
9.	Awareness-cum-supplementary fish seed stocking programme	To create awareness on culture based fisheries in closed beels	Urpad beel, Assam; 25-26 February, 2021	35
10.	Awareness-cum-supplementary fish seed stocking programme	To create awareness on culture based fisheries in closed beels	Dhamal beel, Assam; 27-28 February, 2021	17
11.	Awareness-cum-supplementary fish seed stocking programmes for culture-based fisheries in Borboi beel	To create awareness on culture based fisheries in closed beels	Borboi beel, Assam; 06 March, 2021	20
12.	Awareness-cum-supplementary fish seed stocking programmes for culture-based fisheries in Borboi beel	To create awareness on scope of culture based fisheries in beels	Satbhoni beel, Assam; 06 March, 2021	34
13.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Ghorajan, Assam; 07 March, 2021	35
14.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Dandua, Assam; 10 March, 2021	32
15.	Awareness-cum-supplementary fish seed stocking programmes for culture-based fisheries in Borboi beel	To create awareness on culture based fisheries in closed beels	Go beel, Assam; 11 March, 2021	21

	Name of the Camp	Purpose	Venue and date	No. of participants
16.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Kapla, Assam; 12 March, 2021	20
17.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Hirakata-Rowmari, Assam; 15 March, 2021	18
18.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Duamara-Batamara, Assam; 17 March, 2021	17
19.	Awareness-cum-fish seed stocking programmes for stock enhancement in Ghorajan beel	To create awareness on fish stock enhancement in seasonally-open beels	Rowmari, Assam; 18 March, 2021	25
20.	Mass awareness camp on conservation of Mahseer and trout	Conservation of important hill stream fishes in river Ganga	Tehri, Uttarakhand; 18-20 March, 2021	40
21.	Awareness programme on pen aquaculture technology for livelihood improvement	To create awareness on pen culture in beels	Bor beel, Arunachal Pradesh; 24 March, 2021	51
22.	Management of beel eco-systems of Assam for sustainable fisheries	To create awareness on sustainable beel fisheries management	ICAR-CIFRI RC, Guwahati; 10 July, 2021	85
23.	Livelihood enhancement scope in reservoir fisheries	Sustainable fisheries for livelihood enhancement in reservoirs	Vazhani dam, Thrissur; 10 July, 2021	30
24.	Ecosystem-based management of fisheries in NER	To create awareness on ecosystem based fisheries management	ICAR-CIFRI RC, Guwahati; 10 July, 2021	300
25.	Reservoir fisheries management for sustainable development	To create awareness on ecosystem based fisheries management	Manchanabele reservoir, Karnataka; 10 July, 2021	150
26.	Livelihood enhancement through inland fisheries	To create awareness on scope of livelihood improvement through reservoir fisheries	Umetha village, Vadodara; 10 July, 2021	65
27.	Culture based fisheries for sustainable development	To create awareness on benefit of CBF	Kariyala village, Karnataka; 04 August, 2021	40
28.	National campaign on system diversification in aquaculture under Azadi Ka Amrit Mahatsov	Fisheries enhancement in inland open waters	Kanhirapuzha Dam, Palakkad; 1 September, 2021	40
29.	Enclosure culture for enhanced fish production from beels	To create awareness on enclosure culture in beels	Ghorajan beel, Assam; 7 September, 2021	42
30.	International Year of Millets – 2023 Campaign on Nutri-garden and Tree plantation	To create awareness on nutri-garden and health benefits of millet as food	Ghorajan beel, Assam; 17 September, 2021	20
31.	International Year of Millets – 2023 Campaign on Nutri-garden and Tree plantation	To create awareness on nutri-garden and health benefits of millet as food	Kumbalanghi, Kerala; 17 September, 2021	15

	Name of the Camp	Purpose	Venue and date	No. of participants
32.	Hilsa and dolphin conservation in river Ganga under the NMCG programme	To create awareness on hilsa and dolphin conservation	Farakka, West Bengal; 20 September, 2021	216
33.	Antimicrobial resistance in culture-based fisheries	To create awareness on antimicrobial resistance in CBF	Vanivilassagar reservoir, Karnataka; 23 November, 2021	52
34.	Antimicrobial resistance in fish	To create awareness on antimicrobial resistance in fish	Lakhanabandhabeel, Nagaon, Assam; 24 November, 2021	58
35.	Antimicrobial resistance in fish	To create awareness on antimicrobial resistance in fish	Vadodara centre; 24 November, 2021	50
36.	Cage culture for enhanced fish production from Dumbur reservoir of Tripura	To create awareness on cage culture in reservoirs	Gandacherra, Tripura; 07 September, 2021	50
37.	Enclosure culture for fish production in reservoir	To create awareness about enclosure culture as a livelihood option for the displaced farmers	Mapithel dam, Manipur, 29 October, 2021	38
38.	Climate change and its deleterious impacts on wetland fisheries under NICRA	To create awareness on deleterious impacts on wetland fisheries	Chand wetland, West Bengal; 4 December, 2021	54
39.	Mass production of Black Soldier Fly for utilization as fish feed	To create awareness on new fish feed options	Peechi, Kerala; 16 December, 2021	20
40.	Endocrine Disrupting Chemicals (EDCs) and fish health management in collaboration with C-DAC, Kolkata	To create awareness on EDC and fish health	Charan beel, Assam; 23 December, 2021	60

Glimpses of a few awareness programmes

Exhibitions participated

Name of the exhibition	Date	Venue
Brahmaputra Amantran Abhiyan	05 January, 2021	Majuli district, Assam
Brahmaputra Amantran Abhiyan	14 January, 2021	Guwahati, Assam
XV Agricultural Science Congress & ASC Expo	13-16 November, 2021	Institute of Agricultural Sciences, BHU, Varanasi

Exhibition on the occasion of 'Brahmaputra Amantran Abhiyan' at Majuli, Assam

ICAR-CIFRI exhibition staff at XV Agricultural Science Congress

CONFERENCES, WORKSHOPS, MEETINGS ORGANIZED

Stakeholders' Meet for Wetland Fishers under ICAR-WorldFish Collaborative Project

A stakeholder meet was organised on 21 January, 2021 at the Institute HQ under the ICAR-WorldFish (W-3) collaborative project on "Small scale fisheries in wetlands for livelihood and nutritional security" for fishermen of Beledanga wetland, North 24 Parganas. Dr. B. K. Das, Director and PI of the project chaired the meeting. Representatives of the Beledanga Fishermen Cooperative Society, State Fisheries Department and the project team attended the meeting. The objective of the meet was to discuss the problems faced by the stakeholders in the wetland fisheries enhancement/ management and participatory prioritization of the problems. The scientist-stakeholder interaction discussed at length the management interventions required to address individual problems and chalked out an ecosystem-based management plan, integrating technological interventions, for fisheries management of the wetland.

The Stake-holder meeting participants with the project team

Institute Management Committee (IMC) Meeting

The 49th Meeting of IMC of the Institute was held at Barrackpore on 10 February, 2021. Dr. B.K.Das, Director chaired the meeting and Shri Rajeev Lal, Joint Director (Admn.) & Registrar served as the Member Secretary. The external members, namely, Dr. K. K. Krishnani, Head, Aquaculture Division of ICAR-CIFE, Mumbai; Dr. Vindhya Mohindra, Head, Fish Conservation Division of ICAR – NBFGR, Lucknow; Dr. Akshaya Panigrahi, Principal Scientist, ICAR-CIBA, Chennai; Dr. S. K. Das, Sr Finance & Accounts Officer, ICAR-NRRI, Cuttack were present on virtual mode. In addition, 2 non-official members, namely, Shri Devmalya Sarkar and Shri Sanjit Baral were also present. Due to the COVID-19 situation, meeting of the IMC could not be convened in 2020. The Chairman briefed the members about research and development activities being carried out in the Institute since last IMC meeting, overall Institute management and linkages established with other stakeholders. The Agenda items were discussed.

A glimpse of the IMC meeting

Workshop at ICAR-CIFRI Regional Centre, Guwahati

Stakeholders meet on Pong reservoir

Workshop on Business Plan for Fishery FPC

A workshop on 'Business plan for fishery FPC' under Assam Agribusiness and Rural Transformation Project (APART) was organized by ARIAS Society, Assam in collaboration with ICAR-CIFRI Regional Centre, (RC) Guwahati and Department of Fisheries, Govt. of Assam on 10 February, 2021. Dr. B.K. Bhattacharjya, Head, ICAR-CIFRI Regional Centre, Guwahati briefed them about the prospects of business in fishery sector. Dr. S. Sarmah, Fishery Coordinator, ARIAS Society discussed about the work plan under APART project. Dr. D. Debnath, Sr. Scientist, ICAR-CIFRI RC discussed about fish feed mill as a business plan in Assam. The workshop focussed on formation of ten fish farmers producers companies working on different aspects of fisheries business.

Stakeholders Meet for GIZ Sponsored Project on Pong Reservoir

The Institute in association with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH organized a stakeholder meeting on 19 February, 2021 in virtual mode under the project "Assessment and management of fisheries resources of Pong Reservoir, Himachal Pradesh". The objective of the meeting was to involve all the stakeholders of the reservoir in formulating policy for sustainable fisheries exploitation of the reservoir. Dr. B. K. Das, Director and PI of the project presented the research findings and recommendations for sustainable extraction of fisheries resources of the reservoir. Mr. Satpal Mehta, Director-cum-Warden of Fisheries, Himachal Pradesh, and Dr. Kunal Bharat from GIZ were also present. During the meeting, important issues like the impact of tourism on fish production, the impact of migratory birds on fish production, stocking and harvesting policy were thoroughly discussed. The meeting was attended by more than 50 participants including official staff of DoF, Himachal Pradesh and the members of 15 Primary Fishermen's Cooperative Societies of the reservoir.

Workshop on Hirakud Reservoir, Odisha

The Institute organized a workshop on "Strategic planning for nutritional security and productivity enhancement in Hirakud reservoir: An approach to community mobilization" at Sambalpur, Odisha on 01 March, 2021, in collaboration with a NGO (BANO charitable trust, Odisha) and State fisheries department, Odisha. The programme was conducted to aware and motivate the fishers about sustainable reservoir management and its scientific planning. About 120 fishermen from 6 different primary fishermen cooperative societies participated in the workshop. District magistrate, Shree S. Saxena, IAS graced the programme as chief guest. Dr.

Workshop on fisheries development planning of the Hirakud reservoir

B.K. Das, Director highlighted the importance of the strategic scientific planning for sustainable increase in fish production from the Hirakud reservoir. He emphasized that ICAR-CIFRI's technologies such as cage and pen, will play important role for production of advanced fingerling as a suitable stocking material which in turn would enhance production of the reservoir. Mr. B. P. Dwibedy, Deputy Director Fisheries, Govt. of Odisha, Dr. A. Rashid, Chairman BANO trust, Mr. S. Kaushlesh, Dr. P.K. Parida, Mr. H.S. Swain and Mr. M.H. Ramteke, Scientists, ICAR-CIFRI were also present in the meeting.

Second Meeting of Project Review and Steering Group (PRSG) for the MEAN Project

The second meeting of PRSG on "Measuring Endocrine Disrupting Chemicals (EDC) and Aquatic diagnostics through Bio-Sensory Network with a special reference to Northeast India" was held on 11 March, 2021 at the Institute HQ in hybrid mode (both offline and online) following the COVID-19 safety guidelines. The project is being implemented jointly by C-DAC Kolkata, ICAR-CIFRI and IIT, Hyderabad. The meeting was chaired by PRSG members Prof. Rajib Bandhopadhyay of Jadavpur University, Smt. Sunita Verma, Scientist 'G' and HoD, ESDA, Meit Y, Shri Tara Shanker, Ex Scientist-G, Meit Y, Special Invitee. The meeting was attended by the project team members.

Meeting of MEAN project

Workshop-cum-Training Program on "Wetland Fisheries Development"

The Institute organized workshop-cum-training program on "Wetland fisheries development for fishers of East Champaran, Bihar" on 22-23 March, 2021 at Krishi Vigyan Kendra, DRPCAU, Piprakothi, East Champaran. Shri Pramod Kumar, Hon'ble Minister of Sugarcane Industries and Law Department, Government of Bihar, was the chief guest of the inaugural function. About 600 fishers of oxbow lakes of East Champaran attended the training program on 23 March, 2021 in the KVK. Further, about two hundred fishers of Kothia maun attended the workshop cum training program at Kothia maun on 22 March, 2021. The training programs stressed on importance of culture-based fishery and technologies like cage, pen and *in situ* nurseries for development of wetland fisheries. Further, role and management of macrophytes in the wetland ecosystem and sustainable fish production enhancement were discussed.

Inauguration of workshop at KVK, Piprakothi

RAC Meeting

The Research Advisory Committee meeting of the Institute was held during 01-02 April, 2021 in both offline and virtual modes. The Chairman Prof. (Dr) Baskaran Manimaran attended the meeting physically while the other RAC Members Dr. K.G. Padmakumar, Dr. Sharad Kumar Jain and Dr. S. C. Pathak participated online. Dr. B. K. Das, Director appraised the Committee about various research and developmental activities of the Institute highlighting new research initiatives, COVID-19 guidelines developed for fishers/PFCS, high impact publications and infrastructure development amidst the pandemic. The Chairman in

RAC meeting in progress

IRC meeting in progress

his inaugural remarks appreciated the achievements of the Institute. He urged the scientists of the Institute to play a major role in providing technical guidance and management plans in the context of the ambitious PMMSY and stressed upon the need to focus on ESG. The initial remarks by the Chairman and Members of the RAC was followed by presentation of Action Taken Report by Dr. A. K. Das, Member Secretary of RAC. Heads of Divisions, Heads/ In-charges of the Regional Centres and Stations presented achievements made under different Institute projects and other activities. Chairman and other members expressed their satisfaction in the overall progress and also appreciated various initiatives taken by the Institute.

IRC Meeting

Institute Research Committee Meeting for the year 2020-21 was held during 17-19 June, 2021 at the Institute headquarters both in on-line and off-line mode. The meeting started with a welcome address by Dr. Arun Pandit, Member Secretary IRC. The IRC mourned the demise of Dr. B.C. Jha and observed 2 minutes silence in honour of the departed soul. The Director gave a brief overview of the recent developments in the research, developments, linkages, and other areas of the Institute. He requested the staff to do the assigned work from home during lockdown sincerely to the satisfaction of their respective HoDs. He also instructed to submit the final reports of all completed projects including externally funded projects on-time, in good shape, both in digital and in soft copy. He remarked that since the travel is restricted due to COVID-19, the pending desktop works along with publications and other in-house jobs may be completed during this time. Following this, Scientists presented their achievements and future work plans. New project proposals were also presented in the IRC.

Review Meeting of NASF Hilsa Project

A review meeting was held for the NASF Project entitled "Captive breeding of hilsa, *Tenualosa ilisha*: Phase II" on 03 August, 2021 both in-person and virtual modes where the Director, project PI and Co-PIs including administrative personnel of ICAR-CIFRI and CCPIs of the partner Institutes attended. Director requested all the partner Institutes to take initiatives to overcome the constraints faced in executing the project activities under the ongoing pandemic and damages caused by cyclone Yaas. Dr. S. Samanta, Dr. D. N. Chattopadhyay, Dr. D. De and Dr. S. Dasgupta presented the objective-wise progress made during last 6 months and discussed the proposed research plan of actions to be performed in next 3 months followed by budget utilization of the respective ICAR partner

A glimpse of the Hilsa project meeting

A screenshot of the webinar on impact of COVID-19

Imparting training on mass production of black soldier fly

Institutes. Loss of established broodstock in the ponds of ICAR-CIBA, Kakdwip by the cyclone Yaas was mentioned. Ponds maintained at Kolaghat were also heavily damaged in the cyclone. Development of joint common protocols for breeding of hilsa, coupled with engaging more ponds for brood stock management was suggested.

Webinar on 'Impact of COVID-19 on Ecology and Fisheries of River Ganga'

The webinar on "Impact of COVID-19 on ecology and fisheries of River Ganga" was organized on 18 October, 2021 in online mode by the Prayagraj Regional Centre. About 100 participants including farmers, entrepreneurs, students and teachers from different universities participated in the webinar.

Meeting-cum-Demonstration on Mass Production of Black Soldier Fly

ICAR-CIFRI Regional Centre, Bengaluru and ICAR-National Bureau of Agricultural Insect Resources, Bengaluru jointly organized a one-day meeting-cum-demonstration on "Mass production of Black soldier fly for utilization as fish feed" on 16 December, 2021 at Government Fish Seed Hatchery at Peechi, Thrissur, Kerala. Around 35 participants from State Department of Fisheries, Private fish hatcheries and farmers participated in the programme. Dr. Preetha Panikkar, Principal Scientist & Head of the ICAR-CIFRI Regional Centre and Dr. Amala Udayakumar, Scientist (Entomology) organized the meeting. Mrs. Joemol, Assistant Fisheries Extension Officer, Government Fish Seed Hatchery, Peechi coordinated to conduct of the meeting. Dr. Panikkar highlighted the global scenario of using insect protein in aquacultural diets and progress made in use of BSF as a protein supplement in fish feed. The problems related to rearing of Black soldier fly such as breeding of other flies in the waste bins and methods to overcome the same were discussed.

Training-cum-Workshop on Catch Estimation Methods

The institute conducted a one-day virtual training-cum-workshop on "Catch estimation methods for inland open water bodies" on 06 July, 2021 for State Fisheries Dept. officials of India. The programme was aimed to provide the basic understanding of sampling strategies and their implementation for estimation of fish catch in various inland open water bodies. Dr. B.K. Das, Director briefed about the fish catch scenarios of the country and objectives of the programme. Dr. Malay Naskar, Principal Scientist, elaborated on fish catch estimation techniques for estuarine, wetland, reservoir, river. The lecture was followed by demonstration for fish

A glimpse of the Training-cum-workshop on fish catch estimation methods

A glimpse of the workshop on fisheries in NE region

catch estimation from different water bodies. About 35 participants from different State Fisheries Departments including Haryana, Chhattisgarh, Bihar, Assam, Tamil Nadu, Kerala, Himachal Pradesh, Goa, Andhra Pradesh, Mizoram, Dr. V.V. Sugunan, FAO consultant and many Scientists of the Institute attended the programme.

Workshop on 'Open Water Fisheries Enhancement of Northeast Region of India'

The Institute organized an interactive regional workshop on "Open water fisheries enhancement of Northeast region of India" on virtual mode on 20 December, 2021. The objectives of this workshop were to appraise the State Fisheries Department about the open water fisheries management guidelines/ technologies developed by ICAR-CIFRI, to understand research support requirements and to explore collaborative work programmes. Dr. B. K. Bhattacharjya, Head (Actg.) ICAR-CIFRI Regional Centre, Guwahati & PI of NEH project explained the background of the workshop. Dr. B. K. Das, Director discussed in detail about the recent interventions and activities carried out by ICAR-CIFRI in the Northeastern states of India. Directors of Fisheries of NE states and their representatives from Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura explained the status of inland fisheries and their expectations from ICAR-CIFRI. Dr. A. Pandit, Principal Scientist and Coordinator of the workshop, proposed vote of thanks.

Interactive Workshop on 'Cage Culture in Umiam Reservoir'

The interactive workshop on "cage culture in Umiam reservoir" was organized by the ICAR-CIFRI Regional Centre, Guwahati, in collaboration with ICAR Research Complex for NEH Region, Umiam at Umniuh Khwan village of Umiam, Meghalaya on 21 December, 2021. The programme was attended by 55 tribal farmers (including 25 women) of Ri-Bhoi Farmers' Union led by Mr. D. Mazzao (President) and Mr. Brightstar K (Secretary). On the occasion, a leaflet on "Management of openwater fisheries in Meghalaya: ICAR-CIFRI interventions" was released for the benefits of the stakeholders. A total of 9000 fish fingerlings were released in cages installed in the reservoir and four tons of CIFRI-CAGEGROW feed was provided to the beneficiaries for use in cage culture. Dr. B.K Bhattacharya and Dr. Pronob Das discussed on cage culture technology and experiences of previous cage culture trials in the reservoir.

Dignitaries of the workshop on cage culture in Umiam reservoir

75th Foundation Day of ICAR-CIFRI

The Institute celebrated its 75th Foundation Day on 17 March, 2021 both in offline and online modes. Dr. B. K. Das, Director in his address stressed that in 75 years of its existence the Institute has developed useful inland fishery technologies such as induced breeding and fish seed production, composite fish culture, fish seed prospecting and spawn collection in rivers; reservoir and floodplain wetland fisheries management and *in situ* fish seed production in cage and pen. The institute has also developed guidelines for sustainable management of inland fisheries management. Swami Viswamayananda Ji, Secretary, Ramakrishna Mission Ashram, Sargachi, Murshidabad graced the occasion as the Chief Guest and appreciated the work of ICAR-CIFRI despite the COVID-19 pandemic. He emphasized that innovation and invention should reach each and every door of common people. Dr. J. K. Jena, Deputy Director General (Fy. Sc.), ICAR addressed the audience online. Dr. B. S. Mahapatra, Vice Chancellor, BCKV; Dr. D. S. Shakyawar, Director, ICAR-NINFET; Dr. Gauranga Kar, Director, ICAR-CRIJAF; Dr. V. V. Sugunan, FAO consultant and Former ADG, (Inland Fy.) were also present on the occasion. Publications, viz. 'ICAR-CIFRI Stride with Time', 'Common plankton of river Ganga', 'Strategic plan for inland open water fisheries development under PMMSY', '*Antarstaliya matsyiki samvardhan ebam sanrakshan*' and Hindi folders on 'Fisheries development in wetlands of Bihar' were released by the dignitaries. Appreciation awards were given to meritorious students of the staff family. Institutional awards for best scientist, technical, administrative, supporting, and research scholar for the year 2020-2021 were also presented. The inaugural ceremony was culminated with ranching of 20,000 advance fingerlings of indigenous fishes in River Ganga by the dignitaries at Barrackpore ghat. Farmers Scientists interaction session was organized on this occasion, where more than 150 fishers participated. A grand cultural evening was organized by the staff.

Fishers-Scientist interaction

Ganga Pledge

Cultural Programme

Brahmaputra Aamantran Abhiyan

"Brahmaputra Aamantran Abhiyan" Rafting Expedition

ICAR-CIFRI Regional Centre, Guwahati participated in the "Brahmaputra Aamantran Abhiyan" organized by the Brahmaputra Board, Ministry of Jal Shakti, Govt. of India during 23 December, 2020 to 21 January, 2021. The Centre took part in rafting expedition from Pashighat in Arunachal Pradesh to Dhubri in Assam with team members from Indian Institute of Technology, Guwahati, National Disaster Response Force (NDRF), State Disaster Response Force (SDRF) and other collaborators. Water quality, soil and aquatic organisms (mainly fish and shellfish species) were assessed at different stretches of the river. The Institute also took part in awareness programmes and exhibitions organized at Pashighat (Arunachal Pradesh), Majuli and Guwahati (Assam) as part of the expedition and spread the message on "Sustainable fisheries from river Brahmaputra".

Republic Day

The Institute celebrated the 72nd Republic Day with great enthusiasm on 26 January, 2021. Dr. B.K. Das, Director unfurled the tri-colour and paid rich tribute to the nation. He remarked that India gained freedom after immense struggle and sacrifices by the freedom fighters. Hence, preserving unity of the nation is our sacred duty. In his speech, he also recounted the achievements of the Institute in last one year. He remarked that a good working atmosphere and team spirit are the keys to success. All the CIFRI staff and their family members graced the occasion.

International Women's Day

The Institute celebrated the International Women's day on 8 March, 2021 at Barrackpore on the theme "Choose to challenge". On this occasion, three women entrepreneurs were awarded for their exemplary contributions in the fisheries sector. Smt. Subha Pathak, an IMC seed grower from Naihati, Smt. Rumpa Meyur and Ms. Hossenara Khatun, ornamental fish growers were also felicitated. Dr. Aparna Roy, Sr. Scientist made a presentation on "Women in fisheries sector: A journey towards 3E's". Dr. Kaushalya Nayek, Lecturer, DAV College, Odisha highlighted the balancing role of women in professional and family life. Ms. Sarmistha Das, IAS, MD, Benfish graced the occasion as Chief Guest. Dr. B.K Das, Director appreciated the women scientists and staff for their contribution for the cause of science. About 220 persons including 30 fisher women, State Department officials and ICAR-CIFRI staff members participated in the programme.

Republic Day

Awardees in Republic Day

International Women Day

World Water Day

World Water Day

The institute organized a virtual seminar on "Valuing water for sustainable fisheries" on the occasion of World Water Day on 22 March, 2021. Shri U.P. Singh, IAS, Former Secretary of the Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti and currently Secretary, Ministry of Textiles, Govt. of India was the Chief Guest. Prof. Govind Chakrapani, Vice-Chancellor, Berhampur University, Odisha was the Guest of Honour. Shri Singh highlighted various issues of water management and different Govt. schemes for water conservation. Prof. Mst. Kaniz Fatema, Head, Fishery Resource Management, Bangladesh Agricultural University talked on water management for sustainable fisheries from Bangladesh perspective. Prof. Tuhin Ghosh, Director, School of Oceanographic studies, Jadavpur University also talked on the occasion.

World Environment Day

The institute observed the World Environment Day on 5 June, 2021 in collaboration with Inland Fisheries Society of India in online mode. Prof. J. K. Panigrahi Secretary, Odisha Environment Society, Dr. A. K. Sanyal, Former Director, ZSI, Kolkata delivered World Environment Day lectures. Dr. B.K Das in his remarks highlighted the importance of conservation of aquatic environment.

Technology Transfer License Agreement of "ICAR-CIFRI ARGCURE"

CIFRI ARGCURE Technology transfer license agreement was signed by Dr. B. K. Das, Director of the Institute and Mr. Sariful Islam, Managing Director, Glaucus Agrochem Pvt. Ltd., Kolkata on 7 July, 2021 in presence of Dr. J. K. Jena, Deputy Director General (Fy. Sc.), ICAR and Dr. Sudha Mysore, CEO, Agrinnovate India Ltd., New Delhi. The commercialization of CIFRI-ARGCURE technology has been facilitated by Agrinnovate India Ltd. (a Govt. of India enterprise) and the technology license on non-exclusive basis for manufacturing and sale for 5 years is going to be transferred to Glaucus Agrochem Pvt. Ltd., Kolkata.

75th Independence Day

75th Independence Day, Azadi Ka Amrut Mahotsav was celebrated by the Institute with great fanfare. All the staff including scientists, research scholars along with their

World Environment Day

Signing of License Agreement

Independence Day

Parthenium Awareness Week

family members gathered on the occasion. Dr. B. K. Das, Director, hoisted the national flag in the grand ceremony. In his address he congratulated all the members of ICAR-CIFRI on the occasion of 75th anniversary of Indian independence. He congratulated everyone for working together and getting the prestigious Sardar Patel Best ICAR institute Award for 2020. He thanked all CIFRIANS for contributing to the nation building. He emphasized need for efforts to be taken up for livelihood improvement of fishermen communities throughout the country. He also added that in last five years four technologies have been commercialized, four patent, six trademarks and 2 designs have already been registered.

16th Parthenium Awareness Week

The Institute observed Parthenium Awareness Week during 16-22 August, 2021 to ensure parthenium free campus under the aegis of *Swachh Bharat Abhiyaan*. Various awareness programs and demonstrations regarding the health and environmental hazards posed by partheium was organized. Control of Parthenium by uprooting and herbicide spraying both inside and outside the CIFRI campus premises was also taken up. Local areas surrounding the Institute were also included in this program. The uprooted weeds were put in the vermicompost pit of the Institute. In addition, outreach programs regarding parthenium awareness was conducted in the villages surrounding Khalsi beel, Nadia and Beladanga beel of North 24 Parganas districts of West Bengal.

Fit India Freedom Run 2.0

The Institute organized Fit Indian Freedom Run 2.0 under the aegis of *Azadi Ka Amrut Mahotsav* on 9, 18 and 25 September, 2021. The event was organized as per the call of the Ministry of Youth Affairs and Sports, Govt. of India to commemorate the *Azadi ka Amrit Mahotsav.* The Institute staff resolved to include physical activity of at least 30 minutes daily in their life, i.e. *Fitness ki dose, aadha ghanta roz*. The run was also aimed at making the general public aware of this noble initiative, and to make the *"Jan Bhagidari se Jan Andolan"* a grand success. The Run commenced at 7.00 am from the Institute Hqs. at Fisheries Gate, Manirampur and came back after reaching Chiriamore, Barrackpore which is around 5 km from the Institute headquarters. All the staff members (including research scholars, contractual persons) joined the run following all the COVID protocols. The Director led the team and encouraged the general public to make fitness activities a daily routine in their life.

Fit India Freedom Run 2.0

Hindi Saptah

भाकृअनुप–केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर, कोलकाता, पश्चिम बंगाल में हिन्दी सप्ताह 2021 का पालन

भाकृअनुप–केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर में दिनांक 14–21 सितंबर, 2021 के दौरान हिंदी सप्ताह का आयोजन किया गया। इस वर्ष कोविड–19 महामारी के कारण हिन्दी सप्ताह का उदघाटन तथा अन्य प्रतियोगिताएं ऑनलाइन मोड में आयोजित की गई। जिसमें संस्थान मुख्यालय के साथ इसके क्षेत्रीय केन्द्रोंध्स्टेशनों (इलाहाबाद, बैंगलोर, गुवाहाटी, वडोदरा, कोलकाता और कोच्चि) ने भी भाग लिया। इस उद्घाटन समारोह की मुख्य अतिथि डॉ. (श्रीमती) विजय लक्ष्मी सक्सेना, महाध्यक्ष (निर्वाचित), भारतीय विज्ञान कांग्रेस संस्था तथा विशिष्ट अतिथि डॉ. अशोक कुमार सक्सेना, पूर्व महाध्यक्ष, भारतीय विज्ञान कांग्रेस संस्था उपस्थित थे। संस्थान के निदेशक डॉ. बि. के. दास ने कार्यक्रम को आगे बढ़ाने से पहले गृह मंत्रालय, राजभाषा विभाग द्वारा निर्देशित राजभाषा प्रतिज्ञा की शपथ ऑफलाईन/ऑनलाईन पर उपस्थित समस्त अधिकारियों/कर्मचारियों को दिलवायी।संस्थान के निदेशकमहोदयने सर्वप्रथम सभी को हिन्दी दिवस की बधाई दी और कहा कि यदि शिक्षा व्यवस्था को सुदृढ़ करना है तो मातृभाषा को मजबूत करना चाहिए। चूंकि देश में हिन्दी बोलने वालों की संख्या बहुत अधिक है इसलिए इसका विकास और सुदृढीकरण अत्यंत आवश्यक है। उन्होंने कहा कि मात्स्यिकी शोध को हिंदी माध्यम से किसानों तक पहुंचाना चाहिए। इस अवसर पर संस्थान की हिंदी सिफरी मासिक समाचार पत्रिका, अंक अगस्त 2021तथा "अलवण जल एवं मत्स्य पारिस्थितिकी" पुस्तक का विमोचन किया गया।

हिंदी सप्ताह समापन समारोह दिनांक 21 सितम्बर, 2021 को ऑफलाईनध्ऑनलाईन मोड में किया गया। हिंदी सप्ताह के दौरान आयोजित प्रतियोगिताओं के विजेताओं को पुरस्कार वितरण किया गया। निदेशक महोदय ने हिंदी प्रकाशन में उत्कृष्ठ कार्य करने वाले वैज्ञानिकों एवं तकनीकी अधिकारियों को प्रशस्ति पत्र एवं पुरस्कार राशि से सम्मानित भी किया।

Campaign on Nutri-Garden and Tree Plantation

As a part of the International Year of Millets 2023, a Campaign on nutri-garden and tree plantation (*Poshan Vatika and Vriksharopan*

Campaign on Nutri-Garden and Tree Plantation

Field Day at Khalsi

Stocking of fingerlings in pens

Mahaabhiyan) was organized by the institute on 17 September, 2021. Two hundred saplings of fruits viz. mango, guava, lichi, lemon, jackfruit, pomegranate, jamun, coconut, bael, custard apple, java apple, sapota and health trees like neem, tulsi were planted at Institute headquarters and Regional Centres. Apart from this 117 saplings were also planted at different outreach locations viz. Chamardaha and Chamta beel in North 24 Parganas and Kolaghat Hilsa field station. In an awareness meeting Dr. B. K. Das, Director, enlightened the staff regarding importance of including millets in their daily diet for a healthy life. Millet products were also distributed on this occasion.

'Field Day' at Khalsi Wetland, West Bengal

The Institute organized a 'Field day' at the Khalsi wetland of Haringhata Block, West Bengal on 24 September, 2021 for sensitizing the women beneficiaries on diversified income generating enterprises under the DBT project "Empowering women of Wetland-dependent fisher folk community of lower Gangetic plain through cost-effective technologies". A total of 71 participants from the adjacent villages of the Khalsi wetland, namely, Khalsi, Mathpara, Kanapukurdanga, Uttarbrahmapur took part in the programme. Dr. Aparna Roy, the project PI, encouraged them to continue their hard work in coming years. She also explained benefits of various components of the project and their role in nutritional and livelihood security. The other project scientists Dr. A.K. Bera and Dr. Arun Pandit (ICAR-CIFRI), Prof. Pintoo Bandopadhyay, Dr. Sanchita Mandal (BCKV, Kalyani) also spoke on the occasion. The sensitization programme was followed by stocking of 420 kg good quality IMC fingerlings in four pens installed in the wetland and also providing CIFRI CageGrow feed.

World Rivers Day

The Institute, in association with National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti celebrated the "World Rivers Day" at Farakka, West Bengal in river Ganga on 26 September, 2021 with a special focus on dolphin conservation. The major objective was to create awareness among the fishermen and public to keep rivers clean and to conserve the aquatic biodiversity. On this occasion, 78 adult Hilsa of average weight 250g were ranched at upstream of the Farakka barrage. Fishermen were provided with posters and leaflets on Dolphin and Hilsa conservation. Staff of ICAR-CIFRI explained the impact of domestic and industrial sewage on the aquatic ecosystem and their impact on aquatic biodiversity and suggested measures towards improving the river health.

World Rivers Day

Inauguration of training Center

Address by the DG

Demonstration of sampling using drone

Visit of the Secretary, DARE and DG, ICAR

Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR visited ICAR-CIFRI, Barrackpore on 6 October, 2021. His visit started with river ranching of 75000 fingerlings of Indian Major carps in Ganga River at Gandhi ghat, Barrackpore with. Simultaneously 50 Catla fishes were also tagged and released to study its migration and to take conservation measures. The DG, ICAR also launched drone facility for sampling of water bodies as a part of use of IOT in fisheries. Then he inaugurated the Multi-facility Training Complex, ICP-MS facility and laid the foundation stone of 2nd floor of main building of the institute. Dr J.K. Jena, DDG (Fy. Sc.), Dr. B. K. Mahapatra, Vice Chancellor, BCKV, Mohanpur, Dr. Anil Rai, ADG (ICT), Directors of ICAR-NINFET, Kolkata, ICAR-CRIJAF, Barrackpore, Director, ICAR-ATARI, Kolkata, officers and staff members of ICAR institutes were present on this occasion. More than 100 farmers and farm women attended the programme.

Visit of DDG (Fisheries Science), ICAR to Moyna Fish Hub

Dr. J.K. Jena, DDG (Fy. Sc.), ICAR visited the Moyna fisheries hub, Moyna, West Bengal on 9 October, 2021. About 8000 ha of depressed lands spread over seven Blocks have been brought under intensive fish culture providing livelihood support to more than 5 lakh people. Dr Jena was accompanied by Dr. B.K. Das, Director and scientists of ICAR-CIFA & ICAR-CIFRI. He was appraised about the constraints faced by the fishers in anaquafarmer's interactive meet. Dr B.K. Das urged the stakeholders to come forward to be trained with modern knowledge of fish culture at CIFRI. Dr. Jena & Dr. Das addressed the people of Moyna through Pally Bangla FM Radio run by Ramakrishnayan Society of Moyna.

Vigilance Awareness Week

The Institute observed "Vigilance Awareness Week" during 26 October to 01 November, 2021 focusing on the theme "Independent India@75: Self reliance with integrity" maintaining the COVID 19 protocols. The week-long observance started with administration of pledge on 26 October by the Director. Many of the staff also took e-pledge. Large numbers of posters, banners, placards were displayed at the campus premises showing the ill effects of corruption and the commitment of CIFRI toward zero tolerance on corruption. Next day, all the staff formed a human chain showing the unity in fighting the corruption. Walkathon, quiz programme, extempore and lecture by Shri Rajeev Lal, Jt. Director (Adm.)-cum-Registrar were the other programmes. Shri Jayadevan A., IPS, Supdt. of Police and HoB, EO-IV, CBI, Kolkata was the Chief Guest in the concluding ceremony on 01 November 2021.

Interaction with Aqua Farmers at Moyna

Interaction of DDG (Fisheries Science) with a fish vendor

Integrity pledge

Vigilance rally

Field Day at Takmu Pat, Manipur

The Institute, in collaboration with the Department of Fisheries, Govt. of Manipur, had successfully carried out culture of the endemic carp, *Osteobrama belangeri*, in HDPE modular cages in Takmu pat, Bishnupur district of Manipur under the NEH component of ICAR-CIFRI. On the occasion of final harvesting and release of fish, a field-day was conducted on 28 October, 2021 at Takmu pat cage culture site to share the results with the fishery officers, fishers and other participants on cage farming of indigenous species having high local demand and solicit suggestions for future experiments. About 50 fishers participated in the programme.

Ganga Utsav 2021

The Institute celebrated "Ganga Utsav 2021" at Barrackpore, Farakka and Prayagraj on river Ganga during 01-03 November, 2021. The NMCG, Ministry of Jal Shakti, Government of India has put forward Ganga Utsav-2021 river festival with major objective of "Jan Bhagidari" in revival of Ganga with a focus on encouraging stakeholder engagement and public participation. ICAR-CIFRI carried out a series of activities like '*Ganga Aarti*', river ranching of hilsa and small indigenous fish species, '*Ganga Pratigya*', rolling of ICAR-CIFRI-NMCG tableau at various ghats, mass awareness programme, quiz competition, rangoli and painting competition and a cultural evening. Dr Nabarun Bhattacharya, Senior Director, C-DAC graced the valedictory function.

Field Day at Takmu pat

Inauguration of 'Matsyalok Guest House' at ICAR-CIFRI, Prayagraj

Dr. J.K. Jena, Deputy Director General (Fy. Sc.), ICAR,

Ganga Utsav

Inauguration of guest house at Prayagraj

Parliamentary Committee on Official Language

inaugurated five rooms' guest house at Prayagraj Regional Centre of the Institute on 15 November, 2021. Dr. B.K. Das, Director, was also present on the occasion. The inaugurated guest house has been named as 'Mastyalok' to serve the people engaged in fisheries sector. DDG (Fy. Sc.) addressed the scientists and staffs of the centre and motivated & inspired for the better research and development of the fishery and fishermen.

World Fisheries Day

ICAR-CIFRI celebrated "World Fisheries Day-2021" focusing on the theme 'Riverine fisheries conservation and sustainability' on the bank of river Ganga at Farakka on 21 November, 2021. On this occasion, Shri. R. Azhagesan, General Manager, Farakka Barrage Project, Dr. Sandeep Behera, Biodiversity consultant NMCG, New Delhi graced the occasion. Dr. D.K. Meena, Scientist, ICAR-CIFRI briefed Hilsa fisheries improvement programme undertaken by the Institute in the river Ganga. More than 1500 fishermen, and general public participated in the programme. The Institute also organized an awareness programme on Ecosystem-based wetland management at Khalsi beel where 67 farmers from the Khalsi Udbastu Unnayan Samiti participated. Another awareness programme was organized at Ram Krishna Mission Ashram, Sargachi, Murshidabad on 23 November, 2021 where more than 500 farmers, students, teachers participated. Dr. A. K. Das, Principal Scientist highlighted role of fisheries in livelihood and income generation.

Visit of the Parliamentary Committee on Official Language

The Second Sub-committee of the Parliamentary Committee on Official Language inspected the progress made in implementation of the Official Language in office works by the Central Govt. offices including ICAR-CIFFRI at Kolkata during 22-23 November, 2021. Smt. Ranjanben Dhanjay Bhatt, Convener of the Committee, and other members expressed satisfaction over the efforts being made by ICAR-CIFRI to comply with the Official Language policy and appreciated Hindi publications of the institute. The Committee also indicated the areas of further improvements related to working in Hindi.

Agricultural Education Day

The ICAR has designated 3rd December as the "Agricultural Education Day" to commemorate the birth anniversary of first President of Independent India and Union Minister of

Agricultural Education Day

Women in Agricultural Day

Agriculture, Bharat Ratna Dr. Rajendra Prasad. The objective of the day is to expose students to various facets of agriculture and its relevance to country's development, inspire them and attract them towards agriculture, so that they develop interest in agriculture and allied subjects, choose professional career after schooling in some of these courses, engage themselves in agriculture and related activities or become agrientrepreneurs in future. The day was fervently observed at the Institute headquarters on 03 December, 2021. The director and all HoDs spoke on the occasion. Dr. A.K. Das delivered a lecture on importance and relevance of agriculture education. He appealed to the students to connect with the soil to know the agriculture better.

Women in Agriculture Day

To recognize the efforts and contribution of women in agriculture, Indian Council of Agricultural Research celebrates 4th December, as "Women in Agriculture Day". On this occasion a brainstorming session was organized at the Institute. All the scientists, technical officers and students working in the Institute participated in this brainstorming session. Dr. Sajina AM, Scientist. Dr. Suman Kumari, Scientist, Ms. Hena Chakraborty, Young Professional-II and Dr. Shreya Bhattacharya, Young Professional-II presented views on women's participation in agriculture. Dr. B.K. Das appreciated the efforts and dedication of all the women employees for their research as well as in the Institute building activities.

World Soil Day

The "World Soil Day" was organized by the Institute on 5 December, 2021 at Barrackpore Headquarters in online and offline modes to highlight the importance of soil health for agricultural production and maintaining environmental health. Prof. Pabitra Mani, eminent soil scientist and Head of Department, BCKV, Mohanpur, West Bengal was present as the Chief Guest in this programme. Director opined that providing soil health cards to inland open water areas could be a commendable effort in coming days so that more productivity could be achieved through fisheries promotion.

Climate Resilient Fisheries Initiative at Elamkunnapuzha

Kochi Centre of ICAR-CIFRI stocked 6000 seeds of Pearl spot in culture based fisheries establishments associated with Vembanad lake at Elamkunnapuzha on 09 December, 2021 as a part of climate resilient fisheries programme taken up under NICRA project. The stocking programme was inaugurated by Mr. Sinoj Kumar, Vice-president, Ezhupunna Grama Panchayat and Mr. Joy K.J, ward member in the presence of Dr. Thankam Theresa Paul, Scientist and was participated by fish farmers of the area. The programme envisaged multi-stocking and multiple harvesting strategies for sustained livelihood to the farmers associated with wetland. The strategy ensures a yearlong assessment of the reproductive and feeding variations of Pearlspot in climate change scenario.

Inauguration of ICAR-CIFRI Pen Culture-cum-Reservoir Fisheries Enhancement Programme

Shri Bishweswar Tudu, Hon'ble Union Minister of State for Jal Shakti and Tribal Affairs, Govt. of India, inaugurated the ICAR-CIFRI Pen Culture Demonstration-cum-Reservoir Fisheries Enhancement Programme at Balidiha and Badjod Dam, Mayurbhanj District, Odisha on 11 December, 2021. The Minister stressed on disseminating the benefits of the Reservoir Fisheries Development Programme to the local community. Dr. B.K. Das, Director, briefed about the activities being carried out by the Institute in Odisha. The institute installed two pens in each reservoir for fingerling raising. About 250 fishermen in each reservoir site participated.

Nadi Utsav

ICAR-CIFRI, in association with National Mission for Clean Ganga (NMCG), celebrated "Nadi Utsav" at Seoraphully Nistarini Ghat on 22 December, 2021. The Ministry of Jal Shakti, Government of India has put forward 'Nadi Utsav' with an aim to create awareness on river ecosystem among different stakeholders including the populace living in and around Ganga river banks. Dr. B. K. Das,

World soil day

Stocking of pearl spot

Nadi Utsav

Director emphasized the role of river festivals celebrated in different major rivers of the world and sought peoples' participation for keeping river healthy. Dr. Sandeep Behera, Biodiversity Consultant, NMCG highlighted the importance of the river festival and important activities carried out by the NMCG towards river health, ecosystem and biodiversity conservation. Cultural programmes on river health management and ecosystem restoration including road show, folk songs and Ganga Aarati were organized in which more than 150 people representing local fishermen, public, and representatives from Wild life Institute of India (WII) were present.

National Campaign on Climate Resilient Inland Fisheries

Several national and regional level campaigns were organized on "Climate-Resilient Inland Fisheries" in December 2021 as a part of the "Bharat Ka Amrut Mahotsav", a programme to commemorate 75 Years of India's Independence to sensitize and create awareness about climate change and mitigation at the local level at various freshwater (Media, Chand, and Raja wetlands) and coastal wetlands (Bermajur wetland) of West Bengal.

National Campaign at Bermajur wetland

Other significant events

Poush Sankranti celebration

Saraswati Puja celebration

Inauguration of new garage at HQ

Ganesh Puja in residential quarters area

Pledge taking on Rashtriya Ekta Diwas on 31 October 2021

Receiving Ganga Mashal at Barrackpore on 23 November 2021

Ganga Aarti on the Bank of River Hooghly at Barrackpore on 24 November 2021

AZADI KA AMRIT MAHOTSAV

Azadi Ka Amrit Mahotsav is an initiative of the Government of India to celebrate and commemorate 75 years of the glorious history of independent India, its culture and achievements. In this regard, ICAR organized various programmes and events to celebrate the achievements of the last 75 years. It is also the Platinum Jubilee Year of ICAR-CIFRI. To commemorate these monumental occasions, ICAR-CIFRI organized a series of workshops, campaigns, awareness, sensitization, lectures, etc. for a renascent, Aatmanirbhar Bharat.

National Campaign on Ecosystem Based Management For Sustainable Fisheries

The 10 July, also known as National Fish Farmers Day, is an auspicious day in the history of Indian fisheries and was selected for initiating the National Campaign on Ecosystem based management for sustainable fisheries across the country. A total of four webinars were organized simultaneously at the Institute HQ and Regional Centres in National and regional languages covering more than 8000 farmers, students, community leaders, FPOs, etc. On-field awareness programmes were also organized to sensitize the fishers, fisher women, general public regarding the importance of conservation and ecosystem-based management in Mahi river basin of Gujarat, Vazhani reservoir in Kerala, Manchanabele reservoir in Karnataka; Ganga River at Farakka and Hooghly estuary. Ranching programmes were also organized at Prayagraj and Barrackpore for restoration of fish diversity in river Ganga. To support livelihoods of fishers the Institute also distributed gillnets to the fishers of marginal community. Shri Pratap Chandra Sarangi, Hon'ble Minister of State, Ministry of Fisheries, Animal Husbandry and Dairying graced the occasion as Chief Guest. Dr. J.K. Jena, DDG (Fy. Sc.), was also present in the interaction session. Voices from field, issues raised by fishers and fish farmers were compiled for address by scientists, planner and policy makers to help combat hunger and malnutrition.

Institute Headquarters, Barrackpore

A webinar on "Ecosystem management for sustainable fisheries" was organized on the Fish Farmers' Day which was graced by Dr. J. K. Jena, DDG (Fy. Sc.) and other stalwarts of the fisheries sector of the country such as Dr. N. K. Sarangi, Dr. V. V. Sugunan, Dr. Dilip Kumar, Dr. M. V. Gupta, Dr. K. G. Padmakumar, Dr. A. Gopalakrishnan and Dr. Ravishankar. Dr. B. K. Das, Director, addressed the participants and reiterated about importance of the day and the role of ICAR-CIFRI in continuing its legacy.

A ranching-cum-awareness programme was held where 40,000 IMC fingerlings were released in river Ganga to mark the occasion. Hilsa awareness programme was also held where 500 hilsa fishes were tagged and released in river Ganga at Nawabganj, West Bengal. An awareness programme on dolphin was also organized at Debipur, West Bengal. Demonstration of climate-smart fisheries was done in Media beel of North 24 Parganas. Awareness was also generated on ecosystem-based fisheries management in Kholsi and Kumli wetlands of West Bengal.

On the occasion of the National Fish Farmers Day, gill nets were distributed to 12 riverine fishers of West Bengal who earn their

Webinar on ecosystem management for sustainable fishing

Distribution of gillnets

Ganga river ranching

livelihood by fishing in river Hooghly. The inputs were handed over by Dr. B. K. Das, Director, and Dr. Asim Nag, Asst. Prof., Birsa Munda University.

Guwahati Centre

An online interactive programme was held by ICAR-CIFRI Regional Centre Guwahati, in collaboration with ICAR-ATARI (Zone VI), Guwahati on "Ecosystem-based fisheries management for fisheries and aquaculture of North-East region". The key speakers in the programme were Dr. B. K. Bhattacharjya, Principal Scientist and Head, ICAR – CIFRI Guwahati Regional Centre and Dr. R. Bordoloi, Principal Scientist and In-Charge, ICAR-ATARI (Zone VI), Guwahati. About 100 fish farmers from the states of Assam and Arunachal Pradesh participated in the programme. An online awareness programme, in collaboration with Assam Fisheries Development Corporation Limited (AFDC), Guwahati was organized on "Management of ecosystem of floodplain wetlands of Assam" for sustainable fisheries. Sri Ramakanta Deuri, MLA and Chairman, AFDC was Chief Guest of the programme. Mrs. Anuradha Adhikari Sarma, ACS, MD, AFDC was an Invited Guest. The key speakers for the awareness programme were Dr. B.K. Bhattacharjya, Principal Scientist and Head, ICAR-CIFRI Guwahati Regional Centre and Dr. P. K. Hazarika, OSD / PD, AFDC, Guwahati. About 1,000 wetland fishers of Assam participated in the programme.

Bengaluru Centre

An awareness programme was organized on "Reservoir fisheries management for sustainable development of the Manchanabele reservoir, Karnataka" on 10 July, 2021. Fisheries officials from various districts of Karnataka and about 200 fish farmers participated in the programme in online mode. The key speakers in the programme were Dr. P. Panikkar, Head, ICAR-CIFRI Regional Centre Bengaluru; Mr. Jagadeesh T.D., Asst. Director of Fisheries, DoF, Govt. of Karnataka; Dr. Harsha Naik, Asst. Professor, FRIC, Hessarghatta, Bengaluru and Mr. Mahadeva, Sr. Asst. Director of Fisheries, DoF, Govt. of Karnataka.

Kochi Centre

An online awareness programme on "Sustainable fisheries for livelihood enhancement in reservoirs" was held by Kochi Station of ICAR-CIFRI at Vazhani reservoir of Kerala. *Etroplus suratensis* seed was distributed in the programme. An online interactive session was also held with the fish farmers of the Thrissur district.

Awareness programme on sustainable management of reservoir fisheries

1st platinum jubilee lecture by Dr.S Ayyappan

Prayagraj Centre

A ranching programme was held at Prayagraj where 20,000 IMC fingerlings were released in river Ganga.

Vadodara Centre

An awareness programme was held at Mahi river by ICAR-CIFRI Vadodara centre.

Platinum Jubilee Lecture Series

To commemorate the 75th year of Indian Independence Azadi ka Amrit Mahotsav and 75th year of ICAR-CIFRI platinum Jubilee, the institute organized a series of lectures by eminent scientists from India and abroad. The first lecture of the series on "CIFRI: Remembering with reverence" was delivered by Dr. S. Ayyappan, Former Secretary, DARE and DG, ICAR on 03 August, 2021. Dr. Ayyappan highlighted the journey of CIFRI with milestones since its humble beginning in 1947 and also went with a vision of reaching new horizons in the inland fisheries sector. He also emphasized on the potential areas that CIFRI has the scope of expanding in terms of reach and further progress, and hoped that the Institute will continue to lead the country and the region in fisheries development and livelihood. Dr. M. V. Gupta, Former ADG World Fish, and World Food laureate; Dr. A. Eknath, Former DG, NACA; Dr. Dilip Kumar, Former Vice Chancellor and Director ICAR-CIFE; Dr. S. D. Tripathi, Former VC and Director, ICAR-CIFE; Dr. N. Sarangi, Former Director, ICAR- CIFA; Dr. K. K. Vass, Former Director, CIFRI; Prof.. A. P. Sharma, Former Director, CIFRI; Dr. V.V. Sugunan, ADG Inland Fisheries; Dr. Riji John, VC, KUFOS; Sri K Suresh, Former IAS congratulated Dr. Ayyappan for the nice lecture and vision for the fisheries sector. Dr. J. K. Jena, DDG (Fy. Sc.), ICAR concluded the session and emphasized on importance of the sector in present days. The programme ended with standing ovation to Dr. S. Ayyappan for his outstanding services in the field of fisheries and agriculture sector. More than 1000 participants participated and benefitted from the lectures on virtual platforms including live screening on YouTube and Facebook.

The second lecture on "Indian fisheries: Introspection to course correction" was delivered by Dr. Dilip Kumar, Fisheries Sector Planning, Policy and Development Advisor, Former Director/ Vice Chancellor, ICAR-CIFE, Mumbai on 28 October 2021. He highlighted past developments in the field of fisheries and portrayed future needs.

Dr. Rai S. Kookana, Chief Research Scientist, CSIRO, Australia, delivered the third lecture on "Organic contaminants

2nd platinum jubilee lecture by Dr. Dilip Kumar

3rd platinum jubilee lecture by Dr. Rai S Kookana

Ranching in River Ganga

of emerging concern for aquatic ecosystems" on 26 November, 2021. He focused on toxic pollutants entering in to open waters and their likely deleterious effects, and the role every country should play in reducing environmental pollution towards healthy environment for survival of human and animals, including fish.

Mass Awareness Programme on Culture Based Fisheries for Sustainable Development

As part of celebration of Azadi Ka Amrit Mohotsav, ICAR-CIFRI Regional Centre, Bengaluru organized a mass awareness programme on "Culture based fisheries for sustainable development" on 4 August, 2021 at Kariyala village, Chitradurga district, Karnataka. The programme was attended by 40 fisher folks who are engaged in fisheries activities at Gayatri reservoir in Chitradurga District. Dr. Preetha Panikkar, Principal Scientist and Head of the Centre welcomed the fishers and briefed them about the enhancement strategies for increasing fish production from the small reservoir. The farmers also interacted on various issues like parasitic infestation of fishes, fluctuations in reservoir water levels as the area is under continuous drought for several years.

Multi-location Ranching in River Ganga

Population of lucrative and prized fishes of the river Ganga especially Indian Major Carp (IMC, *Labeo rohita, Labeo catla* and *Cirrhinus mrigala*) have declined severely over the period due to several anthropogenic stresses. To enhance the IMC population, ICAR-CIFRI ranched 5 lakhs seeds of IMC in different stretches of river Ganga. The programme was coordinated under the flagship project 'Namami Gange' at five different places, viz., Maharajpur, Sahebganj, Farakka, Jangipur and Berhampore covering Jharkhand and the West Bengal on 5 August 2021. As a part of awareness building, more than 250 fishers along the river Ganga were sensitized about riverine fisheries. Significance of conservation of Gangetic fishes including prized Hilsa was highlighted to the fishermen. The awareness campaign also embraced the critically endangered Gangetic Dolphin species so as to ensure its healthy population in the river system. The programme was graced by General Manager, Farakka Barrage, Director, Jharkhand Fisheries Co-operative Society and other local dignitaries.

Prayagraj regional Centre of the Institute ranched 30,000 Catla, Rohu, and Mrigal seeds on 15 November, 2021 in the holy

Ranching in Ganga at Prayagraj

Ranching in River Ganga

confluence of river Ganga and Yamuna. Dr. B.K. Das, Director, informed the gathering about the Namami Gange (NMCG) project and the biodiversity and cleanliness of Ganga. The chief guest of the program, Dr. J.K Jena, DDG (Fy. Sc.), ICAR, explained the importance of ranching in the river Ganga and ways to increase the livelihood of fishermen; 20 cast nets were distributed among the fishermen to encourage fisheries. The program was attended by Ganga Vichar Manch, Wildlife Institute of India, Ganga Prahari, Ganga Task Force, pilgrims, fishermen from nearby villages, fish traders, and local people living on the river banks.

National Campaign on System Diversification in Aquaculture

ICAR-CIFRI conducted a webinar and two awareness programmes as a part of National Campaign on "System diversification in aquaculture" to commemorate India @75 – Azadi Ka Amrit Mahotsav.

ICAR-CIFRI, Headquarters

The webinar on "Enclosure culture for fish production enhancement in Inland open waters" was started with welcome address by Dr. B.K Das, Director. He stressed upon more use of enclosure culture (cage and pen) of fish in reservoirs and wetlands for enhancing fish production through seed rearing and table fish production and for reducing pressure on land-based fish farms. Topics like status and prospects of enclosure systems, culture protocols, diversified species, feeding protocols for enclosure culture, health management aspects as well as various schemes under PMMSY were covered in the webinar. More than 200 participants were present in the webinar. The questions raised by the participants were answered by expert members.

RRC-CIFRI, Guwahati

An awareness programme on "Enclosure culture for enhanced fish production from beels" was organized by ICAR-CIFRI Regional Centre, Guwahati at Ghorajan beel, Amingaon, Kamrup (Rural), Assam on 01 September, 2021, in collaboration with AFDC Ltd., Guwahati. A total of 42 beel fishers, entrepreneurs and members of Trimurti Multipurpose Cooperative Society, Kamrup (R), Assam participated in the programme. Scientists of the Centre discussed various options of beel fisheries management including pen and cage culture as diversified production systems for increasing fish production.

CIFRI Research Station, Kochi

An awareness programme on "System diversification for fisheries enhancement in inland open waters" was conducted at Kanjirapuzha reservoir, Palakkad district, Kerala. About 40 active fishermen belonging to the Kanjirapuzha SC ST Fisheries Cooperative Society participated in the programme. Officials from the fisheries and irrigation departments also participated in the programme.

Stakeholders' Meeting for Sustainable Management of Fisheries

The Institute organized a stakeholder's meeting on 22 September, 2021, in both online and offline modes, for the sustainable management of fisheries in different corners of the country under STC program. The main objective of the meeting was to discuss with the stakeholders regarding the prospects and benefits under STC for their greater involvement in fisheries activities to harness maximum productivity as well as profitability. In this meeting, the stakeholders were from vulnerable Tribal communities who have been supported with various fisheries inputs like fish seed, feed, lime, net, coracle, pen, boat etc. from time to time in different selected areas of the country by CIFRI under STC programme. The Institute is working consistently to improve core competency of the tribal populace to achieve Hon'ble Prime Minister's flagship programme of 'doubling farmers income' and 'per drop more crop' in participatory mode. A total of 76 stakeholders (57 women and 19 male) from West Bengal, Jharkhand, Odisha, Gujarat, Kerala were present in the meeting. An interactive session was conducted between the stakeholders and the scientists of the Institute where they discussed about their experience and planning for future activities.

Hon'ble Prime Minister's Address and Farmer-Centric Programme at ICAR-CIFRI

The Institute fervently conducted "Farmers-scientists interface meet on Climate resilient varieties, technologies & practices" on 28 September following the Council's instructions for creating climate awareness amongst farmers. The programme started with a presentation on "Climate resilient agriculture", which was elaborated to 103 participating farmers by the Institute's scientists. This was followed by inaugural ceremony of ICAR-NIBSM, Raipur, Chhattishgarh and address by Hon'ble Prime Minister Shri Narendra Damodar Das Modi Ji which were attended by farmers, scientists and other staff of the

Address by Hon'ble Prime Minister

ICAR-CIFRI Staff and fishers gathering for interface meet

Institute. Thirty five climate resilient varieties of different crops were dedicated to the nation by Hon'ble Prime Minister who also conferred Clean Green Campus Awards to four agricultural universities. Importance and incorporation of millets to our daily food basket for nutritional security was elaborated during the deliberations, which has been well taken by the farmers. This program was subsequently followed by farmers-scientists interface meet at the Institute for resolving various problems faced by the fishers in inland open waters.

Campaign on Climate Resilient Inland Fisheries at Raja Wetland

The aquatic ecology and fisheries of wetlands are highly impacted due to the climate change and increasing anthropogenic activities. Raja wetland is a vulnerable wetland due to the prevalence of climatic anomaly and urbanization causing unstable fisheries and ecological status of the wetland leading to livelihood insecurity of the fishers. To mitigate this problem ICAR-CIFRI conducted a national campaign at Raja wetland, North 24 Parganas, West Bengal on 06 November, 2021 to raise awareness on climate resilient inland fisheries under the NICRA project. The campaign was participated by 20 fishermen. An interactive session on mitigation and adoption strategies against climate change was held with local fishermen. Fishermen were also sensitized about climate smart fish culture system like pen culture and cage culture.

National Campaign on Antimicrobial Resistance in Fish

Antimicrobial resistance (AMR) is a threat to global health and development. It requires urgent multi-sectoral action to achieve the Sustainable Development Goals (SDGs). The Institute organized "National campaign on Antimicrobial resistance in fish" during 22-24 November, 2021. Several programs were organized by the Headquarters and Research Centers under the leadership of Director in different parts of the country. About 352903 fishermen, students, general public were made aware on various aspects of AMR.

ICAR-CIFRI, Headquarters

An awareness programme was organized in two *ferry ghats* (Shrirampur and Sheoraphuli) in the locality on 22 November, 2021. One thousand pamphlets prepared on AMR in English, Hindi and Bengali were distributed; importance of safe and responsible use of antimicrobials was also discussed among the people. A Kisan Sammelan was organized at Farakka on 22 November, 2021 to create awareness about AMR; around 180 fishermen, youth, women and students participated in the event. Awareness camp was organized on 23 November 2021 at Ranabutia village, East Kolkata wetland, West Bengal and 507 fishermen including 395 men and 112 women participated in the programme. Prof. T.J. Abraham, Dean, Prof. Gadadhar Das, WBUAFS, Kolkata and Shri Prabir Sarkar, Social Worker, East Kolkata Wetlands were present in the event. During the programme, the team shared their knowledge on aquatic environment as well as antimicrobial resistance issues, status of fish disease management in freshwater aquaculture in India, aquaculture development, etc.

Another event was organized at Sargachi, Murshidabad, West Bengal, supported by Dhanya Ganga KVK of RKMVERI on 23 November, 2021. Total 508 students, faculty, SHGs, WSHGs, Fishermen and youth participated. Swami Vishwamayanand Secretary, RKM, Sargachi inaugurated the programme giving a new look to the youth through agri-

Mass awareness on AMR

Radio Talk on AMR

entrepreneurship as a means of income under the changed regime of the country driven by the pandemic. Dr. A. K. Das, Principal Scientist while welcoming the participants urged the students and youth to engage in knowledge and technology driven present agriculture and especially fisheries and aquaculture as a means of livelihood in the coming era. Dr. S.K. Manna, Principal Scientist, gave a lucid presentation on 'Antimicrobial resistance – its implications in fish and human health'. The session on question-answers by students, farmers, scientists, teachers and professors was also included. The Head of the Department, Department of Zoology, Baharampur Girls' College shared his knowledge on this important aspect.

On 24 November, 2021, a public awareness programme was organized in Moyna, East Midnapore, in association with Moyna Ramakrishnan Association, West Bengal. More than 500 farmers, students, and college lecturers participated in the event. Dr. B.K. Das, Director, highlighted the issue of random use of antibiotics without any susceptibility testing, which ultimately leads to massive economic losses due to AMR and recurrent fish disease outbreaks and mortality. He also conducted a sensitization program on this burning issue through Radio Talk in FM 92.1 radio channel, which was broadcasted to around 3.5 lakh residents of that area.

National campaign on AMR and World Fisheries Day at Sargachi

RRC-CIFRI, Bengaluru

A public awareness program was organized by ICAR-CIFRI Regional Center Bengaluru on 23 November, 2021 at Vanvilas Sagar Reservoir, Chitradurga District, Karnataka under the overall guidance of Dr. B.K. Das. The program was conducted by Dr. P. Panikkar, Principal Scientist and Head, Dr. A. Saha, Scientist. A total of 52 people were made aware on the topic.

RRC-CIFRI, Vadodara

Dr. S. P. Kamble, In-charge Vadodara Center and Dr. Vaishak, Scientist, Vadodara Center organized an awareness programme on "Antimicrobial Resistance in Fish" on 24 November, 2021 at Dev Dam, Bhamaria Village (Panchmahal District), Gujarat.

RRC-CIFRI, Guwahati

An awareness programme was organized on "Antimicrobial resistance in fish" by Regional Research Center Guwahati on 24

November, 2021 at Lakhanbandha Beel, Nagaon in Assam. About 40 fishers participated in the awareness programme.

RRC-CIFRI, Prayagraj

ICAR-CIFRI Regional Centre, Prayagraj celebrated National campaign on AMR from 22-24 November 2021, On 23 November, an awareness programme was organized in major transport ghats at Sangam, Prayagraj.

National campaign on AMR and World Fisheries Day at Sargachi

Awareness campaign on AMR at Vanvilas Sagar Reservoir site

MERA GAON MERA GAURAV

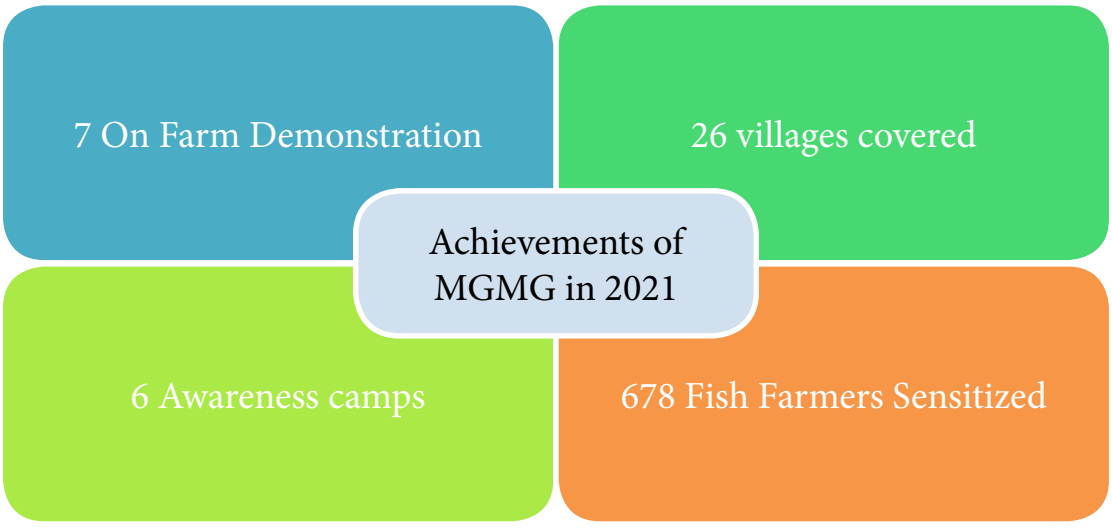
Mera Gaon Mera Gaurav (MGMG) is flagship programme of Indian Council of Agricultural Research to promote direct interface of scientists with the farmers to hasten the process of Lab-to-Land technology dissemination. In this direction, the Institute took the following initiatives:

- To identify a village and strengthen interface with farmers
- Periodically update the fishers and fish farmers about fisheries/agricultural activities through phone and mobile messages
- Provide technology handouts as per the agro-ecological conditions of the village; provide information to fishers, fish farmers and crop and live stock growers about fisheries and agricultural inputs, technologies, climate, market etc.
- Create awareness among fishers and fish farmers about the programmes being implemented by various organizations and institutions working at local level
- Make farmers aware of the sensitive issues of national importance such as Swachh Bharat Abhiyaan, conservation of bio-diversity, climate change, water conservation etc.
- Organize farmers' meet by visiting the selected villages as per need and facilitate the participation of specialists of the concerned institute
- Identify technical problems at village level and make use of those in prospective research programmes and generate technical, social and economic data related to a village

Despite severe COVID-19 related restrictions, the Institute scientists have made the below achievements in 2021 under the MGMG programme.

Success story under MGMG

Ashadullapur village of Sriniketan block, Birbhum was adopted as MGMG village by the Institute. On-farm demonstration was conducted in the village to motivate the village population to adopt fish culture practices as an alternative to earn their livelihoods. Under the Institute support and guidelines, a tribal women-SHG, named Chandurakab SHG, of this village has adopted scientific fish culture practices in a community pond (1 bigha) and harvested 31% more fish than the last year. Each of the SHG members received around Rs. 910/- as net return from fish culture in one season. Moreover, the quantity of fish consumption by the SHG members and their families has also increased significantly providing quality protein. Now the SHG is planning to improve their fishing enterprise with more support and guidance from CIFRI.



SWACHHATA ACTIVITIES

Swachhata Pledge

Cleanliness is a path toward the progress of individuals as well as a society. The Swachh Bharat Abhiyan, initiated nationwide on 2nd October 2014, is the most significant cleanliness campaign by the Government of India. The second phase is being implemented between 2020-21 and 2024-25, aiming at sustainable Swachhata.

In first phase, the institute emphasized the outreach programmes of Swachh Bharat Mission through:

- Pledge taking
- Digitization of office records and e-office
- Basic maintenance of the office campus
- Sanitization and clean water campaigns
- Cleaning and beautification of the surrounding areas
- Waste to wealth
- Swachhta awareness
- Fostering healthy competitions
- Social media coverage and impact

Pledge taking for Swachhata

Digitization of office records and e-office

Regular cleaning and sanitization of office rooms, buildings, campus

Regular cleaning and sanitization of office rooms, buildings, campus

Cleaning of banks of River Ganga and the locality

Creating awareness on dangers of Parthenium plant as part of Parthenium Awareness Week (16-22 August 2021)

Tree plantation

From organic waste to wealth generation – Biochar production

Generating peoples' awareness on Swachhata

Creating awareness through parting and debate competition on environment

Generating awareness among women farmers on Vermicompost – from waste to wealth

राजभाषा कार्य

भाकृअनुप–केंद्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान में हिन्दी सप्ताह 2021 का आयोजन

भाकृअनुप–केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर में दिनांक 14–20 सितंबर 2021 के दौरान हिंदी सप्ताह आयोजित किया गया है। प्रत्येक वर्ष संस्थान में राजभाषा हिंदी को बढ़ावा देने की दिशा में हिंदी सप्ताह का आयोजन किया जाता है। इस वर्ष कोरेाना महामारी के कारण हिन्दी सप्ताह का उदघाटन तथा अन्य प्रतियोगिताएं ऑनलाइन मोड में "'गूगल मीट" प्लेटफार्म पर आयोजित की गई। हिन्दी सप्ताह का उदघाटन दिनांक 14 सितंबर 2021 को किया गया। उदघाटन समारोह में संस्थान मुख्यालय कर्मियों के साथ इसके क्षेत्रीय केन्द्रों/स्टेशनों (इलाहाबाद, बैंगलोर, गुवाहाटी, वडोदरा, कोलकाता और कोच्चि) ने भी भाग लिया। इस उद्घाटन समारोह में भारतीय विज्ञान कांग्रेस संस्था से डॉ. (श्रीमती) विजया लक्ष्मी सक्सेना, महासचिव (निर्वाचित) मुख्य अतिथि के रूप में तथा डॉ. अशोक सक्सेना, पूर्व महासचिव उपस्थित थे। उद्घाटन समारोह के स्वागत अभिभाषण में हिन्दी के सर्वकार्याधिकारी, डॉ. एस सामन्ता ने संस्थान के हिन्दी कार्यों की उपलब्धियों के साथ संस्थान को प्राप्त पुरस्कारों जैसे भारतीय कृषि अनुसंधान परिषद का सरदार पटेल सर्वश्रेष्ठ संस्थान पुरस्कार, रफी अहमद श्रेष्ठ वैज्ञानिक पुरस्कार और नीलांजलि पत्रिका को प्रोत्साहन पुरस्कार बारे में बताया। उन्होने कहा कि संस्थान का हिन्दी वृत्तचित्र विज्ञान और प्रौद्योगिकी मंत्रालय के वेबसाइट पर अपलोड किए गए है जो हमारे संस्थान के लिए गर्व की बात है। संस्थान के निदेशक, डॉ. बि के दास ने सर्वप्रथम सभी को हिन्दी दिवस की बधाई देते हुए कहा कि यद्यपि संस्थान के हिन्दी संबंधी कार्यों में बहुत विविधता है और उनकी संख्या में भी बढ़ोतरी हुई है पर हमें इस दिशा में और भी प्रयास करना चाहिए। उन्होने बताया कि यदि शिक्षा व्यवस्था को सुदृढ़ करना है तो मातृभाषा को मजबूत करना चाहिए। हमारे देश के किसानों में प्रौद्योगिकी विस्तार के लिए भी हिन्दी को बढ़ावा देना चाहिए। मात्स्यिकी विज्ञान और हिन्दी का सम्मिलन किसानों के विकास के लिए पथ–प्रदर्शक का कार्य करेगा। मुख्य अतिथि डॉ. (श्रीमती) विजया लक्ष्मी सक्सेना, महासचिव (निर्वाचित), भारतीय विज्ञान कांग्रेस संस्था ने संस्थान के हिंदी प्रकाशनों की सराहना करते हुए कहा कि कोरोना महामारी में भी सिफरी ने अपने अथक प्रयास से संस्थान के कार्यों में वृद्धि की है। हिन्दी को बढ़ावा देने में सोशल मीडिया का विशेष महत्व है और सरल हिन्दी के प्रयोग से इसके विस्तार में बहुत सहायता मिलेगी। संस्थान के सह–निदेशक एवं कुलसचिव, श्री राजीव लाल ने कहा कि चूंकि सितंबर माह में देश भर में हिन्दी सप्ताह अथवा पखवाड़ा अथवा मास मनाया जाता है इसलिए सितंबर महीना एक प्रकार से हिन्दी के लिए ही समर्पित है। इस अवसर पर संस्थान की मासिक पत्रिका, "अगस्त 2021" तथा "अलवण जल एवं मत्स्य पारिस्थितिकी" पुस्तक का विमोचन किया गया। हिन्दी सप्ताह के दौरान कई प्रतियोगिताएं आयोजित की गईं जिसमें संथान कर्मियों ने बढ़ चढ़ कर भाग लिया और पुरस्कार जीते।

संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 22 नवम्बर, 2021 को भाकृअनुप–केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर, कोलकाता, पश्चिम बंगाल में राजभाषा संबंधी निरीक्षण

संसदीय राजभाषा समिति की दूसरी उप समिति द्वारा दिनांक 22 नवम्बर, 2021 को भाकृअनुप–केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान, बैरकपुर को राजभाषा कार्यान्वययन में हुई प्रगति का निरीक्षण किया गया। निरीक्षण बैठक में संसदीय राजभाषा समिति के संयोजक माननीया श्रीमती रंजनबेन धनजय भट्ट, समिति के अन्य माननीय सदस्य, श्री दुर्गादास उइके तथा समिति सचिवालय के अवर सचिव, श्री रामेशवर लाल मीणा, श्री कमल स्वरूप, अनुसंधान अधिकारी एवं श्री अनिल कुमार, रिपोर्टर उपस्थित थे। संस्थान की तरफ से डॉ. बि. के. दास, निदेशक, डॉ. श्रीकान्त सामन्ता, प्रभागाध्यक्ष एवं सर्वकार्यभारी, हिंदी कक्ष, श्री राजीव लाल, संयुक्त् निदेशक (प्रशासन) सह कुलसचिव, भारतीय कृषि अनुसंधान परिषद (भाकृअनुप), नई दिल्ली के प्रतिनिधि के रूप में डॉ. बी. पी. मोहान्ति, सहायक महानिदेशक (अंतर्स्थलीय मात्स्यिकी), भारतीय कृषि अनुसंधान परिषद (भाकृअनुप), नई दिल्ली के प्रतिनिधि के रूप में श्रीमती सीमा चोपड़ा, निदेशक (राजभाषा), भारतीय कृषि अनुसंधान परिषद

(भाकृअनुप), नई दिल्ली के प्रतिनिधि के रूप में श्री मनोज कुमार, मुख्य तकनीकी अधिकारी (राजभाषा) तथा निरीक्षण कार्यालय के अन्य अधिकारी; मोहम्मद कासिम, मुख्य तकनीकी अधिकारी तथा सुश्री सुनीता प्रसाद, सहायक मुख्य तकनीकी अधिकारी उपस्थित थे। निदेशक महोदय ने संस्थान द्वारा विकसित प्रौद्योगिकी, गंगा रैंचिंग आदि पर प्रस्तुति दी गयी। संसदीय समिति के गणमान्य सदस्यों ने बड़ी ही उत्सुकता के साथ इस पॉवर पॉइंट प्रस्तुति को देखा तथा विभिन्न तकनीकी के बारे में जानकारी ली। समिति की संयोजक, माननीया श्रीमती रंजनबेन धनजय भट्ट ने संस्थान के प्रकाशन कार्यों की सराहना की। निरीक्षण के दौरान तैयार प्रश्नानवली के आधार पर सवाल किए गए। राजभाषा नीति के अनुपालन हेतु संस्थान के प्रयासों पर माननीय सदस्यों ने संतोष व्यक्त किया तथा इसे और भी अधिक उन्नत करने के निर्देश दिए। भारतीय कृषि अनुसंधान परिषद (भाकृअनुप), नई दिल्ली के प्रतिनिधि डॉ. बी. पी. मोहान्ति, सहायक महानिदेशक (अंतर्स्थलीय मात्स्यिकी) ने धन्यवाद ज्ञापन दिया।

पुरस्कार

1. वर्ष 2019–20 के दौरान केंद्र में राजभाषा के कार्यान्वयन पर उत्कृष्ट कार्य के लिए संस्थान के क्षेत्रीय केंद्र, बैंगलोर नगर राजभाषा कार्यान्वयन समिति, बैंगलोर द्वारा हिन्दी में उत्कृष्ठ कार्य के लिये द्वितीय पुरस्कार से सम्मानित किया गया।
2. सस्थान की वार्षिक पत्रिका, नीलांजलि को वर्ष 2020 के लिये परिषद् की गणेश शंकर विद्यार्थी प्रोत्साहन पुरस्कार दिया गया है।

Activities of Hindi Saptah

LIBRARY AND INFORMATICS

Library and Informatics section acts as the main repository of publications of ICAR-CIFRI and relevant publications from other agencies/institutes. The present total holding of books in the library is 12,642. During 2021, ICAR-CIFRI Library had added 64 new books including Hindi publications, 31 Indian Journals, 56 leaflets and 6 ICAR-CIFRI publications despite COVID-19 pandemic situation. Some of the publications including the ICAR-CIFRI publications were sent to various other institutes and universities of the country besides the libraries of Institute's own regional centres. This section has spacious reading areas for visitors and a mini-conference room for small group meetings, discussions etc. Library section also has modern gadgets like book scanner and android smart TV with Wi-fi connectivity.

The Library and Informatics section is divided into four segments for ease of management, *viz*., scientific books, journals, ICAR-CIFRI publications and Hindi books. The cataloguing system has been digitized and is managed by KOHA Open-Source Library Management software; the database is accessible through ICAR-CIFRI website as well as through the Union catalogue AGRICAT to all NARS institutes. Being an active member of CeRA Consortium, ICAR-CIFRI has sent 50 documents to different NARS institutes through Document Delivery Request (DDR).

The Library receives requests for books from scientists of ICAR-CIFRI and 15 books were ordered this year for purchase. The subscription of most of the journals (13 no.) are continued and a new journal (Agri-aqua Science Research Journal) is planned to be subscribed from 2022. Besides, one English book and three Hindi books written by institute scientists were purchased.

INTELLECTUAL PROPERTY RIGHTS MANAGEMENT

Trademark registered

- "CIFRI ARGCURE" is registered under the trademark Class 5, as chemical preparation for veterinary purpose with Trademark no. 4614213 and Certificate no. 2652706, sealed on 27 February 2021 and valid up to 2031.

Trademark filed

- "CIFRI Fish Tanavhari" with Application no. 5164182 has been filed on 07 October 2021 under the trademark Class 5 in the name of the Indian Council of Agricultural Research to the Trademark Registry, Indian Patent office, Kolkata.

Commercialization of technology

- The "CIFRI ARGCURE" technology was commercialized on 7 July 2021 through Agrinnovate India Ltd. AGIN to Glaucus Agrochem Pvt. Ltd. Park Circus, Ballygunge, Kolkata, West Bengal 700017. The license agreement was signed between ICAR-CIFRI and the licensee in virtual presence of DDG (FS), ADG (Inland Fisheries) and CEO, AGIN.

Release of new technology

- Plant based sedative for fish "CIFRI Fish Tanavhari" was released by Dr. Trilochan Mohapatra, Secretary DARE and DG, ICAR on 6 October 2021 at ICAR-CIFRI, Barrackpore.

Signing of MoU between ICAR-CIFRI and Fakir Mohan University, Odisha

Memorandum of Understanding signed

With Government Department/Public Institution/Public Sector unit

- A MoU was signed between ICAR-CIFRI and The Directorate of Fisheries, Govt. of Odisha on 28 October 2021 for ''Environmental and aquatic animal health monitoring in Hirakud reservoir under cage culture programme"

For technology commercialization

- A MoU was signed between Glaucus Agrochem Pvt. Ltd., Kolkata, Agrinnovate India Ltd. (AgIn) and ICAR-CIFRI, Barrackpore on 7 July 2021 at Barrackpore for License agreement of "CIFRI ARGCURE" Technology.

For research collaboration

- A MoU was signed between ICAR-CIFRI, Barrackpore and ICAR-NBAIR, Karnataka on 26 July 2021 for the joint implement project ''Studies on exploitation of insects as food and feed."

For academic collaboration

- A MoU was signed between ICAR-CIFRI, Barrackpore and West Bengal University of Animal and Fishery Sciences (WBUAFS), West Bengal, on 27 January 2021 for Academic and research collaboration in the field of inland fisheries.
- ICAR-CIFRI inked a MoU with Fakir Mohan University, Balasore, Odisha for academic and research collaboration, and student guidance on 8 February 2021.
- A MoU was signed between ICAR-CIFRI, Barrackpore and Munger University, Bihar on 18 March 2021 for academic and research collaboration in the field of inland fisheries.

For technical guidance

- A MoU was signed between ICAR-CIFRI, Barrackpore and Pradhan NGO on 30 June 2021 for technical guidance and support for fisheries stock enhancement and fisheries management.

Technology leaflets published

PUBLICATIONS

Research Papers

Ajina SM, Gladston Y, SriHari M, Kiruba-Sankar R, Pavan-Kumar A, Dam Roy S and Jaiswar AK (2021). New distributional record of black lash scorpion fish, *Portinus nigerinium* Eschmeyer, 1983 from Andaman waters, Eastern Indian Ocean. *Thalassas*: *An International Journal of Marine Sciences,* doi.org/10.1007/s41208-021-00360-x

Alam A, Kumar J, Sarkar UK, Jha DN, Srivastava SK, Kumar V and Das BK (2021). Evaluating the effectiveness of fingerling stocking and ecological perspectives in enhancing fish harvest in a large tropical reservoir of Northern India. *Environment, Development and Sustainability,* 23:13221-13241. https://doi.org/10.1007/s10668-020-01207-w

Baitha R, Manna SK, Koushlesh S, Das N, Bera AK, Prasad K, Raghavan S and Das BK (2021). Occurrence, morpho-histopathological characterization and infection dynamics of *Posthodiplostomum* sp. (Strigeidida: Diplostomidae) in cyprinid fishes of River Ganga. *Folia Biologica (Krakow),* 69(3):113-120. doi.org/10.3409/fb_ 69-3.13

Bandopadhyay C, Manna SK, Samanta S, Chowdhury AN, Maitra N, Mohanty BP, Sarkar K and Mukherjee SK (2021). Culture-dependent study of arsenic reducing bacteria in deep aquatic sediments of Bengal Delta. *Environmental Science and Pollution Research*, 28:57440-57448. doi.org/10.1007/s11356-021-16312-0

Banik SK, Suresh VR and Manna RK (2021). Seasonal variability of water quality index in the Hooghly Estuary. *Journal of Inland Fisheries Society India,* 53: 75-80

Barik SK, Bramha S, Samanta S, Pattanaik AK, Patel RK, Bastia TK, Samal RN, Behera D and Rath P (2021). Phosphorus sorption behavior of the largest brackish water lagoon, South Asia. *Journal of Earth System Science,* 130: 48 doi.org/10.1007/s12040-020-01550-6

Basu S, Bhattacharyya S, Gogoi P, Das Gupta S and Das SK (2021). Variations of surface water quality in selected tidal creeks of Sagar Island, Indian Sundarban eco-region: a multivariate approach. *Applied Water Science,* 11(3):63

Basu S, Chandra A, Gogoi P and Bhattacharyya S (2021). A multi-decadal comparative analysis of a set of physicochemical and nutrient parameters in the tropical tidal creeks of Indian Sundarban Mangrove Biosphere Reserve. *Thalassas: An International Journal of Marine Sciences*, DOI: 10.1007/s41208-020-00273-1

Basu S, Chandra A, Gogoi P and Bhattacharyya S (2021). Organochlorine pesticides and heavy metals in the zooplankton, fishes, and shrimps of tropical shallow tidal creeks and the associated human health risk. *Marine Pollution Bulletin*, 165(1–4):112170

Behera BK, Chakraborty HJ, Patra B, Rout AK, Dehury B, Das BK and Mohapatra T (2020). Metagenomic analysis reveals bacterial and fungal diversity and their bioremediation potential from sediments of river Ganga and Yamuna in India. *Frontiers in microbiology*, 11: 2531

Behera BK, Dehury B, Rout AK, Patra B, Mantri N, Chakraborty HJ and Rai A (2021). Metagenomics study in aquatic resource management: Recent trends, applied methodologies and future needs. *Gene Reports*, 25: 101372

Behera BK, Paria P, Das A and Das BK (2022). Molecular identification and pathogenicity study of virulent *Citrobacter freundii* associated with mortality of farmed *Labeo rohita* (Hamilton 1822), in India. *Aquaculture*, 547: 737437

Behera BK, Patra B, Chakraborty HJ, Sahu P, Rout AK, Sarkar DJ and Mohapatra T (2020). Metagenome analysis from the sediment of river Ganga and Yamuna : In search of beneficial microbiome. *PloS One*, 15(10): e0239594

Behera PR, Parida PK, Karna SK, Raman RK, Suresh VR, Behera BK and Das BK (2020). Trophic fingerprinting of Chilika, a Ramsar site and the largest lagoon of Asia using Ecopath. *Regional Studies in Marine Science*, 37: 101328

Bera AK, Das BK, Mohanty D, Chakraborty N, Dey S, Malick RC, Manna RK, Majhi P, Lianthuamluaia

L, T. Tasso, Swain HS, Sahoo AK, Chowdhury H and Sarkar UK (2021). Multiple etiological factors led septicemic disease with mass mortality of fishes in a freshwater reservoir of Odisha, India. *Aquaculture*, 548(2): 737696

Bera AK, Das N, Bhattacharya S, Malick RC, Swain HS, Chowdhury H, Sinha A, Manna SK, Sarkar UK and Das BK (2021). Molecular confirmation of metacercaria of *Clinostomum complanatum* recovered from one-stripe spiny eel *Macrognathus aral*. *Aquaculture Research*, 52: 4362-4370. https://doi.org/10.1111/are.15273

Bhakta D, Das BK, Kamble SP, Som S, Sahoo AK, Chandra G and Samanta S (2021). First record of walton's mudskipper *Periophthalmus waltoni* Koumans, 1941 from Narmada estuarine region of Gujarat, India. *National Academy Science Letters*, 44(3): 199-201

Bhakta D (2020). A review of food and feeding habits, reproductive biology of *Osteobrama cotio* (Hamilton, 1822). *Research Biotica*, 2(4):141-144

Bhakta D and Das SK (2021). Sciaenid species diversity and associated gears at in Hooghly-Matlah estuary of West Bengal, India. *Journal of Marine Biological Association of India*, 63(1): 56-61

Bhakta, D, Das BK, Kamble SP, Das SK, Samanta S and Mitra S (2021). New record of two isopods *Alitropus typus* and *Tachaea spongillicola* from riverine freshwater fishes in the river Tapti. *Journal of Parasitic Diseases*, 1-6. https://doi.org/10.1007/s12639-021-01449-z

Bhakta, D, Manna RK and Bera AK (2021). Milkfish, *Chanos chanos* a candidate species for open water stock enhancement with potentiality in augmenting fish production. *Aquaculture Spectrum*, 4(2): 11-21

Bhakta, D, Das, SK, Das BK and Nagesh TS (2021). Biology of reproduction in *Otolithoides pama* (Hamilton, 1822) in Hooghly-Matlah Estuary of West Bengal, India. *Indian Journal of Fish*eries, 68(1): 27-39. DOI: 10.21077/ijf.2021.68.1.90574-04

Bhattacharjya BK, Yadav AK, Debnath D, Saud BJ, Verma VK, Yengkokpam S, Sarkar UK and Das BK (2021). Effect of extreme climatic events on fish seed production in Lower Brahamaputra Valley, Assam, India: Constraint analysis and adaptive strategies. *Aquatic Ecosystem Health & Management*, 24(3): 39-46. (Special issue) (IF: 0.86)

Bhowmick S, Sajina AM, Samanta S, Paul SK, Sudheesan D, Nag SK, Kumar V and Baitha R (2020). Application of Health Assessment Index for assessing the ecological health of River Mahanadi. *Journal of the Inland Fisheries Society of India,* 52(2): 150-156

Borah, N, Das SK, and Bhakta D (2020). Length-weight relationship and relative condition factor of *Polynemus paradiseus* (Linnaeus, 1758) from Hooghly-Matlah estuary, West Bengal. *Journal of the Inland Fisheries Society of India,* 52(2): 204-209

Chakraborty N, Das BK, Das AK, Manna RK, Chakraborty HJ, Mandal B, Bhattacharjya BK, Raut SS (2021). Antibacterial prophylaxis and molecular docking studies of ketone and ester compounds isolated from *Cyperus rotundus* L. against *Aeromonas veronii*. *Aquaculture Research,* DOI: 10.1111/are.15670

Chirwatkar, BB, Das SK and Bhakta D (2021). Length-weight relationship, relative condition factor and morphological studies of *Arius arius* (Hamilton, 1822) in Hooghly-Matlah estuary, West Bengal. *Indian Journal of Geo-Marine Sciences*, 50(01): 60-66

Chirwatkar BB, Das SK, Bhakta D, Nagesh TS and Behera S (2021). Growth, mortality and stock assessment of *Arius arius* (Hamilton, 1822) from Hooghly-Matlah estuary, West Bengal. *Indian Journal of Geo-Marine Sciences*, 50(04): 302-309

Chowdhury AA, Hossain MY, Mawa Z, Khatun D, Islam MA, Rahman MA, Hasan MR, Rahman O, Konok RH, Rahman MA and Parvin MF (2021). Some biological aspects of the spotted snakehead *Channa punctata* (Bloch, 1793) in the wetland ecosystem, Gajner Beel, North-western Bangladesh. *Indian Journal of Fisheries*, 68(3): 17-26

Dam Roy S, Saravanan KR, Sankar Kiruba J, Praveen Raj and Varghese B (2021). Insights of inland aquaculture in tropical archipelago of Andaman and Nicobar, India. *Journal of Andaman Science Association*, 26 (1): 39-43

Das BK, Behera BK, Chakraborty HJ, Paria P, Gangopadhyay A, Rout AK and Rai A (2020). Metagenomic study focusing on antibiotic resistance genes from the sediments of River Yamuna. *Gene*, 758: 144951

Das BK, Bhakta D, Kumar L, Nair SM, Koushlesh SK, Sajina AM, Roshith CM and Samanta S (2021). Ichthyofaunal diversity of the major Indian rivers: A review. *Journal of the Inland Fisheries Society of India*, 53(1&2): 22-35

Das BK, Ray A, Johnson C, Verma SK, Alam A, Baitha R, Manna RK, Roy S and Sarkar UK (2021). The present status of ichthyofaunal diversity of river Ganga India: Synthesis of present v/s past. *Acta Ecologica Sinica*, doi.org/10.1016/j.chnaes.2021.10.008

Das BK, Roy A, Som S, Chandra G, Kumari S, Sarkar UK, Bhattacharjya BK, Das AK and Pandit A (2021). Impact of COVID-19 lockdown on small-scale fishers (SSF) engaged in floodplain wetland fisheries: evidences from three states in India. *Environmental Science and Pollution Research*, 6:1-12

Das P, Behera BK, Chatterjee S, Das BK and Mohapatra T (2020). *De novo* transcriptome analysis of halotolerant bacterium *Staphylococcus* sp. strain P-TSB-70 isolated from East coast of India: In search of salt stress tolerant genes. *PloS One*, 15(2): e0228199

Das Sarkar S, Sarkar UK, Naskar M, Roy K, Bose AK, Nag SK, Karnatak G, Das BK (2021). Effect of climato-environmental parameters on chlorophyll a concentration in the lower Ganga basin, India. *Revista de Biología Tropical*, 69(1): 60-76

Debnath D, Bhattacharjya BK, Yengkokpam S, Sarkar UK, Paul P and Das BK (2021). Ecosystem vulnerability of floodplain wetlands of the Lower Brahmaputra Valley to climate and anthropogenic factors. *Aquatic Ecosystem Health and Management*, 24(3): 57-71

Debnath D, Das BK, Yengkokpam S, Das P, Yadav AK, Sharma N, Borah S, Ray BC, Kakati A, Sarkar UK and Bhattacharjya BK (2021). Evaluating growth, production and economics of a new candidate species *Labeo bata* in cages: a regional model for table fish production in floodplain wetlands of North East India. *Aquaculture,* 546: 737344

Devi MS, Xavier KM, Singh AS, Edwin L, Singh VV and Shenoy L (2021). Environmental pressure of active fishing method: A study on carbon emission by trawlers from north-west Indian coast. *Marine Policy*, 127: 104453

Dong H, Roy S, Zheng X, Kumar V, Das BK, Duan Y, Sun Y and Zhang J (2021). Dietary teprenone enhances non-specific immunity, antioxidative response and resistance to hypoxia induced oxidative stress in *Lateolabrax maculatus*. *Aquaculture*, 533: 736126

Dwivedi AK, Sarkar UK, Mir JI, Tamot P and Vyas V (2021). Age and growth of the Indian major carp, *Cirrhinus mrigala* (Hamilton, 1822) (Cypriniformes: Cyprinidae) from six drainages of Ganges basin, India, *Biology Bulletin*, 48(5): 569-576

Ekka A, Pandit A, Katiha PK and Biswas DK (2020). Economic value of ecosystem services of Gosaba estuarine ecosystem of Sundarbans. *Journal of Inland Fisheries Society of India,* 52(2): 157-163

Ekka A, Pande S, Jiang Y and der Zaag PV (2020). Anthropogenic modifications and river ecosystem services: A landscape perspective. *Water*, 12(10): 2706

Gogoi P, Ahirwal SK, Chakraborty SK, Bhattacharjya BK, Jaiswar AK, Singh J and Behera P (2021). Investigations on age, growth and mortality parameters of *Ailia coila* Hamilton, 1822) (Siluriformes: Ailiidae) from Brahmaputra river system of Assam, India. *Indian Journal of Fisheries,* 68(2): 8-14

Gogoi P, Kumari S, Sarkar UK, Lianthuamluaia L, Puthiyottil M, Bhattacharjya BK and Das BK (2021). Dynamics of phytoplankton community in seasonally open and closed wetlands in the Teesta–Torsa basin, India, and management implications for sustainable utilization. *Environmental Monitoring and Assessment*, 193(12): 1-25

Gogoi P, Sinha A, Tayung T, Naskar M, Das Sarkar S, Ramteke MH, Das SK, Kumar KL, Suresh VR and Das BK (2021). Unravelling the structural changes of periphyton in relation to environmental variables in a semilotic environment in the Sundarban eco-region, India. *Arabian Journal of Geosciences*, 14(19): 1-16

Hasan, MR, Hossain MY, Mawa Z, Tanjin S, Rahman MA, Sarkar UK and Ohtomi J (2021). Evaluating the size at sexual maturity for 20 fish species (Actinopterygii) in wetland (Gajner Beel) ecosystem, north-western Bangladesh through multi-model approach: A key for sound management. *Acta Ichthyologica et Piscatoria,* 51(1): 29-36

Jana C, Alam NM, Ghosh BN, Raja P and Sharma NK (2021). Modelling and mapping weekly rainfall for crop planning in north-western Himalayan states. *Indian Journal of Agricultural Sciences*, 91 (10): 1546–8

Johnson C, Sarkar UK, Koushlesh SK, Das AK and Naskar BK (2021). Fish assemblage, ecosystem status and potential impact of Nile tilapia in Halali Reservoir of Central India. *Environment, Development and Sustainability*, doi.org/10.1007/s10668-021-01756-8

Karnatak G, Das BK, Puthiyottil M, Tayung T, Kumari S, Lianthuamluaia L, Sarkar UK, Behera BK, Tiwari VK, Chadha NK and Das AK (2021). Environmental parameters and stocking density influence growth, feed utilization and economics of butter catfish, *Ompok bimaculatus* (Bloch, 1794) production in floating net cages in a large tropical reservoir, India. *Environmental Science and Pollution Research*, 28(42): 59720-59730. doi.org/10.1007/s11356-021-14900-8

Karnatak G, Sarkar UK, Puthiyottil M, Lianthuamluaia L, Ghosh BD, Baksi S, Das AK and Das BK (2021). Enhancing adaptive capacity of wetland fisheries through pen culture in the phase of changing climate: a case study from a tropical wetland. *Aquatic Ecosystem and Health Management*, 24(3): 83-93. https://doi.org/10.14321 /aehm.024.03.10

Khan MF, Panikkar P and Das BK (2021). Population dynamics of Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) at Kelavarappalli Reservoir in Tamil Nadu. *Journal of the Inland Fisheries Society of India*, 53(1&2): 57-65

Khan MF, Panikkar P, Salim SM, Leela RV, Sarkar UK, Das BK and Vijaykumar ME (2021). Modeling impacts of invasive sharp tooth African catfish *Clarias gariepinus* (Burchell 1822) and Mozambique tilapia *Oreochromis mossambicus* (Peters, 1852) on the ecosystem of a tropical reservoir ecosystem in India. *Environmental Science and Pollution Research*, 28(41): 58310-58321

Kiruba Sankar R, Praveenraj J, Saravanan K, Lohith Kumar K, Haridas H and Biswas U (2021) Stakeholder perceptions and strategies for management of non-native freshwater fishes of Andaman and Nicobar Islands, India. *Aquatic Ecosystem Health & Management,* 24 (2): 96-104

Kripa MK, Lele N, Panda M, Kumar Das S, Nivas AH, Divakaran N, Sawant A, Naik-Gaonkar S, Pattnaik AK, Samal RN, Thangaradjou T, Saravanakuma A, Bernard FR, Dam Roy S, Kiruba-Sankar R, Lohith Kumar K, Angel RJ, Raghavan P, Mankad AU and Murthy TVR (2021). Biodiversity assessment of Indian mangroves using *in situ* observations and remotely sensed data. *Biodiversity,* 21: 1-19

Kumar A, Das SK and Bhakta D (2021). Temporal variations in bio-indices of *Oreochromis niloticus* (Linnaeus, 1758) in East Kolkata wetlands, India. *Journal of the Inland Fisheries Society of India,* 53(1&2): 66-74

Kumar, A, Das, SK and Bhakta D (2020). Dynamics of temporal foraging and feeding index of *Labeo rohita* (Hamilton, 1822) in East Kolkata wetlands, a Ramsar site. *Journal of the Inland Fisheries Society of India,* 52(2): 164-172

Kumar SV, Das Sarkar S, Das BK, Sarkar DJ, Gogoi P, Maurye P, Mitra T, Talukder AK, Ganguly S, Nag SK, Munilkumar S and Samanta S (2021). Sustainable biodiesel production from microalgae *Graesiella emersonii* through valorization of garden wastes-based vermicompost. *Science of the Total Environment*, 807: 150995. doi.org/10.1016/j.scitotenv.2021.150995

Kumar SV, Raman RK, Talukder A, Mahanty A, Sarkar DJ, Das BK, Bhowmick S, Samanta S, Manna SK and Mohanty BP (2021). Arsenic bioaccumulation and identification of low-arsenic-accumulating food fishes for aquaculture in arsenic-contaminated ponds and associated aquatic ecosystems. *Biological Trace Element Research,* doi.org/10.1007/s12011-021-02858-0

Kumar V, Baruah K and Bossier P (2021). Bamboo powder protects gnotobiotically-grown brine shrimp against AHPND-causing *Vibrio parahaemolyticus* strains by cessation of PirAB^{VP} toxin secretion. *Aquaculture*, 539:736624

Kumar V, Roy S, Behera BK and Das BK (2021). Biofloc microbiome with bioremediation and health benefits. *Frontiers in microbiology*, 12:741164. doi:10.3389/fmicb.2021.741164

Kumar V, Roy S, Behera BK, Bossier P and Das BK (2021). Acute hepatopancreatic necrosis disease (AHPND): virulence, pathogenesis and mitigation strategies in shrimp aquaculture. *Toxins*, 13(8): 524. 10.3390/toxins13080524

Kumar VS, Raman RK, Talukder A, Kakati A, Bhowmick S, Manna SK, Samanta S, Mohanty BP (2020). Clinico-epidemiological study of

arsenicosis in arsenic endemic areas of West Bengal, India. *Journal of Inland Fisheries Society of India,* 52 (1): 68-74

Kumari K, Naskar M, Aftabuddin M, Das Sarkar S, Ghosh BD, Sarkar UK, Nag SK, Jana C and Das BK (2021). Evaluation of three prokaryote primers for identification of prokaryote community structure and their abode preference in three distinct wetland ecosystems. *Frontiers in Microbiology*, doi.org/10.3389/fmicb.2021.643945

Kumari K, Sinha A, Koushlesh SK, Das Sarkar S, Borah S, Baitha R and Das BK (2020). Genetic differentiation and phylogenetic relationship of 11 Asian Sisorinae genera (Siluriformes: Sisoridae) with new record of *Pseudolaguvia foveolata*. *Mitochondrial DNA Part A*, 31(1):35-41

Kumari S, Jaiswar AK, Jahageerdar S, Abidi ZJ, Chakraborty SK, Kumar T and Sarkar UK, (2021). Inter and intra variation of sciaenid fishes (Teleostei: Perciformes: Sciaenidae) through osteological and morphological approach from North West Coast of Indian waters, Arabian Sea. *Journal of Experimental Zooogy India,* 24: 1409-1421. https://connectjournals.com/03895.2021.24.1409

Maity SB, Kushwaha BP, Singh S, Kumar A, Nag SK, Das SK, Rai AK and Dixit AK (2021). Milk Fatty acid profile of Indian dairy cows reared under organic and conventional feeding management. *Indian Journal of Animal Sciences,* 91(2): 155-158

Maity A, Saha B, Pandit A, Patra P (2021). Farming practices of *Litopenaeus vannamei*: An empirical study in West Bengal, India, *Journal of Inland Fisheries Society of India,* 53(1&2): 101-108

Manna RK, Ray A, Bayen S, Bera T, Palui D, Das BK (2021). First record of exotic alligator gar, *Atractosteus spatula* (Actinopterygii: Lepisosteiformes: Lepisosteidae), from Ganga River system, India: A possible threat to indigenous riverine fish diversity. *Acta Ichthyologica et Piscatoria* 51(4): 385–391. doi.org/10.3897/aiep.51.72676

Manna RK, Salim S, Vijaykumar ME, Kumar L, Roshith CM, Sharma SK, Mandi RC and A. Roychowdhury (2021). Crab as bait to lure carnivorous fishes in hook and line fishery in River Cauvery. *Fishery Technology,* 58: 263-266

Manna SK (2021). Novel coronavirus vulnerability: Metabolic derangements and altered dehydrogenase enzyme activities are central to the virus pathogenesis in human, bat and other animals. *Exploratory Animal and Medical Research*, 11(1): 1-9

Manna SK, Bera AK, Sarkar DJ, Nag SK, Baitha R, Kumar A, Krishna N, Ravindran R, Patil PK and Das BK (2021). Pharmacokinetics, bioavailability and withdrawal period of antibiotic oxytetracycline in catfish *Pangasianodon hypophthalmus*. *Environmental Toxicology and Pharmacology,* 89. doi.org/10.1016/j.etap.2021.103778

Manna SK, Das N, Bera AK, Baitha R, Debnath D, Panikkar P, Nag SK, Sarkar S Das, Das BK and Patil PK (2021). Reference haematology and blood biochemistry profiles of striped catfish (*Pangasianodon hypophthalmus*) in summer and winter. *Aquaculture Reports*, 21: 100836. doi.org/10.1016/j.aqrep.2021.100836

Maurye P, Basu A, Jana C, Devi MS, Kumari K and Naskar M (2021). Mobile electrophoresis kit for high school students: Scientific practices with innovation. *Biochemistry and Molecular Biology Education*, 50: 75-90. doi.org/10.1002/bmb.21588

Maurye P, Basu A, Kumari K, Dey P, Sen S and Devi MS (2021). A unified quartet DNA gel electrophoresis instrument with integrated agarose gel casting, electrophoresis, staining, and imaging facilities. *Separation Science Plus*, 4(9): 337-346

Meena DK, Sahoo AK, Jayant M, Sahu NP, Srivastava PP, Swain HS and Das BK (2021). Bioconversion of *Terminalia arjuna* bark powder into a herbal feed for *Labeo rohita*: Can it be a sustainability paradigm for Green Fish production? *Animal Feed Science and Technology*, 284:115132. doi.org/10.1016/j.anifeedsci.2021.115132

Meena DK, Sahu NP, Srivastava PP, Jadhav M, Prasad R, Mallick RC and Das BK (2021). Effective valorisation of facile extract matrix of *Terminalia arjuna* (Roxb) against elite microbes of aquaculture industry–a credence to bioactive principles: Can it be a sustainability paradigm in designing broad spectrum antimicrobials? *Industrial Crops and Products*, 171: 113905

Meena DK, Sahoo AK, Srivastava PP, Sahu NP, Jadhav M, Gandhi M, Swain, HS, Borah S, Das BK (2021). On valorization of solvent extracts of *Terminalia arjuna* (arjuna) upon DNA scission and free radical scavenging improves coupling responses and cognitive functions under in vitro conditions.

Scientific Reports, doi.org/10.1038/s41598-021-88710-w

Meetei WA, Bhakta D, Kamble SP, Chanu TN, Koushlesh SK, Gogoi P, Das SK, Baitha RJ, Solanki K, Suresh VR, Samanta S and Das BK (2021). Macrobenthic invertebrates' community structure of river Tapti, a westerly flowing river in peninsular India. *Journal of Inland Fisheries Society of India*, 52(1): 60-67

Monga S, Rana Rajesh K and Pandit A (2021). Impact of Government initiatives on total factor productivity of pigeon pea cultivation in India. *Indian Journal of Agricultural Research*, 10.18805/IJARe.A-5749

Mukherjee S, Pal S, Paria P, Bhattacharyya S, Ghosh K, Pal A, Ghosh D, Singh OK, Sarkar P, Behera BK, Das SCS, Bhand S and Bhattacharyya N (2021). On-spot biosensing device for organophosphate pesticide residue detection in fruits and vegetables. *Current Research in Biotechnology*, 3: 308-316

Nair SM, Kumari K, Kumar AP, Raghavan R and Jaiswar AK (2021). The identity and distribution of striped bagrid catfish, *Mystus tengara* (Hamilton 1822) revealed through integrative taxonomy. *Molecular Biology Reports*, 49: 351-361

Nair SM, Gangan SS, Raut S, Raghavan R, Kumar AP, Singh LK and Jaiswar, AK (2021). Otoliths as taxonomic tool to identify catfishes of the genus *Mystus* (Teleostei: Bagridae) from India. *Indian Journal of Fisheries,* 68(1): 1-8

Naskar M, Das Sarkar S, Sahu SK, Gogoi P and Das BK (2021). Impact of barge movement on phytoplankton diversity in a river: A Bayesian risk estimation framework. *Journal of Environmental Management*, 296: 113227

Naskar M, Sarkar UK, Puthiyottil M, Karnatak G, Saha S, Bandopadhyay A, Bakshi S, Das Ghosh B and Das BK (2021). Assessing vulnerability of wetland fisheries to climate change: a stakeholders' perception-based approach. *Climate and Development*, DOI: 10.1080/17565529.2021.1956410

Nayak P, Dam Roy S, Dube K and Kohli MPS (2021). A comparison of growth and colouration of *Carassius auratus* (Linnaeus, 1758) under different culture systems. *Journal of Andaman Science Association,* 24(2): 106-113

Ngasotter S, Waikhom D, Sharma S, Meitei MM, Mangang YA, Irungbam SK, Devi MS and Singh AS (2021). Characteristics and mechanism of potential probiotics with special reference to lactic acid bacteria from traditional fermented fish products: A review. *Journal of Experimental Biology and Agricultural Sciences*, 9(3): 263-275

Pandit A, Das BK, Chandra G, Roy A, Debroy P, Yadav AK, and Biswas DK (2021). Impact of cage culture in reservoir on the livelihood of fishers: A case study in Jharkhand, India. *Indian Journal of Fisheries*, 68(1): 76-81

Panikkar P, Khan MF, Sarkar UK and Das BK (2021). Changing food webs of Indian aquatic ecosystems under the threats of invasive species: An overview. *Aquatic Ecosystem Health and Management*, 24(2): 24-32

Parakkandi J, Das BK, Saha A, Ramya VL and Gunasekharan J (2021). Cage culture of *Etroplus suratensis* (Bloch, 1790) in a tropical reservoir in India and associated impacts on water and sediment quality. *Journal of the World Aquaculture Society*, 52, https://doi.Org/ 10.1111/jwas.12828

Parakkandi J, Saha A, Sarkar UK, Das, BK., Puthiyottil, M, Muhammadali, SA, Ramteke M, Johnson C. and Kumari, S (2021). Spatial and temporal dynamics of phytoplankton in association with habitat parameters in a tropical reservoir, India. *Arabian Journal of Geosciences*, 14**:** 827. doi.org/10.1007/s12517-021-07194-0

Paria P, Behera BK, Mohapatra PKD and Parida PK (2021). Virulence factor genes and comparative pathogenicity study of *tdh*, *trh* and *tlh* positive *Vibrio parahaemolyticus* strains isolated from Whiteleg shrimp, *Litopenaeus vannamei* (Boone, 1931) in India. *Infection, Genetics and Evolution*, 95: 105083

Parida PK, Lianthuamluaia L, Kayal T, Das BK, Sarkar UK, Koushlesh SK and Behera BK (2021). Spatio-temporal changes in ecology and fisheries in a tropical large Indian reservoir: Insights from a long-term data series for sustainable development. *Environmental Science and Pollution Research International*, doi.org/10.21203/rs.3.rs-885951/v1

Pathak AK, Sarkar UK, Dayal R, Chaturvedi R and Kumar R (2021). Freshwater fish diversity database of Central India: Implementation and utility. *Indian Journal of Fisheries*, 68(2): 43-51

Paul TT, Manoharan S, Salim SS, Sreenath KR, Sarkar UK, Landge A and Das BK (2021). Understanding the trade-offs in tropical reservoir fishery in a protected ecosystem in a socio-ecological perspective, *Indian Journal of Fisheries*, 68(4):118-127. DOI:10.21077/ijf.2021.68.4.107880-13

Paul TT, Panikker P, Sarkar UK, Manoharan S, Kuberan G, Sreenath K, Sreenath R, Zachariah PU and Das BK (2021). Assessing vulnerability and adopting alternative climate resilient strategies for livelihood security and sustainable management of aquatic biodiversity of Vembanad lake in India. *Journal of Water and Climate Change*, 12(4): 1310-1326

Petchimuthu M, M Rosalind George, Rijijohn K and Kumar VS (2020). Isolation, molecular characterization and virulence study (pathogenesis) of *Photobacterium damselae* subsp. *damselae* isolated from sea-cage and wild fishes. *Indian Journal of Animal Research,* (55): 679-688

Phukan B, Talukdar A, Kalita R, Nath BB, Sharma N, Mir IN, Annam PK and Baishya S (2021). Effects of dietary *Leucas aspera* levels on growth performance, nutrient utilization, digestive enzymes and physio-metabolic and health status of bagrid catfish, *Rita rita* (Hamilton, 1822). *Aquaculture Research*, 53 (1): 22–35

Puthiyottil M, Sarkar UK, Karnatak G, Lianthuamluaia L, Das AK, Koushlesh SK, Kumari S and Das BK (2021). Effectiveness of carp seed stocking in large reservoir ecosystems of India. *International Review of Hydrobiology*, 106(5-6): 259-276

Puthiyottil M, Sarkar UK, Lianthuamluaia L, Karnatak G, Hassan MA, Kumari S, Ghosh BD and Das BK (2021). Floodplain wetland of Eastern India in a changing climate: Trophic characterization, ecological status, and implications for fisheries. *Aquatic Ecosystem Health and Management*, 24(3): 47-56

Ramya VL, Behera BK, Das BK, Gopalakrishna, AP and Khan MP (2021). Stock Structure analysis of the endemic fish, *Barbodes carnaticus* (Jerdon, 1849) for conservation in a biodiversity hotspot, *Environmental Science and Pollution Research International*, 28: 55277–55289

Ramya VL, Jesna PK, Saha A, Mol SS, Panikkar P, Vijaykumar ME, Karthikeyan M, Sarkar UK and Das BK (2021). Habitat based fish assemblage and distribution pattern in a large reservoir of peninsular India, *Arabian Journal of Geosciences,* 14: 689. doi.org/10.1007/s12517-021-07059-6

Ray A, Johnson C, Manna RK, Baitha R, Gupta SD, Tiwari NK, Dasgupta S and Das BK (2021). Establishment and impact of exotic *Cyprinus carpio* (Common Carp) on native fish diversity in Buxar stretch of River Ganga, India. *Aquatic Ecosystem Health and Management*, 24(2): 52-63. doi.org/10.14321/aehm.024.02.09

Roshith CM, Manna RK, Suresh VR, Samanta S, Baitha R, Koushlesh SK, Mol SS, Kumar L, Sharma SK, Chowdhury AR, Vijayakumar ME, Pal R and Das BK (2021). Length-weight relationship of six indigenous fish species from the River Cauvery and its estuary, India. *Journal of Applied Ichthyology*, 37: 795–798. doi.org/10.1111/jai.14190

Rout AK, Acharya V, Maharana D, Dehury B, Udgata SR, Jena R and Behera BK (2021). Insights into structure and dynamics of extracellular domain of Toll-like receptor 5 in *Cirrhinus mrigala* (mrigala): A molecular dynamics simulation approach. *PloS one*, 16(1): e0245358

Rout AK, Paramanik S, Dehury B, Acharya V, Swain HS, Pradhan SK and Das BK (2020). Elucidating the molecular interaction of Zebrafish (*Danio rerio*) peptidoglycan recognition protein 2 with diaminopimelic acid and lysine type peptidoglycans using in silico approaches. *Journal of Biomolecular Structure and Dynamics*, 38(12): 3687-3699

Roy A, Som S, Bhattacharyya S, Das BK, Pandit A and Yadav AK (2021). Impact of trainings in increasing farmers income: Evidence from Bihar, India. *Journal of Environmental Biology,* 42: 499-504

Saha A, Jesna PK, Ramya VL, Mol SS, Panikkar P, Vijaykumar ME, Sarkar UK and Das BK (2021). Evaluation of spatio-temporal variations in physico-chemical limnology, trophic status and cyanobacterial diversity of an impacted tropical reservoir, India for its sustainable management. *International Journal of Environmental Analytical Chemistry*, DOI : 10.1080/03067319.2021. 1919654

Saha, A, Jesna PK, Ramya VL, Mol SS, Panikkar P, Vijaykumar ME, Sarkar UK and Das BK (2021). Phosphorus fractions in the sediment of a tropical reservoir, India: Implications for pollution source identification and eutrophication. *Environmental Geochemistry and Health*, 29: 1-21

Saha, A, Ramya VL, Jesna PK, Mol SS, Panikkar P, Vijaykumar ME, Sarkar UK and Das BK (2021). Evaluation of spatio-temporal changes in surface water quality and their suitability for designated uses, Mettur Reservoir, India. *Natural Resources Research*, 30(2): 1367-94

Sahoo AK, Bhakta D, Meena DK, Sadhukhan D, Das T, Kamble SP, Majhi, D, Samanta S and Das BK (2021). Isopod parasite, *Nerocila depressa* Milne Edwards, 1840 infestation in *Thryssa stenosoma* Wongratana, 1983, as a first record from Narmada estuary, west coast of India. *Journal of Parasitic Diseases*, doi.org/10.1007/s12639-021-01451-5

Sahoo AK, Sadhukhan D, Meena DK, Das T, Raman RK, Udgata SK, Shashikala KB, Mitra S and Das BK (2021). Wild fish of aquaculture importance, as new host for isopod *Tachaea spongillicola* Stebbing, 1907 infestation with emphasis on prevalence and histopathology: A case report. *Aquaculture*, 547: 737436. doi.org/10.1016/j.aquaculture.2021.737436

Sahoo AK, Das BK, Lianthuamluaia L, Raman RK, Meena DK, Roshith CM, Chowdhury AR and Sadhukhan D (2021). Dynamics of river flows towards sustaining floodplain wetland fisheries under climate change: A case study. *Aquatic Ecosystem Health and Management*, 24(3): 72-82

Sajina AM, Sarkar UK, Canciyal J, Das, BK, Saha A, Mishal P, Jesna PK, Ramteke M. and Das AK (2021). Influence of cage farming and environmental parameters on spatio-temporal variability of fish assemblage structure in a tropical reservoir of Peninsular India. *Limnologica*, 91: 125925

Sau, S, Nagesh, TS, Trivedi, RK Abraham TJ, Dubey SK, Rout SK, Biswas I and Bhakta D (2021). Spatial distribution and diversity inventory of macro-benthic fauna in the Indian Sundarban. *Indian Journal of Fisheries,* 68(1): 9-18

Samanta S, Kumar V, Nag SK, Raman RK, Saha K, Bandyopadhyay S, Mohanty BP and Das BK. (2020). Metal contaminations in sediment and associated ecological risk assessment of river Mahanadi, India. *Environmental Monitoring and Assessment*, 192 (Suppl. 1): 810. doi.org/10.1007/s10661-020-08708-1

Sankar RK, Krishnan P, George G, Lohith Kumar K, Angel RJ, Saravanan K and Roy SD (2021). Fisheries governance in the tropical archipelago of Andaman and Nicobar – opinions and strategies for sustainable management. *Journal of Coastal Conservation,* 25:1-3

Sarkar DJ, Das Sarkar S, Das BK, Praharaj JK, Mahajan DK, Purokait B, Mohanty TR, Mohanty D, Gogoi P, Kumar S and Behera BK (2021). Microplastics removal efficiency of drinking water treatment plant with pulse clarifier. *Journal of Hazardous Materials*, 413(1):125347. doi.org/10.1016/j.jhazmat.2021.125347

Sarkar DJ, Das Sarkar S, Das BK, Sahoo BK, Das A, Nag SK, Manna RK, Behera BK and Samanta S (2021). Occurrence, fate and removal of microplastics as heavy metal vector in natural wastewater treatment wetland system. *Water Research*, 192: 116853. doi.org /10.1016/j.watres.2021.116853

Sarkar DJ, Shakil NA, Kumar J, Rana VS, Kar A, Behera BK and Das BK (2021). Macroporous open cell polyester amphigel using citric acid and PEO: Solvent absorption, thermal behavior, and slow release of pesticide. *Journal of Applied Polymer Science*, 138(4): 49723

Sarkar S, Sarkar UK, Ali S, Kumari S and Puthiyotti M (2021). Status, ecological services and management of aquatic weeds of floodplain wetlands in India: An overview. *Lakes & Reservoirs*, 26: 76-91. doi.org/10.1111/lre.12353

Sarkar UK and Das BK (2021). Research advances in climate and environmental change impacts on inland fisheries of India: status, vulnerability, and mitigation strategies. *Aquatic Ecosystem Health and Management*, 24(3): 7-17

Sarkar UK, Ghosh BD, Puthiyottil M, Das AK, Lianthuamluaia, Karnatak G, Acharya A and Das BK (2021). Spatio-temporal change analysis of three floodplain wetlands of eastern India in the context of climatic anomaly for sustainable fisheries management. *Sustainable Water Resources Management*, 7(3): 1-16. doi.org/10.1007/ s40899-021-00529-5

Sarkar UK, Johnson C, Kumari S, Bakshi S, Karnatak G, Das Ghosh B, Lianthuamluaia L, Puthiyottil M and Das BK (2021). Population dynamics of Indian river shad *Gudusia chapra* (Hamilton, 1822) using length frequency analysis for fisheries management in a floodplain wetland of Ganga River basin, India. *Lakes & Reservoirs*, 26: e12365. doi.org/10.1111/lre.12365

Sarkar UK, Paul TT, Puthiyottil M, Karnatak G, Das VG, Bandyopadhyay A, Bakshi S and Das BK (2022). Inland heat waves (IHWs) and associated impacts on hydrobiology of aquatic ecosystems in lower Ganga basin, India. *International Journal of Biometeorology*, 66(1): 235-245. doi: 10.1007/s00484-021-02210-0

Sarkar UK, Puthiyottil M, Karnatak G, Lianthuamluaia, Saha S, Bandyopadhyay A, Ghosh BD. (2021). Regional climatic variability and fisher's adaptation to climate-induced risks in an impacted tropical floodplain wetland: a case study. *Sustainable Water Resources Management*, 7(4): 1-12. doi.org/10. 1007/s40899-021-00545-5

Sarkar UK, Roy K, Karnatak G, Naskar M, Puthiyottil M, Baksi S, Lianthuamluaia L, Kumari S, Ghosh BD and Das BK (2021). Reproductive environment of the decreasing Indian river shad in Asian inland waters: disentangling the climate change and indiscriminative fishing threats. *Environmental Science and Pollution Research International*, 28(23): 30207-30218

Sarkar UK, Roy K, Naskar M, Karnatak G, Puthiyottil M, Baksi S, Kumari S, Lianthuamluia L and Das BK (2021). Assessing vulnerability of freshwater minnows in the Gangetic floodplains of India for conservation and management: Anthropogenic or climatic change risk? *Climate Risk Management*, 33: 100325, doi.org/10.1016/j. crm. 2021.100325

Sinha A, Gogoi P, Tayung T, Das Sarkar S, Kumar L, Mitra A, Suresh VR and Das BK (2021). Quantification and visualization of the variability of phytoplankton assemblage in a semi-lotic seasonal canal in Sundarbans, India. *Journal of the Indian Society of Coastal Agricultural Research*, 39(2): 206-220

Sinha A, Tayung T, Gogoi P, Ramteke MH, Roy A, Mitra A, Mondal S and Das BK (2021). Sustainable fish production through ecological and fisheries management of canals in Indian Sundarbans (West Bengal). *Journal of Aquatic Sciences and Oceanography,* 2(1): 204

Som S, Roy A, Das BK, Bera AK, Pandit A, Bhattacharya S, Saha A and Naskar M (2020). Exploring Bennett's hierarchy for developing methodology for training impact assessment. *Journal of the Inland Fisheries Society of India,* 52 (2): 214-221

Som S, Roy A, Das BK, Pandit A, Saha A and Das AK (2020). Assessing trainees' experience from the skill development programmes on inland fisheries management and its impact on human capital. *Journal of the Inland Fisheries Society of India*, 52(1): 83-85

Suresh VR, Sandhya KM, Sajina, AM, Manna RK, Mukherjee J, Banik SK, Maity T, Samanta R, Raman RK, Jayaraman J, Behera BK (2021). Reproductive potential and stock status of the anadromous shad, *Tenualosa ilisha* (Hamilton, 1822): Implications for managing its declining fisheries in northern Bay of Bengal bordering India. *Regional Studies in Marine Science*, doi. org/10.1016/j.rsma.2021.101753

Suresh VR, Sandhya KM, Banik SK, Mukherjee J, Mukherjee, Sajina AM, Maity, T, Mukhopadhyay MK, Manna RK and Behera BK (2021). Farming of the anadromous shad, *Tenualosa ilisha*: Signs of taking off in India. *Aquaculture Asia,* 25(3): 10-14

Swain HS, Bayen S, Ray A, Johnson C, Baitha R, Bohr M and Verma SK (2021). Present status, distribution and relative abundance of IUCN Red-listed fish species of River Ganga. *Current Science*, 121(5): 709. DOI: 10.18520/cs/v121/i5/709-714

Thangapalam JA, Julinta RB, Roy A, Singha J, Patil PK, Kumar KA and Behera BK (2021). Dietary therapeutic dose of oxytetracycline negatively influences the antioxidant capacity and immune-related genes expression in Nile tilapia *Oreochromis niloticus* (L.). *Environmental Toxicology and Pharmacology*, 87:103685. doi: 10.1016/j.etap.2021.103685

Upadhyay A, Swain HS, Das BK, Ramteke MH, Kumar V, Krishna G, Mohanty BP, Chadha NC and Das AK (2021). Stocking density matters in open water cage culture: Influence on growth, digestive enzymes, haemato-immuno and stress responses of *Puntius sarana* (Ham, 1822). *Aquaculture,* 547: 737445. doi.org/10.1016/j. aquaculture.2021.737445

Vilizzi L, Copp GH, Hill JE, Adamovich B, Aislabie L, Akin D, Al-Faisal AJ, Almeida D, Azmai MA, Kumar L, Bakiu R and Bellati A (2021). A global-scale screening of non-native aquatic organisms to identify potentially invasive species under current and future climate conditions. *Science of the Total environment*, 788: 147868

Vaisakh G, Roshith CM, Chandra G, Behera BK, Kamble SP, Parida PK and Das BK (2021). First record of pouched octopus, *Cistopus platinoidus* in a tropical estuary. *Estuarine, Coastal and Shelf Science*, 262: 107598

Vilizzi L, Copp GH, Hill JE, Adamovich B, Aislabie L, Akin D, Al-Faisal AJ, Almeida D, Azmai MA, Lohith Kumar K, Bakiu R, Bellati A et al (2021). A global-scale screening of non-native aquatic organisms to identify potentially invasive species under current and future climate conditions. *Science of the Total environment*, 788: 147868

Zheng X, Han B, Kumar V, Feyaerts AF, Van Dijck P and Bossier P (2021). Essential oils improve the survival of gnotobiotic brine shrimp (*Artemia franciscana*) challenged with *Vibrio campbellii*. *Frontiers in Immunology*, 12: 693932. doi: 10.3389/fimmu.2021.693932. eCollection 2021

Books, Book Chapter and Reviews

Bhakta D, Manna RK, Samanta S and Das BK (2021). Spawn Collection from Estuarine Systems for Coastal Aqua farming: Sustainability Issues and Way Forward. In: *Souvenir, International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security* (eds. Mandal UK, Lama TD, Burman D, Mandal S and Raut S). Indian Society of Coastal Agricultural Research, ICAR-CSSRI, Canning Town, West Bengal, pp. 58-67

Das BK, Behera BK, Samanta S, Parida PK, Sahoo AK, Bhakta D and Roshith CM (2020). Proceedings of Webinar for Enhancing Conservation of river dolphins through Sub-Regional Cooperation: "Exploring the impact of COVID-19 on the ecosystem health of rivers and its dolphin population: Present status and future strategy for conservation in India-Bangladesh-Myanmar-Nepal" 24 - 25 August, 2020, ICAR-CIFRI, Barrackpore, National Mission for Clean Ganga & Inland Fisheries Society of India, pp 27

Das BK, Meena DK, Sahoo AK, Swain HS and Sinha A (2021). Historical Growth and Future Perspectives of Fishery Education and Extension in India. In: *Agricultural Higher Education, Research and Extension in India*. (ed. Dasgupta D), AGROBIOS (INDIA), pp. 107-122

Das Sarkar S. and Gogoi P (2021). Habits and habitat of 'Nutri-smart' fish species. In: *NUTRISMART FISH to boost the Nutritional security of the rural women* (eds. Das BK, Phand S, Roy A, Bera AK, Swain PR), National Institute of Agricultural Extension Management (MANAGE), Hyderabad & ICAR-CIFRI, Barrackpore, ISBN: 978-93-91668-39-6, pp. 59-66

DebRoy P, Das BK, Parida PK, Roy A and Chakraborty S. (2021). Economic injustice in small-scale wetland Fisheries in West Bengal, India. In: *Blue Justice For Small-Scale Fisheries: A Global Scan* (eds. Kerezi V, Chuenpagdee R), vol 2. TBTI Global Publication Series, St. John's

Jain AK, Sinha A and Saini VP (2021). Policy issues on ornamental fisheries development in India. Ornamental Fisheries training and Research Institute, India, ISBN: 978-81-953207-0-7, 144p

Kumar V, Roy S, Behera BK and Das BK (2021). RNA interference and its potential applications in aquatic animal health management In: *Biotechnological Advances in Aquaculture Health Management* (eds. Gupta SK and Giri SS). *Springer International Publishing*

Kumar V, Roy S, Behera BK, Parhi J and Das BK (2021). Disease diagnostic tools for health management in aquaculture In: *Advances in Aquaculture Biotechnology* (eds. Pandey PK and Parhi J). Springer Singapore, pp.363-382. https://doi.org/10.1007/978-981-16-3215-0

Kumari K and Maurye P (2021). Cryopreservation in aquaculture. In: Advances in Fisheries Biotechnology (eds. Pandey PK and Parhi J). *Springer Singapore*. p. XV, 532

Roy S, Kumar V, Behera BK, Parhi J and Das BK (2021). Epigenetics: perspectives and potential in fisheries and aquaculture In: *Advances in Aquaculture Biotechnology* (eds. Pandey PK and Parhi J). Springer Singapore, pp 133-150. https://doi.org/10.1007/978-981-16-3215-0

Saha A, Ghosh RK, Bhaduri D (2021). Pesticide Pollution in Soils and Sediment in India: Status, Impact and Countermeasures. In: *Soil Science: Fundamentals to Recent Advances* (eds. Rakshit A, Singh S, Abhilash P, Biswas A), Springer, Singapore, pp. 823-874

Saha A, Ghosh RK, Jesna PK and Choudhury PP (2021). Bioindicators of pesticide contaminations. In: *Sustainable Agriculture Reviews 48: Pesticide Occurrence, Analysis and Remediation Vol. 2 Analysis*. (eds. Inamuddin, Ahamed MI and Lichtfouse E), Springer International Publishing, New York, pp. 185-231

Sajina AM and Paul TT (2021). Exotic species in Indian reservoirs: impacts and management. In: *Recent Advances in Reservoir Fisheries of India* (eds. Sarkar UK and Das BK), SS Publishing House, ISBN:978-93-90660-11-7, pp. 75-92

Sarkar DJ and Singh A (2021). Hydrogel formulations for increasing input use efficiency in agriculture. In: *Soil Management for Sustainable Agriculture: New Research and Strategies*, *CRC Press*, pp. 423-455

Sarkar DJ, Sarkar SD, Mukherjee S and Das BK (2021). Impact and fate of microplastics in the riverine ecosystem. In: *Contaminants in Drinking and Wastewater Sources*, *Springer, Singapore*, pp. 95-115

Sarkar UK and Das BK (2021). Recent advances in reservoir fisheries of India. SS Publishing House, Delhi, ISBN:978-93-90660-11-7, 287p

Singh SK, Baidya S, Das P and Biswas P (2021). Functional role of dietary supplements on reproductive physiology of fishes. In: *Recent advances in molecular endocrinology and reproductive physiology of fish* (eds. Sundaray JK, Rather MA, Kumar S and Agarwal D), Springer, Singapore. https://doi.org/10.1007/978-981-15-8369-8_17

Sinha A (2021). Breeding and culture of freshwater ornamental fish. (ed. Pandey PK), New India Publishing Agency, New Delhi, ISBN: 978-93-90512-23-2, 242p

Swain PR (2021). Cost effective nutrition sensitive innovations to address nutritional security. In: *NUTRISMART FISH to boost the Nutritional security of the rural women,* (eds. Das BK, Phand S, Roy A, Bera AK, Swain PR), National Institute of Agricultural Extension Management (MANAGE), Hyderabad & ICAR-CIFRI, Barrackpore, ISBN: 978-93-91668-39-6, pp.114-126

Policy paper

Bhattacharjya BK, Sarkar UK and Das BK (2021). Fisheries management modules for floodplain wetlands of India. Director, ICAR-CIFRI, Barrackpore, ISSN: 0970-616X, 52p

Training Manual, Abstract, Conference Papers

Chakraborty L, Nag SK, Das BK and Mondal S (2021). Accumulation of heavy metals in some aquatic vegetation and crustaceans at lower part of River Hooghly. In: *Book of Abstracts of International Webinar on 'Coastal Agriculture: Ttransforming Coastal Zone for Sustainable Food and Income Security'* Organized by Indian Society of Coastal Agricultural Research (ISCAR), Canning Town, West Bengal, India during March 16-19, 2020. p. 153

Dam Roy S (2021). Coral growth and sustenance under water pollution and global warming. In: *Book Abstract of International Webinar of Coastal Agriculture: transforming Coastal Zone for sustainable Food and Income Security*. 16-19 March 2021. pp. 146-147

Das BK, Parida PK, Swain PR, Bhattacharya S (2021). *Rangin Macha chaser Margadarshika.* CIFRI/ Training Manual/2021/12) ICAR-CIFRI, 40p

Das Sarkar S, Kumar VS, Das BK, Sarkar DJ, Gogoi P, Chakraborty H, Nag SK, Samanta S (2021). Valorization of solid garden wastes to relishing nutrient media - An innovative technology for microalgae-based biodiesel. In: *Summary/ Abstract. XV Agricultural Science Congress 2021 on energy and agriculture: challenges in 21st century*, Theme 3: Agricultural Engineering and Technology. November 13-16. Jointly organized by National Academy of Agricultural Sciences and Banaras Hindu University, pp. 332

Manna SK, Maity S, Das N, Roy U, Bera AK, Baitha R, Das BK and Patil PK (2021). Assessing fish health and economic loss from diseases in inland cage culture in India. In: *Abstract Book, VX Agricultural Science Congress on "Energy and Agriculture: Challenges in 21st Century"* held at Varanasi, India during 13-16 Nov. 2021, p.450

Nag SK, Das Sarkar S, Samanta S and Das BK (2021). Assessment of food safety of fishes through dietary exposure – few case studies. Session Paper presented orally at *XV Agricultural Science Congress* organized by NAAS and held at BHU, Varanasi from November 13-16, 2021, Summary/ Abstracts, p.53

Panikkar P, Jesna PK, Amala U, Khan MF, Das BK, Vijaykumar ME, Yandigeri M (2021). Agricultural solid waste management to develop fish feed using Black soldier fly *Hermetia illucens*. In: *XV Agricultural Science Congress and ASCEXPO* organized by National Academy of Agricultural Sciences and Institute of Agricultural Science, BHU, Held at BHU, Varanasi13-16 Nov. 2021. pp.461

Roy A, Sajin AM, Devi S, Parida, P.K (2021). *Matsya jibider jibon jibikar unnatikalpe jalashyaye matsya chas.* ICAR-Central Inland Fisheries Research Institute. Training Manual no.1. pp 48

Saha A, Jesna PK, Ramya VL, Mol SS, Panikkar P, Vijaykumar ME, Sarkar UK and Das BK (2021). Assessment of phosphorus fractions and their availability in the sediment of a hyper-eutrophic tropical reservoir, India to support effective management policies and restoration. In: *XV Agricultural Science Congress and ASCEXPO* organized by National Academy of Agricultural Sciences and Institute of Agricultural Science, BHU, Held at BHU, Varanasi13-16 Nov. 2021. p.443

Sukham MD, Dam Roy S, Kiruba SR, Kumar L and AKO Rateesh (2021). Osteology a Taxonomic tool. ICAR-CIARI, Port Blair. Andaman & Nicobar Islands

Sukham MD, Kiruba SR., Kumar L, AKO Rateesh, Dam Roy S, Shirke SS. and Baidya M (2021). Fisher resources of *Pristipomoides filamentosus* (Valenciennes, 1830) *and Pristipomoides multidens* (Day , 1879) from Andaman waters. In: *Book of Abstract, International Webinar of Coastal Agriculture: transforming Coastal Zone for sustainable Food and Income Security,* 16-19 March 2021. p121

Sukham MD, Kiruba SR., Kumar L, AKO Rateesh, Dam Roy S, Shirke SS. and Sandhya KM (2021) Length weight relationship, Gonado somatic index and fecundity of *Pristipomoides filamentosus* (Valenciennes,1830) *and Pristipomoides multidens* (Day, 1879) from Andaman sea. In: *Book of Abstract of International Webinar of Coastal Agriculture: transforming Coastal Zone for sustainable Food and Income Security*. 16-19 March, 2021, p.127

Popular Articles

Hassan MA, Das BK, Puthyottil M, Karnatak G and Kumari S (2021). Fisheries enhancement through participatory technological interventions in oxbow lakes of Eastern India: A success story. *World Aquaculture*, 52(3): 64-69

Khan MF (2021). Stocking- A strong tool for achieving reservoir fisheries enhancement in reservoirs. *Fishing Chimes,* 39(6): 55-50

Khan MF (2021). Stocking - A strong tool for achieving reservoir fisheries enhancement in reservoirs. *Fishing Chimes*, 39(6): 40-46

Paul TT and Palaniswamy R (2021). Role of cooperatives and self-help groups in reservoir fisheries management-success stories in Kerala. *Fishing Chimes*, 39(6):105-108

Paul TT, Das VG, Sudheesan D, Sandhya KM, Manoharan S and Das BK (2021). Fisheries sector of Kerala: Pandemic scenario. *Biotica Research Today*, 3(1): 58-61

Paul TT, Kuberan G, Panikkar P, Sudheesan D, Manoharan S, Usha U, Sarkar UK and Das BK (2020). Climate resilient multi-trophic system in Vembanad lake adaptive strategy for enhancement of clam fisheries. *Indian Farming*, 69(2):0019-4786

Hassan MA, Das AK and Das BK (2021). Eds Hate kalame khanchai machh chasher proshikkhon. ICAR-Central Inland Fisheries Research Institute. Training Manual no.2. pp 51

Pamphlets/Leaflets/Folders

Das BK, Das P, Borah S, Yadav AK, Meena DK, Yengkokpam S and Bhattacharjya BK (2021). Management of open water fisheries in Meghalaya: ICAR-CIFRI interventions. Leaflet No. 12, ICAR-CIFRI, Barrackpore

Das BK, Parida PK, Sarkar UK, Das AK, Koushlesh SK, Swain HS and Ramteke M (2021). Strategic planning for nutritional security and productivity enhancement in Hirakud reservoir: An approach to community mobilization. ICAR-CIFRI, Barrackpore

Das BK, Roy A, Karnatak G, Parida PK, Das AK., Behera BK, Pandit A, Sahoo AK, Chakraborty S and Chandra P (2021). Small scale fisheries in wetlands for livelihoods and nutritional security. ICAR-Central Inland Fisheries Research Institute, Barrackpore

Jha DN, Sharma SK, Alam A, Thakur VR, Kumar J and Srivastava K (2021). *Ganga nadi ki paaristhitiki aur maatsyaki par Covid 19 ka prabhav*. ICAR-Central Inland Fisheries Research Institute, Barrackpore

Newsletter

Pandit A and Das Sarkar S (eds.) CIFRINEWS, Institute Newsletter, Vol.25, No. 2

Pandit A and Bhakta D (eds.) CIFRINEWS, Institute Newsletter, Vol.26, No. 1

Ready Reckoner

Alam A, Kumar J, Jha DN, Sharma SK, Kumar BK, Sarkar UK (2021). Ecosystem health card Rihand Reservoir, Uttar Pradesh. ICAR-Central Inland Fisheries Research Institute, Barrackpore, 12p.

Alam A, Kumar J, Jha DN, Thakur VR, Das BK (2021). Ecosystem health card Jargo reservoir, Uttar Pradesh. ICAR-Central Inland Fisheries Research Institute, Barrackpore, 12p.

Bulletin

Absar A, Jha DN, Kumar J, Das SCS, Thakur VR, Sharma SK and Das BK (2021), River Yamuna: Ecology and Fisheries, CIFRI Bulletin # 202, 33p.

Jha DN, Absar A, Thakur VR, Kumar J, Sharma SK, Srivastava K and Das BK (2021). Bibliography of ICAR-CIFRI, Prayagraj publications from 1952-2021, CIFRI Bulletin # 203, 90p.

Electronic publications

Albert CA, Paul TT, Das VG, Manoharan S, Sudheesan D, Meharoof M and Das BK (2021) Reservoir fisheries in Kerala - An Unmined Resource. *Biotica Research Today*, 3(3): 176-180

Das BK, Phand S, Roy A, Bera AK, Swain PR (2021). NUTRISMART FISH to boost the Nutritional security of the rural women (E-book). National Institute of Agricultural Extension Management (MANAGE), Hyderabad & ICAR-Central Inland Fisheries Research Institute, Barrackpore, ISBN:978-93-91668-39-6. https://www.manage.gov.in/ publications/eBooks/NUTRISMART%20FISH%20to%20Boo%20the%20Nutritional%20Security%20of%20the%20Rural%20Women.pdf

Das VG, Paul TT, C Albin Albert, Manoharan S, Sudeeshan D and Das BK (2021). Lacustrine Fisheries of Kerala. *Biotica Research Today,* 3(5): 285-289

Paul TT, Das VG, Sudheesan D, KM Sandhya, Manoharan S and Das BK (2021). Fisheries Sector of Kerala: Pandemic Scenario. *Biotica Research Today*, 3(1): 58-61

Roy A (2021). SIF to boost nutritional security – CIFRI's experience. In: *NUTRISMART FISH to boost the Nutritional security of the rural women [E-book]* (eds. Das BK, Phand S, Roy A, Bera AK, Swain PR). National Institute of Agricultural Extension Management (MANAGE), Hyderabad & ICAR-CIFRI, Barrackpore, pp.67-70

Roy A and Chaterjee P (2021). Assessment of nutritional needs of Rural people with special emphasis on women. In: *NUTRISMART FISH to boost the Nutritional security of the rural women [E-book]* (eds. Das BK, Phand S, Roy A, Bera AK, Swain PR). National Institute of Agricultural Extension Management (MANAGE), Hyderabad and ICAR-CIFRI, Barrackpore, pp. 25-31

Sajina AM, Sudheesan D, Kumar L and KM Sandhya (2021). Fish as ecological health indicators of freshwater ecosystems. *Biotica Research Today*, 3(1): 77-80

Sajina AM, Sudheesan D, Kumar LK and Sandhya KM (2021). Fish as ecological health indicators of freshwater ecosystems. *Biotica Research Today*, 3(1): 77-80

Hindi Publication

सिन्हा ए (2021)। मोला मछली पालन से रोजगार, खेती, विशेषांक – जनवरी 2021, पृष्ठ सं. 44–45

नीलांजली 2019, संपादन – दास बि के, श्रीवास्तव एन पी, डा. सामन्ता एस, मो. कासिम, दास सुमेधा एवं प्रसाद सुनीता

राय अपर्णा, मो0 अफ्ताबुद्दीन, प्रसाद सुनीता एवं दास बि के, 2019 – पश्चिम बंगाल में बील (आर्द्रक्षेत्र) मात्स्यिकी विकासः समस्यायें एवं निदान। नीलांजली (पर्यावरण–विमर्श विशेषांक), वर्षः 2019, अंकः 10, 2019 पृष्ठ सं. 53–54

आलम अबसार, कुमार जीतेंद्र, ठाकुर वेंकटेश रामाराव, गुप्ता मोनिका, श्रीवास्तव कल्पना, कुमार विजय, श्रीवास्तव रमाशंकर एवं दास बसंत कुमार, 2019 दृ जल संसाधनों से मीथेन का उत्सर्जनः एक बढ़ती वैश्विक चिंता। नीलांजली (पर्यावरण–विमर्श विशेषांक), वर्षः 2019, अंकः 10, 2019 पृष्ठ सं. 51–52

कुमार जीतेंद्र, आलम अबसार, ठाकुर वेंकटेश रामाराव, गुप्ता मोनिका, झा धर्मनाथ, श्रीवास्तव रमाशंकर एवं दास बसंत कुमार, 2019 दृ पर्यावरण में बदलाव का मछलियों पर प्रभाव। नीलांजली (पर्यावरण–विमर्श विशेषांक), वर्षः 2019, अंकः 10, 2019 पृष्ठ सं. 33–34

नीलांजली 2020, संपादन – दास बि के, श्रीवास्तव एन पी, सामन्ता डा. एस, कासिम मो., दास सुमेधा एवं प्रसाद सुनीता

दास बि के, रॉय अपर्णा और प्रसाद सुनीता, 2020 – भारत

में छोटे पैमाने पर मत्स्य पालन पर कोविड 19 का प्रभाव। नीलांजली (कोविड–19 विशेषांक), वर्षः 2020, अंकः 11, 2019 पृष्ठ सं. 1–5

श्रीवास्तव कपलन, पांडे अमित रंजन, ठाकुर वेंकटेश आर, झा धर्मनाथ एवं दास बि के, 2020 – कोविड–19 लाकडाउन ने दी प्रकृति को राहत और मानव को सबक। नीलांजली (कोविड–19 विशेषांक), वर्षः 2020, अंकः 11, 2019 पृष्ठ सं. 14–17

दास बि के, स्वैन एच एस, रामटेके मितेश, तिवारी नीतीश, दासगुप्ता शुभदीप एवं प्रसाद सुनीता, 2020 – स्वच्छ गंगा परियोजना के लिए राष्ट्रीय मिशन के तहत गंगा नदी में इंडियन मेजर कार्प प्रजातियों का पालन और संरक्षण। नीलांजली (कोविड–19 विशेषांक), वर्षः 2020, अंकः 11, 2019 पृष्ठ सं. 22–28

कुमारी सुमन, भट्टाचार्य श्रेया, स्वैन एच एस, प्रसाद सुनीता एवं दास बि के, 2020 – अलंकारी मछली विपणन पर कोविड–19 महामारी का प्रभाव। नीलांजली (कोविड–19 विशेषांक), वर्षः 2020, अंकः 11, 2019 पृष्ठ सं. 22–28

खेती 2021 प्रचलित लेख

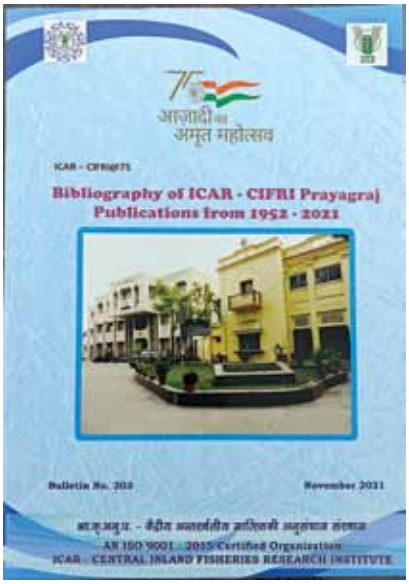
पॉल थैंकम थेरेसा, पणिक्कर प्रीथा, दास बि के, सरकार यू के और प्रसाद सुनीता, 2021 – वेम्बानाड झील में काली सीपी का पेन में पालनः जलवायु तन्यक उत्पादन संवर्धन प्रणाली। खेती (मात्स्यिकी विषेशांक), वर्षः 73, अंकः 8, जनवरी 2021, पृष्ठ सं. 15–17

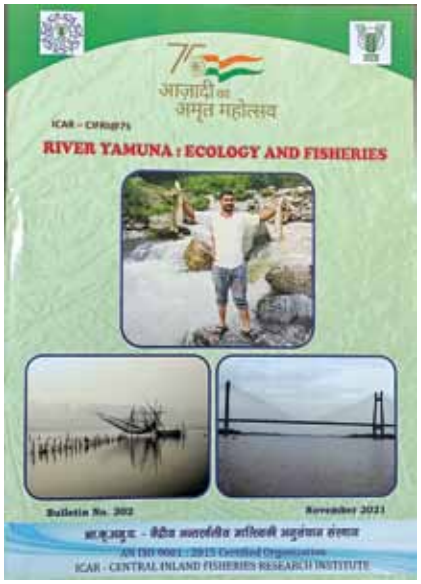
कर्नाटक गुंजन, दास बसंत कुमार, सरकार उत्तम कुमार, पी मिशाल. और प्रसाद सुनीता, 2021 – *लेबीयो बाटा* – जलाशयों एवं आर्द्रक्षेत्रों में पिंजरा पालन में प्रजाति विविधीकरण हेतु एक संभावित प्रजाति। खेती (मात्स्यिकी विषेशांक), वर्षः 73, अंकः 8, जनवरी 2021, पृष्ठ सं. 20–21

स्वैन एच एस, रामटेके एम एच, उपाध्याय ए., मीना डी के, दास बि के और प्रसाद सुनीता, 2021 – पिंजरों में बायोफाऊलिंग नियंत्रण के लिए शाकाहारी मछली प्रजातियों का पालन। खेती (मात्स्यिकी विषेशांक), वर्षः 73, अंकः 8, जनवरी 2021, पृष्ठ सं. 34–35

दास बि के एवं प्रसाद सुनीता, 2021 अन्तर्स्थलीय खुला जल मात्स्यिकी विकास। खेती, वर्षः 74, अंकः 04, अगस्त 2021, पृष्ठ सं. 39–43

- ''अन्तर्स्थलीय मात्स्यिकी का संरक्षण, समस्या और सम्भावनाए'' पर हिंदी पुस्तक
- ''अलवण जल एवं मत्स्य पारिस्थितिकी'' पर हिंदी पुस्तक





AWARDS & RECOGNITIONS

The Best ICAR Institute Award

ICAR-Central Inland Fisheries Research Institute has been conferred upon **the Sardar Patel Outstanding ICAR Institution Award 2020** under Large Institute Category by ICAR. The Award was shared with the ICAR-Central Institute of Agricultural Engineering. The award was conferred by Shri Narendra Singh Tomar, Hon'ble Minister of Agriculture and Farmers Welfare on the occasion of 93rd ICAR Foundation Day and Award Ceremony on 16 July 2021. The Institute received ₹ 5 Lakh cash award with a citation. The Institute has been acknowledged for significant scientific and technological progresses towards generating knowledge base for ensuring sustainability of inland open water ecology, aquatic biodiversity, fisheries, nutritional and livelihood securities.

Agri-Food Award of Excellence 2021

The Institute was bestowed upon the **Agri-Food Empowering India Awards 2021** as the recognition for excellence in Research & Development in agri-food and its remarkable contribution to the food sector. The award was conferred by Shri Prahllad Singh Patel, Hon'ble MoS, Ministry of Food Processing Industry, Govt. of India at New Delhi on 18 November 2021.

Award for Official Language Implementation

ICAR-CIFRI Regional Centre, Bengaluru was awarded with the Second prize for excellent implementation of Official Language in office works at the RC in the year 2019-20. The award was conferred by the Town Official Language Implementation Committee (TOLIC), Bengaluru.

Ganesh Shankar Vidyarthi Protsahan Purashkar

The Institute Hindi magazine "Nilanjali" received the Ganesh Shankar Vidyarthi Protsahan

Purashkar for C region for regular publication of excellent articles that enhance knowledge and encourage fisheries development in the country.

Awards conferred to staff members

- Dr. B.K. Das, Director, was conferred with **Rafi Ahmed Kidwai Award 2020** for outstanding research in agricultural sciences under Animal & Fisheries Sciences category. The award carries a cash reward of ₹ 2.5 lakh and a citation. The award has been shared with Dr. A.K. Tiwari, Director, ICAR-CARI, Izatnagar.
- Dr. Ajoy Saha, Scientist, received the **Best Research Paper Award 2020** by the ICAR-Directorate of Medicinal Aromatic Plants Research, Anand for the research paper on "Sustainable fertilization through co-application of biochar and chemical fertilizers improves yield, quality of *Andrographis paniculata* and soil health," authored by Saha A, Basak BB, Gajbhiye NA, Kalariya KA, Manivel P (2019) and published in Industrial Crops and Products, 140:111607.
- Dr. Sajina A.M., Scientist, received the **Best Poster Award** in XV Agricultural Science Congress held at BHU, Varanasi during 13-16 November 2021

Recognitions of staff members

- Dr. A. Sinha, Principal Scientist, was invited as an Expert in stakeholder meeting of Aqua Rainbow India Group, convened by Dr. Rajeev Ranjan, Secretary, and Shri Sagar Mehra, Joint Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India on 24 July 2020.
- Dr. A. Sinha, Principal Scientist, acted as Panelist in National level virtual stakeholder consultation "Indian ornamental fisheries 2.0 - The way forward" organized by ICAR-CIFA, Bhubaneswar during 22-24 April 2021.
- Dr. A. Sinha, Principal Scientist, was invited by Controller of Examination, ASRB, New Delhi as an expert for ARS main Examination during 28-30 September 2021.
- Dr. A. Sinha, Principal Scientist, was invited to assist the Union Public Service Commission (UPSC) in the Selection Committee Board for the Post of Director held in UPSC, Dholpur House, Shahjahan Road, New Delhi on 10 November 2021.
- Dr. B. K. Bhattacharjya, Principal Scientist and HoC, ICAR-CIFRI Regional Centre, Guwahati, acted as PhD thesis Examiner of Dept. of Zoology, Guwahati University, Guwahati.
- Dr. B. K. Bhattacharjya Principal Scientist and HoC, ICAR-CIFRI Regional Centre, Guwahati, acted as PhD thesis Examiner of Dept. of Aquaculture, College of Fisheries, AAU, Raha.
- Dr. B.K. Bhattacharjya, Dr. S. Yengogkokpam, Dr. D. Debnath, Dr. P. Das, Dr. S. C.S. Das and Dr. S. Borah delivered guest lectures to students of Cachar College in a training program titled "Fish and Fisheries Management," organized by Cachar College, Silchar, Assam during 19-24 January 2021.
- Dr. B. K. Bhattacharjya, Principal Scientist and HoC, ICAR-CIFRI Regional Centre, Guwahati, acted as Member, Board of Directors of AFDC Ltd. Guwahati.
- Dr. B. K. Bhattacharjya, Principal Scientist and HoC, ICAR-CIFRI Regional Centre, Guwahati, acted as Member of Assam State Wetland Authority, Guwahati.
- Dr. B.K. Bhattacharjya,

Principal Scientist and HoC, and Dr. Pronob Das, Scientist acted as experts on Fisheries and Aquaculture in Krishi Darshan Program of DDK, Guwahati.

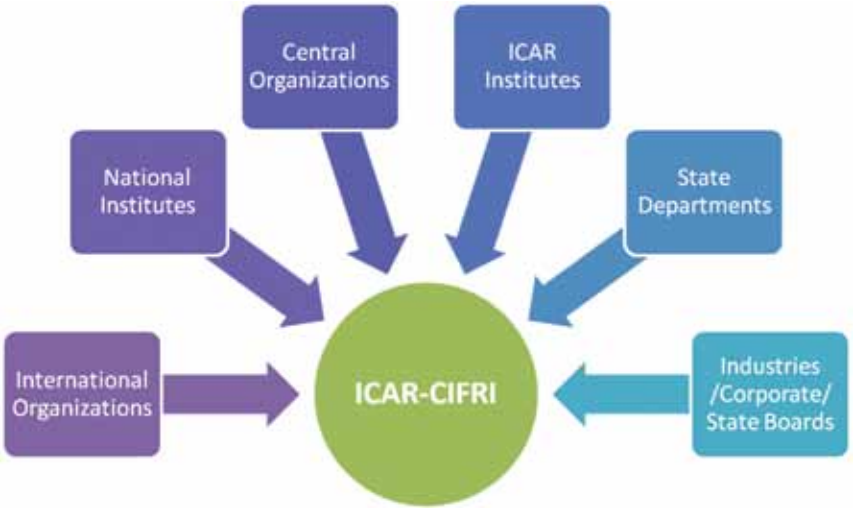
- Dr. B.K. Das, Director, graced the Foundation Day Programme of ICAR-CRIJAF, Barrackpore as the Guest of Honour on 09 February 2021
- Dr. B.K. Das, Director, delivered a talk on Aqualife vis-a-vis Anthropocene in rivers: A holistic management approach is need of hour in 1st International Conference on River Corridor Research and Management organized by IIT Jammu on 25 February 2021.
- Dr. B.K. Das, Director, delivered the Foundation day lecture at College of Fisheries, Assam Agricultural University on 7 March 2021.
- Dr. B.K. Das, Director, attended the virtual UK-India Aquaculture Partnership Meeting on 9 March 2021.
- Dr. Pronob Das, Scientist, acted as an External Examiner for viva voce examination of Ph.D student, Department of Aquaculture, College of Fisheries, AAU, Raha on 24 July 2021.
- Dr. Preetha Parikkar, Principal Scientist & HoC, ICAR-CIFRI Regional Centre, Bengaluru was nominated as Member of the High-power Committee constituted by Directorate of Fisheries, Govt. of Karnataka for cage culture programs in the State.
- Dr. Preetha Parikkar, Principal Scientist & HoC, ICAR-CIFRI Regional Centre, Bengaluru was nominated as Member of Tilapia Steering Committee for Govt. of Karnataka.
- Dr. Preetha Parikkar, Principal Scientist & HoC, ICAR-CIFRI Regional Centre, Bengaluru was nominated by ASRB as a member of the assessment Committee at ICAR-CMFRI, Kochi.
- Dr. Simanku Borah, Scientist, Member of the District Level Committee, Nalbari district, Assam for Pradhan Mantri Matsya Sampada Yojana.
- Dr. S. Dam Roy, Principal Scientist, acted as RAC Member of ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, on 26-27 March 2021.
- Dr. S. Dam Roy, Principal Scientist, acted as a Member of DBT Project Monitoring Committee of GOI on 27 September 2021.
- Dr. S. Dam Roy, Principal Scientist, acted as an External Examiner in viva voce of a Ph.D. Thesis of ICAR-CIFE Mumbai on 3 May 2021.
- Dr. S. Dam Roy, Principal Scientist, delivered an invited talk in "International webinar of coastal agriculture: Transforming coastal zone for sustainable food and income security" and acted as Co-Chair during 16-19 March 2021.
- Dr. D.J. Sarkar, Scientist, delivered an invited lecture on "Nano-Agrochemicals: from lab to field" in a webinar on Applications of Nanotechnology in Agriculture sector "Next Generation Smart Delivery Systems for Agrochemicals", organized by TERI-Deak in Nanobiotechnology Centre, The Energy and Resources Institute (TERI) on 27 September 2021.
- Dr. D.J. Sarkar, Scientist, delivered an invited talk on "Nanopolymers for agri input delivery: advances and future outlook" in the 5th International Nano for Agri-2021: Technology readiness and overcoming regulatory barriers to implement nanotechnology-enabled agriculture for sustainable future" during 8-9 December 2021.
- Dr. Kavita Kumari, Scientist, evaluated Ph.D. thesis of B.R.A. Bihar University, Muzaffarpur, Bihar.
- Dr. U.K. Sarkar, Principal Scientist & HoD, was nominated as an External Examiner and evaluated Ph.D. thesis of the Rajshahi University, Bangladesh.
- Dr. U. K. Sarkar, Principal Scientist & HoD, was nominated as an External Examiner and evaluated Ph.D. thesis of ICAR-CIFE, HNB Garhwal University, West Bengal University of Animal and Fishery Sciences, Vidyasagar University, Dr. B R Ambedkar University, and Guru Nanak Dev University.
- Dr. U. K. Sarkar, Principal Scientist & HoD, was nominated as Research Advisory Committee member of UGC–SAP Programme of the Department of Zoology, Guru Nanak Dev University, Amritsar, Punjab.
- Dr. U. K. Sarkar, Principal Scientist & HoD, was nominated as an Expert Member of West Bengal Biodiversity Board, and National Exotics Committee, MoF AH & D, Govt. of India.

PhD Degree awarded

The following scientists of the Institute were awarded with Ph.D. degree:

Scientist	Date	Awarding University/ Institution	Title of the Ph.D. thesis
Dr. S. Borah	24 March, 2021	ICAR-Central Institute of Fisheries Education, Mumbai	Fishery biology and stock characterization of *Tenualosa ilisha* (Hamilton, 1822) in Brahmaputra river, Assam, India
Dr. H.S. Swain	05 November, 2021	ICAR-Central Institute of Fisheries Education, Mumbai	Studies on growth and immunological responses of *Labeo rohita* (Ham. 1822) and *Pangasianodon hypophthalmus* (Sau. 1878) in cage based polyculture
Dr. D.K. Meena	05 November, 2021	ICAR-Central Institute of Fisheries Education, Mumbai	Evaluation of herbal extracts of Arjuna, *Terminalia arjuna,* on growth, immune responses and disease resistance in *Labeo rohita* (HAM, 1822)

LINKAGES DEVELOPED



ICAR-CIFRI has been maintaining close linkages with the stakeholders involved in fisheries research and development in India and abroad. Beside research and development, the Institute has also established its linkages with several organizations for extension, outreach activities, seminars, workshops, publications, etc. Linkages are important in the spread and diffusion of knowledge, innovation, and developmental activities.

During 2021 the Institute maintained linkages with the following organizations

International Linkages and Collaboration

International Multilateral Organizations

- Food and Agriculture Organization, UN
- Bay of Bengal Programme Inter-Governmental Organization
- International Union for Conservation of Nature, Indonesia
- Network of Aquaculture Centres in Asia-Pacific, Bangkok
- World Fish Centre, Malaysia
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Germany

Foreign Universities

- Ghent University, Ghent, Belgium
- RMIT university, Melbourne, Australia
- Tribhuwan University, Nepal
- University of Manitoba, Canada
- University of Ottawa, Canada
- University of Waterloo, Canada
- Wageningen University, Netherlands

International Societies and Humanitarian organizations

- Aquatic Ecosystem Health & Management Society, Canada
- Rotary International
- International Collective in Support of Fish workers
- Wetlands International South Asia
- World Wide Fund for Nature, India

Linkages within India

Central Departments, Boards and Authorities

- Agrinnovate India Ltd., New Delhi
- AkashVani, Kolkata
- Brahmaputra Board, Ministry of Jal Shakti, Govt. of India
- Bureau of Indian Standards, New Delhi
- Central Water Commission, New Delhi
- Department of Animal Husbandry, Dairying and Fisheries, New Delhi

- Department of Biotechnology, New Delhi
- Farakka Barrage Authority, Murshidabad, West Bengal
- Indian Science Congress Association, Kolkata
- Ministry of Environment, Forest & Climate Change, Govt. of India, New Delhi
- Narmada Control Authority, Department of River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Govt. of India, Indore
- National Bank for Agriculture and Rural Development
- National Biodiversity Authority
- National Fisheries Development Board, Hyderabad
- National Mission for Clean Ganga, Department of River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Govt. of India, New Delhi
- National Statistical Organization, National Accounts Division, Min. of Statistics and Programme Implementation, Govt of India
- Zoological Survey of India, Kolkata

National Universities & Institutes

- Assam Agricultural University, Jorhat
- Benares Hindu University, Varanasi
- Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia
- Bihar Animal Science University, Patna
- C-DAC, Kolkata
- Central Silk Board- CSRTI, Mysore and CTR&TI, Ranchi, Ministry of Textiles, Govt. of India
- Central University of South Bihar, Patna
- Chaudhury Charan Singh National Institute of Agricultural Marketing, Jaipur
- College of Fisheries, Central Agricultural University, Lembucherra, Agartala
- Department of Zoology, University of Calcutta, Kolkata
- Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur
- G.B. Pant University of Agriculture & Technology, Pantnagar
- Indian Institute of Technology, Hyderabad
- Indian Institute of Technology, Jammu
- Indian Institute of Technology, Kharagpur
- Indian Statistical Institute, Kolkata
- Manipur University, Imphal
- University of Kalyani, Kalyani
- Utkal University, Bhubaneswar
- Vidyasagar University, Midnapore
- Visva-Bharati University, Santiniketan
- West Bengal University of Animal and Fisheries Sciences, Kolkata
- Wildlife Institute of India, Chandrabani, Dehradun

ICAR Organizations

- Dhaanyaganga KVK, North 24 Parganas, Nadia, West Bengal
- ICAR Research Complex for NEH Region, Umiam
- ICAR-Agricultural Technology Application Research Institute, Kolkata
- ICAR-Central Institute of Brackishwater Aquaculture, Chennai
- ICAR-Central Institute of Fisheries Education, Mumbai
- ICAR-Central Institute of Fisheries Technology, Kochi
- ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar
- ICAR-Central Institute of Sub-tropical Horticulture, Regional Research Station Malda, West Bengal
- ICAR-Central Marine Fisheries Research Institute, Kochi
- ICAR-Central Research Institute of Jute & Allied Fibre, Barrackpore
- ICAR-Directorate of Coldwater Fisheries, Bhimtal
- ICAR-Indian Agricultural Statistics Research Institute, New Delhi
- ICAR-National Academy of Agricultural Research Management, Hyderabad
- ICAR-National Bureau of Agricultural Insect Resources, Bengaluru
- ICAR-National Bureau of Fish Genetic Resources, Lucknow
- Krishi Vigyan Kendra, DRPCAU, Piprakothi, East Champaran, Bihar

- Krishi Vigyan Kendra, Malda, West Bengal
- Rathindra Krishi Vigyan Kendra, Visva-Bharati, Sriniketan, Birbhum, West Bengal

State Departments, Boards and Authorities

- Assam Fisheries Development Corporation Ltd.
- Assam Rural Infrastructure and Agricultural Services Society (ARIAS)
- Chilika Development Authority, Bhubaneswar
- Department of Fisheries & Aquatic Resources, Nagaland
- Department of Fisheries, Govt. of Gujarat
- Department of Fisheries, Govt. of Manipur
- Department of Fisheries, Govt. of Tripura
- Department of Fisheries, Govt. of Uttarakhand
- Department of Forest, Govt of Gujarat, Ukai
- Department of Environment, Forest and Climate Change, Government of Bihar, Patna
- Department of Forest, Govt. of Odisha
- Department of Forest, Govt. of West Bengal
- Directorate of Fisheries, Govt. of Andhra Pradesh
- Directorate of Fisheries, Govt. of Arunachal Pradesh
- Directorate of Fisheries, Govt. of Assam
- Directorate of Fisheries, Govt. of Bihar
- Directorate of Fisheries, Govt. of Chhattisgarh
- Directorate of Fisheries, Govt. of Himachal Pradesh
- Directorate of Fisheries, Govt. of Jharkhand
- Directorate of Fisheries, Govt. of Karnataka
- Directorate of Fisheries, Govt. of Kerala
- Directorate of Fisheries, Govt. of Madhya Pradesh
- Directorate of Fisheries, Govt. of Maharashtra
- Directorate of Fisheries, Govt. of Meghalaya
- Directorate of Fisheries, Govt. of Odisha
- Directorate of Fisheries, Govt. of Telangana
- Directorate of Fisheries, Govt. of Tripura
- Directorate of Fisheries, Govt. of Uttar Pradesh
- Directorate of Fisheries, Govt. of West Bengal
- Gujarat Maritime Board, Bharuch
- Narmada Control Authority, Gujarat
- Narmada Control Authority, Indore
- Narmada Water Resources, Water Supply and Kalpasar Department, Gandhinagar
- Sardar Sarovar Narmada Nigam Limited
- Sundarban Development Board, West Bengal
- Swami Vivekananda State Police Academy, Barrackpore
- West Bengal Biodiversity Board

State Colleges/Universities

- Bihar Agricultural University, Sabour
- College of Fisheries, Kishanganj, Bihar
- Fakir Mohan University, Balasore
- Munger University, Bihar
- University of Kalyani, Kalyani
- West Bengal University of Animal and Fishery Sciences (WBUAFS), West Bengal

Central Public Sector Units

- National Hydroelectric power corporation (NHPC) Limited
- North Eastern Electric Power Corporation (NEEPCO) Limited
- Satluj Jal Vidyut Nigam (SJVN) Limited

Other Organizations/ NGO

- Assam Agribusiness and Rural Transformation Project (APART)
- BANO charitable trust, Odisha
- Glaucus Agrochem Pvt. Ltd., Kolkata
- MR Aquatech, Bhubanaswar
- NIRMAN, Odisha
- Odisha Environment Society
- Pradan NGO
- Ram Krishna Mission Ashram, Sargachi, Murshidabad
- Ramakrishna Mission, Bhadrak
- Ramakrishna Mission, Sargachhi
- Ramakrishnayan Society of Moyna, West Bengal
- Ri-Bhoi Farmers' Union, Meghalaya
- SKSVYCS, NGO, Sundarbans,
- Sundarban Dreams

PRESS AND MEDIA COVERAGE

TRAINING AND CAPACITY BUILDING OF ICAR EMPLOYEES

The Annual Training Plan (ATP) of all categories of employees of the Institute for the year 2021-2022 was prepared based on the training need assessment and was submitted through TMIS. The number of persons attended training for the period April 2021 - December 2021 was meagre due to restrictions imposed during COVID-19 pandemic since the planned training programmes could not be conducted by training organizing institutes. Few staff members could attend some of online training/capacity building programmes.

Annual Physical and Financial Targets and Achievements (April - December 2021)

Physical Targets and Achievements

S. No.	Category	Total No. of Employees	No. of trainings planned for each category during 2020-21 as per ATP	Total No. of employees undergone training during April 2020 to December 2020
1	Scientist	84	14	01
2	Technical	46	5	01
3	Administrative & Finance	35	12	06
4	SSS	37	5	-
	Total	202	36	08

Financial Targets and Achievements (April - December 2021)

BE 2021-22 for HRD (₹ in lakhs)	Actual Expenditure up to 31 December, 2021 for HRD	% Utilization of allotted budget
5.78	0.68	11.76

MEETINGS, WORKSHOPS, SEMINARS ATTENDED

S. No.	Name of the programme	Name of the Official(s)	Date	Organizer & Venue
1.	Review Meeting of Officers & Staff of DARE & ICAR	B.K. Das, Director	01 January, 2021	ICAR, New Delhi; virtual mode
2.	Meeting of Output-Outcome Monitoring Framework (OOMF), DoWR, RD & GR, Ministry of Jal Shakti	B.K. Das, Director	05 January, 2021	Ministry of Jal Shakti, Govt. of India, New Delhi; virtual mode
3.	Research Advisory Group (RAG) Meeting on "Financing Fishery Value Chain in Jharkhand"	B.K. Das, Director	12 January, 2021	NABARD, Jharkhand Regional Office, Ranchi
4.	Interaction Meeting of ICAR Fisheries SMD & Fisheries Dept. of Jharkhand	B.K. Das, Director	13 January, 2021	ICAR, New Delhi; virtual mode
5.	Webinar on Breeding and Seed Production of *Hypselobarbus pulchellus*	M. Feroz Khan, V.L Ramya	22 January, 2021	ICAR-CIFA, Bhubaneswar; virtual mode
6.	Annual Review Meeting with the Consultative Group on International Agricultural Research Centres (WFC)	B.K. Das, Director	3 February, 2021	ICAR, New Delhi; virtual mode
7.	Virtual talk on "Alternative Economic Opportunities in Aquaculture & Potential in the Smart Aqua Expo India 2021	B.K. Das, Director	8 February, 2021	SMART AGRIPOST& AQUA POST, New Delhi; virtual mode
8.	Meeting of Fisheries SMD	B.K. Das, Director	10 February, 2021	Fisheries SMD, ICAR, New Delhi; virtual mode
9.	Fifth Meeting of Joint Committee for Ensuring Compliance to Hon'ble NGT PB, Delhi	B.K. Das, Director	12 February, 2021	CPCB, New Delhi; virtual mode
10.	Talk on Innovation in Aquaculture for Farmers' Prosperity in 6th National Youth Convention on "Innovation and Agricultural Reforms for Farmers Prosperity"	B.K. Das, Director	20-21 February, 2021	AIASA, ICAR and PJTSAU, Hyderabad; virtual mode
11.	Fisheries Institute- Industry Interface Meet	B.K. Das, Director	25 February, 2021	Agrinnovate India Ltd., New Delhi
12.	1st International Conference on River Corridor Research and Management	B.K. Das, Director	25 February, 2021	IIT, Jammu; virtual mode
13.	EAC for River Valley & Hydroelectric Projects	B.K. Das, Director	1 March, 2021	Ministry of Environment, Forest and Climate Change, New Delhi; virtual mode

14.	Workshop on Strategic Planning for Nutritional Security and Productivity Enhancement in Hirakud Reservoir: An Approach to Community Mobilization	S.K. Koushlesh	01 March, 2021	Sambalpur, Odisha
15.	UK-India Aquaculture Partnership Meeting	B.K. Das, Director	9 March, 2021	ICAR - CIBA, Chennai; virtual mode
16.	75th Foundation Day of ICAR-CIFRI	All staff members of the Institute	17 March, 2021	ICAR-CIFRI, Barrackpore
17.	ISCAR Webinar - International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security	B.K. Das, S. Dam Roy, S. K. Nag	16-19 March, 2021	ISCAR, Canning Town, West Bengal
18.	World Water Day 2021 Webinar on 'Valuing Water for Sustainable Fisheries'	All scientists of ICAR-CIFRI	22 March, 2021	ICAR-CIFRI, Barrackpore
19.	14th meeting of the Fish, Fisheries and Aquaculture Sectional Committee, FAD 12 (BIS)	B.K. Das, Director	24 March, 2021	Food & Agriculture Department, Bureau of Indian Standards, New Delhi; virtual mode
20.	Stakeholder Meeting on Conservation of Ganga River Dolphin in Ganga-Brahmaputra-Meghna basin	B.K. Das, Director	25 March, 2021	Rivers, Wetlands & Water Policy WWF-India; virtual mode
21.	Meeting with Ms. Devjani Patra, Member (Environment & Rehabilitation), Narmada Control Authority, Indore	B.K. Das, Director	25 March, 2021	Environment & Rehabilitation, Narmada Control Authority, Indore; virtual mode
22.	Sixth Meeting of the Joint Committee on O.A No 06/2012	B.K. Das, Director	8 April, 2021	CPCB, New Delhi; virtual mode
23.	First Meeting of the Indian Side of the India-Bangladesh Joint Technical Committee (JTC) on Ganga-Padma Barrage Project (GBP)	B.K. Das, Director	9 April, 2021	Hydrology NE Dte, CWC; virtual mode
24.	Six monthly review meeting of the XXV ICAR Regional Committee II	B.K. Das, Director	12 April, 2021	ICAR-NRRI, Cuttack; virtual mode
25.	Mid-term Review Meeting of the ICAR Regional Committee VIII	B.K. Das, Director, Arun Pandit, P. Panikkar, T.T. Paul	12 April, 2021	ICAR-CMFRI, Kochi; virtual mode
26.	Webinar on *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) for India @75 celebration *'Azadi Ka Amrut Mahotsav'* (AKAM) in Fisheries sector	B.K. Das, Director & all the scientists	12 April, 2021	Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi; virtual mode
27.	10th Meeting of the Expert Appraisal Committee for "River Valley Projects"	B.K. Das, Director A.K. Sahoo	15 April, 2021	Ministry of Environment, Forest and Climate Change Indira Paryavaran Bhawan, New Delhi

28.	Virtual lecture on 'Aquaculture-Avenue for assuring food security income growth social upliftment and health life' delivered by DDG (Fisheries Science)	B.K. Das, Director & all the scientists	16 April, 2021	ICAR, New Delhi; virtual mode
29.	Advisory Committee Meeting of NASF Project on "Captive breeding of Hilsa, *Tenualosa ilisha* : Phase II	B.K. Das, Director & all the project scientists	19 to 20 April, 2021	ICAR-CIFRI, Barrackpore
30.	Transboundary Rivers of South Asia Annual Learning & Reflection Forum (ALF) 2021	B.K. Das, Director	21 April, 2021	Oxfam affiliates, Oxfam Novib, Cambodia office; virtual mode
31.	International Conference Bionext 2021 Frontiers on modern biology	B.K. Das, Director	22 April, 2021	Adamas University, virtual mode
32.	Meeting of team members of FAO document on inland fisheries of India	B.K. Das, Director and all team members	27 April, 2021	ICAR-CIFRI, Barrackpore, virtual mode
33.	Expert Committee Meeting on Fishery Science	B.K. Das, Director	29 April, 2021	Neotia University, virtual mode
34.	50th Annual General Meeting of Inland Fisheries Society of India	All scientists and technical staff of HQs	10 May, 2021	ICAR-CIFRI, Barrackpore
35.	Meeting on construction of fish pass on the banks of Naitwar Mori HEP	B.K. Das, Director	13 May, 2021	SJVN, virtual mode
36.	Meeting with FARD Dept, Odisha regarding Hirakud Cage Culture	B.K. Das, Director	19 May, 2021	FARD Dept, Odisha, virtual mode
37.	Meeting with officials of Department of textiles, Government of Odisha for waste to wealth utilization of silk worm pupae	B.K. Das, Director	19 May, 2021	Department of textiles, Government of Odisha, virtual mode
38.	Expert Appraisal Committee meeting on River Valley Projects	B.K. Das, Director; A.K. Sahoo	25 May, 2021	MoEF & CC, Indira Paryavaran Bhawan, New Delhi; virtual mode
39.	National webinar organized by Dept. of Zoology, Nehru Gram Bharti University, Kotwa-Jamunipur, Prayagraj	Scientists of ICAR-CIFRI, Prayagraj	29 May, 2021	Nehru Gram Bharti University, Prayagraj
40.	Sixth Meeting of Joint Committee for Ensuring Compliance to Hon'ble National Green Tribunal (NGT) PB, Delhi	B.K. Das, Director	31 May, 2021	National Green Tribunal; virtual mode
41.	Programme on "*Bharat Ka Amrut Mahotsav*" ICAR Lecture Series #8 on Food and Dietary Concepts of Ayurveda- Indian Traditional Wisdom of Food for Better Nutrition and Health	All scientists of ICAR-CIFRI	01 June, 2021	Ministry of AYUSH, New Delhi ; virtual mode
42.	Webinar on "Wealth from Waste and Sustainable Eco-farming" as part of the Virtual Celebration of *Bharat Ka Amrut Mahotsav*	B.K. Das, Director	3 June, 2021	ICAR, New Delhi; virtual mode

43.	Stakeholder Consultation Meeting on Ban on African catfish, *Clarias gariepinus*	B.K. Das, Director	04 June, 2021	Ministry of Fisheries, New Delhi; virtual mode
44.	SFC Discussion of 3 Schemes of Fisheries SMD	B.K. Das, Director	5 June, 2021	DDG (Fy. Sc) ; virtual mode
45.	Webinar on "Ecosystem Restoration, Climate Change and Biodiversity Conservation" on the Occasion of World Environment Day	U.K. Sarkar, H. Chowdhury, Sajina A.M., Lianthuamluaia, S. Kumari, Mishal P., A. Meetei, P. Majhi, S.K. Koushlesh, B.K. Bhattacharjya, S. Yengkokpam, D. Debnath,A.K. Yadav, P. Das, S.C.S. Das, N. Sharma, S. Borah,N.S. Singh, D. Sudheesan, T.T. Paul, S. Manoharan	05 June, 2021	Directorate of Extension, BAU, Sabour; virtual mode
46.	61st Foundation Day of ICAR-CIFE	B.K. Das, Director	6th June, 2021	ICAR-CIFE, Mumbai; virtual mode
47.	Programme on "*Bharat Ka Amrut Mahotsav*" ICAR Lecture Series #9 on "Public-Private Partnership for Sustainable Irrigation: Roles of Government, Users & the Private Sector.	All scientists of ICAR-CIFRI	07 June, 2021	ICAR, New Delhi; virtual mode
48.	13th Meeting of the Expert Appraisal Committee on River Valley Projects	A.K. Sahoo	16 June, 2021	Ministry of Environment, Forest and Climate Change, Govt. of India, New Delhi; virtual mode
49.	27th meeting of National Committee on introduction of Exotic Species into Indian waters	B.K. Das, Director	16 June, 2021	Ministry of Fishery, Animal Husbandry & Dairying, Govt. of India; virtual mode
50.	Webinar on "Aquaculture Health Management"	B.K. Das, Director	19 June, 2021	CoF, Kishanganj; virtual mode
51.	National Dialogue on Innovative Food for Hospitality Industry" under the Chairmanship of Secretary (DARE) & Director General (ICAR)	B.K. Das, Director	22 June, 2021	ADG (IP&TM), ICAR, KAB-I, Pusa, New Delhi; virtual mode
52.	National Webinar on Casting into the Future of Aquaculture and Fisheries	V.R. Thakur	22 -23 June, 2021	Centurion University of Technology and Management, Odisha; Bhubaneswar; virtual mode
53.	Meeting of team members of FAO document on inland fisheries of India	B.K. Das, Director and all team members	23 June, 2021	ICAR-CIFRI, Barrackpore, virtual mode
54.	Webinar on Fish Passage 2021 (Oceania/Asia session)	S.K. Koushlesh	24 June, 2021	World Fish Migration Foundation, the Netherlands; virtual mode
55.	CII Livestock Taskforce Meeting	B.K. Das, Director	30 June, 2021	CII ; virtual mode

56.	ICAR-Director Conference under the Chairmanship of Secretary (DARE) & DG ICAR	B.K. Das, Director	2 July, 2021	ICAR; virtual mode
57.	Meeting of EAC - River Valley and Hydroelectric Projects	B.K. Das, Director A.K. Sahoo	7 July, 2021	NIC MoEFC; virtual mode
58.	Meeting on PPP Technology Collaboration with IDFPL, Kolkata	B.K. Das, Director	8 July, 2021	IDFPL; virtual mode
59.	National Campaign for Ecosystem Management for Sustainable Fisheries on the occasion of National Fish Farmers' Day Webinar in Kannada	All Scientists and technical staff of ICAR-CIFRI	10 July, 2021	Video conferencing mode organized by ICAR-CIFRI
60.	National Webinar on "Recent Prospect and Strategies of Aquaculture"	B.K. Das, Director	10 July, 2021	Dept of Zoology, Vidyasagar College; virtual mode
61.	Chief Guest on the occasion of Fish Farmers' Day	B.K. Das, Director	10 July, 2021	All India Agricultural Students Association (AIASA) ; virtual mode
62.	ICAR Foundation Day and the Award Ceremony 2021	B.K. Das, Director	16 July, 2021	ICAR, New Delhi; virtual mode
63.	Interaction with Padma Awardee Farmers	B.K. Das, Director	16 July, 2021	Secretary (DARE) & DG (ICAR) ; virtual mode
64.	Meeting of Fisheries SMD & Directors of ICAR Fisheries Institutes with Director & Senior Officers of Department of Fisheries, Govt of Bihar	B.K. Das, Director	20 July, 2021	Fisheries SMD, ICAR; virtual mode
65.	28th Meeting of National Committee on Introduction of Exotic Aquatic Species into Indian Waters	B.K. Das, Director	23 July, 2021	Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi; virtual mode
66.	CIFE Alumni Meet	B.K. Das, Director	24-25 July, 2021	ICAR-CIFE Alumni Association, Mumbai
67.	1st meeting of National Dolphin Research Centre	B.K. Das, Director	26 July, 2021	Department of Environment, Forest and Climate Change, Government of Bihar, Patna
68.	15th EAC - River Valley and Hydroelectric Projects	B.K. Das, Director, A.K. Sahoo	27 July, 2021	NIC MoEFC; virtual mode
69.	Webinar on "An Intersectional Lens on the Costs and Benefits of Compelled Migration as an Adaptation to Environmental Degradation"	B.K. Das, Director	30 July, 2021	Virtual mode
70.	Statutory Meeting of the Executive Committee of Indian Science Congress Association, Kolkata	B.K. Das, Director	2 August, 2021	Indian Science Congress Association, Kolkata; virtual mode
71.	Platinum Jubilee Lecture Series: Lecture-I by Dr. S. Ayyappan on 'CIFRI: Remembering with Reverence'	All staff members of the Institute	03 August, 2021	ICAR-CIFRI, Barrackpore; both in-person and virtual mode

72.	International Webinar on "Fish Vaccination: Theory, Innovations and Applications"	P. Das	04 August, 2021	Asian Fisheries Society, Malaysia and NACA, Bangkok; virtual mode
73.	International Webinar on "Sensitization on Hilsa Fisheries Conservation and Livelihood Improvement in River Ganga"	All scientists of ICAR-CIFRI	11 August, 2021	ICAR-CIFRI, Barrackpore
74.	Monthly Meeting of Fisheries SMD & Directors of Institutes	B.K. Das, Director	13August, 2021	Fisheries SMD, ICAR, New Delhi; virtual mode
75.	29th Meeting of National Committee on Introduction of Exotic Aquatic Species into Indian Waters	B.K. Das, Director	19August, 2021	Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi; virtual mode
76.	Meeting on Approval of ICAR Network Project on Precision Agriculture (NePPA)	B.K. Das, Director	21 August, 2021	DST Network program, , ICAR-IARI, New Delhi; virtual mode
77.	6th Meeting of the Central Standing Committee (CSC) on *Pradhan Mantri Matsya Sampada Yojana* (PMMSY)	B.K. Das, Director	24 August, 2021	Ministry of Fisheries, Govt. of India; virtual mode
78.	Webinar on 'System Diversification in Aquaculture'	All scientists of ICAR-CIFRI	01 September, 2021	ICAR-CIFRI, Barrackpore; both on-line and offline mode
79.	International Webinar on "Status of the use of Artemia Cysts in Fish and Crustacean Hatcheries around the World"	P. Das	02 September, 2021	Network of Aquatic Centres in Asia-Pacific (NACA), Thailand; virtual mode
80.	NMCG Hilsa Research Activity & meeting with GM Farakka, IWAI Officials and CISF Commandants	B.K. Das, Director A.K. Sahoo	2 September, 2021	ICAR-CIFRI
81.	Foundation Day Function at ICAR-Indian Institute of Horticultural Institute, Bengaluru	P. Panikkar	7 September, 2021	ICAR-IIHR, Bengaluru
82.	16th EAC - River Valley and Hydroelectric Projects	B.K. Das, Director A.K. Sahoo	7 September, 2021	NIC MoEFC; virtual mode
83.	Meeting with Director, and Engineers of Sardar Sarovar Narmada Nigam Limited, Gandhinagar on e-flow of Narmada River Downstream of Sardar Sarovar Dam	B.K. Das, Director	9 September, 2021	Sardar Sarovar Narmada Nigam LTD., Gandhinagar; virtual mode
84.	Monthly Meeting of Fisheries SMD & Directors of Institutes	B.K. Das, Director	11 September, 2021	Fisheries SMD, ICAR, New Delhi; virtual mode
85.	XXVII Meeting of ICAR Regional Committee No. VIII	B.K. Das, Arun Pandit, P. Panikkar	14 September, 2021	ICAR-CMFRI, Kochi; virtual mode
86.	Launch meeting of CIFRI ARGCURE	Associated scientists of ICAR-CIFRI	14-15 September, 2021	ICAR-CIFRI, Barrackpore; virtual mode
87.	Hindi Week celebration	All scientists of ICAR-CIFRI	14-20 September, 2021	ICAR-CIFRI, Barrackpore and all centrtes

88.	Meeting with the Directors of Fisheries Research Institutes for Discussions on Organisation of Campaign on Nutri-garden and Tree Plantation	B.K. Das, Director	16 September, 2021	Fisheries SMD, ICAR, New Delhi; virtual mode
89.	Nutricereals Multi-stakeholders Mega Convention, and *Poshan Vatika* and Tree Plantation Campaign Event for International Year of Millets 2023	All scientists of ICAR-CIFRI	17 September, 2021	ICAR-IIMR, Hyderabad; virtual mode
90.	Stakeholders Meeting under Scheduled Tribe Component (STC)	P. Panikkar	18 September, 2021	ICAR-CIFRI, Bengaluru
91.	Governing Body Meeting of Nijasharana Sri Ambigara Chowdiah N. Karnataka Inland Fisheries Development Meeting	P. Panikkar	22 September, 2021	Directorate of Fisheries Govt. of Karnataka, Bengaluru
92.	Stakeholder's Meeting for Sustainable Management of Fisheries	U.K. Sarkar, H. Chowdhury, Sajina A.M., Lianthuamluaia, S. Kumari, Mishal P., A. Meetei, P. Majhi, Arun Pandit, S.K. Koushlesh, D. Sudheesan, T.T Paul	22 September, 2021	ICAR-CIFRI, Barrackpore
93.	SDG-aligned Artemia Aquaculture Workshop	P. Das	22 September, 2021	Network of Aquaculture Centres in Asia-Pacific (NACA), Thailand; virtual mode
94.	30th Meeting of National Committee on Introduction of Exotic Aquatic Species into Indian Waters	B.K. Das, Director	23 September, 2021	Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi; virtual mode
95.	17th EAC - River Valley Projects	B.K. Das, Director A.K. Sahoo	27 September, 2021	NIC MoEF & CC; virtual mode
96.	Prime Ministers' Farmer-Scientist interface Meet on climate resilient, Varieties, Technologies and Practices	All Scientists of RRC Bengaluru	28 September, 2021	Govt. of India; virtual mode
97.	Webinar on ICAR Research Data Repository for Knowledge Management (KRISHI)	U.K. Sarkar, H. Chowdhury, Sajina A.M., Lianthuamluaia, S. Kumari, Mishal P., A. Meetei, P. Majhi, S.K. Koushlesh, D. Sudheesan, Arun Pandit, T.T Paul, S. Manoharan	29 September 2021	ICAR-IASRI, New Delhi; virtual mode
98.	International webinar on "Alternate Cropping Systems for Climate Change and Resource Conservation"	P. Das	29 September -01 October, 2021	ICAR-IIFSR, Modipuram, Meerut; virtual mode

99.	Session on Panel Discussion on "Learnings, Challenges & legal aspects; Border Issues at Regional Fisheries Management"	B.K. Das, Director	29 September, 2021	TROSA and Oxfam; virtual mode
100.	Meeting on IoT based DO Monitoring in Multiple Cages with CIFRI	B.K. Das, Director	30 September, 2021	C-DAC, Kolkata
101.	18th Meeting of the Committee for Commercial Utilization of Bioresources	B.K. Das, Director	1 October, 2021	West Bengal Biodiversity Board
102.	Meeting Regarding FAO Project	B.K. Das, Director, M. Naskar, Arun Pandit, U.K. Sarkar, B.K. Bhattacharjya	1 October, 2021	ICAR-CIFRI; virtual mode
103.	Meeting with DDG (Fisheries), ICAR	All scientists of ICAR-CIFRI	05 October, 2021	ICAR-CIFRI, Barrackpore
104.	Meeting with Secretary, DARE and DG, ICAR	All scientists of ICAR-CIFRI	06 October, 2021	ICAR-CIFRI, Barrackpore
105.	2nd International e-Conference on 'Advances in Agriculture, Technology and Allied Sciences for Sustainable Development' in collaboration with Department of Seed Science & Technology, Ch. Charan Singh University, Meerut, and in association with Scientific & Applied Research Centre, Meerut	N. Samarendra Singh	9-10 October, 2021	SERS, Meerut, India, Graphic Era Hill University, Dehradun
106.	Launch of PM Gati Shakti National Master Plan	B.K. Das, Director	13 October, 2021	Govt. of India, New Delhi
107.	Webinar on Impact of Covid-19 Pandemic on Ecology and Fisheries of River Ganga	All Scientists of the Institute	18 October, 2021	ICAR-CIFRI, Prayagraj; virtual mode
108.	Lecture delivered by Dr. Dilip Kumar on the Occasion of the 75 years of ICAR-CIFRI	All Scientists of the Institute	20 October, 2021	ICAR-CIFRI, Barrackpore, both online and offline mode
109.	National Webinar on Fish for Health and Fish for Wealth Campaign	U.K. Sarkar, H. Chowdhury, Sajina A.M., Lianthuamluaia, S. Kumari, Mishal P., A. Meetei, P. Majhi, S.K. Koushlesh, T.T. Paul	21 October, 2021	Dept. of Fisheries, MoFAHD, Govt of India; virtual mode
110.	International Webinar on Diversity Conservation Concerns of Marine Mammals	S. Das Sarkar	23 October, 2021	Carmel College of Arts, Science and Commerce for Women, Goa in collaboration with Goa State biodiversity board and Wildlife Institute of India; virtual mode

111.	First International Symposium on Aquatic Biodiversity of the North Eastern Region of India, organized by Detusche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH, Federal Republic of Germany in Collaboration with Zoological Society of India and Gauhati University"	A.K. Yadav, P. Das, S. Borah	26-27 October, 2021	Gauhati University, Assam; virtual mode
112.	Interaction meeting of Secretary DARE & DG, ICAR with ICAR Scientists	All scientists of ICAR-CIFRI	28 October, 2021	ICAR, New Delhi; virtual mode
113.	Platinum Jubilee Lecture series II by Dr. Dilip Kumar on 'Indian Fisheries -Introspection to Course Correction'	All staff members of the Institute	28 October, 2021	ICAR-CIFRI, Barrackpore; both online and offline mode
114.	Meeting of the National Committee on Introduction of Exotic Aquatic Species to Aquaculture	B.K. Das, Director	02 and 9 November, 2021	Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairy, New Delhi
115.	Nutri Smart Villages: An Innovative Model for Strengthening *Poshan Abhiyan*	U.K. Sarkar, H Chowdhury, Sajina AM, Lianthuamluaia, Suman Kumari, Mishal P, Anand Meetei, P Majhi, SK Koushlesh, D. Sudheesan, T.T Paul, S. Manoharan	10 November, 2021	ICAR, New Delhi; virtual mode
116.	XV Agricultural Science Congress & ASC Expo 2021	Offline: B.K. Das, S.K. Nag, Sajina A.M; D.N. Jha, S.K. Sharma,Vijay Kumar On-line: S. Das Sarkar, Lianthuamluaia, S. Kumari, S.K. Manna	13-16 November, 2021	BHU, Varanasi both offline and on-line mode
117.	Inception Workshop on 'Taking Nutrition-Sensitive Carp-SIS Polyculture Technology to Scale'	S. Yengkokpam, P. Das, S. Borah, N. Sharma	16 November, 2021	World Fish in collaboration with GIZ, Germany; virtual mode
118.	1st Steering Committee Meeting on Precision Agriculture with Director General, ICAR at Bhubaneswar, Odisha	B.K. Das, Director	18 - 19 November, 2021	ICAR-IIWM, Bhubaneswar
119.	Meeting with Second Sub-Committee of the Parliamentary Committee on Official Language (Rajbhasa) at Kolkata	B.K. Das, Director	22 November, 2021	ICAR Institutes at Kolkata
120.	Platinum Jubilee Lecture Series III by Dr. Rai S. Kookana on 'Organic Contaminants of Emerging Concerns for Aquatic Ecosystem'	All Scientists of the Institute	25 November, 2021	ICAR-CIFRI, Barrackpore; both on-line and off-line mode

121.	Platinum Jubilee Lecture Series No. 3 as a part of the Institute's 75 years celebration: lecture by Dr. Rai S. Kookana "Organic Contaminants of Emerging Concerns for Aquatic Ecosystem"	All the scientists of the institute	26 November, 2021	ICAR-CIFRI, Barrackpore, on-line mode
122.	Agricultural Education Day-2021	All staff members of the Institute	03 December, 2021	ICAR-CIFRI, Barrackpore
123.	Webinar on World Soil Day	All Scientists of the Institute	05 December, 2021	ICAR-CIFRI, Barrackpore; both on-line and offline mode
124.	91+ Annual Session & Symposium on 'Interface between Biological and Physical Sciences towards Atmanirbhar Bharat' (Celebrating 75 years of India's independence- 'Azadi ka Amrit Mahotsav')	All Scientists of the Prayagraj centre of the Institute	05 December, 2021	National Academy of Sciences (NASI), Prayagraj; virtual mode
125.	Interactive Meeting with the DG, ICAR and Young Scientists'	All the young scientists of the institute	8 December, 2021	ICAR, New Delhi; virtual mode
126.	Conference on Natural Farming (Zero Budget Natural Farming)	U.K. Sarkar, H. Chowdhury, Sajina A.M., Lianthuamluaia, S. Kumari, Mishal P., A. Meetei, P. Majhi, S.K. Koushlesh, D. Sudheesan, T.T Paul	16 December, 2021	ICAR, New Delhi; virtual mode
127.	International Conference on "Integrated Approaches towards Sustainable Management of Environment for Safe Food, Nutrition and Improved Health"	B.K. Das, Director	15-17 December, 2021	University of Kalyani, Kalyani
128.	Webinar on "Interactive Regional Workshop on Open Water Fisheries Enhancement on North-East Region of India"	B.K. Das, Arun Pandit, U.K. Sarkar, H. Chowdhury, Sajina A.M., Lianthuamluaia, S. Kumari, Mishal P., A. Meetei, P. Majhi, S.K. Koushlesh and all scientists of Guwahati centre	20 December, 2021	ICAR-CIFRI, Barrackpore both on-line and offline mode
129.	Integrated Fisheries Management in Sardar Sarovar Reservoir	B.K. Das, Director	20 December, 2021	Narmada Control Authority; virtual mode
130.	Interactive workshop on 'Cage culture in Umiam reservoir, Meghalaya'	B.K. Das, Director and all scientists of Guwahati centre	21 December, 2021	Umniuh Khwan village of Umiam, Meghalaya
131.	117th meeting of Technical Advisory Committee (TAC) of Farakka Barrage Project (FBP)	B.K. Das, Director A.K. Sahoo	21-23 December, 2021	Farakka Barrage, West Bengal

132.	International River Congress	B.K. Das, Director	27–29 December, 2021	South Asian Institute for Advanced Research & Development (SAIARD), National Mission for Clean Ganga, Ministry of Jal Shakti & National Institute of Urban Affairs, Ministry of Housing & Urban Affairs, Govt. of India; National Library Campus, Kolkata

Glimpses of different meetings, seminars, etc.

DISTINGUISHED VISITORS

Dr. B.K. Mahapatra, Vice Chancellor, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur visited ICAR-CIFRI, Barrackpore on the occasion of inauguration of Multi-facility Training Complex on 06 October 2021.

Dr. Arunava Pattanayak, Director, ICAR-Indian Institute of Agricultural Biotechnology, Namkum, Ranchi-834010 visited the Institute on 23 August 2021.

Shri Jayadevan A., IPS, Supdt. of Police and HoB, EO-IV, CBI, Kolkata, Salt Lake, Kolkata visited ICAR-CIFRI, Barrackpore on 01 November 2021 and graced the Valedictory Function of Vigilance Awareness Week as Chief Guest.

Shri G.P. Sharma, Director, Finance (ICAR), New Delhi visited ICAR-CIFRI, Barrackpore on 13 February 2021.

Dr. J. K. Jena, DDG (Fy. Sc.), ICAR visited the ICAR-CIFRI Regional Centre, Prayagraj and inaugurated the 'Matsyalok Guest House' on 15 November 2021.

Ms. Anamika Chaudhari (State coordinator of Ganga vichar manch) graced the Ranching cum Mass Awareness program, held on 05 March 2021 at Sangam Nose (Prayagraj).

Shri Ravindra Prasad, CEO of Fisheries Department, Varanasi and former Principal Scientist, Dr. B. K. Singh (Special Guest) were present in Ranching cum mass awareness program held on 08 March 2021 at Raj Ghat (Varanasi).

Shri Srikanta Mahata, Hon'ble Minister of the Department of Micro, Small & Medium Enterprises and Textiles, Government of West Bengal, visited research facilities of ICAR-CIFRI, Barrackpore on 17 December 2021

Dr. Sanjeev Kumar Balyan, Hon'ble Minister of State, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India visited ICAR-CIFRI, Barrackpore during 8-9 April 2021.

Dr. T. Mohapatra, Secretary DARE & Director General, ICAR visited the Institute on 06 October 2021 and inaugurated the Multi-facility Training Complex at ICAR-CIFRI, Barrackpore. He was accompanied by Dr. J.K. Jena, DDG (Fy. Sc.), and Dr. Anil Rai, ADG (ICT), ICAR on this occasion.

Dr. Pravin Putra, ADG (M. Fy.), ICAR visited the Bengaluru Research Centre on 20 March 2021

Dr. J. K. Jena, DDG (Fy. Sc.) visited the ICAR-CIFRI Research Centre, Bengaluru on 25 February 2021 and interacted with the scientists of Regional Research Centre of ICAR-CIFRI and ICAR-CIFA, Bengaluru

STAFF INFORMATION

STAFF POSITION AS ON 31 DECEMBER 2021

Category	Sanctioned Strength	Filled up	Vacant
R.M.P	1	1	-
Scientist	88	83	5
Technical	86	49	37
Administrative	66	36	30
Skilled Support Staff	65	26	39
TOTAL	306	195	111

Head office / Centre-wise staff in position

Name of the Centre	RMP	Scientist	Technical	Administrative	Skilled Support Staff	Total
Barrackpore	1	52	33	30	15	131
Kolkata	-	3	1	-	1	5
Vadodara	-	3	2	1	4	10
Allahabad	-	6	6	1	3	16
Bengaluru	-	8	3	1	1	14
Guwahati	-	9	2	2	2	15
Kochi	-	2	2	-	-	4
TOTAL	1	83	49	36	26	195

NEW JOINING

S.No.	Name of the staff	Date of joining
1	Sh. Subhankar Dey, FAO	08.11.2021
2	Sh. Rajdip Dutta, Assistant	28.09.2021

TRANSFER

(i) **Inter-institutional transfer**

S. No.	Name of the staff	From	To
1	Sh. Tasso Tayung, Scientist	ICAR-CIFRI, Barrackpore	ICAR Research Complex for NEH Region, Umiam
2	Dr. Monika Gupta, Scientist	Regional Centre, ICAR-CIFRI, Prayagraj	ICAR-NBFGR, Lucknow
3	Sh. N. V. R. N. Murty, SFAO	ICAR-CIFRI, Barrackpore	ICAR-CRIDA, Hyderabad
4	Dr. Sonalika Sahoo, Scientist	ICAR-NBSSLUP, Nagpur	Regional Centre, ICAR-CIFRI, Bengaluru

(ii) **Intra-institutional transfer**

S. No.	Name of the staff	From	To
1	Sh. K. Lohith Kumar, Scientist	ICAR-CIFRI, Barrackpore	Research Station, ICAR-CIFRI, Vadodara
2	Sh. Wakambam Anand Meetei, Scientist	Research Station, ICAR-CIFRI, Vadodara	ICAR-CIFRI, Barrackpore
3	Sh. U. S. Ram, Skilled Support Staff	ICAR-CIFRI, Barrackpore	Regional Centre, ICAR-CIFRI, Prayagraj

Ms. Sohini Chatterjee, Stenographer Grade.III was relieved from ICAR-CIFRI on 31.10.2021 for joining to the post of Stenographer Grade I (Pay Level 6) at the Office of the Principal Commissioner of Customs (Airport & A.C.C.), Kolkata.

PROBATION CLEARANCE OF TECHNICAL, ADMINISTRATIVE AND SKILLED SUPPORT STAFF

S. No.	Name of the officials	Name of the post in which probation is completed
Technical category - 9		
1	Sh. Mohammed Naim	Technical Assistant
2	Ms. Sangeeta Chakraborty	Technical Assistant
3	Sh. Kausik Mondal	Technical Assistant
4	Ms. Ambily M.N.	Technical Assistant
5	Ms. Sadrupa Bhowmick	Technical Assistant
6	Sh. Rakesh Pal	Technical Assistant
7	Sh. Anjon Kumar Talukder	Technical Assistant
8	Sh. Avishek Saha	Technical Assistant
9	Ms. Sumedha Das	Technical Assistant
Administrative category - 6		
1	Ms. Sreemanti Saha	LDC
2	Sh. Syed Abol Kabi	LDC
3	Sh. Debasish Acharya	LDC
4	Sh. Aritra Datta	LDC
5	Ms. Sohini Chatterjee	Steno. Gr.III
6	Sh. Somenath Banerjee	LDC
Skilled support staff - 8		
1	Sh. B. Shankar Reddy	SSS
2	Sh. Tapan Kr. Bhattacharjee	SSS
3	Ms. Anita G. Gavate	SSS
4	Sh. Ashok Kr. Nishad	SSS
5	Sh. Ajay Kumar Nishad	SSS
6	Sh. Jayanta Pramanik	SSS
7	Sh. Niranjan Kumar	SSS
8	Sh. Divakar Rajendran	SSS

PROMOTION

Scientist		
S. No.	**Name & Designation**	**Promoted to**
1	Sh. Anil Kumar Yadav, Scientist	Scientist with Pay Level-11 w.e.f. 09.11.2014
2	Ms. Chayna Jana, Scientist	Scientist with Pay Level-11 w.e.f. 15.12.2014
3	Dr. Aparna Roy, Scientist	Senior Scientist with Pay Level-12 w.e.f. 23.06.2018
4	Dr. Suhas Prakash Kamble, Scientist	Scientist with Pay Level-11 w.e.f. 01.07.2018
5	Dr. Dharm Nath Jha, Scientist	Senior Scientist with Pay Level-11 w.e.f. 06.11.2018
6	Dr. Raju Baitha, Scientist	Scientist with Pay Level-11 w.e.f. 04.12.2018
7	Dr. Pranay Kumar Parida, Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2019
8	Sh. K. Lohith Kumar, Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2019
9	Sh. Mishal P., Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2019

10	Dr. Venkatesh R. Thakur, Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2019
11	Ms. Gunjan Karnatak, Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2019
12	Ms. V. L. Ramya, Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2019
13	Sh. Rahul Das, Scientist	Scientist with Pay Level-11 w.e.f. 01.01.2020
Administrative		
1	Sh. Suranjan Kr. Singh	Promoted to the post of Assistant
2	Sh. Raushan Kumar	Promoted to the post of AAO
3	Sh. Shyamali Mitra	Promoted to the post of AAO
4	Ms. S. Sumitha Devi	Promoted to the post of AAO
Technical		
1	Sh. J. K. Solanki	Promoted to TO
2	Sh. Vijay Kumar	Promoted to TO
3	Sh. Manabendra Roy	Promoted to TO
4	Sh. Amulya Kakati	Promoted to TA
5	Sh. T. K. Halder	Promoted to STA
Skilled Support Staff		
1	Sh. Debasis Singha	Promoted to the post of LDC
2	Sh. Prokash Chandra Pramanick	Promoted to the post of LDC
3	Sh. P. R. Mahata	Promoted to the post of LDC
4	Sh. M. Pennappa	Promoted to the post of Technician
5	Sh. M. Mari	Promoted to the post of Technician
6	Sh. P. V. Shajil	Promoted to the post of Technician
7	Sh. Munshi Ram Rana	Promoted to the post of Technician
8	Sh. Ratan Das	Promoted to the post of Technician
9	Sh. Binod Kumar Sahani	Promoted to the post of Technician

SUPERANNUATION

S. No.	Name	Designation	Date of Retirement	Place of posting
1	Sh. Soumitra Roy	ACTO	31.01.2021	Barrackpore
2	Sh. Amarnath Prasad	SSS	31.01.2021	Barrackpore
3	Ms. Swapna Chattopadhyay	Assistant	31.01.2021	Barrackpore
4	Sh. Arjan V. Dangar	SSS	28.02.2021	Vadodara
5	Sh. Manabendra Dutta	SSS	31.03.2021	Barrackpore
6	Sh. T. K. Halder	TA	01.03.2021(VRS)	Barrackpore
7	Sh. Debasis Saha	TO	31.08.2021	Barrackpore
8	Sh. Giridhari Paramanick	TA	30.09.2021(VRS)	Barrackpore
9	Dr. S. K. S. S. Hameed	STO	31.10.2021(VRS)	Barrackpore
10	Ms. Shyamali Mitra	Assistant	31.10.2021	Barrackpore
11	Dr. Sanjay Bhowmick	CTO	31.12.2021	Barrackpore
12	Dr. S. Dam Roy	Principal Scientist	31.12.2021	Kolkata

DEMISE

S. No.	Name of the Official	Designation	Date of death
1	Sh. Rathva Nagajibhai Kantibhai	SSS	17. 07. 2021
2	Ms. Laxmi Devi	SSS	13. 08. 2021

PERSONNEL AS ON 31 DECEMBER 2021

Headquarter, Barrackpore
Director
Dr. B. K. Das
Head of Division
Dr. S. Samanta
Dr. U. K. Sarkar
Dr. M. A. Hassan
Dr. S. K. Nag
Dr. B. K. Behera
Principal Scientist
Dr. Malay Naskar
Dr. S. K. Manna
Dr. A. K. Das
Dr. R. K. Manna
Dr. Md. Aftabuddin
Dr. Sanjay Kumar Das
Dr. Arun Pandit
Dr. Hemanta Chowdhury
Dr. A. K. Bera
Senior Scientist
Dr. A. K. Sahoo
Dr. Aparna Roy
Scientist
Sh. P. Maurye
Sh. Ganesh Chandra
Dr. D. Das
Sh. S. K. Sahu
Dr. Sajina A. M.
Dr. Soma Das Sarkar
Dr. P. K. Parida
Ms. Prajna Ritambhara Swain
Sh. Roshith C. M.
Dr. Raju Baitha
Dr. Suvra Roy
Dr. Kavita Kumari
Sh. S. K. Koushlesh
Sh. M. H. Ramteke
Ms. Thangjam Nirupada Chanu
Dr. D. K. Meena
Dr. Suman Kumari
Dr. Vikash Kumar
Dr. Lianthuamluaia
Ms. Gunjan Karnatak
Sh. Mishal P.
Dr. Himanshu Sekhar Swain
Dr. Pritijyoti Majhi
Ms. Anjana Ekka
Dr. Tanushree Bera
Ms. J. Canciyal
Dr. Dhruba Jyoti Sarkar
Dr. Piyasi Debroy
Sh. Rahul Das
Dr. Dibakar Bhakta
Ms. Tanuja Abdulla
Ms. Chayna Janna
Sh. W. Anand Meetei
Ms. Sangeetha M Nair
Dr. Manoharmayum Shaya Devi
Sh. Santhana Kumar V
Technical Staff
Dr. Sanjay Bhowmick
Ms. Keya Saha
Sh. Raban Chandra Mandi
Md. Quasim
Sh. Sujit Chowdhury
Ms. Sunita Prasad
Sh. Abhijita Sengupta
Sh. Yousuf Ali
Sh. Manabendra Roy
Sh. Asish Chakraborty
Sh. Rabiul Sk.

Technical Staff (contd…..)
Sh. Subhendu Mondal
Sh. Bablu Kumar Naskar
Sh. Sanjay Kumar Das
Sh. Asim Kumar Jana
Sh. Arun Kumar Mondal
Sh. Sudarsan Bandopadhyay
Sh. Suvra Saha
Sh. Subrata Das
Sh. Atanu Das
Sh. Arijit Ghsoh
Sh. Lokenath Chakraborty
Sh. Anjon Kumar Talukder
Ms. Sumedha Das
Ms. Sadrupa Bhowmick
Ms. Sangeeta Chakraborty
Sh. Kausik Mondal
Sh. Avishek Saha
Sh. Rakesh Pal
Ms. Ambily M. N.
Mohammed Naim
Sh. B. K. Sahani
Sh. Ratan Das
Administrative Staff
Sh. Rajeev Lal
Sh. Subhankar Dey
Sh. Sudipta Gupta
Sh. Biswajit Barua
Sh. S. S. Ghosh
Ms. Paushali Mukherjee
Sh. Subir Das
Sh. Ashwini Kumar
Ms. Jolly Saha
Sh. Santosh Sarkar
Sh. Ganesh Chandra Barman
Sh. Raushan Kumar
Sh. Kishore Shaw
Ms. Ruma Ghosh
Sh. Chandan Chakraborty
Ms. Mousumi Banerjee (Nan)
Sh. Bijoy Roy
Sh. Pradipta Sen
Sh. Suranjan Singh
Sh. Fazal Khan
Sh. B. L. Dhanuk
Sh. Somenath Banerjee
Ms. Sreemanti Saha
Sh. Syed Abol Kabi
Ms. Ankita Ghosh
Sh. Debasish Acharya
Sh. Aritra Datta
Sh. Debasis Singha
Sh. P. R. Mahata
Sh. P. C. Paramanik
Skilled Support Staff
Sh. Gopal Ch. Roy
Sh. M. L. Sarkar
Sh. Sukhen Das
Sh. Shibani Bhattacharya
Sh. Shabbir Ahmed
Ms. Bindu Singh
Sh. Ravi Kumar Sonkar
Sh. B. Shankar Reddy
Sh. Tapan Kumar Bhattacharjee
Ms. Anita Ganesh Gawate
Sh. Ashok Kumar Nishad
Sh. Ajay Kumar Nishad
Sh. Jayanta Pramanick
Sh. Niranjan Kumar
Sh. Divakar R.

Regional Centre of ICAR-CIFRI, Allahabad
Scientist
Dr. Dharm Nath Jha, Scientist-In-Charge
Dr. Md. Absar Alam, Scientist
Sh. Jeetendra Kumar, Scientist
Sh. V. Ramrao Thakur, Scientist
Sh. Vikas Kumar, Scientist
Sh. Shravan Kumar Sharma, Scientist
Technical
Sh. S. K. Srivastava, CTO Dr. (Mrs.) Kalpana Srivastava, CTO Sh. Vijay Kumar, STA Sh. Jitendran Kr. Singh, STA Sh. Munshi Ram Rana, Technician Sh. Ram Sajiwan, TO (Driver)

Administrative
Sh. Manish Kumar Singh, UDC
Skilled Support Staff
Sh. Gopal Chand, SSS
Sh. V. S. Ram, SSS
Sh. Anil Kumar, SSS

Regional Centre of ICAR-CIFRI, Guwahati
Scientist
Dr. B. K. Bhattachariya, Principal Scientist & Acting Head
Dr. Sona Yengkokpam, Senior Scientist
Dr. Depesh Debnath, Senior Scientist
Sh. Anil Kumar Yadav, Scientist
Dr. Pranob Das, Scientist
Ms. Niti Sharma, Scientist
Dr. Simanku Borah, Scientist
Dr. N. S. Singh, Scientist
Dr. S. C. Sukla Das, Scientist
Technical
Sh. Bipul Ch. Ray, Senior Technical Officer
Sh. Amulya Kakati, Senior Technician
Administrative
Sh. Ganesh Bhanja, UDC
Sh. Rajdip Dutta, Assistant
Skilled Support Staff
Sh. S. Kalita, SSS
Sh. Hemanta Das, SSS

Research Station of ICAR-CIFRI, Kochi
Scientist
Dr. Deepa Sudheesan, Scientist-in-Charge
Dr. Thankam Theresa Paul, Scientist
Technical
Sh. S. Monoharan, CTO
Sh. P. V. Shajil, Technician

Regional Centre of ICAR-CIFRI, Vadodara
Scientist
Dr. Kamble Suhas Prakash, Scientist & In-Charge
Sh. K. Lohit Kumar, Scientist
Dr. Vaisakh G., Scientist
Technical
Sh. R. K. Sah, Technical Officer
Sh. Solanki Jayesh K., Senior Technical Assistant

Administrative
Sh. C. D. Parmer, Assistant
Skilled Support Staff
Sh. H. J. Chetanbhai, SSS
Sh. Machi Suresh Bhai Chimanbhai, SSS
Sh. Tadvi Santibhai Chandubhai, SSS
Ms. Harshaben A. Joshi, SSS

Regional Centre of ICAR-CIFRI, Bengaluru
Scientist
Dr. Preetha Panikkar, Principal Scientist & Officer-in-Charge
Sh. M. Feroz Khan, Scientist
Sh. M. Karthikeyan, Scientist
Dr. Ramya V. L., Scientist
Dr. Sibina Mol, Scientist
Dr. Ajoy Kumar Saha, Scientist
Sh. Jesna P. K., Scientist
Dr. Sonalika Sahoo, Scientist
Technical
Sh. Vijay Kumar M. E., Technical Officer
Sh. M. Mari, Technician
Sh. M. Pennappa, Technician
Administrative
Ms. G. Vinodalaxmi, Personal Assistant
Ms. S. Sumithra Devi, Assistant
Skilled Support Staff
Sh. R. Nagrrajan, SSS

Research Station of ICAR-CIFRI, Kolkata
Scientist
Dr. Archana Sinha, Principal Scientist
Sh. Pronob Gogoi, Scientist
Technical
Sh. Arunava Mitra, Technical Officer
Skilled Support Staff
Ms. Kalyani Biswas, SSS

IMPORTANT CONTACTS

Dr. B. K. Das, Director
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25920177(0); 033-25920029(R)
033-25920388 (F); 033-25450997 (F)
director.cifri@icar.gov.in;director.cifri@gmail.com
http://www.cifri.res.in

Dr. S. Samanta, Acting Head
Riverine Ecology and Fisheries Division,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25921190-91 Ext- 229 (0)
033-233726578; 9830849393(M)
samantacifri@gmail.com

Dr. S. K. Nag, Acting Head
Fisheries Resource Assessment and Informatics Division,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata -700120, West Bengal
033-25452061(0), 033-25921190-91 Ext- 230 (0),
8902648620 (M)
nagsk_67@rediffmail.com

Dr. U. K. Sarkar, Acting Head
Reservoir and Wetland Fisheries Division,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata -700120, West Bengal
033-25935289 (0); 033-65226871 (R), 9800347666;
9051668588(M)
uksarkar1@gmail.com

Dr. M.A. Hassan, Acting Head
Fisheries Enhancement & Management Division,
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata-700 120, West Bengal
033-25921191-90 Ext-210, 0-9674388968 (M)
ma_hassan@rediffmail.com

Dr. B. K. Behera, Acting Head
Aquatic Environmental Biotechnology &
Nanotechnology Division,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata -700120, West Bengal
033-25921190-91 Ext- 414 (0); 91632095808,
9163209582 (M)
beherabk18@yahoo.co.in

Dr. D. N. Jha, Officer-in-charge
ICAR-CIFRI Regional Centre,
24 Pannalal Road, Allahabad - 211002, Uttar Pradesh
0532-2461529 (0); 0532-2460531 (0), 9956610404 (M)
dharmnath.jha@gmail.com

Dr. B. K. Bhattacharjya, Acting Head
ICAR-CIFRI Regional Centre,
Housefeed Complex, Central Building,
4th Floor, Beltola Basistha Road,
Dispur, Guwahati -781006, Assam
0361-2224893 (0), 0361-2228486(0); 9435553274 (M)
bkbhattacharjya@yahoo.com

Dr. (Ms.) Preetha Panikkar, Officer-in-charge
ICAR-CIFRI Regional Centre,
Hassarghatta Post, Bengaluru - 560089, Karnataka
080-28449889 (0); 080-23203633 (R), 98455367481
(M)
preetha23@gmail.com

Dr. Kamble Suhas Prakash, Officer-in-charge
ICAR-CIFRI Regional Research Centre
2nd floor, New Administrative Building,
GERI Compound, Behind Yash Complex,
Gotri, Vadodara- 390 021
(0265)-2371601 (Telefax); 9004057233(M)
cifrivad@yahoo.co.in; suhaskamble149@gmail.com

Dr. (Ms.) Archana Sinha, Officer-in-Charge
ICAR-CIFRI Research Station,
CGO Complex, 2nd Floor, C-Wing,
DF Block, Salt Lake, Kolkata – 700064
033-23379444 (Telefax); 9433033950 (M)
sinhaarchana@yahoo.com

Dr. Deepa Sudheesan, Officer-in-charge
ICAR-CIFRI Research Station,
CMFRI Campus, Ernakulam North P.O.,
Kochi – 682018, Kerala
0484-2395973 (0), 8981049833 (M)
deepasudheesan@gmail.com

Dr. A. K. Das, ln-charge
Extension & Training Cell,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25921190-91 Ext- 231 (0); 033-25429978;
9432247006(M)
archandas@yahoo.com

Dr. Arun Pandit, ln-charge,
Economics and Policy Unit
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25921190-91 Ext- 213 (0); 9903136521 (M)
arunpandit74@gmaiLcom

Dr. B. K. Behera, In-charge
Prioritisation, Monitoring and Evaluation Cell,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata -700120, West Bengal
033-25921190-91 Ext- 235 (0)
91632095808; 9163209582 (M)
beherabk18@yahoo.co.in

Dr. S. Samanta, ln-charge
Hindi Cell,
ICAR-Central lnland Fisheries Research Institute,
Barrackpore, Kolkata -700120, West Bengal
033-25921190-91 Ext- 225 (0)
033-233726578; 9830849393(M)
samantacifri@gmail.com

भाकृअनुप-केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान

बैरकपुर, कोलकाता-700 120, पश्चिम बंगाल

ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE

Barrackpore, Kolkata - 700120, West Bengal

Phone: (033) 2592 0177 (O), Fax : (033) 2592 0388. EPABX: (033) 2592 1190 / 91

www.cifri.res.in